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A Mechanisation of Victorian Values:
The Making of W.S. Jevons'
Theory of Political Economy

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This thesis has had a long gestation period and I have incurred a significant number of debts in the process of writing it.

Chapters 2, 3, 4, 5 and 8 have previously been published in refereed journals and a book. A note at the beginning of each of those chapters gives the precise publication details and acknowledges the helpful comments and advice received from a number of scholars in each case. Those chapters have been lightly edited to maintain consistency, especially in referencing, within the thesis.

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Finally I want to express my appreciation to Peter Groenewegen, Geoff Harcourt, John King and Philip Mirowski for work over the years that has inspired, in different ways, the analysis that follows.

STATEMENT

This thesis contains no material which has been submitted for the award of any other degree or diploma of any university and, to the best of my knowledge and belief, contains no material, written or published by another person, except where due reference is made in the text of the thesis.

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INTRODUCTION

In August 1890, a review of the first edition of the Principles of Economics by Alfred Marshall, professor of political economy at Cambridge University, was published in the journal Nature. The review was written by Francis Ysidro Edgeworth, soon to become Marshall's counterpart as occupant of the Drummond chair at Oxford University.[1] Edgeworth announced that the publication of Marshall's text had put to rest the disputes over value theory that had racked British economics during the nineteenth century. Using a Marshallian partial equilibrium (price-function) supply and demand diagram to illustrate his case, Edgeworth argued that Marshall had established the necessary "symmetry" to explain the value of commodities as "the equilibrium between demand and supply".[2] He was the first to "adequately" do so, "uniting in a comprehensive view the doctrine of final utility, which [William Stanley] Jevons and other recent writers have made prominent, with the equally eternal verities relating to `cost of production,' which are connected with the name of [David] Ricardo ... From this point of view is apparent the inaccuracy of those who describe value as altogether an affair of final utility, and speak of Ricardo as being `preposterous' in the classic sense of putting the cart before the horse" [Edgeworth 1890, p.362]. The `inaccuracy' was due to Jevons who had opened his Theory of Political Economy, first published in 1871, by declaring that "value depends entirely on utility" and had announced in the second edition of 1879 that it was necessary to "fling aside, once and forever, the mazy and preposterous assumptions of the Ricardian school" along with a "cost of production theory of value" [Jevons 1970, pp.77,67,68].[3] For Edgeworth, division and acrimony could now be replaced by harmony, with the theoretical apparatus of Marshall's Principles providing the means to both explain the meaning and assess the validity of previous contributions to value theory.

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[1] The Preface to the first edition of Marshall's text was dated September 1890 [Marshall 1961, I, p.xi]. As Edgeworth's review was published in August, he was presumably working from page proofs.

[2] The diagram, Edgeworth [1890, p.362] suggested, `followed' A. A. Cournot's Recherches (1838).

[3] All emphases in citations in this thesis appear in the original texts.

Edgeworth's review could be considered from a number of perspectives in a history of British post-classical (or `neoclassical') economics.[4] An analysis of `professionalisation', for example, might consider how the publication of the review in Nature was symptomatic of the close of an era in which there was no journal specifically devoted to the discussion of economics. That situation was to change in the same year with the formation of the British Economics Association. Indeed, Edgeworth was the first editor of the Association's Economic Journal and was to review the second edition of Marshall's Principles in the first volume [Edgeworth 1891]. The review could also be considered as part of an ongoing struggle between British and European theorists regarding the content and method of the newfound symmetry. Edgeworth's extravagant praise for Marshall was in marked contrast with the more guarded tone in his review, also published by Nature in the previous year, of the second edition of Leon Walras' Elements of Political Economy [Edgeworth 1889]. That review was the opening salvo in what was to become a rather bitter exchange between Edgeworth and Walras regarding the explanation of how of an equilibrium between demand and supply was attained and whether the theoretical adjustment process could explain events in `actual' markets [Bridel and Huck 2002]. Contrary to the impression given in the review of Marshall, the explanation for an equilibrium between demand and supply remained contentious.

The issues indicated above are relevant for this thesis, the purpose of which is to provide an account of the principal arguments, the production and the significance of Jevons' Theory of Political Economy (TPE) in a history of economics. Jevons (1835-1882) had, for example, been a frequent contributor to Nature from its inception in 1870, using that journal to publish experimental results regarding the explanation of behaviour in TPE [Jevons 1870].[5] His discussion in TPE of an equilibrium in market trading was also used as a resource by Edgeworth and Walras in their subsequent disputation. It is, however, Edgeworth's summary assessment of TPE that provides a convenient introduction to the analysis that follows. Edgeworth was simply repeating the claim in Marshall's Principles that TPE presented both a `one-sided' and confusing account of value theory. The discussion was one-sided in that Jevons insisted that value was determined by the final degree of utility which was relevant for

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[4] Both these terms will be used in the thesis although, partly for the reasons outlined by Tony Aspromorgous [Aspromorgous 1986], post-classical is more appropriate.

[5] For an extensive Jevons bibliography, see Inoue and White 2002.

explaining demand.[6] In Marshallian terms, this was, at best, a special case, where a downward-sloping demand curve was crossed by a perfectly inelastic supply curve [Marshall and Marshall 1879, pp.145,148]. In more general terms, however, Marshall argued that Jevons had exaggerated the importance of (consumer) demand. At the same time, the argument in TPE was confused and confusing because, when he did refer to the role of cost of production in explaining value, Jevons' summary statement could be reduced to the argument that cost of production determined value. The problem, Marshall implied, was, in part, that Jevons' deficent mathematical ability left him unable to understand the `fundamental symmetry' between demand and supply [Marshall 1961, I, pp.817-20].[7]

Edgeworth's review was symptomatic of how quickly Marshall's verdict was generally accepted within the British economics profession, including the early editors of Jevons' work. For Henry Higgs, who edited Jevons' incomplete and posthumously published Principles of Economics, "the original contribution Jevons made to pure theory [in TPE] was his examination of the theory of Demand, and its connection with Value through the principle of Final or Marginal Utility" [Higgs 1905, p.vi]. A.W. Flux, who, like Jevons, was Cobden lecturer at Owens College (later the University of) Manchester and was subsequently to edit the third edition of Jevons' The Coal Question [Jevons 1906], had earlier conceded that, if Jevons had "possessed a clearer and more intuitive perception of mathematical ideas, he would not have fallen into some errors which unfortunately mar his work. To grasp the concurrent variation of more than two commodities required an effort of which at times he was incapable." Jevons' deficient mathematical intuition provided "the key" to understanding his confusing statements regarding value [Flux 1894, pp.339, 342]. The basic contours of Marshall's reading have also proven remarkably resilient for those historians of economics who consider Jevons' arguments about value theory and the role of supply and demand. In such accounts, Jevons can be credited with using a marginal utility theory to explain consumer demand, setting out the basic condition for consumer equilibrium still used in today's microeconomics textbooks. If it is also

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[6] For much of the analysis in this thesis, Jevons' `final degree of utility' and Marshall's `marginal utility' can be taken as equivalent. The difference in the mathematical expression [Marshall 1961, I, p.838] meant that it was not possible to obtain a total integral of utility from Jevons' formulation. The relevance of that matter for explaining the argument in TPE is considered in Chapter 7 below.

[7] Marshall's critique, which initially appeared in the body of the text, was transferred to Appendix I ("Ricardo's Theory of Value") from the fifth edition [Marshall 1961, II, pp.813-21].

acknowledged that he made some interesting remarks about the analysis of labour supply, his discussion of value in relation to cost of production is nevertheless depicted as `naïve' and confused [Blaug 1997, p.297].[8] The verdict of confusion is reinforced if it is accepted that, despite his explicit statements to the contrary, Jevons "did not reject a cost of production theory of value" [Peart 2003, p.9].

There was a second component of Marshall's commentary which, although not mentioned by Edgeworth, is also reflected in and structures much of the commentary on TPE today. With all prices explained by reference to supply and demand, initially represented by the diagram that Edgeworth reproduced, Marshall assumed that the only way the behaviour represented by the diagram could be explained was in the terms of a marginal utility theory. It followed that if Ricardo had not dealt completely satisfactorily with demand, it was because he was searching for, but had failed to precisely identify, that theory. Although, in places, Ricardo "seems to be feeling his way towards the distinction between marginal and total utility", he was prevented from clearly doing so by his deficient mathematical knowledge – he was "ignorant of the terse language of the differential calculus" [Marshall 1961, I, p.814]. The implication of this claim is that there was a natural fit between the geometry of the supply and demand diagrams and the calculus of the marginal utility theory that had always existed but had not been fully recognised. Jevons' contribution had been to recognise that deficiency on the demand side and then to `call attention' to and `develop' it [*ibid.* p.820].

While Marshall's account suggested that the deficiencies in Ricardo's and Jevons' expositions of value theory were in part due to their deficient mathematics, it also entailed that there was nothing substantially new in the theory of behaviour presented in TPE. The theory of marginal utility had always existed; it simply needed to be discovered. Indeed, according to Marshall, "Ricardo and his followers ... and even Cournot" had understood the the importance of the final degree of utility for explaining demand, but "thought it too obvious to be explicitly mentioned". In any case, W. F. Lloyd had "anticipated many of the central ideas of the prevalent doctrine of utility" in the early 1830s [ibid. p.101]. The subsequent industry in the history of

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[8] This is not the only reading given of TPE. Another strand of commentary, referred to in Chapter 7 of this thesis, reads TPE in the terms of a twentieth-century `Edgeworth-Bowley box'. If that reading is problematic, the accompanying commentary solves the problem of accounting for Jevons' statements about value by *ignoring* them.

economics of identifying `anticipators' or `precursors' of the marginal utility theory has led many of today's historians of economics to Marshallian-like conclusions, such as the following: "Most of Jevons's theoretical innovations, such as marginal utility, maximising behaviour, the emphasis on consumption theory, were present in the work of other economists long before Jevons, though not in the Ricardian mainstream". There is, consequently, little that can be depicted as innovative in the "theoretical content" of TPE" [Maas 2001, p.3]. When this verdict is coupled with Jevons' confusion regarding supply and demand, TPE is reduced to a theoretical staging post on the path to the later more complete and balanced work of Marshall [Blaug 1997, p.292].

In whatever variants they appear, the Marshallian readings of TPE are Whig constructions that rest on the crucial, albeit implicit, assumption that there is only one possible theoretical framework in which nineteenth-century references to `supply and demand' and the `underlying' behaviour can be understood and made coherent. The texts considered in such a history are then read in the terms of, and for the extent to which they approximate, that theoretical framework. No careful consideration is given to the possibility that different frameworks may have been used in the texts considered. There is, therefore, no recognition of the possibility that statements or arguments which appear incomplete or `confused' in terms of the reading framework are made to appear so because their particular terms of reference have been erased.

In the case of TPE, where the frame of reference (or reading grid – see chapter 2 of this thesis) is Marshall's Principles, the result is a caricature of Jevons' analysis. To take only one example, it is not difficult to show that Jevons at no point argued that relative prices depended simply on demand as he insisted that the utility analysis provided a theoretical basis for explaining both demand and supply.[9] The point of identifying the misreading is not, however, to issue a plaint before the court of history that Jevons has been misunderstood. It is rather to show that, in the nineteenth century, supply and demand were conceptualised in different ways and that, even at the beginning of the post-classical period, the representation of supply and demand was a contested terrain. The 'Marshallian cross' representation was analytically quite

[9] Marshall did, in effect, acknowledge that Jevons explained supply and demand in terms of the marginal utility and disutility of commodities, but claimed that a "series of interpretations" were necessary to establish the argument [Marshall 1961, I, p.818]. The significance of that acknowledgement was, however, not pursued and subsequent commentators in the Marshallian mould have generally ignored it.

different to that in TPE, where Jevons' approach in part reflected that taken by most of his British predecessors. In such accounts, references to supply and demand provided only one part of an explanation for relative prices. Moreover, although Jevons was familiar with the first published use in English of (quantity-function) supply and demand diagrams by the engineer H.C. Fleeming Jenkin [Jenkin 1870] before TPE was published, he could see little value in their use because he understood the `laws of supply and demand' to be empirical `phenoma' or `facts'. Jevons' argument that supply and demand had a limited role in explaining relative prices and his understanding of the meaning of the `laws' make no sense when read in the terms of Marshall's Principles.

The assumption in the Whig histories of a natural fit between the marginal utility theory and the (Marshallian) supply and demand diagrams is actually belied by Marshall's early work in economics. Although he had begun working with supply and demand diagrams before 1871, Marshall did not use a marginal utility theory to explain the underlying behaviour until after he received his review copy of TPE.[10] If that point alone raises the possibility that Jevons' behavioural theory was new and distinctive, the rejection of that theory by Fleeming Jenkin [Jenkin 1871, pp.618,620], following his correspondence on the matter with Jevons in 1868, indicates that, initially at least, the theory was a contested device for explaining market trading. In the early 1870s, it was thus possible to: draw supply and demand diagrams without a marginal utility theory (Jenkin and the pre-TPE Marshall); draw the diagrams, while rejecting the use of any equations to describe them (Jenkin post-TPE); and, use a marginal utility theory but reject supply and demand diagrams (Jevons). Marshall's representation of supply and demand in the Principles thus had to be constructed as it did not exist when TPE was first published. I shall argue here that reading TPE through that construction erases many of the explanatory categories, terms of reference and hence the structure of Jevons' analysis. Consequently, the Marshallian readings have distracted attention from an examination of the analytical breaks Jevons made with his predecessors and the resources he used to produce his arguments.

To understand the arguments in TPE and the ways in which they were produced, it is first necessary to note how that text expressed a number of the fundamental beliefs

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[10] See Whitaker 1975, pp.122,130-1,145; Groenewegen 1995, pp.158-62; White 1996.

of the northern Unitarian grouping of businessman and intellectuals which included the extended Jevons family from Liverpool.[11] When Jevons moved to Manchester in the early 1860s, first as general tutor and subsequently as professor of mental philosophy and political economy at Owens College, he returned to a similar social milieu, epitomised by his by his presidency of the Manchester Statistical Society and his friendship and intellectual collaboration (in analysing `commercial fluctuations') with the banker John Mills. The fundamental beliefs included an unswerving commitment to `free trade' and a work ethic where market outcomes ultimately reflected relative skill and effort. Work itself was a form of duty, which was necessary to provide for both the present and the future, in the form of savings. Vigilance was required on all fronts to counteract the special interests and misguided actions that undermined the basis of future progress. As Jevons informed the Statistical Society in his Presidential Address of November 1869, the campaign then being waged by manufacturers in Manchester showed their proclivity to the siren call of protectionism [Jevons 1883, pp.181-3]. Moreover, "certain portions of the trading classes" could wreak significant damage with their "reckless or even criminal' speculative activities which had "disturbed the course of unrestricted industry' [ibid. p.182]. The greatest danger, however, came from the labouring classes. Trades unions disrupted and restricted trade, driven by a "harmful and hopeless" belief of a necessary "struggle against capital". Even more alarming was the pursuit of leisure rather than work and the failure to save. The dissipation of both wages and leisure time in the form of drinking and other wasteful activities meant an inevitable resort to charity and the prevalence of pauperism, which was a "reproach to the civilization of this country" [ibid. p.192]. Similar themes were evident when Jevons addressed the British Association for the Advancement of Science as president of Section F at Liverpool in the following year [ibid. pp.194-216].

Those fundamental beliefs were clearly evident in TPE. In general, Jevons argued, with competitive markets, "so far as consistent with the inequality of wealth in every community ... perfect freedom of exchange must be to the advantage of all" [Jevons 1970, p.171]. Consistent with that belief, international `free trade' was sacrosanct. With the exception of a general customs revenue tariff, "the time is past when any economist should give the slightest countenance to ... [customs duties] for manipulating trade, or for interfering with the natural tendency of exchange to

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[11] For biographical details of Jevons and his family, see Konekamp 1972; Schabas 1990, ch. 2.

increase utility" [ibid. p.174]. Given competition in both final product and labour markets, "capitalists" would receive a "proper fraction" of the output, while "workmen will strongly tend to secure ... all their legitimate share in the ultimate produce", at least in the long run [ibid. p.258].[12] There were, however, limits to production in that different classes had different work habits. In the `professions', such as law and medicine, or the "highest kinds of labour, such as those of the philosopher, scientific discoverer, artist etc.", it was "questionable how far great success is compatible with ease". Moreover, the "rich man in modern society is often supplied apparently with all he can desire, and yet he often labours unceasingly for more". That was not the case for the working classes who "seem generally to prefer greater ease to greater wealth" and for whom working hours were falling. Such behaviour was even more marked in those of "a lower race, a Negro for instance," whose "exertions soon stop" [ibid. pp.197,198]. For Jevons, the recognition of work as "a man's duty" [ibid. p.92] depended on "a state of civilization, [where] a vague though powerful feeling of the future is the main incentive to industry and saving" [ibid. p.99]. If the lack, in varying degrees, of civilization could be explained in terms of the "character" of a class or race [ibid. p.198], there was also a clear warning that a state of perdition would ultimately befall those who failed the industry and saving test:

> We may safely call that man happy who, however lowly his position and limited his possessions, can always hope for more than he has, and can feel that every moment of exertion tends to realise his aspirations. He, on the contrary, who seizes the enjoyment of the passing moment without regard to coming times, must discover sooner or later that his stock of pleasure is on the wane, and that even hope begins to fail [ibid. p.99].

The ethical language used to characterise behaviour and its outcomes in TPE was presented in a variant of another of the fundamental beliefs of the northern group – that human behaviour could be explained in terms of a `Benthamite calculus'. In the stringent version Jevons adopted, all behaviour was driven by the pursuit of pleasure and the avoidance of pain, with the outcomes of actions judged by the criterion of the greatest good of the greatest number [ibid. p.92].[13] The domain of political economy

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[12] The owners of land, however, received a return simply for the ownership of that resource. The significance of this for explaining a `legitimate share' of output was not considered.

[13] It was the use of this criterion that explains why Jevons regarded equity as an irrelevant consideration when assessing market and policy outcomes [White 1996].

was restricted in that it could deal only with behaviour entailed in the production and distribution of wealth. It was, therefore, concerned only with the "lowest rank of feelings" and Jevons specifically precluded any consideration in TPE of `higher questions' of ethics, consideration of which could place constraints on the pursuit of wealth [ibid. p.93]. Nevertheless, because he regarded political economy as part of the wider discourse of moral philosophy, the language of TPE embodied a Utilitarian ethics. In the first edition, for example, pleasure and pain constituted "good" and "evil" for an actor, speculators who cornered markets drove prices to `improper' or "unnatural ratios of exchange" [Jevons 1871, p.46,86] and, as noted above, labour and capital received their `proper' shares of output.

The basic beliefs articulated in TPE were so bluntly expressed that they read like a stereotypical list of `Victorian values' in political economy. There was nothing in that text which approximated the more nuanced exposition of, for example, John Stuart Mill's Principles of Political Economy. In part, this was because of the different lengths and the range of topics considered. TPE was a summary of the core theory that, Jevons considered, underpinned the more detailed discussion of economic topics in his other publications. It was not meant to be a complete account of economic activities, even in a summary form. Moreover, TPE assumed [Jevons 1970, pp.92-5] that, in general, the market behaviour of one group of actors did not directly harm the welfare of another group (the exception was the reference to speculators mentioned above). Consideration of the ways in which such harm could occur provided one criterion for state intervention that Jevons discussed elsewhere [Jevons 1882a; 1883]. If the analysis in TPE was necessarily restricted in those respects, Jevons nevertheless presented the basic beliefs of the northern group with regard to human behaviour, trade and distribution as characteristic of `actual' markets. That the stark and often dogmatic presentation of those beliefs appears to have been common in Jevons' social circle is suggested by the reviews of the first edition of TPE that were published in the Manchester press. If historians of economics today consider the first reviews of TPE, they tend to focus on those written by Alfred Marshall, J.E. Cairnes and the anonymous Saturday Review(er) that appeared in the `quality' London journals [Black 1973-81, VII, pp.141-57]. Taken alone, those reviews give the impression of a hostile response to TPE, albeit from different analytical perspectives. There were, however, a significant number of other reviews, two of which appeared in the Manchester Examiner and Times and the

Manchester Guardian, the latter written by John Mills.[14] The reviews indicated the attention paid to debates regarding theories of value and distribution (among other matters of political economy) by organisations such as the Statistical Society as well as the space given to reports of those debates in the local press. Both reviews were careful, lengthy ($3^{1/4}$ columns of a broadsheet page) and deeply impressed by Jevons' attempt to construct a new `scientific' foundation for political economy with a mathematical theory of pleasure and pain. If they differed regarding the extent to which Jevons had broken with the prevailing theories of value and found the distribution analysis problematic, they had no difficulty in understanding how the behavioural theory in TPE provided an explanation for both supply and demand in market trading. The length, quality of the discussion and appreciation expressed for TPE's `practical' implications in the reviews suggest that the issues Jevons addressed and the language he used had a particular resonance in the north. In that regard, it should also be noted that the northerners were more sympathetic to Jevons' critique of the `orthodoxy' of Ricardo and Mill. The Examiner review thought that, in attacking the `noxious influence of authority' in political economy [Jevons 1871, pp.265-7], Jevons "will probably find few to disagree with him, since he has only given definite form and expression to what many students and investigators have frequently thought". In the Guardian, John Mills was somewhat alarmed by Jevons' talk of the need for theoretical "sedition and even anarchy" [ibid. p.266]. Nevertheless, he praised the style of Jevons' criticism as "bold and muscular". Similar approval was noticeably absent from the southern reviews.

The importance of considering the fundamental beliefs articulated in TPE is, in part, that it draws attention to the ways in which Jevons presented his theory in terms of class (and race) behaviour. In much of the commentary on TPE, the significance of that matter has been ignored or denied with claims that TPE was concerned with `individuals' (see chapter 5 below). The more general significance of the basic beliefs, however, is that they help explain Jevons' objectives in writing TPE which was, as he put it, a `sketch' of a theory of value (i.e. an explanation of relative prices) and distribution. It is clear from a number of the quotations above that the purpose of the distribution theory was to show how labour and capital were ultimately rewarded according to their relative contributions to production. That analysis was presented in the final three chapters of TPE, dealing with rent (Chapter VI), the interest rate on

[14] "Jevons on the Theory of Political Economy", Manchester Examiner and Times, 15 November 1871, p.7; "Professor Jevons on the Theory of Political Economy", Manchester Guardian, 22 November, 1871, p.7.

capital (Chapter VII) and wage rates (Chapter VIII). The discussion of distribution required a set of relative prices for the final outputs produced. The explanation for those prices turned on a representation of the exchange of money for both intermediate and final products (thereby incorporating an analysis of consumer demand) and their cost of production (chapters IV and V). In this regard, TPE was as much about work as it was about consumption. Jevons made that clear when he described the `economic problem' with which his analysis was concerned. In the concluding chapter, he argued that the "great problem" could be summarised as follows: "Given, a certain population, with various needs and powers of production, in possession of certain lands and other sources of material: required, the mode of employing their labour which will maximise the utility of the produce" [Jevons 1970, p.254]. To explain how labour could be `employed to maximise the utility of the produce' required a discussion of both production and consumption. With competitive markets based on an extensive division of labour and free trade, costs of production would ultimately be driven to the minimum consistent with the available resources and technology. In the same process, the composition of final outputs would reflect the desires and wants of the purchasers.

While the `Victorian values' expressed in Jevons' basic beliefs are important for understanding the overall objective of and some of the language in TPE, the historical significance of the text was that it introduced a series of fundamental theoretical breaks with the then dominant theories of value and distribution. The key to identifying both the extent of those breaks and the means by which Jevons was able to produce TPE was the explanation and hence representation of human behaviour. Jevons' initial summary of his theory in 1862 [Jevons 1866b (1862)] indicated that the core of the theory was the work decision.[15] A representative actor `balanced' the pleasure or incremental reward (the final degree of utility) from work with the incremental pain (the final degree of disutility) experienced in the effort of work. It was that `model' that Jevons used to construct his theory of relative prices and, by extension, the distribution analysis.

In providing an overall view of the structure and presentation of the argument in TPE, Chapter 1 of the thesis explains why, Whig readings aside, the analysis is difficult to understand. Despite his extensive criticism of other economists for failing to clearly define key terms, Jevons did not explain the meaning of a series of important

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[15] See the discussion in Chapter 6 below.

explanatory categories in the text, such as value, cost of production and supply and demand. He also failed to explain clearly how his analysis was based on the prevailing distinction between a market period and a long period. Unravelling the meaning of those categories and the ways Jevons used them reveals how his analysis both drew upon and broke with the prevailing theories of value and distribution. The debts to the existing framework meant, for example, that he argued references to supply and demand could form only one part of a long-period explanation of relative prices. At the same time, TPE introduced a decisive analytical break by arguing that it was possible to provide a systematic explanation of both market-period prices (explained in terms of supply and demand) and long-period prices (incorporating an explanation of cost of production) in terms of the behaviour of a representative actor (or `body'). The chapter also shows how Jevons attempted to link the long-period analysis of relative prices to his distribution theory. He was, however, unable to do so because he could not reconcile the explanation of differential wage rates with the analysis of relative prices. I suggest it was Jevons' attempt to resolve that problem which explains why, in the Preface to the second edition, he outlined elements of a `new' distribution theory that jettisoned much of the analysis which appeared in Chapters V - VIII of the text.

The representation of behaviour also enabled Jevons to recast `the problem' a theory of value and distribution should address. All behaviour could be represented as the maximisation of pleasure (utility), subject to the constraint of pain (disutility) entailed in each activity. On the same principle, the general `economic problem' summarised in the concluding chapter of TPE (see above) was to explain the maximisation of utility, subject to the available resources in the system. Given that maximisation point, the returns to labour and capital could be explained by their respective contributions to producing the output. Casting the purpose of a theory and value and distribution in that way made a further analytical break with his predecessors as the `principle of population', which was pivotal in the long-period distribution theories of J.E. Cairnes and Mill, played no role in the distribution analysis of TPE.

These conceptual shifts depended on the use of a new conceptualisation of the human body and the analytical procedures by which actions could be depicted. The body was depicted as a machine explained by mechanical principles, so that Jevons described his theory "the mechanics of human interest" [Jevons 1871, p.24] or "the mechanics of utility and self-interest" [Jevons 1970, p.90]. Behaviour was understood in strict functional terms, which could then be represented by the differential calculus

and (mid-nineteenth century) Euclidean geometry. Maximisation would occur at the precise point of balance between the opposing forces of pleasure and pain. Economics would now be more `scientific' precisely because its results could be demonstrated using the concepts and methods of the `natural sciences'. Jevons was able to utilise this approach in part because of his training and work as a chemist and meteorologist.[16] He was, however, drawing on more recent work in, and debates concerning, psychology and physics (`natural philosophy') where human behaviour was depicted as one part of a more general explanation of `natural forces' or, subsequently, `energy'. Human behaviour could become mechanised precisely because it followed the same laws as other `natural forces', such as the law of gravitation. It will be argued here that this particular representation of behaviour was only produced after the mid-nineteenth century. The explanation, then, for why Jevons' depiction of the core of economic theory as the `mechanics of self interest' was so distinctive, why it was so different from that of his predecessors and contemporaries such as Mill and Cairnes, is that it depended on arguments which only became available after the early 1850s. By considering the arguments of TPE in more detail, the following chapters of the thesis justify that conclusion and discuss the difficulties the mechanical approach generated for Jevons' depiction of economic activity.

Chapters 2 to 5 focus on the behavioural theory, explaining why it was distinctive, how it was produced and the analytical devices Jevons used to link it with the categories of class and race. Chapters 2 and 3 consider two commonly accepted arguments which suggest that there was nothing particularly novel in Jevons' marginal utility theory per se. The first, the `water and diamonds paradox', is a foundation myth in the economics profession to day. This claims that the marginal utility theory was not produced until TPE simply because the Classical economists lacked the appropriate mathematical apparatus of the differential calculus to explain relative prices. Chapter 3 shows this account is almost totally mythical and how it was produced in the twentieth century.

The second argument, which has been linked with the first, is that there were numerous `precursors' of the marginal utility theory. In such accounts, as Marshall indicated, Jevons' role was to draw on, or to `rediscover', the insights of the

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[16] In this regard, Jevons' activities in Australia (1854-1859) are now seen as of pivotal importance [Maas 2001, chs. 5 - 8].

precursors, assembling the theory in a more complete manner. Jevons' discussion of Nassau Senior's Outline of the Science of Political Economy (1836) in TPE actually contains the first of the marginalist precursor readings. Chapter 3 of the thesis thus examines Jevons' and subsequent precursor readings of the Outline, showing that text contains a quite different explanation of behaviour that was incompatible with the marginalist approach. The significance of examining Senior's analysis in this regard is that it indicates the general approach to explaining consumption behaviour that was used before the marginalist theory.

Chapter 4 shows how the marginalist theory broke with the previously dominant approach, such as Senior's, and that it depended on the formulation of a stimulus-response `model' of behaviour derived from the new discourse of physiological psychology. This made human actions akin to `natural forces', such as gravitation, which could then be represented in a functionalist format. The key text in that regard was Richard Jennings' Natural Elements of Political Economy (1855), from which Jevons appropriated his basic model of the work decision. Chapter 5 then considers how, in TPE, that basic model was linked to the categories of class and race behaviour which, Jevons argued, could be observed. The link was made via the Victorian notion of character which was used to both describe and judge behaviour. The chapter also shows how the domain of `economic science' in TPE was quite different from that depicted in the post-classical theories of the twentieth century and how that domain specification helps explain the limited references to policy issues in TPE.

The following three chapters closely consider how, in adopting and reworking Jennings' depiction of behaviour in terms of balancing functional forces, Jevons was able to produce his explanation of market activity as a `mechanics of self interest' by 1871. That process depended, in large part, on his knowledge of mechanics and developments in natural philosophy. The equilibrium condition of exchange set out in Chapter IV of TPE, for example, was adapted from that for a lever in static equilibrium in mechanics. The analysis published in 1871 was, however, noticeably different from that which Jevons had outlined outlined in the "Brief Account" of nine years before. The 1862 argument was organised in a different way from that of TPE and there was, consequently, no indication of the distinction between market and long periods which underpinned the analysis in Chapters IV and V of TPE. Chapter 6 of the thesis shows how Jevons was able to both rework his original analysis and

hence produce the summary of the marginalist program by drawing on contemporoary debates regarding conservation principles in natural philosophy.

The available textual evidence suggests that Jevons had reworked much of his analysis by the late 1860s. There was, however, one further aspect of the context of the production of TPE: a fierce debate during the late 1860s over the role and representation of `the laws of supply and demand' in explaining relative prices and, particularly, the distribution of income between labour and capital. The debate was crystallised by the publication of William Thornton's On Labour in 1869, with its critique of the role of the laws of supply and demand in explaining relative prices and a defence of trade unions in bargaining over wages [White 1994b; Donoghue 1998]. One result of that debate was the publication of Fleeming Jenkin's paper, where his (quantity-form) supply and demand diagrams were designed, in large part, to counter Thornton's arguments. Another was the publication of TPE as Jevons attempted, following the publication of Jenkin's article, to establish his own theoretical contribution in explaining the laws and a `harmonious' theory of income distribution.

While the debate over unions and supply and demand provided the opportunity and the impetus for Jevons to finally write up a more detailed account of his marginalist project, the terms of the debate left their mark on the treatment of supply and demand in Chapter IV of TPE. Jevons' discussion indicates that the issues raised by Thornton and Jenkin generated two substantial problems for his theory. The first was that he realised he could not explain how a market-period equilibrium point would be attained. This was because the process depicted in his mechanics of exchange was incompatible with his characterisation of the laws of supply and demand. Chapter 7 shows how Jevons attempted to dismiss the significance of that problem by using the metaphor of `virtual velocities' from (variational) mechanics. The second problem was that, because it was couched in terms of the infinitesimal calculus, the marginalist theory could not explain the prices of indivisible and heterogeneous commodities. In explaining how and why this created a significant difficulty for Jevons, Chapter 8 complements the previous chapter in providing a further illustration of the rhetorical devices Jevons used to dismiss the significance of problems he realised would derail his arguments.

Considered in its own terms and in the light of Jevons' objectives, his marginalist project was, ultimately, a failure. Jevons could not provide a coherent explanation of distribution, showing how relative wage rates reflected labour's contribution to

production. Nor could he produce a coherent theory of relative prices as his depiction of supply and demand could not be reconciled with his mechanistic depiction of behaviour in exchange. If the significance of TPE was that its theory and representation of behaviour was adopted by Jevons' post-classical successors, the analysis given here of how that theory was first produced explains why it is necessarily mechanistic and why its depiction of behaviour in terms of equilibrium states was, and continues to be, deeply problematic.

Chapter 1

GHOSTS IN THE MACHINE: VALUE AND DISTRIBUTION IN JEVONS' THEORY OF POLITICAL ECONOMY

> Value is the most invisible and impalpable of ghosts, and comes and goes unthought of while the visible and dense matter remains as it was.
>
> W. Stanley Jevons, 1863.

In the Preface to the second edition of his Theory of Political Economy (TPE), Jevons "beg[ged] the reader to bear in mind that this book was never put forward as containing a systematic view of economics. It treats only of the theory, and is but an elementary sketch of elementary principles" [Jevons 1970, p.67]. If it was only a sketch, it has been observed that the organisation of the argument appears puzzling, with a common complaint that Jevons failed to satisfactorily integrate the "theory of pricing of consumables and the pricing of factor services" [Rogin 1956, p.457].[1] While TPE is a difficult text, such accounts erase the theoretical context of Jevons' analysis by both reading and assessing TPE from the perspective of later `neoclassical' economic theory [Black 1970, pp.17-18].[2] The principal purpose of this chapter is to recover that context by showing how TPE was an intervention in contemporary debates over value and distribution theory. The context had two linked components. The first was the general objective that drove Jevons' marginalist project. The second was his `context of refutation' – the assessment of prevailing theories, rebuttal of particular arguments and challenges to assessments in the literature that provided "the overriding force of underlying arguments, the ... resonances of key terms, the exploitable tensions within accepted beliefs" [Collini 1979, p.9]. The examination of the context of refutation will also show a number of ways in which Jevons' value and distribution theory marked a theoretical break with the work of his contemporaries and predecessors.

It should be stressed that the discussion here provides an introduction to the following chapters in that it presents an overall view of TPE, explaining Jevons'

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[1] See also Robbins (1936) 1982; Stigler 1941, ch. 2; Peart 1996, pp.115,116,262.

[2] Black's reading of TPE [Black 1970, pp.15-20] is quite different to that given here.

principal objectives, the meaning of a number of key analytical categories and why the argument was structured in a particular way. Placing TPE in the context of the then dominant theories of value and distribution provides the means to show, in general terms, the extent to which Jevons both adopted and broke with the theoretical framework of his predecessors. Using that perspective, it is also possible to see how Jevons linked his explanation of relative prices and distribution, a link that is invisible when TPE is read through the prism of later postclassical theory. Subsequent chapters will consider the more specific ways in which TPE broke with the theory of his British predecessors and the resources Jevons used to produce his analysis.

The formulation of the marginalist project can be traced through diary entries and letters written by Jevons in 1860, the early summary in the `Brief Account' of 1862, and the two editions of TPE published during Jevons' lifetime (1871; 1879).[3] In the process, Jevons reworked and reorganised his argument in a number of ways. The ordering of the argument in the Brief Account, for example, was quite different to that in TPE (see Chapter 6 of this thesis). There was, nevertheless, a dominant objective underlying the project which, as Jevons noted in 1872, was to show how, with `the true theory' of value, "everyone who works for pay will ultimately be paid according to what he contributes to the general industry" [Black 1973-81, iii, p.255]. To realise that objective, the correct theory had to explain the distribution of output by initially assuming "that the abilities of men are infinitely varied whether by nature or by education" [Jevons 1866 (1862), p.284].[4]

The objective provided the core of the context of refutation in TPE, with attacks on the value and distribution theories of David Ricardo and John Stuart Mill. For Jevons, Ricardo's labour theory of value depended on the assumption of homogenous units of labour, an "erroneous simplification" that erased the problem of accounting for the markedly different inputs to production of each type of labour

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[3] For the diary entries, Black 1973-81, vii, p.120; for the letters, Black 1973-81, ii, pp.410,422. Although the Brief Account was first published as Jevons 1866 (1862), Ivor Grattan-Guinness [2002] has recently discovered a longer unpublished version.

[4] This is not to suggest that Jevons' project can be simply explained by the distribution objective. The argument is rather that the objective can explain the general terms and organisation of the analysis.

by treating differences in labour "power" as "mere exceptions to the rule" [Jevons 1866 (1862), p.284]. By contrast, Jevons argued, "I hold labour to be essentially variable, so that its value must be determined by the value of the produce, and not the value of the produce by that of the labour" [Jevons 1970, p.187]. Mill was also criticised for a confusing discussion of value. While he dismissed Ricardo's concept of a natural wage, Jevons also rejected Mill's wage fund theory. With its focus on an average wage, that theory was a "mere truism". Because it did not relate wage rates to the productivity of the labourer, it was "delusive" as a "solution of the main problem of the science – to determine the wages of labour" [ibid. p.43].

To depict wages as `determined by the value of the produce', Jevons first discussed an alternative theory of value and cost of production to explain relative prices, the analysis of which can be found in Chapters IV and V of TPE, following the discussion of the marginal utility theory in Chapters II - III. Here, the context of refutation is also crucial in that Jevons argued he had provided an alternative theoretical explanation for a number of commonly accepted `inferences' or propositions. As he put it in 1874, the "principal inferences from the [marginalist] theory ... [are] the laws of supply and demand, and the doctrine of the relation of value to cost of production already so well known in political economy". This meant that, on the one hand, "the laws of supply and demand, as generally accepted by economists, are easily deduced from the [marginalist] theory of exchange, so that the theory is verified by experience and statistical science". On the other hand, there was confirmation of "the prevailing doctrine, that the values of commodities tend to become approximately equal to their cost of production" [Jevons 1875a, pp.16,18-9].

The analysis turned on Jevons following his predecessors in using what has since been termed `the Classical method' to distinguish between market-period (Chapter IV) and long-period (Chapter V) outcomes. There are, however, two substantive difficulties in understanding the theory Jevons used with that method. The first is a frustrating lack of clarification. The discussion in TPE was marred by a failure to clearly explain both the use of the Classical method and the meaning of pivotal categories such as value, cost of production and the laws of supply and demand. Some further explanation can be found in Jevons' 1874 address to the Manchester Statistical Society [Jevons 1875a], Political Economy primer [Jevons 1878a], the unfinished Principles of Economics [Jevons 1905] and the record of his lectures at

Owens College [Black 1973-81, vi]. While those references will be used here to explain the analysis in TPE, the lack of clarification in that text was particularly important because, having repeatedly criticised the use of key categories by other economists, Jevons defined them in rather odd, if not idiosyncratic, ways. There were, however, some precedents for his argument and Section 1.1 below suggests that his discussion of value and cost of production echoes the previous use of the Classical method by G.P. Scrope. The following two sections then consider the discussion of value and cost of production in TPE.

If Jevons' failure in TPE to explain his use of the Classical method may help explain why some commentators have concluded that he rejected it [Forget 1989, pp.117-8; Schabas 1990, p.86], the second difficulty with understanding Jevons' approach in Chapters IV and V is that it was quite different from both his contemporaries and later post-classical theory. While using the Classical method, Jevons introduced a clear analytical break by arguing that, with the marginal utility theory, it was possible to provide a systematic theoretical explanation for both market-period and long-period outcomes. At the same time, Jevons also followed Mill and J.E. Cairnes in arguing that the `laws of supply and demand' characterised trading in a market-period and the adjustment, through a series of market periods, towards a long-period position. The laws did not, however, explain the long-period position itself. This was quite different from later post-classical theory that explained all prices, regardless of their periodisation, in terms of supply and demand functions. Those aspects of Jevons' argument are considered in Sections 1.4 and 1.5 below.

The long - period analysis of distribution was sketched in Chapters VI – VIII of TPE. While Jevons agreed with Ricardo and Mill that rent was a surplus that accrued to the owners of land, he attempted to show that the returns to capital (interest) and labour (wages) reflected their respective contributions to production. The analysis is, again, difficult to understand for two reasons. The first is that the theory and order of presentation of the argument reflected his particular definition of `production'. The second is that the discussion in Chapters VI (rent) and VII (interest) assumed a given wage rate across the economy for each long period. Neither point was clearly explained and it was only in the concluding chapter that Jevons sketched an explanation for differential wage rates (Section 1.6).

If the procedure of first using a given wage as a simplifying device and then allowing for differential wage rates might be regarded as analogous to that in Adam Smith's Wealth of Nations or Mill's Principles [Smith 1976 (1776), Book I, chs. viii,x; Mill 1965 (1909), Book II, chs. xi,xiv], it will be argued in Section 1.7 that Jevons failed to achieve the objective that drove his marginalist project. His analysis of long-period equilibrium was only consistent with differential wage rates in a special case. I suggest it was Jevons' realisation of that problem which explains why, in the Preface to the second edition of TPE, he announced a new approach to distribution theory that jettisoned much of the analysis in Chapters V - VIII of the text (section 1.7).

1.1 G.P. Scrope and the Classical Method

When J.E. Cairnes reviewed the first edition of TPE, he was "surprised" that Jevons did not "discriminate" between "normal or average, or (to use Adam Smith's phrase) `natural' values, and ... fluctuations in value, or, as it is commonly expressed, `market values'" [Black 1973-81, vii, p.148]. Here Cairnes was referring to the classical method of analysis[5] that argued it was possible to provide a systematic theoretical explanation of long-period prices, variously described as `natural', `ordinary', `normal', `average' or `prices of production'. Under a system of `free competition', with capital mobility between sectors of the economy, prices of production would, subject to a given set of techniques, correspond to a cost-minimising production system where there was a uniform profit rate and uniform rates of renumeration for each of the `primary' production inputs. Long-period prices were "taken to be known independently of the interplay of `demand and supply'" [Kurz and Salvadori 1995, p.5]. They acted as `centres of gravitation' or `attractors' for market or `actual' prices which, in fluctuating around and/or tending towards the minimum costs of production, were explained in terms of demand and supply. Hence, for Cairnes, market prices were not capable of being analysed in the same systematic way as prices of production, because they were subject to `forces' of an accidental or temporary nature [Cairnes 1857, pp.81-8]. Such fluctuations in prices (and outputs) could be analysed in a detailed descriptive

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[5] See the discussion of classical method and theory in Kurz and Salvadori 1995, ch.1.

manner, but that necessitated a different type of analysis from that for a long-period outcome.

Jevons responded to Cairnes' criticism by arguing that he had used the classical method to distinguish between market-period and long-period (or `cost') prices, a distinction which corresponded to the division of material in chapters IV ("Theory of Exchange") and V ("Theory of Labour") in TPE. As Jevons put it, although "I have not made many express references to the differences of market & cost values by those names ... in reality the difference is implied in the chapters on Exchange and Labour. I did not use the names because I considered values to be always governed by the same general principles in each case" [Black 1973-81, III, p.246]. If the method was basically the same, Jevons' reference to `value' indicated that that he had used a different theory with that method. The difference over value theory was longstanding. In 1863, when Cairnes drew attention, in The Economist, to Jevons' A Serious Fall in the Value of Gold, he objected to Jevons' definition of value as a "rate of exchange" explained in terms of supply and demand [Jevons 1884, pp.18-9]. For Cairnes, "in discussions concerning variations in value, whether of gold or commodities, we shall only convey just notions by using these terms with constant reference to what Adam Smith, Ricardo and Mill call `natural value' - that is to say, value in its relation to cost" [Cairnes 1863, p.593]. Jevons then wrote to Cairnes, arguing that

> I cannot find my use of the word value to be faulty or against the authority of many good writers. I have however long had a horror of the word & doubt whether it should not be altogether excluded from the theory of Economy. Exchange value merely means, as I take it, the ratio of exchange of any two articles in given units.
>
> You look rather to production which may be regarded as an exchange of labour & use of capital for the commodity produced, & which ultimately rules the exchange of one com. against another. As regards the supply of gold this is what we have to look to, & and what you look to. I look to the more complex relation of gold to other commodities ... [Black 1973-81, iii, p.22].

Some remarks in TPE suggest that Nassau Senior and Richard Whately were among the `many good writers' Jevons followed when formulating his critique of Ricardo's and Mill's value and distribution theories. Claiming that Senior had

`incidentally' referred to a marginal utility theory in his Outline [Jevons 1970, p.112],[6] Jevons linked his analysis to Senior who had "admirably defined wealth, or objects possessing value, as `those things, and those things only, which are transferable, are limited in supply, and are directly or indirectly productive of pleasure or preventive of pain'" [ibid. p.184; Senior 1951 (1836), pp.6,13-15; see also Jevons 1905, pp.1,8-9,21-2]. Senior (and Whately) had followed British economists such as the Earl of Lauderdale 1962 [(1804), pp.12-18], Francis Horner [1957 (1803)] and Samuel Bailey [1967 (1825), pp.1-8, ch.ix] in arguing that value could only be defined as an exchange ratio, referring to the `esteem' in which commodities were held by transactors and thus explained by supply and demand. Senior's argument was directed in large part against Ricardo and J.R. McCulloch who had distinguished between the systematic explanation of values in a long-period by reference to their conditions of production, and their market-period values explained by reference to the proportion between supply and demand. Jevons agreed with Senior in restricting the meaning of value to the wants or desires that underpinned the transactions in a market exchange ratio which was, in turn, to be explained by the laws of supply and demand (see Section 1.2). When, in TPE, he criticised Ricardo's labour theory of value, arguing that the value of labour "must be determined by the value of produce, not the value of the produce by that of the labour" [Jevons 1970, p.187], the argument was also reminiscent of Whately's dictum that `men dive for pearls because they are valuable' and not vice versa [Whately 1832, pp. 252-3; 1853, p.33]. The connection to Whately in that regard was clear when Jevons discussed the `origin' of value in his lectures at Owens College and in the primer [Black 1973-81, vi, p.94; Jevons 1878a, pp.101-3].

If it is possible to see why Jevons referred approvingly to Senior and Whately, there was also an important analytical difference between them. Apparently adapting and modifying, the theoretical nihilism of Bailey [1967 (1825), ch.xi], Senior also criticised the classical method by arguing that there were very few commodities for which the cost of production provided a "centre of oscillation" for market-period prices [Senior 1951 (1836), pp.102-3]. Because long-period prices depended on various monopolistic factors (patents, limited substitution) and different (falling and rising) average cost structures, he argued that most prices "are but little governed by general rules" and hence not subject to "accurate

[6] As shown in Chapter 3 below, this was a Whig reading of Senior's analysis.

investigation" [ibid. pp.114,111]. For Jevons that was not the case. Cost of production was one element in the systematic explanation of a long-period position in the economy (Section 1.3).

Given that divergence, it is important to note that, three years before the publication of Senior's Outline, George Poulett Scrope had defined value in much the same way, while retaining the basic Classical method. In his Principles of Political Economy (1833), Scrope argued that the value of commodities depended on whether they were "desirable" (having "useful or agreeable qualities"), their "scarcity" and exchangeability. Value should be understood as an exchange relation or ratio, explained by the `proportion' between demand ("the quantity required") and supply ("the quantity produced") [Scrope 1833, pp.164,165,168,185]. The use of the term value was thus restricted to the market-period price of a commodity: "the value of a thing is the quantity of other goods or of money, that is, the price, it will command at a particular time and in a particular place" [ibid. p.169]. In a passage Jevons was to cite as consistent with his discussion of `the law of indifference' [Jevons 1905, p.59; cf. 1970, p.137], Scrope also argued that the forces of competition would establish a uniform price in a market period: "It is ... certain that there cannot be two prices (or values) for goods of the same quality, in the same market and at the same time ... The competition of buyers and sellers with one another in the same market, will always bring the value of articles of the same quality in one market to the same level" [Scrope 1833, p.171]. Demand and supply could thus explain the market-period prices of reproducible commodities (disturbed by 'temporary" fluctuations in supply) and the prices of irreproducible commodities such as rare art [ibid. pp.168-9,188].

In a long period, however, the prices of reproducible commodities were `determined' by their cost of production: "The constant tendency both of demand and supply is to come to an equilibrium, and the point about which they oscillate is that selling price of the commodity which will just cover the costs of its production at that time and place" [Scrope 1833, p.198]. This result would follow the movement of capital between industries or sectors with differential rates of return. It was, however, only a tendency in that the value of commodities oscillated around the long-period position:

> These oscillations of price about the mean level of the costs of production are continually taking place; - the circumstances which influence supply and demand being of so complicated a character that the one can never for a length of time remain exactly adjusted to the other. The producers can never anticipate with precision the extent of the demand, and will therefore usually be something within or beyond it [ibid. p.199].

Scrope's argument showed that it was possible to argue, within the broad contours of the classical method, that value could only be defined as an exchange ratio explained by supply and demand in a market period. This was different from Ricardo and J.S. Mill who used the term value for both long and market period outcomes. As explained below, Jevons' position was similar to Scrope's in arguing that value, explained in terms of supply and demand, was only relevant for explaining an exchange ratio, while cost of production was essential for deriving a long-period equilibrium position. Scrope also argued that the wages of each labourer "must be determined by the value of his produce in the market. And this will increase in proportion to the talent, skill, and application of the labourer, or any other circumstance which may render his labour more productive than that of any other" [Scrope 1833, p.87]. That statement was consistent with the objective that underpinned Jevons' marginalist project.

Jevons had read Scrope's Principles by 1865 as a paper in that year discussed his proposal for a `tabular standard' to measure value [Jevons 1884, p.122; Scrope 1833, pp.405-8], reference to which was also made in Money [Jevons 1875b, pp. 329-33].[7] In his Principles, Jevons also referred to Scrope's discussion of the `law of indifference' (see above) and to his critique of J.S. Mill on the definition of wealth and the analysis of capital [Jevons 1905, pp.16-17,57,89n,131-3].[8] Chapter 6 of this thesis shows that, in the mid-1860s, Jevons began reworking his argument in the Brief Account, making it consistent with the distinction between market and long periods. Given the similarity of their approach

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[7] In 1865, Jevons referred to Scrope's standard as "scarcely practicable" [Jevons 1884, p.123]. Although later commentary has cited that verdict [Persky 1998, p.199], Jevons must have changed his mind, for he wrote in Money that "the practical difficulties are not of a serious character" [Jevons 1875b, p.330].

[8] A number of those arguments appeared only in the second edition of Scrope's text [Scrope 1873].

to value and the Classical method, it may be that Jevons found Scrope's analysis helpful when reformulating his position. This is not to suggest, however, that Jevons' theory was the same as Scrope's for there was nothing in his Principles that Jevons could construe as an anticipation of marginal utility theory as he claimed was the case for Senior's Outline. Moreover, Scrope defined cost of production as composed of the labour required to produce a commodity, the expenses required in bringing a commodity to market and a rate of return on capital [Scrope 1833, p.172]. As will be shown below, this was quite different from Jevons.

1.2 Abstract and Concrete: Value and Exchange

The equilibrium condition in a market period as depicted by Jevons in chapter IV of TPE can be summarised as follows. Assume given quantities and the distribution as endowments of two commodities, X and Y, with the corresponding final degrees of utility for a representative actor (du/dx; du/dy), in a `perfect' market where there is one exchange ratio (y/x) at any `moment'.[9] As will be shown below, Jevons used the device of a representative `individual' extensively in TPE, arguing that "the general forms of the laws of economics are the same in the case of individuals and nations" [Jevons 1970, p.86]. Consistent with this, when discussing his theory of labour, he claimed that "I give the formulae as they would apply to an individual, only because they are identical in general character with those which apply to a whole nation" [ibid. p.199]. The discussion of international trade in Chapter IV also depicted a `nation' as a representative actor [ibid. pp.171- 4]. Although the point will not be pursued here, Jevons' claim that he could model a "single average individual", whose behaviour was only "theoretically true [although] practically true in the case

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[9] As discussed in Chapter 7 below, for Jevons a `perfect' market required that at any moment there were: large numbers of transactors; "more or less" perfect information about market prices and commodity stocks; homogenous, infinitely divisible commodities of each type; and a given exchange ratio [Jevons 1905, p.56; 1970, pp.132-4,148,154]. Using Jevons' symbols as far as possible, the summary here follows the second edition of TPE [Jevons 1970], which provided a more detailed statement of the theory. While the summary is restricted to two commodities and two transactors, Jevons considered a 3x3 case, arguing that the analysis could be generalised with "more numerous bodies" [ibid. pp.153-4]. Little account will be taken of Jevons' treatment of international trade, for which see Aldrich 2000.

of large aggregates" [ibid. pp.119,135] marked a clear analytical break with the work of Mill and Cairnes.[10]

With utility maximisation, the final degree of utility ratio would equal the exchange ratio, which also corresponds to a marginal exchange in the market (dy/dx). It is clear from the discussion in chapter IV that exchange would, in general, be carried out with money. It was, however, only in chapter V of the second edition that Jevons noted that the exchange ratio expressed in money could be represented by the notation p_1/p_2, where p_1 (p_2) is the price of X (Y) measured in gold [Jevons 1970, pp.203-4].[11] Since all actors must trade at the same marginal exchange ratio, and substituting ϕX and ψY for the respective final degrees of utility, the condition for market equilibrium is

$$\phi x/\psi y = dy/dx = y/x = p_1/p_2 \qquad (1)$$

Jevons insisted that in so far as the word value could be used in political economy, it was only in the context of the theory of exchange. As he put it in his primer, "The word value only means that so much of one thing is given for so much of another, and it is the proportion of these quantities ... which measures the values of the things" [Jevons 1878, p.98]. The value ratio ("Value per unit of X / Value per unit of Y") would thus be the same as the other ratios in condition (1). Nevertheless, the ratio of the "value of the substances" was quite distinct, because value was an abstract name [Jevons 1970, pp.203-5]. Although there was no explanation for this categorisation in TPE, it can be found in the Elementary Lessons in Logic, where Jevons defined a "concrete" name as that given to "a physically-existing thing", such as a "red house", a "useful" book or by describing two things as "equal". An "abstract" name, on the other hand, was given to "a quality, attribute, or circumstance of a thing", such as "redness", "usefulness" or "equality". The

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[10] For discussion of the theoretical basis of Jevons' representative actor and its use in TPE, see White 1989; Chapters 4 and 5 of this thesis. Cf. the suggestions that the use of the representative actor in postclassical economic theory can first be found in the work of F.Y. Edgeworth [Kirman 1992, p.120] or Alfred Marshall [Hartley 1992].

[11] Jevons noted that "price ... is the quantity of legal money for which the commodity can be exchanged" [1970, p.203]. As suggested by Steedman [1972, p.33] and indicated elsewhere by Jevons [1875b, pp.8-12,67-8], gold was the numeraire for the monetary magnitudes of the system.

classification did not turn on a distinction between `material' objects and a quality arbitrarily attributed to them because a quality could not "exist physically apart from the matter in which it was manifest to us. Redness [for example] means either a notion in the mind, or it means that in real objects which excites the notion". It was essential, however, not to confuse abstract and concrete names since this resulted in "[m]uch injury ... [being] done to language", an example of which could be found in Mill's System of Logic [Jevons 1882b, pp.20-1,43-4]. That example was important because Jevons acknowledged that his distinction between abstract and concrete names in the Elementary Lessons followed the discussion in Book I, chapter 2 of Mill's text [Mill 1868, esp. pp.29-31].

Jevons argued also that Mill had contributed to the endemic confusion in political economy over the meaning of value, since he had failed to understand that value was an abstract name meaning usefulness: "value is a property, or a quality, or a circumstance, or a relation, not a thing. It is abstract, not concrete" and was, therefore, "a numerical ratio, an abstract number", such as 1/1 [Jevons 1905, pp.51,52]. The word value, "so far as it can be correctly used, merely expresses the circumstance of ... [one substance] exchanging in a certain ratio for some other substance". If an ounce of gold exchanged for a ton of pig-iron with a ratio of 1/1, the `scientifically correct' expression was not that "the value of the ton of iron is the ounce of gold", but rather "that the value of the ton of iron is equal to the value of the ounce of gold, or that their values are as one to one" [Jevons 1970, pp.127,128]. To say that the value of a ton of iron is the ounce of gold would categorise "value ... [as] a quantity of some other product", thus representing it as "a lump of matter". This was analogous to saying that "the reflection of a light is a mirror, or yellowness is gold" [Jevons 1905, p.52]. Herein lay Mill's error when he argued that value "is a relative term. The value of a thing means the quantity of some other thing, or of things in general, which it exchanges for" [Mill 1965 (1909), p.478]. For Jevons, Mill's statement transformed the abstract concept of value into a concrete magnitude. As a "relation", value could only be a "circumstance of an object", not a "thing or an object" [Jevons 1970, p.127].

While the value ratio should be distinguished carefully from the other ratios in condition (1), it was linked to the concrete aspects of exchange via the final degree of utility ratio. On the one hand, because it referred to a specific commodity, such as X (as in dx), that ratio had a "concrete signification". Jevons complained, again,

that there was confusion here because the word commodity was originally an abstract name.[12] Nevertheless, he would accept its current usage as a concrete category, so that commodity would designate "any object, substance, action or service, which can afford pleasure or ward off pain". At the same time, utility (as in du) denoted "the abstract quality whereby an object serves our purposes, and becomes entitled to rank as a commodity. Whatever can produce pleasure or prevent pain may possess utility" [Jevons 1970, p.101]. Utility was an abstract term because it represented "the ensemble of all the qualities and circumstances which ... enable [a commodity] to ... satisfy any of the wants of some person" [Jevons 1875, p.10]. It was, in other words, "a convenient name for the aggregate favourable balance of feeling produced - the sum of the pleasure created and the pain prevented". Since it reflected such feelings, it was "measured by, or even ... actually identical with, the addition made to a person's happiness" by a commodity [Jevons 1970, p.106]. The concept of the final degree of utility thus acted as a bridge between the abstract and concrete terms of exchange because of its two "dimensions" - the quantity of the commodity and "the intensity of the effect produced upon the consumer" [ibid. p.108]. The final link to the concrete aspects of exchange was the requirement in equilibrium condition (1) that the ratio of the final degrees of utility for two commodities was equal to the exchange ratio for the marginal exchange in a market, the market exchange ratio and the price ratio, all of which were concrete categories.

Although Jevons' distinction between abstract and concrete terms is problematic [Ray 1892 (1886), pp.30-6], it was consistent for him to argue that utility was "the basis of value" [Jevons 1875, p.32], that "value depends entirely upon utility" and that "value depends upon desire for more" [Jevons 1970, pp.77,176]. All those expressions rested on the proposition that the abstract value ratio depended on, but was analytically distinct from, that for the final degree of utility, so that the "value of a divisible commodity, if I may for a moment use the dangerous term, is measured ... by its final degree of utility, that is by the intensity of the need we have for more of it" [ibid p.168]. Finally, because of the links between the abstract and concrete categories, value could also be "estimated by price, that is, by the quantity of legal money for which the commodity may be exchanged" [ibid. p.203]. In that case, if

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[12] Originally, commodity meant "the quality of anything by which it was capable of serving man" [Jevons 1970, p.101].

the price of a ton of pig-iron was £7, the correct expression was that the "value of a ton of iron is equal to £7" and not that "the value of a ton of pig-iron is £7" [Black 1973-81, VI, p.80]. Understood as a ratio, price could estimate, but was quite distinct from, value.

Jevons' characterisation of value as a term which, reflecting desire, could only be used in relation to an exchange ratio, was similar to that of Scrope, Senior and Whately. His theoretical explanation was, however, quite different. Apart from the use of the marginal utility theory, his discussion also separated the abstract value ratio from the other ratios in condition (1). It was noted above that, in his System of Logic, Jevons indicated that his distinction between abstract and concrete was consistent with that of J.S. Mill. There was, however, another basis and more specific reason for the argument in TPE. In a critique of Mill's discussion of value in the opening paragraph of the Preface to the second edition, Jevons argued that the `fundamental equation' of exchange, i.e. equilbrium condition (1) without the price ratio, provided the means to analytically distinguish between a "numerical ratio" (value), a "mental state" ($\phi x/\psi y$) and a "mass of commodity" (dy/dx) [Jevons 1970, p.46]. The fundamental equation was derived from that for a balance or lever in static equilibrium [ibid. pp.144-7].[13] In early 1861, as he was working on the marginalist project, Jevons wrote a detailed article on `the balance' for a Dictionary of chemistry. He noted there that, in theory, with the balance in equilibrium, "an arbitrary weight ... [is] assumed as a standard" of comparision for the "ratios of commensurable weights". To the chemist, the choice of the standard "is a matter of indifference" because the results are "merely comparative or proportional" [Jevons 1863, pp.481,484]. Similarly in TPE, he argued that the ratio of exchange referred to "the ratio of the number of units of the one commodity to the number of units of the other commodity for which it exchanges, the units being arbitrary concrete magnitudes, but the ratio an abstract number" [Jevons 1970, p.130]. The categorisation of value as an abstract category was thus consistent with his metaphorical representation of behaviour and exchange as a balancing machine, the underlying fundamental equation for which could be expressed without reference to the arbitrary magnitude of money.

If Jevons criticised Mill for confusing the discussion of value by failing to distinguish properly between abstract and concrete categories, he also argued that there was

`confusion' more generally because the word was `popularly' used to refer to all the marginalist categories of total utility, final degree of utility and ratio of exchange [Jevons 1970, pp.128-32]. His own discussion, however, was confusing. Failing to explain the meaning and basis of the distinction between abstract and concrete categories, he argued in TPE that value was a "dangerous name". He would, therefore, "discontinue the use of the word value altogether ... and substitute the wholly unequivocal expression ratio of exchange" [Jevons 1970, p.130]. The dangerous name, however, appeared subsequently in the text, the most prominent example occurring in the concluding section of the same chapter discussing "The Origin of Value" [Jevons 1871, pp.155-61;1970; pp.184-7]. The secondary literature on Jevons has made much of his statement in TPE that the word value should be banished from the lexicon of political economy. It should be noted, however, that while Jevons' `horror' with the word dated from the early 1860s (see above), he had apparently abandoned his campaign by the end of his life as chapters in the primer and the Principles discussed `value' without any suggestion that the term should never be used [Jevons 1878a, ch.xi; 1905, ch.viii].

1.3 Cost of Production

A market period was characterised by a parametric stock of commodities from which exchange and consumption could take place. In chapter V, Jevons considered how the stocks could differ between market periods by changing output levels, where labour was the variable input, working with a stock of raw materials.[14] To depict the conditions which would prevail in "long run" equilibrium [Jevons 1970, p.200], he again used the device of a representative actor to explain the `cease point' of labour which would depict the amount of labour worked with a given set of techniques.[15]

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[13] For Jevons' use of the balance metaphor, see Chapter 7 of this thesis.

[14] It seems evident from Jevons' definition of production (see below) and the discussion in Chapter V that he assumed labour worked with a stock of raw materials.

[15] "I give the formulae as they would apply to an individual, only because they are identical in general character with those which apply to a whole nation" [Jevons 1970, p.199].

The analysis first assumed a labourer who could produce both X and Y.[16] Marginal labour productivity, which Jevons termed the `degree of productiveness', was assumed constant, giving a `uniform rate of production' that was characteristic of the manufacturing sector using "machine labour" [Jevons 1970, p.194]. The amount of labor worked depended on the relation between the respective marginal products of labour (dx/dl; dy/dl) and the final degrees of utility for the outputs, which the actor could either consume or exchange. Work would cease at the point where the degree of productiveness was equal to the final degree of utility in each case. For X, that point was dl/dx = du/dx, so that the actor balanced the increment of pain from work (since dl was simultaneously a unit of work effort and of disutility) against the increment of pleasure from consumption. Assuming utility maximisation, work would be distributed between X and Y such that

$$du_1/dx \,.\, dx/dl_1 = du_2/dy \,.\, dy/dl_2 \qquad (2)$$

With the device of the representative actor, Jevons claimed that the "formulae" could simultaneously represent "an individual" who chose between producing both X and Y, and "a whole nation" with an extensive division of labour, so that each actor was "performing one trade only". At equilibrium, following condition (2), "there can be no motive for altering or regretting the distribution of labour, and the utility produced is at its maximum" [Jevons 1970, pp.199,200]. This analysis, with the assumption of constant marginal (and therefore average) labour productivity, carried an important implication regarding the wage rate. In the first edition, Jevons noted that points on the abscissa of his diagram for the labour cease-point represented "the amount of produce or the day's wages" [Jevons 1871, p.169]. He thus assumed that the real wage rate, reflecting the marginal product, was constant. That assumption was obscured in the second edition as the reference to `the day's wages' was omitted [cf. Jevons 1970, p.191].[17] A given wage rate, however, appeared in his discussion of the cost of production in the same edition.

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[16] The first edition considered three commodities [Jevons 1871, pp.179-80].

[17] See Chapter 5 of this thesis, where it is shown that, given the assumption of constant labour productivity, Jevons' analysis could only account for labour income from production and was thus a special case. It could not deal with manufacturing `machine labour' using capital.

Jevons introduced cost of production by writing the marginal utility ratios as in (1) and substituting ω_1 and ω_2, respectively, for the marginal labour products of X and Y. Equilibrium condition (2) was then restated as

$$\phi x/\psi y = \omega_2/\omega_1 \qquad (3)$$

Since $\phi x/\psi y = y/x = \omega_2/\omega_1$ in equilibrium, this condition entailed that "commodities will exchange in any market in the ratio of the quantities produced by the same quantity of labour" [Jevons 1970, p.201]. The cost of production for a commodity was defined as varying directly with "the reciprocal of the degree of productiveness. The rate of wages remaining constant, the cost per unit of commodity must ... be lower as the quantity produced in return for a certain amount of wages is greater" [Jevons 1970, p.204]. While this indicates that cost of production was understood to be, in effect, the real unit labour cost of production, the definition was not clearly explained and no symbol was given for the term. The argument appears to entail, however, that there is a given wage rate, presumably measured in gold, which is the same in both industries. Cost of production can thus be represented, for X and Y respectively, as $c_1 = (1/\omega_1)w$; $c_2 = (1/\omega_2)w$, where w is the given wage rate. The long-period equilibrium condition, discussed in some detail in the second edition [ibid. pp.203-5], is then

$$\phi x/\psi y = dy/dx = y/x = p_1/p_2 = \omega_2/\omega_1 = c_1/c_2 \qquad (4)$$

With this result, Jevons argued that his "theories ... lead directly to the well-known law, as stated in the ordinary language of economists, that value is proportional to cost of production" [Jevons 1970, p.200]. Of course, the meaning attributed to, and thus the significance of, this statement of the `law' depended on the definitions of the two terms. The abstract value ratio, as explained above, would appear as a separate term, preceding $\phi X/\psi Y$ [ibid. p.203]. Cost of production was also a highly restricted notion since, with no capital in the analysis, direct labour was the only variable input. Any labour costs entailed by transportation and other `expenses of commerce' were excluded as they were accounted for in the analysis of market exchange (see Section 1.5 below). If that point alone is sufficient to reject the claim that the long-period equilibrium condition "is tantamount to a labor theory of value"

[Schabas 1990, p.45],[18] Jevons' definition of cost of production was unusual in that most economists included a return to capital in their definition.[19] Torrens [1821, pp.50-55] was an exception.

The peculiar analysis of cost of production in TPE was underpinned by two theoretical considerations. The first was the meaning Jevons attributed to production. In the Elementary Lessons on Logic, he complained that, as with `commodity', the word production was used as a concrete category although it was an abstract name: "Production is properly the condition or state of a person who is producing or drawing something forth; but it has now become confused with that which is produced, so that we constantly talk of the productions of a country, meaning the products" [Jevons 1882b, p.22]. Consistent with this, Jevons explained elsewhere that the "correct idea" of production was that "we draw wealth forth ... Labour creates nothing, but merely draws from the crust of the globe the materials which allow it to be utilised" [Jevons 1905, p.68]. In his primer [Jevons 1878a, pp.25-8] and the Principles [Jevons 1905, pp.67-70], he argued that labour and raw materials were the `primary requisites' of production, while capital was a `secondary requisite'. (In TPE, labour was "the first element of production" [Jevons 1970, p.254]). His linking of that argument to conservation principles from physics can explain why his discussion of capital was quite separate from that of production with labour and raw materials in chapters V and VI of TPE (see Chapter 6 of this thesis).

Jevons' definition of production, while unusual, was not unique. It was similar to that given by H.D. Macleod, who also expressed some sympathy for Torrens' argument that profits formed no part of the definition of cost of production [Macleod 1863, pp.559-60,581].[20] If it is possible to locate the meaning of production in TPE, that does not explain why Jevons treated the category of cost of production as if it had a

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[18] Other commentators have also suggested that Jevons regarded his analysis as consistent with a `cost of production theory of value' [Laidler 1982, p.334n; Peart 1996, pp.124, 182]. The claim that Jevons identified "subjective labour cost with cost of production" [Rogin 1956, pp.462-3; see also Noller 1972] conflates Jevons' degree of productiveness with the cost of production.

[19] Jevons was reported as saying in his Owens College lectures that the long-period "cost value" for Ricardo and Mill was "defined by this circumstance, that it just obeys the ordinary rate of wages and profits" [Black 1973-81, VI, p.84].

[20] For Jevons' peculiar commentary on, and possible debts to, Macleod in TPE, see White 2002.

subordinate analytical role. The reader was given no guide as to its meaning in the first edition [Jevons 1871, pp.181-2]. While the second edition was more forthcoming, the definition was not precise, no symbol was provided for it, and Jevons `preferred' to "state the ...law ... to the effect that the ratio of exchange of commodities will conform in the long run to the ratio of productiveness" [Jevons 1970, p.200]. The reason given for this preference was that, like value, the term cost of production was ambiguous: "For the sake of accuracy I have avoided the use of the word value; the expression cost of production, so continually recurring in in most economical treatises, is also here conspicuous by its absence" [ibid. p.203].[21] For Jevons, the lexicon of political economy was replete with ambiguities, since even the term `price' fell within that category. But while an explanation was given for the ambiguity of price, there was none for cost of production in TPE.[22]

Once again, an explanation can be found in remarks Jevons made elsewhere. The reason followed his use of the analysis of the ratio of productiveness to explain international trade based on comparative advantage in chapter V of TPE, where it clarified why "the absolute facility of producing the commodities will not determine the character and amount of trade" [Jevons 1970, p.205]. Commenting on papers read to the Statistical Society in 1877 and 1878, Jevons argued that "manufacturers and others" often used `cost of production' to refer to "the rate of wages" alone, so that "high wages meant high cost of production" which made a country less competitive. Such "theories" had been "unequivocally and utterly disproved" by

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[21] Another comment suggests the problem was due to `accurate interpretation' of the `expression': "cost of production, so far as this expression can be accurately interpreted, varies as the reciprocal of the degree of productiveness" [Jevons 1970, p.204]. Jevons was also reported as stating in a February 1876 Owens College lecture that "we get into this very doubtful and troublesome talk about the cost of production" [Black 1973-81, VI, p.83].

[22] Jevons argued that `price' was ambiguous because it could mean "either the price of the whole quantity" [$p_1.x$; $p_2.y$], or the price per unit of the quantity", which conveyed the correct meaning of a ratio, as in $p_1/p_2 = y/x$, where it was clear that the "quantities exchanged are reciprocally as the prices" [Jevons 1970, pp.203-4]. No reference was given for the use of price as `the whole quantity'. It could, however, have derived from Jevons' early reading of T.C. Banfield's Organization of Industry which argued that "the value of an object for a political economist is expressed by the product of its fractional price multiplied with the extent of the demand for it" [Banfield 1848, p.21]. Banfield's text was referred to in TPE and the Principles [Jevons 1970, pp.104-5,112; 1905, pp.52-3]. A note in the Jevons Archive indicates that Jevons had read it by 1862 [Jevons Archive, John Rylands University Library of Manchester, JA 6/15/2].

Cairnes in his Leading Principles. Assuming that labour was the only variable input in production, the different average (real) wage rates between countries reflected differences in average labour productivity. Cairnes had thus "proved that the cost of production [meaning wages] was not the cause, but the effect of the efficiency of industry ... [T]he rate of wages measures the produce and not the cost".[23] At the aggregate level, differences in competitiveness should thus be related to differences in real unit labour costs of production, which was consistent with the subsequent definition of cost of production in TPE. The argument was also consistent with the objective of explaining wage rates in terms of `the value of the produce'.

Although Jevons' explanation of cost of production was not published until 1879, he had made a similar point in a draft of an unpublished letter to a Manchester newspaper in 1871, soon after the completion of the first edition of TPE. The letter argued that the "general" rate of wages in a country could not explain relative success in international trade: "No one who has ever comprehended the principles of international trade as they are unanimously given by the best writers on political economy will suppose for a moment that the general high rate of wages in England in the least disqualifies us to compete with foreigners".[24] The expansion or contraction of tradeable goods industries depended on their relative productiveness or `efficiency' [cf. Mill 1909, Book iii, ch.xviii]. The letter was consistent with Jevons' subsequent argument that the term cost of production was misleading since it was taken to refer to a general rate of wages, rather than to real unit labour costs, which depended on the productiveness of labour. It seems reasonable to conclude that Jevons' definition of cost of production was assumed, though not explained, in the first edition of TPE.

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[23] See Cairnes 1874, pp.345-6. For Jevons' comments, see the Journal of the Statistical Society, Vol. 40, March 1877, p.37; Vol. 41, March 1878, p.118. See also Mill's discussion of why the "cost of labour" could not simply be equated with the wage rate [Mill 1965 (1909), pp.419-20].

[24] "Foreign Competition (Draft)", 27 April 1871, JA 6/23/11.

1.4 Strange Attractor: Cost of Production and Long-Period Equilibrium

Although Jevons initially assumed constant labour productivity in Chapter V of TPE, his discussion of the properties of a long-period position included commodities that, with a given set of techniques, had either constant or variable marginal costs. In the case of constant marginal productivity and costs, the ratio of productiveness would act as the centre of gravitation for the system (although Jevons did not use that term) since the exchange ratio would ultimately conform to it. This was consistent with Jevons' summary of his position, noted above, that the ratio of exchange "will conform in the long run to the ratio of productiveness which is the reciprocal of the ratio of the costs of production". However, after restating that proposition as expressing "the truth, that articles will exchange in quantities inversely as the costs of production of the most costly portions, i.e. the last portions added", Jevons also discussed cases of increasing marginal costs, especially in international trade, with raw materials as production inputs. Jevons thus assumed, like Mill, that with a given technology and wage rate, manufacturing outputs were produced under constant costs while increasing costs prevailed in the raw materials sector. Although no representation of the return to the owners of raw materials appeared in his equations,[25] with changes in the quantities produced, the long-period outcome would depend on a series of sequential adjustments in the ratios of productiveness and utility. The adjustments could not be instantaneous, Jevons indicated elsewhere, in part because of the time lags required in changing production levels.[26] Ultimately, after "a kind of struggle between the conditions of consumption and production", in equilibrium the "ratio of exchange governs the production as much as the production governs the ratio of exchange". However, apart from some general comments about the effects of the interaction (for example, the results of the abolition of the Corn Laws on the production levels of wheat), it was "not easy to express in words how the ratios of exchange are finally determined" and no explanation was actually given [Jevons 1970, pp.200-2,208].

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[25] This was because Jevons assumed such returns would take the form of rent which was price-determined (see below).

[26] When discussing Ricardo and Mill in an 1876 Owens College lecture, Jevons was reported as saying that the "chief cause" for the divergence between market and cost `value' was the time lag between a change in market price and consequent change in production: "things cannot be made instantaneously. They require some time to grow, or to be manufactured" [Black 1973-81, VI, p.84].

While Jevons did not explain how a long-period position would occur, various comments suggest he regarded his analysis as consistent with those economists who argued that the attainment of such a position would be only temporary or `momentary'. One example was G.P. Scrope (see above). Another was Mill who, in referring to reproducible commodities, defined a "stable equilibrium" as one where the market price would "settle" at the natural price (`value') if "fresh disturbing forces were not continually arising to make it again deviate". With the natural price providing a `centre line' "about which value oscillates and to which it always tends to return", a stable equilibrium would rarely occur and would not be sustained: "On an average of years sufficient to enable the oscillations on one side of the centre line to be compensated by those on the other, the market value agrees with the natural value; but it very seldom coincides exactly with it at any particular time". In this sense, the centre line constituted an "average" value for the system [Mill 1965 (1909), pp.456,453,450,478]. As Jevons noted, for Mill, "value never coincides except momentarily and accidentally with the cost value" [Jevons 1905, p.64; see also Black 1973-81, VI, p.83]. If the economy was only momentarily in long-period equilibrium, in terms of condition (4) there would be a persistent series of inequalities between the price ratio (and the ratios to its left) when compared with the ratios for productiveness and cost of production. That Jevons assumed such divergences between market prices and long-period outcomes to be the rule was suggested at a number of places in TPE when he noted that labour would often be subjected to bouts of (what would now be termed) unemployment.[27] In Chapter V, for example, when dismissing the possibility of generalised "over-production", represented as a stagnation outcome due to a general `satiation' in consumption, he noted that overproduction could occur in particular industries due to "miscalculation" by firms so that customers would "refuse ... to purchase ... [those commodities] at ratios of exchange corresponding to the labour expended" in producing them. In effect, price would fall below the cost of production with "an apparent glut and a real loss of labour" [ibid. p.212].

Since there was no role for capital in Chapter V, a tendency to long-period equilibrium could not be depicted as the result of capital movements between industries, which would explain why Jevons found it difficult to explain how a long-

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[27] Jevons did refer to the "unemployed" in the Principles [Jevons 1905, p.343], as had Thomas Chalmers [Chalmers (1840) 1856, p.421].

period result could occur. There seems little doubt, however, that he agreed with his predecessors once capital was taken into account. For example, in the Principles of Economics, he quoted the following description of the tendency to long-period equilibrium from Cairnes' Leading Principles:

> where the price of a commodity is above the normal level, and where consequently the producers are reaping more than average [i.e. long-period] rewards, more producers will be drawn to that employment, and the supply of the commodity will be increased. But the increase of supply, by the competition for sales, will tend to lower price, and thus bring it down toward the normal level [Cairnes 1874, pp.41-2; cited Jevons 1905, pp.65-6].

Jevons described Cairnes' statement as a "reasonable doctrine" [Jevons 1905, p.66], thereby indicating his agreement. He presumably also agreed with Cairnes' statement that market-period prices oscillated around the long-period position [Cairnes 1874, p.45]. This was consistent with his discussion in TPE's concluding chapter of how "capitalists, or entrepreneurs" who were "first in the field" of an industry could make "large profits" which would subsequently be reduced to an average return on capital due to falling prices as output expanded or as wages rose. Alternatively, he noted that, "as a matter of fact, we often observe that there is abundance of capital to be had at low rates of interest, while there are also large numbers of artisans starving for want of employment" [Jevons 1970, pp.257,255].

Those references suggest Jevons regarded divergences from the long-period position as the norm so, from that analytical perspective, the economy was virtually always in disequilibrium.[28] Although the comments in TPE were brief, the initial version of the marginalist project was apparently to include a more extensive discussion of the matter. In the Brief Account, Jevons noted that the "higher complications of the subject" would consider "the effects of money, of credit ... of the risk and uncertainty of undertakings, and of bankruptcy" [Jevons 1866 (1862), p.287]. Coupled with the lags between changing prices and production, the discussion of uncertainty would be consistent with explaining why the economy would rarely be at the long-period position. In TPE, however, apart from the elliptical

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[28] Although the point will not be pursued here, the market-period analysis in TPE was quite different in that Jevons argued as if all trades took place at equilibrium. See Chapter 7 of this thesis.

references to miscalculations by firms, that analysis was not considered. This was not unusual in that, as noted above, Jevons failed to clearly explain the meaning and relevance of other key components of his argument concerning value and cost of production. Much the same point can be made about the meaning he gave to 'the laws of supply and demand' in that context.

1.5 The Laws of Supply and Demand

The characteristics of a long-period equilibrium in condition (4) can be divided into those terms explained by means of the utility theory ($\phi x/\psi y = y/x = \omega_2/\omega_1$) and their monetary equivalents ($p_1/p_2 = c_1/c_2$). The actual state of the economy, with persistent inequalities between the price and cost of production ratios, would necessitate continual adjustments in the quantities of commodities produced and sold. Since prices provided the signals for the adjustments, an explanation was required for changes in market prices which were summarised in the laws of supply and demand. However, precisely because they were "purely empirical" [Jevons 1905, p.58], the laws had to be explained by the theory of exchange. Hence the laws of supply and demand "form the empirical basis of the theory of value" [ibid. p.54] and, "when properly stated, are the practical manifestation of the theory" of exchange [Jevons 1970, p.148]. The laws were used in the analysis of adjustments within and between market periods. They could not specify the long-period position itself, so that "the values of things are [principally] governed ... [by] the laws of supply and demand", where supply "means the quantity of any goods which people are willing to give in exchange at a certain value and demand means similarly the quantity of goods which people are willing to give in exchange" [Jevons 1878a, p.99].

The links that Jevons made in TPE between the value theory and its 'empirical basis' can be shown by first examining his discussion in chapter IV of an exchange between two representative actors or 'trading bodies'.[29] Assume given amounts of X and Y produced and distributed, such that trading body 1 has the endowment a of X, while trading body 2 has the endowment b of Y. At the given exchange ratio,

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[29] It has sometimes been suggested that Jevons restricted his use of the term trading body to cases of price-taking behaviour, precluding its use when considering other cases such as bilateral monopoly. Chapter 8 below shows that was not the case and provides an explanation for Jevons' use of the term.

trading body 1 exchanges the quantity x for the quantity y from trading body 2. With $x < a$ and $y < b$, the equilibrium condition [Jevons 1970, p.143] is

$$\phi_1 (a-x)/\psi_1 y = y/x = \phi_2 x/\psi_2 (b-y) \qquad (5)$$

Jevons linked this elaboration of the value theory to the laws of supply and demand via a critique of Mill's characterisation of the value of a non-reproducible commodity when demand equalled supply. Mill argued that the "idea of a ratio, as between demand and supply, is out of place, and has no concern in the matter: the proper mathematical analogy is that of an equation. Demand and supply, the quantity demanded and the quantity supplied, will be made equal" [Mill 1909, p.448; cited Jevons 1970, p.143]. The problem here, Jevons argued, was that the reasoning and theory were incomplete, so that Mill "fails to reach the root of the matter". Economics "must deal not merely with analogies; it must reason by real equations." Mill's "equation" stated that the quantity of one commodity given by one body was equal to that received by the other. That might appear to be "a mere truism, for this equality must necessarily exist if any exchange takes place at all". It was, nevertheless, correct as far as it went. The substantive problem was that an equation was required for each of the traders as in condition (5), where the ratios depicted "the equivalence of supply and demand" [Jevons 1970, p.143]. For x was the quantity supplied on the one side (by trading body 1) and demanded on the other (by 2), while y was the quantity demanded on the one side (by 1) and supplied on the other (by 2). So far as the depiction of equilibrium was concerned, the "laws of supply and demand are ... the result of what seems to me the true theory of value or exchange" [ibid. p.144].

That conclusion requires some amplification. For any set of transactions within a market period, equilibrium trades of X and Y necessitated taking the following as given: the exchange ratio, the total amounts of the commodities which could be exchanged and a distribution of those amounts as endowments. The amounts actually traded at any moment then depended on the respective marginal utilities of the transactors. Both demand and supply could thus be explained by the final degree of utility functions of the two bodies. The treatment of supply, however, required a further factor to be taken into account. In chapter V, Jevons noted that the cost of production "is only one circumstance that governs supply" because it excluded any "expenses of commerce" such as those for transportation [Jevons

1970, pp.207,209]. In chapter IV, it was explained that transportation was one example of a larger genus of expenses paid for "brokers, agents, packers, dock, harbour, light dues etc., together with any customs duties". Those expenses were accounted for in the exchange theory by depicting the traders as `surrendering' a "fraction of the commodity received", since, if they were "expressed in money, [the expenses] can be considered as turned into commodity" [ibid. p.147].[30] Using the example of the trading bodies in condition (5), if the expenses were assumed to be proportional to the amounts of the commodities, the first trading body would receive ny of Y, rather than y (where n < 1), while the second would receive mx, rather than x (where m < 1). The equilibrium condition [ibid. p.148] would then become

$$\phi_1(a-x)/n.\psi_1(ny) = y/x = m.\phi_2(mx)/\psi_2(b-y) \qquad (6)$$

Given the assumptions, it was possible to represent the quantities demanded and supplied at any moment in a market period by means of the exchange theory, although, with the exception of the explanation for (6), the statements of equilibrium conditions assumed that the `expenses of commerce' were zero.[31] Those expenses could be expressed in money since the theory could represent market transactions where money was exchanged for other commodities by treating money as simply another commodity. More specifically, it was "the supply of commodity which forms a person's income. Its final degree of utility is measured by that of any of the other commodities which he consumes" [Jevons 1970, p.170]. Consistent with the theory of exchange, money was supplied on one side of the market and demanded on the other.

If the quantities supplied and demanded at different exchange ratios could be represented by the exchange theory, the observation or statistical records of quantities and prices in actual markets had a different epistemological status when compared with the theory. Supply and demand were `facts', summarised in the laws of supply and demand, which provided an empirical bedrock for the analysis

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[30] The discussion of those costs within the exchange theory was consistent with Jevons' definition of production.

[31] This was presumably for ease of exposition. The effect, as Jevons noted, was that nearly all the statements of equilibrium conditions in chapters IV and V assumed that exchange was `costless' [Jevons 1970, pp.147,153].

[White 1989]. The validity of the theory could thus be shown by matching its explanation with the laws, a statement of which appeared in the record of Jevons' 1876 lectures at Owens College and his primer [Black 1973-81, vi, pp.81-2; Jevons 1878a, pp.99-100]. The lectures noted that the laws could be expressed either in terms of the variability of market price or the variability of supply and demand for a given price. In the first case, the laws stated how prices were "determined in any large market ... large purchases raises the prices. Small purchases lessen the prices. Large supplies lessen the prices; shortness of supplies raises the prices" [Black 1973-81, vi, p.82]. The alternative "expression" was given in the primer [Jevons 1878a, p.99]:

> a rise of price tends to produce a greater supply and a less demand; a fall of price tends to produce a less supply and a greater demand. Conversely, an increase of supply or a decrease of demand tends to lower price, and a decrease of supply or an increase of demand to raise price.
>
> These laws are so important that I will state them over again, in the form of a table:-

Price	Supply	Demand
Higher	Greater	Less
Lower	Less	Greater

In either case, the laws were not represented by theoretical functions since they were statements of `facts' that had to be explained by the value theory.[32] If Jevons' account has sometimes been misunderstood because the absence of theoretical functions made it quite different from that of later post-classical economists such as Alfred Marshall [White 1991a], the discussion in TPE was also confusing. Jevons gave the impression that a statement of the laws was devoid of any theoretical specification: "As founded upon facts, those laws cannot be shaken by any theory"

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[32] In TPE, when Jevons described the "phenomenal laws of supply and demand" as "express[ing] the manner in which the quantities vary in connexion with the price", he argued that, because of this, "the laws <u>are</u> mathematical". `Mathematical' simply meant the analysis was couched in terms of "<u>quantities</u> ... [which are] capable of being <u>greater or less</u>" [Jevons 1970, pp.59,78].

[Jevons 1970, p.43]. The discussion in Chapter IV, however, indicated that they did not apply in cases of commodity indivisibility and bilateral monopoly [ibid. pp.148-9;155-61; see Chapter 8 of this thesis]. As Jevons acknowledged in the Principles, the laws were "only expressions of the general course of phenomena exhibited in commerce where there are many buyers and sellers" [Jevons 1905, p.57]. Moreover, while TPE referred to "the unquestionable truth of the laws of supply and demand" [Jevons 1970, p.43], the Principles also made clear that there were non-trivial exceptions to the law of demand in that, following a price change for one commodity, the prices and the amount demanded of substitute and complementary commodities could be positively related [Jevons 1905, pp.148-9].[33] The discussion of substitute commodities in TPE did not make that precise point clear [Jevons 1970, pp.166-8].

Jevons did acknowledge in TPE that observations or statistics of prices and quantities for particular markets incorporated a complex of explanatory factors that could not be explained solely by the final degree of utility functions for the final transactors on each side of the market. It was noted above, for example, that supply would include a number of transaction costs. Jevons also indicated in TPE that prices could be distorted by speculators cornering a market. In that case, while the exchange equation would still apply, the transactions would occur at "unnatural" or 'artificial' prices, so that the market was no longer 'perfect' [Jevons 1970, pp.133-4]. Nor could demand be explained simply by the final degree of utility functions of the purchasers. Jevons indicated this when, arguing that the utility theory was "in harmony with facts", he discussed how prices would vary according to demand following a change in supply in a market period [ibid. pp.176-8]. Using a series of quotations from Thomas Chalmers' Christian and Civic Economy (1826) which discussed price changes for 'necessary and 'luxury' commodities, Jevons argued that "Men can live without luxuries, but not without necessaries" [ibid. p.177].[34] The changes in prices of necessities would be more marked because their final degree

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[33] It was that discussion to which Jevons was presumably referring when, earlier in the text, he had noted that the "empirical law of demand" was "subject to exceptions and qualifications elsewhere explained" [Jevons 1905, p.58].

[34] This was an unacknowledged crib from Chalmers [(1840), 1856, pp.412-3] in the chapter to which Jevons referred. While Jevons used a different edition from that cited here, the relevant quotations were the same in an early edition of Chalmers' text [Chalmers 1826].

of utility functions would have a steeper slope than those for luxuries [ibid. pp.178-9]. While the slope of the functions could, in effect, represent the degree to which substitution was reflected in the price change, the extent of any change for a luxury would also depend on whether it accounted for a large proportion of expenditure. This, in turn, meant that the price change depended on the distribution of income (and wealth), as Jevons indicated when discussing the importance of changes in the marginal utility of money [ibid. pp.174-6].

Jevons was more forthcoming on this matter in his Principles, where he acknowledged that it was not possible to derive statistico-mathematical price 'laws' for particular commodities that would show how changes in price, reflecting an aggregate final degree of utility function, would change with supply. Such laws could only be obtained from price and quantity time series data. It was impossible to do so, however, because of deficiencies in the quantity statistics and because of the difficulty in accounting for the effects of shifts in utility functions, income and wealth distribution, price changes for other commodities and speculation [Jevons 1905, pp.56-8,146-9]. As Jevons indicated in the Principles, he had reached that conclusion in the early 1860s after much detailed statistical work.[35] It should be noted that his argument was quite different from economists such as Cairnes who argued that it was not possible to provide a systematic theoretical explanation for market-period (as opposed to long-period) prices because of the complexity of the causes involved. For Jevons, it was possible in principle to provide a systematic explanation via the marginal utility theory. His problem was that he could not demonstrate that statistically.

In Chapter IV of TPE, the quantity that could be traded was taken as parametric at the beginning of a market period. The laws of supply and demand could also be used to characterise the sequence of adjustments when production levels were changed so that changes in market prices were required for the economy to tend towards the long-period position. Consistent with the classical method, the market adjustments could be depicted as a change in supply leading to a change in price and the quantity demanded, which fed back into production decisions for

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[35] The remnant of this project appeared in TPE in Jevons' analysis of the King-D'Avenant price quantity table [Jevons 1970, pp.174-6, 178-84], which discussed, in principle, how a 'price law' could be constructed. See Stigler 1994; Maas 2001, chapter 6.

subsequent market periods. Hence, as Jevons put it in the Principles, "cost of production ... operate[s] through, not beside, the laws of supply and demand" [Jevons 1905, p.65]. For Jevons, the laws were relevant only with regard to the ratio of exchange and the other variables to the left of the price ratio in condition (4). As 'facts', the laws of supply and demand were not represented as theoretical functions and could not explain a long-period position. The role of supply and demand was to explain market-period prices and the tendency toward a long-period position. Cost of production affected, but was analytically quite separate from, the analysis of supply and demand.

Given the use of the same method, it is perhaps not surprising that some of Jevons' comments sound like Cairnes or Mill. As late as 1881, he argued that "the values of gold and silver are ultimately governed, like those of other commodities, by the cost of production". However, in the "temporary view of the subject, by which I mean ... the next ten or fifteen years ... the great principle of the cost of production fails us". That was because "the data become wholly uncertain and contingent", so that it was necessary to refer to the 'values' of gold fluctuating in a series of market periods [Jevons 1884, pp.318,320,321]. Jevons' theoretical explanation was, however, quite different from Mill and Cairnes. As noted above, the argument in TPE that the behaviour 'behind' market-period prices could be depicted by the marginal utility theory was quite foreign to their approach where such prices were contingent on specific conditions. That point illustrates a key analytical break introduced by Jevons – the attempt to establish a theoretical symmetry between the explanation of market-period and long-period outcomes in that both were capable of a systematic explanation using the marginalist theory of behaviour. The explanation of the exchange ratio and market-period prices depended on the transactors' final degree of utility functions. The long-period position was specified in terms of the utility function and the degree of productiveness ratios. The explanation of the latter depended, in turn, on the marginal utility theory of work effort. The core of the behavioural theory was thus not simply the utility functions explaining the exchange ratio, but the specification of the work effort decision.

The effect of Jevons' symmetry was to argue that the explanation of cost of production and supply and demand could be integrated in one form, rather than explained by different analytical procedures as was the case with Mill and Cairnes. In this regard, it may be that his specification of a long-period equilibrium was

designed, in part, to counter Mill's discussion of how, in the cases of international trade and joint production of commodities, it was necessary to "fall back" on the "antecedent law ...of supply and demand", rather than the principle of cost of production [Mill (1909) 1965, pp.574,584]. Jevons certainly criticised Mill in that regard in the second edition of TPE and in the Principles [Jevons 1970, p.209; 1905, pp.63-6], echoing the critique of H.D. Macleod that Mill's theory was asymmetrical [White 2002]. If some care needs to be taken with the specific terms of Jevons' critique,[36] it is unclear whether the argument helps explain the motives for Jevons' attempts to produce an alternative value theory in the early 1860s or whether it was only formulated between the publication of the first and second editions of TPE.

1.6 Distribution and Long- Period Equilibrium

In Chapters VI-VIII of TPE, Jevons outlined a long-period theory of distribution, analysing rent (VI) and interest on capital (VII) with some remarks about differential wage rates (VIII). As in Chapter V, he used the assumption of a given wage rate in Chapters VI and VII, where the basic theoretical approach was to assume two inputs, one given in amount and the other variable. All units of the variable input were homogenous and recompensed at the same rate, equal to the marginal product of the last unit used. The marginal product would decline with each additional input. The fixed factor received the residual output. The order of argument followed Jevons' definition of the `requisites of production' mentioned above. Having assumed that labour worked with raw materials and a given wage in Chapter V, Jevons first turned to the explanation of rent, the income received by the owners of land from which the raw materials were extracted. Here, the amount of land was fixed and the quantity of labour variable. With an `intensive margin', where different quantities of labour were applied to a piece of land, Jevons used his discussion of the work decision from Chapter V to argue that work would cease at

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[36] Jevons claimed that "Mill had no firm and clear idea of the theory of value. He vacillated between the two opinions that value depends upon the cost of production, and that it is governed by the laws of supply and demand" [Jevons 1905, p.63]. He argued that, unlike Cairnes, Mill had been inconsistent (a not uncommon complaint). While the argument depended, in part, on the way Jevons had defined value, it was a specific critique of Mill and did not indicate a general disagreement with the use of the classical method. White 2002 has a further discussion of Jevons' critique and its possible relation to Macleod's analysis.

the point where the marginal product of labour was recompensed by the corresponding increment of output [Jevons 1970, pp.221-2]. All units of labour would be paid at the same rate because the last unit was the most `painful'. That rate (a `corn wage'?) appears to correspond to what Jevons characterised as the "ordinary wages" of labour when describing the Classical theory of rent with which he announced his agreement [ibid. p.218]. Rent was simply a surplus, the residual output above the ordinary rate that would decline to zero at the equilibrium point on the "sterile land which it only just pays to take into cultivation" [ibid. p.247; see also p.256].

Jevons again used the device of a representative actor or `body'[37] to extend that result to two pieces of land, the outputs of which can be represented as commodities X and Y. The `body' would allocate labour between the two pieces consistent with equilibrium condition (2) above [Jevons 1970, pp.222-4]. The analysis was also consistent with long-period equilibrium condition (4) as Jevons had indicated in the previous chapter.[38] Rent was price-determined, equal to the difference between the price and cost of production at the equilibrium point and the lower cost of production at preceding levels of output. It was, however, a special case since, with equal costs of production for X and Y (the labour marginal products and the wage rate being the same), condition (4) would only hold if all ratios were equal to 1. The significance of this result will be further considered below.

One other aspect of the rent analysis requires clarification. At the close of chapter IV, Jevons criticised Ricardo's (long period) value theory for the "violent assumption" of homogenous units of labour. Although Ricardo "was aware that labour differs infinitely in quality and efficiency ... his theory rests on the assumed equality of labour." By contrast, Jevons argued his theory

> rests on a wholly different ground ... I hold it to be impossible to compare a priori the productive powers of a navvy, a carpenter, an iron-puddler, a schoolmaster and a barrister. Accordingly, it will be found that not one of

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[37] "I shall suppose ... a certain labourer, or, what comes to exactly the same thing, a body of labourers" [Jevons 1970, p.220].

[38] In long period equilibrium, "articles will exchange in quantities inversely as the costs of production of the most costly portions, i.e.. the last portions added. This result will be of great importance in the theory of rent" [Jevons 1970, p.202].

> my equations represents a comparison between one man's labour and another's. The equation, if there is one at all, is between the same person in two or more different occupations [Jevons 1970. p.187].

At first sight, that statement appears consistent with the rent analysis in that the representative actor allocated units of labour between the different pieces of land. There is, however, a crucial difference. The different marginal labour productivities on the two pieces of land were explained solely by the differential fertility of the land. The `pain' of each unit of labour differed, but there were no differences in each unit due, for example, to different work capabilities or skills. In arguing that the workforce was a representative `individual' or a `body' of labourers, the analysis assumed that each unit of labour was homogenous. The assumption was correct as the mathematics of diminishing returns with a fixed (and fully utilised) factor require homogenous units of the variable factor. It is, however, difficult to reconcile with Jevons' claims in his critique of Ricardo. The words said one thing, the mathematics another.[39] The significance of that point will also be considered below.

Jevons' argument entailed, in a `classical' fashion, that rent could then be put to one side as price-determined. With an explanation for a common wage rate from Chapter VI, he seems to have used that result in Chapter VII to explain the interest rate on capital, although the associated common consumption bundle now included, without explanation, some manufactured commodities. The quantity of labour was taken as fixed with capital as the variable input. Each amount of capital and the corresponding interest rate constituted a long-period position, with labour receiving the residual output [Jevons 1970, pp.248-9]. Over a succession of long periods, the interest rate would decline, a result that Jevons claimed was a `statistical fact' [ibid.

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[39] A further complication was added to the discussion of rent in the second edition. Jevons noted in 1871 that there was no capital in the analysis at that point. This was partly because capital was considered in the following chapter and partly because, following James Mill and J.R. McCulloch, "as all capital was originally produced by labour, the application of additional capital is the application of additional labour" [Jevons 1871, pp.204-5]. In 1879, however, Jevons announced that argument was "erroneous", noting cryptically that he was now assuming that "the increments of labour applied are equally assisted by capital" [Jevons 1970, p.220]. This assumption of a constant labour/capital ratio, which looks peculiar because there is no return to capital in the analysis, appears to have been introduced following a criticism by Leon Walras [Black 1973-81, v, p.198].

pp.245-6].[40] Equilibrium in a long-period position was defined (in Chapter VIII) as the point at which competition between capitals would cease because "only the market rate of interest is obtained for the capital invested" [ibid. p.257].

The explanation for the uniform interest rate on `free capital' depended on a series of restrictive assumptions [Steedman 1972]. For example, technological change was not sufficient to offset the tendency for the interest rate to decline over a number of long periods [Jevons 1970, p.246]. It was also assumed that any "considerations of risk, trouble and other interfering causes" could be ignored [ibid. p.240]. That assumption was necessary so that `free capital' "can be indifferently employed in any branch or kind of industry" and the interest rate "will tend to and closely attain uniformity in all employments" [ibid. pp.239,240]. A further assumption to ensure that result was a given wage rate across the economy. The assumption followed from Jevons' explanation of `free capital', which was defined as "the wages of labour, either in its transitory form of money, or its real form of food and other necessaries of life. The ordinary sustenance requisite to support labourers of all ranks when engaged upon their work is really the true form of capital" [ibid. p.239]. This was consistent with his earlier statement in the chapter that "Capital ... consists merely in the aggregate of those commodities which are required for sustaining labourers of any kind or class engaged in work. A stock of food is the main element of capital ... The current means of sustenance constitute capital in its free or uninvested form" [ibid. p.226].[41] With a common bundle of heterogeneous commodities, capital could be applied `indifferently' to any branch of industry:

> Men and families consume much the same kind of commodities, whatever may be the branch of manufacture or trade by which they earn a living. Hence there is nothing in the nature of free capital to determine its employment to one kind of industry rather than another. The very same wages, whether we regard the money

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[40] Jevons' analysis of the falling interest rate was based on his distinction between the `amount of capital invested' (the quantity of free capital) and the `amount of investment of capital' (the quantity of free capital multiplied by the time for which it was invested) [Jevons 1970, pp.229-32,240-1]. See Steedman 1972; Peach 1987, p.1017.

[41] More specifically, the commodity bundle consisted of "all kinds of food, clothing, utensils, furniture and other articles which a community requires for its ordinary sustenance" [Jevons 1970, p.240].

> wages, or the real wages purchased with the money, will support a man whether he be a mechanic, a weaver, a coal miner, a carpenter, a mason or any other kind of labourer.
> The necessary result is that the rate of interest for free capital will tend to and closely attain uniformity in all employments [Jevons 1970, p.240].

The argument, then, was that, assuming away any consideration of 'risk or trouble', a uniform interest rate would result in a long period because capital could flow between different industries as all units of capital were homogenous, consisting of the same commodity bundle ("free capital is always the same in quality" [Jevons 1970, p.247]).[42] If the assumption of a homogenous variable input was consistent with that used to explain rent, the bundle of a labourer's consumption also helps explain why, at the outset of Chapter III, Jevons restricted the consumption commodity domain in TPE to working class consumption: "A very large part of the labour of any community is spent upon the production of the ordinary necessaries and conveniences of life, such as food, clothing, buildings, utensils, furniture, ornaments, etc.; and the aggregate of these things, therefore, is the immediate object of our attention" [ibid. p.101]. In Chapter IV, the discussion of how the prices of necessaries and luxuries would change with supply was also couched in terms of working class consumption, as the characterisation of necessities and luxuries would differ between income groups. Consistent with that focus, when citing Richard Jennings with regard to declining marginal utility and Thomas Chalmers on price changes (see above), Jevons removed their references to higher income groups from his quotations.[43] The limited consumption domain of chapters III and IV was thus consistent with the analysis of capital in Chapter VII, which represented

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[42] Steedman [1972, p.32] noted that Jevons' use of a commodity bundle assumed either that it was given or that it was explained by a set of relative prices. In the latter case, the analysis was theoretically indeterminate because the relative prices assume an interest rate which has to be explained. As suggested above, Jevons was assuming a given commodity bundle in Chapter VII.

[43] In the quotation from Jennings' Natural Elements in TPE, an ellipsis in the first paragraph indicates the omission of a section where Jennings discussed the different effects on the "rich" and the "poor" of "different quantities of a Commodity" [Jevons 1970, p.113; Jennings 1855, pp.96-7]. In a quotation from Chalmers, the first paragraph omitted, without warning, the phrase "on the part of its consumers in high life", between the words "descent to" [Jevons 1970, p.177; Chalmers (1840) 1856, p.413].

the labour share of output as a residual after the payment of interest. While the definition of capital assumed a given wage rate at the beginning of a long period, the labour share at the close of the period would depend on the quantity of capital used. With a given quantity of labour, the excess output, above that paid as interest, at the end of the period could differ from that at the beginning, so that labour income became endogenous.

Jevons used the analysis of the interest rate and the labour share of output in Chapter VII to criticise the distribution theories of Mill and Ricardo. Mill followed Ricardo in arguing that the "rate of profits depend on wages; rising as wages fall, and falling as wages rise". The profit rate thus depended on "the cost of labour" which consisted of the wage rate, the `efficiency' of labour and the cost of the wage earner's consumption bundle [Mill 1965 (1909), pp.419,420]. Departing from Ricardo, Mill also argued that "gross profits" were composed of interest (the reward for "abstinence"), an "indemnity for risk and renumeration for the labour and skill required for superintendence" of an enterprise [ibid. p.406]. Gross profits set a limit to the "natural" (long-period) interest rate that was governed by the demand and supply of "loans" in financial markets [ibid. pp.637,638]. Jevons followed Mill in arguing that interest was the return for abstinence -- "that temporary sacrifice of enjoyment" [Jevons 1970, p.232]. In the second edition he cited Nassau Senior for the observation that abstinence "stands in the same relation to Profit as Labour does to Wages" [ibid. p.233; Senior 1951 (1836), p.59]. Both labour and capital were thus recompensed for their `pain' in contributing to production. As will be shown below, Jevons also argued that profits contained returns to risk and superintendence. With regard to the explanation of the interest rate and its implications for distribution, however, Jevons' analysis was quite different from that of Mill.

It is evident from comments made by Jevons in 1860 [Black 1973-81, ii, p.422] that his explanation of the interest rate as "determined by the increment of produce which it enables a labour to produce" [Jevons 1970, p.246] was developed as a critique of Mill's explanation in terms of the demand and supply of loans in financial markets. The discussion of possible explanations for the falling rate of interest (provisionally equated with the profit rate) in TPE indicated that Jevons' theory was designed to counter any suggestion of a fundamental conflict of interest between labour and capital [cf. Steedman 1972]. Having referred to Adam Smith's

explanation in terms of the "competition of capitalists", Jevons noted that "later economists ... attributed the fall of interest to the rise in the cost of labour ... if it is necessary to give more to labour, there must be less left to capital, and the rate of profit must fall". For Jevons, however, the interest rate did not depend on `the cost of labour'. Instead, "the returns to capital and labour are independent of each other" [Jevons 1970, p.246]. The following discussion of that proposition [ibid. pp.246-7] was, however, confusing for two reasons. The first was that the analysis of different outcomes depended on labour and capital working with land of differing fertility, thereby also introducing the discussion of rent. The second was that, in referring to wages and interest/profits, two distinct issues were mixed together. Jevons' reference to `the cost of labour' was concerned with the relation between the real unit cost of labour (Mill's `cost of labour') and the interest rate. Jevons, however, mixed analysis of that matter with a discussion of the relative shares of labour and capital in output, a separate, albeit related, issue. The general point, however, seemed to be that there could be no necessary basis for conflict between labour and capital in terms of income shares. This was indicated in the next, and concluding, chapter where Jevons returned to the question of the relative shares of wages and profits. He argued there that, for a given quantity of capital, raw materials and set of techniques, wage rates reflected the contribution of labour to production and, therefore, the duration and intensity of work. It was in that context that he discussed differential wage rates.

In the Preface to the first edition, Jevons wrote that the explanation of wage rates was "the main problem of the science" [Jevons 1970, p.43]. It was a problem that had plagued his theory from the outset. There were two mainstays in his position. The first was, as he put it in TPE when criticising Ricardo's value theory, that the "value [of labour] must be determined by the value of the produce, not the value of the produce by that of the labour" [ibid. p.187]. The second was that the wage rate for each grade of labour (and even each labourer) was to be explained by their contribution to production. Those points underpinned his critique of Ricardo regarding the assumption of homogenous units of labour. The criticism was a key component of the Brief Account in 1862 and elaborated in TPE where Jevons used it to criticise Ricardo's value theory and his concept of a natural wage. The problem was, however, that he could not produce a satisfactory explanation for his belief. The Brief Account indicated that the wage theory was unfinished [Jevons 1866 (1862), p.287]. By 1871, Jevons had adapted the approach in William Hearn's

Plutology to explain the adjustment of wages "in the long run, and on the average of any one branch of employment", in the concluding chapter [Jevons 1970, pp.257,259; cf. Hearn 1864, pp.329-30].

Jevons argued that, in a long period, rent could be "eliminated, for it is ... reduced to zero in the case of the poorest land cultivated" [Jevons 1970, p.256]. With output now composed of profits and wages, profits could be "resolved' into interest; a return for superintendence, which was simply a wage; and, "insurance against risk" which was `equalised in different employments (no explanation was given for this) [ibid. pp.256-7]. Using Mill's terminology while rejecting his wage fund theory as a "delusive" explanation for long-period wage rates [ibid. p.43], Jevons turned to his own explanation, sketching a scenario in which "capitalists, or entrepreneurs", who were "the first in the field" in a "branch of production" were able to make "large profits" in a market period [ibid. p.259]. This depended on their being able, initially, to pay "the lowest current rates for the kind of labour required" [ibid. p.257]. The terminology was confusing in that `common' labour and rates does not seem to refer to unskilled labour but rather to prevailing average rates in the economy for any type of labour, skilled or unskilled (see below). With a greater rate of return to capital than the average, other capitalists would enter the industry, initially bidding up wage rates. That analysis "involves the temporary application of the wage-fund theory" [ibid.]. The eventual long-period result, however, would occur by adjustment in one of two ways. If the `skill and experience' of the labour was the same as in other `branches', competition would reduce output prices and wages would return "to their former point". (Jevons referred to this as a case where "common labour is requisite" in the industry, which apparently meant that, while there were different wage rates for different skills, the rates were the average prevailing in the economy). If, on the other hand, the industry/firm required "a very special kind" of skill and experience, wages would remain high and the "workmen reap the whole excess of produce" in both the short and the long run [ibid. pp.257,258].

The argument assumed there was a given pattern of average wage rates for different skills across the economy. No explanation was given for those rates and Jevons only presented a brief explanation for why some types of labourers would receive a higher rate than the average elsewhere. If careful and detailed analysis was in short supply, the ideology was clear:

> the wages of a working man are ultimately coincident with what he produces, after the deduction of rent, taxes, and interest on capital ... Every labourer ultimately receives the due value of his produce after paying a proper fraction to the capitalist for the renumeration of abstinence and risk. At the same time workers of different degrees of skill receive very different shares as they contribute a common or scarce kind of labour to the result [Jevons 1970, pp.256, 258].

There was no analytical explanation and hence justification for those statements in TPE. Having used a given or constant wage for much of the analysis, the only explanation for differential wage rates in the concluding chapter was that some firms or industries could afford to pay more than the average, depending on the relative number and type of labourers involved.[44] Jevons' associated critique of Ricardo on wage rates in the same chapter was then peculiar in two respects. First, in arguing that that "we have to account for the very different rates [of wages] which prevail in different trades", Jevons criticised Ricardo for his "sweeping simplification" of a natural wage that left "higher rates ... [as] merely exceptional circumstances, to be explained away on other grounds" [ibid. p.256]. This was an extension of the argument made at the close of Chapter IV when criticising Ricardo's value theory. The peculiarity here was that, despite the vehemence and repetition of Jevons' criticism, his explanation for differential wage rates was remarkably limited. The second peculiarity concerned Jevons' criticism of the Ricardian concept of a natural wage. Jevons rejected the concept of a "natural ordinary rate of wages for common [i.e. unskilled] labour" on the ground that it was "utterly impossible ... to define exactly what are the necessaries of life" [ibid. p.256]. This was in direct conflict with the definition of free capital in the previous chapter and with his discussion of price changes for necessaries and luxuries in Chapter IV.[45]

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[44] There was a further source of confusion in Jevons' statement, "I think that in the equation produce = profit + wages, the quantity of produce is essentially variable, and that profit is the part to be first determined" [Jevons 1970, p.256]. This has been read as an enunciation of a residual theory of wages [Davanzati 1995, pp.38-42]. Jevons' subsequent discussion of wage adjustment to a long-period position indicates, however, that both profits and wages were adjusted over a series of market periods. Profits `led' wages, but only in the sense of indicating how wage offers were to be adjusted in the next market period.

[45] The contradiction was not unprecedented. In another peculiar argument at the close of Chapter IV, Jevons attacked Ricardo's labour theory of value for not being able to explain the prices of irreproducible commodities [Jevons 1970,

1.7 The New `Correct Theory'

It was noted in the introduction to this chapter that Jevons has been criticised for failing to satisfactorily `integrate' his explanation of relative prices and distribution. The terms of such criticism are anachronistic in that Jevons is criticised for not producing a later version of postclassical theory. It is, however, possible to see how Jevons linked the long-period equilibrium condition in Chapter V (condition (4) above) with his explanation for rent and a uniform rate of interest. Rent was simply the difference between the long-period price and the cost of production at levels of output before the equilibrium point. While that result was made clear by Jevons, he did not explain the link to the interest rate. In terms of the ratios in condition (4) however, the interest rate would become redundant as it was the same for both commodities. Jevons could thus have regarded his depiction of value and cost of production in Chapter V as consistent with the analysis of rent and interest in the following two chapters. A substantive problem appeared, however, once he allowed for the possibility of differential wage rates in the concluding chapter.

As noted above, Jevons insisted that TPE confirmed the results of `the prevailing doctrine, that the value of commodities becomes approximately equal to their cost of production'. Yet his long-period equilibrium condition (4) only applied in two special cases. The first was with a given wage rate as indicated in his discussion of cost of production in Chapter V. If, however, wage rates reflected different marginal productivities of labor in different industries, the second case was that all ratios equalled 1. This result was noted above in the analysis of rent. Jevons used that ratio when explaining his exchange theory to H.C. Fleeming Jenkin in 1868 and at some points in TPE, although he acknowledged that it would "seldom or never occur" [Black 1973-81, iii, pp.166-78; Jevons 1970 pp.141,169]. Nevertheless, comments added in the second edition suggest that Jevons realised condition (4) required that special condition. Elaborating on the work decision for commodity X (du/dx . dx/dl), Jevons noted it would equal 1. Equilibrium required the same condition for commodity Y, although the significance of that point was not clearly

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p.186]. Apart from a misprepresentation of Ricardo's argument, Jevons appeared unaware that, a few pages before, he had acknowledged that his own value theory could not explain the prices of irreproducibles. Indeed, it could not deal with any commodity that was not infinitely divisible (see Chapter 8 of this thesis). See also his contradictory statements concerning the use of the word value discussed above.

explained [Jevons 1970, p.200]. Jevons expressed frustration with the use of the term `cost of production' because it was commonly used to conflate wage rates and unit labour costs. The irritation may also have reflected his inability to produce a general result for long period equilibrium.

Indeed, there is a further reason to suggest that Jevons realised his discussion of differential wage rates was applicable only in a special case. In the Preface to the second edition of TPE, he announced a new approach to wage rates that pivoted on a redefinition of the cost of production. Jevons argued his "general idea that wages are the share of the produce which the laws of supply and demand enable the labourer to secure" was still valid. However, the "correct theory" to explain that idea required a substantive change to that outlined in TPE in three ways. First, "labour, land, knowledge and capital" were to be depicted as "conjoint conditions of the whole produce, not as causes each of a certain portion of the produce" [Jevons 1970, p.68]. Second, because "the labourer has a monopoly of labour of each particular kind, as much as the landowner of land, and the capitalist of other requisite articles", wages were now to be explained "by the same formal law as rents". Third, rent was now depicted as price-determining, rather than price-determined -- "so far as cost of production regulates the value of commodities, wages must enter into the calculation on the same footing as rent" [ibid. p.69]. With the same principles applying to rent and wages, Jevons reintroduced the argument, mentioned in the Brief Account but omitted from the text of TPE, that the income on "fixed capital" took the form of rent [ibid. p.71].[46] Wages, like rent, were part of the cost of production because, "when labour is turned from one employment to another, the wages it would otherwise have yielded must be debited to the expenses of the new product". Nevertheless, this did not mean that labour of each type received the same wage rate across the economy:

> Every one gets the most which he can from his exertions; some can get little or nothing because they have not sufficient strength, knowledge or ingenuity; others get much because they have, comparatively speaking, a monopoly of certain powers. Each seeks the work in which his peculiar faculties are most productive of utility, as measured by what other people

[46] In the Brief Account, Jevons argued that the profit on "Buildings, tools, &c ... follows the laws of ...rent, or the produce of natural agents" rather than interest on capital [Jevons (1862) 1866, p.287].

> are willing to pay for the produce. Thus wages are clearly the effect, not the causes of the value of the produce [Jevons 1970, p.71].

The new distribution theory contradicted much of the analysis in chapters V-VIII of the text. Jevons had jettisoned the rationale used in chapters VI and VII to identify the marginal contribution to production of a variable input. He had also jettisoned the definition of cost of production and the explanation of rent as price-determined.[47] A careful explanation of the new approach would have necessitated a complete reworking of the analysis in those chapters, although Jevons failed to explain that point to the reader. The details of the new approach, however, remained unexplained. Jevons noted that the "results to be expected are partly indicated in my Primer of Political Economy, but in that little treatise my remarks upon the origin of rent (p.94), as originally printed in the first edition, were erroneous, and the section altogether needs to be rewritten" [Jevons 1970, p.72]. There was, however, little guide to the theoretical specifics of the new approach in the primer. The discussion of specific wage rates, for example, was, as Jevons acknowledged, based on that of Adam Smith [Jevons 1878a, ch.vii]. Even the changes made to the discussion of rent in the second edition were not particularly informative.[48] The discussion of wage rates in Chapter IV of the State in Relation to Labour (1882) also added little to that in the 1879 Preface. That text did, however, reinforce Jevons' Panglossian stance by claiming that even if "the labourer is quite ignorant and indifferent as to what is to be the results of his labour ... [and] simply does what he is asked ... this ignorance will not necessarily deprive him or his class from receiving in the long run their due share" [Jevons 1882a, p.99].[49]

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[47] The contradiction has either gone unnoticed [Stigler 1941, pp.15-16; Schabas 1990, pp.47-8; Peart 1996, p.128] or it has been claimed that Jevons treated rent "exclusively" as price-determining in TPE [Buchanan 1929, pp.124,147-9].

[48] In the second edition of the primer, Jevons changed the section heading from `The Cause of Rent' to `The Origin of Rent'. The first edition stated that "Rent arises from the fact that different pieces of land are not equally fertile". The second edition read: "Rent is frequently due to the fact that ..." [Jevons 1878a, p.94; 1878b, p.94].

[49] Jevons' analysis of labour markets was, of course, more extensive than that discussed here. In the State in Relation to Labour, for example, he considered coordinated bargaining between unions and employers. The concern here, however, is with Jevons' explanation of wage rates in the absence of coordinated bargaining as in TPE. In any case, as Jevons acknowledged, his marginalist theory could not provide a determinate explanation of prices with such bargaining (see Chapter 8 of this thesis).

Apart from referring to "more extensive reading and more careful cogitation" on the topic [Jevons 1970, p.67],[50] Jevons gave no explanation in 1879 for why he had jettisoned much of the analysis in TPE. I suggest, however, that his attempt to explain wage rates by redefining the meaning of cost of production indicates the argument was prompted by the difficulties he encountered in attempting to depict a long-period outcome with different wage rates. It has since been shown that the explanation of relative prices and distribution in TPE was theoretically indeterminate if only because a `dose' of capital cannot be defined unless the labourer's consumption bundle is given. With the rejection of that argument in Chapter VIII, the system was indeterminate because the commodity bundle must be specified by a set of relative prices, including the interest rate [Steedman 1972]. The argument here has been that Jevons realised his analysis was indeterminate, albeit on different grounds. While he gestured towards a new theory to avoid that problem in 1879, the only substantive result was to undermine the theory used in the body of the text.

Conclusions

Jevons' explanation of value and distribution in TPE followed the method, used by most of his predecessors in nineteenth-century British political economy, of distinguishing between the analysis of market-period and long-period prices. Despite some approving citations, he rejected the approach of Nassau Senior who attempted to erase that method by arguing there could be no systematic explanation for long-period outcomes. Instead, Jevons' approach was broadly consistent with that of G.P. Scrope where, although `value' could only be defined in terms of the wants and desires exhibited by transactors in an exchange, a long-period outcome was given a systematic theoretical explanation by reference to the conditions of production.

It was the theoretical explanation of that position that marked Jevons' analytical departure from his predecessors. He argued it was possible to provide a systematic theoretical explanation for market-period and long-period prices with the marginal utility theory. While Jevons was unable to show, statistically, that the effects on

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[50] In that regard, Jevons referred to Leslie 1868 and Shadwell 1877 (see also Shadwell 1872). In the State in Relation to Labour, he also referred to Walker 1877 (presumably chapter 8).

demand and supply of the final degree of utility functions could be clearly separated from other factors affecting prices, this should not obscure the significance of the theoretical symmetry he introduced. At the same time, his argument entailed that, as `facts', the laws of supply and demand were not represented as theoretical functions and could not explain a long-period position. The role of supply and demand was to explain market-period prices and the tendency toward a long-period position. Cost of production affected, but was analytically quite separate from, the analysis of the laws of supply and demand.

In Jevons' analysis of production, labour and raw materials were the `primary requisites'. With a given quantity of raw materials and capital, set of production techniques, division of labour and policies such as `free trade', the level of output depended on the duration and intensity of work by the working class(es). As Jevons put it in the concluding chapter of TPE, labour was "the first element of production and [we] aim at the most economical employment of that labour" [Jevons 1970, p.254]. Indeed, it could be argued that the behaviour of the working class was the principal object of concern in TPE. The work decision depended on the consumption behaviour and work habits of labourers and Jevons' principal complaint in that regard was that the majority of the working class (and `inferior races') were not prepared to work long enough hours (see Chapter 5 of this thesis). Theoretically, the utility and disutility functions of the mass of the population had the wrong shape. If the discussion of consumption in Chapters III and IV was primarily concerned with the working class, the same was true of the distribution theory in that, as Jevons noted, the explanation of wage rates was `the main problem of the science'. With the quantity of capital governed by the amount of gold in the economy, the overall objective was to explain wages by `the value of the produce'. Underpinning this was a dogmatic belief that, in the long run, everyone who worked for pay (this presumably excluded landowners) would be rewarded according to their contribution to production. Jevons was never able to provide a satisfactory theoretical explanation for his belief and his attempt to overcome that deficiency in the preface to the second edition of TPE rendered much of the argument in the body of the text analytically incoherent. He had made clear in the Brief Account of 1862 that his principal objection to Ricardo's labour theory of value was that it precluded a satisfactory theory of differential wage rates by assuming `uniform' units of labour. The critique was repeated with some vehemence in TPE. It is, then,

more than a touch ironic that Jevons' project of formulating an alternative theory of value and distribution foundered on the explanation of differential wage rates.

Chapter 2
THE FABLE OF THE WATER AND DIAMONDS PARADOX[1]

A recent critique of the claim, first published in Paul Samuelson's Economics textbook [Samuelson 1961, pp.444n,448n], that the potato was a 'Giffen good' during the nineteenth-century Irish famine, concluded in an exasperated tone: "Since the Giffen paradox is not useful for understanding the Irish experience, is it too much for future writers of elementary textbooks to find another example? Fictions have no place in the teaching of economics" [Rosen 1999, p.S313]. For historians of economics in particular, there is a marked irony in the last sentence. Although the Journal of Political Economy has published two detailed articles in the past decade on the Irish potato question [Davies 1994; Rosen 1999], cleansing the textbook stables of historical fictions does not have a high priority in mainstream journals.

One illustration of this is the persistent reference by economists to the 'water and diamonds paradox', also known as the Classical paradox of value. The paradox, which is usually traced to a paragraph in Adam Smith's Wealth of Nations, has been summarised by one textbook as follows: Why is it that "water, which has so much value in use, has no value in exchange, while diamonds, which have practically no value in use, are exchanged at high prices" [Ekelund and Hebert 1997, p.294]? The nub of the paradox story is the claim that, having identified the paradox as a puzzle, Smith and the Classical economists were unable to solve it. There was a consequent lacuna in value theory until Jevons used a marginal utility analysis to solve the puzzle in his Theory of Political Economy (TPE).

The story is not confined to textbooks as it has become part of the folklore of the profession.[2] It is, however, a mythical construction as there never was a paradox for Smith and his successors. In showing why the diamonds and water paradox story is a fable, the purpose of this article is to provide an historical perspective on its construction. It will be argued that the fable is one of a series of attempts, dating from the early nineteenth-century, to stabilise the meaning of Smith's

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[2] See, for example, Friedman 1999, p.1. The use of the story is not, however, restricted to economists [Labio 1997, p.138].

diamonds and water paragraph in a theory of value and distribution. While the paradox reading of that paragraph dates from the first edition of TPE, the fable itself was a product of the twentieth-century. After elements of the story began circulating from the 1920s, it was given a canonical representation in the first edition of Samuelson's Economics (1948). The subsequent success of the fable is a striking illustration of how a textbook illustrative device can recirculate, via lectures and other textbooks, to achieve the status of a professional myth.

The principal role of the story in textbooks is to show how a problem that puzzled Smith and succeeding economists can be solved with a marginal utility theory and a partial equilibrium supply and demand diagram.[3] Apart from its simplicity, the more general basis for the success of the story is that the paradox is represented as "the starting-point for the theorising of economists of the later nineteenth century which finally led to the marginal utility doctrine" [Roll 1992, p.139]. A synthesis of accounts that claim that the paradox was a, if not the, crucial factor in explaining the advent of the (British) `marginalist revolution' might read as follows. Until 1871, the explanation for the discrepancy between value in use and value in exchange remained a mystery because the Classical economists were incapable of resolving it. Smith was actually puzzled by his own statement and, hampered by a failure to use the calculus, he and the Classical school were unable to grasp that the correct solution required a distinction between the marginal and total valuation of a commodity. Without that solution, Smith effectively set aside any discussion of value in use and hurried on to explain only the determination of exchange value. Conceptual prisoners of Smith's characterisation of utility, other pre-marginalist economists concentrated on cost of production as the explanation of price. Although a basis for the solution was suggested early in the nineteenth century by Jeremy Bentham and Nassau Senior had the key to the solution in his grasp, it was generally puzzled over for nearly a hundred years in the economics literature. The denouement came in 1871 when Jevons unlocked the paradox with the distinction between marginal and total utility in TPE.

If this provides a neat picture of scientific progress in terms of the solution to a puzzle with the appropriate mathematical apparatus, it is also a myth in virtually every respect. As critics of the story have noted, there is simply no evidence that any economist expressed any difficulty in explaining the relative prices of

[3] While accepting that there was a paradox, Swales [1993] provides a helpful discussion of the rhetorical devices textbooks use when referring to it.

commodities such as water and diamonds.[4] Section 2.1 shows why that was the case for Smith, arguing that his paragraph can be understood by reference to his distinction between long-period (`natural') and market-period values, as well as the discussion of utility in the Theory of Moral Sentiments. That there was no paradox or puzzle is confirmed in section 2.2, which considers some (British) reactions to Smith's paragraph in the period to c.1870. Far from a uniform acceptance of Smith's categorisation, his paragraph was read in different ways. Indeed, by the 1860s, the dominant reading was probably that the paragraph was analytically incoherent. Section 2.3 shows that Jevons took a different tack in his Theory, making Smith's argument coherent within the terms of the new marginal utility theory. Having sketched the notion of a `logical' paradox of value solved by marginalism, however, Jevons later undermined his previous arguments. Section 2.4 then considers how the current paradox was produced by a selective reading of Jevons and some extensive myth-making.

2.1 What Paradox?

In texts of political economy, a distinction between the `usefulness' or `value' of commodities (where they were graded in terms of the `real' or `intrinsic' wants of `mankind') and their `value' in exchange as price, was made by Nicholas Barbon and John Locke in the late seventeenth century. While their discussion could draw on a much older literature concerning use and price,[5] they were followed by Bernard Mandeville and J. Jocelyn early in the next century, the latter referring to water and diamonds. The same example to illustrate a distinction between value in use and exchange can be found in Money and Trade Considered (1705) by John Law and An Essay on Money and Coins (1757) by Joseph Harris.[6] Adam Smith had both those texts in his library.

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[4] For examples of critiques of the paradox story, see Robertson and Taylor 1957; Stephenson 1972; Meek 1973, pp.72-3; Bowley 1973, pp.ix,134-9; Fayazmanesh 1998

[5] See, for example, the discussion and references in Grotius 1964 (1625), pp.351-2; Pufendorf 1964 (1688), pp.680-3. Although the distinction between value in use and in exchange has often been traced to Aristotle, the context and meaning of value in use were quite different in the later discussion of political economy [Schefold 1999].

[6] For a survey of the pre-Adamite literature, see Bowley 1973, ch.2. See also Mandeville 1957 (1714), p.350; Jocelyn 1718, pp.1-5; Harris 1757, p.5; Law 1705, p.4. (The relevance of Law in this context was noted by H.D. Macleod [1858, p.52]; see also Murphy 1994, pp.30-2,57-8). Quesnay also illustrated the distinction between "price" and "use value" using diamonds [Meek 1962, pp.89-90].

In the Wealth of Nations (WN), having considered how "money has become in all civilised nations the universal instrument of commerce", Smith posed the question of "what rules determine what may be called the relative or exchangeable value of goods". He then observed, in the passage that was subsequently read as the classic statement of the diamonds and water paradox, that:

> The word VALUE . . . has two different meanings, and sometimes expresses the utility of some particular object, and sometimes the power of purchasing other goods which the possession of that object conveys. The one may be called `value in use'; the other, `value in exchange'. The things which have the greatest value in use have frequently little or no value in exchange; and, on the contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water; but it will scarce purchase anything; scarce anything may be had in exchange for it. A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it [Smith 1976 (1776), pp.44-5].

Smith then indicated that the analysis which followed was concerned with identifying "the principles which regulate the exchangeable value of commodities" [ibid. p.46], which turned on the distinction between long-period (`natural') and market-period values. That Smith had been referring to long-period values in the diamonds and water paragraph was suggested in his subsequent analysis of rent (Book I, ch.xi), where he argued that the long-period prices of precious stones depended on their utility, beauty and scarcity: "They are of no use, but as ornaments; and the merit of their beauty is greatly enhanced by their scarcity or by the difficulty and expense of getting them up from the mine." Indeed, the prices of precious stones and metals "is regulated all over the world by their price at the most fertile mine in it" [ibid. pp.189-91; also p.563]. While this makes clear that Smith was not puzzled by such prices, it also indicates that utility was only one aspect of the demand for diamonds. It should also be noted that such demand was interdependent in that the wealthy purchased precious stones to display their wealth and position. `Scarcity' not only referred to the expenses of production and the quantity of the commodity, but also helped explain the demand for it.

The analysis of utility which underpinned that in WN was discussed in the Theory of Moral Sentiments (Part IV, ch.i). Distancing himself from Hume's examination of the

topic, Smith argued that, in general, people were deceived by the `machine' or the organisation in which commodities were placed or appeared. Mislead by the machine and driven by interdependence and the desire for emulation of the wealthy, utility or usefulness was attributed to commodities that were, in reality, only `baubles and trinkets'. In a highly ironic analysis, which included a reference to an `invisible hand',[7] Smith argued that it was just as well people were fooled because it was that deception which underlay the drive to accumulate wealth [Smith 1979 (1759), pp.183-4]. He used this discussion of utility, where commodities were ranked in terms of their relative importance in meeting `the wants of mankind', at a number of places in WN. The discussion preceding the analysis of the value of precious stones in the chapter on rent, for example, is similar to that in the Moral Sentiments [Smith 1976 (1776), pp.178-82; see also pp.337-8]. The most extensive use of the framework, however, was in Book II, especially Chapter iv, to explain the growth of towns and how large landowners lost political and economic power because of their wants for "the most childish, the meanest, and the most sordid of all vanities", such as "a pair of diamond buckles ... or something as frivolous and useless" [ibid. pp.418-9].[8]

Smith's references to water and diamonds in the record of his Lectures on Jurisprudence also indicate that he was referring to long-period prices in the WN paragraph. Although the discussion in the Lectures was crude, Smith distinguished between natural prices, explained by the maintenance of the labour necessary to continue producing commodities, and market prices, governed by the "quite other circumstances" of "demand or need", "abundance or scarcity ... in proportion to the needs" and the "riches or poverty" of the purchasers. In normal circumstances when the natural price prevailed, water "is so cheap as to be got for the lifting", while it would have a high market price in a famine or siege. Diamonds, however, "whose use we can hardly conceive", persistently sold above their natural price, driven by the demand of the "extremely rich" [Smith 1978, pp. 358,359,487,496]. When Smith argued that diamond prices were so high because of their `scarcity' he was, as in the WN, not referring simply to the quantity available. The demand, based on display by the rich, depended also on the limited quantity. In later terminology, supply and demand were interdependent. While the record of the Lectures and the

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[7] See Lubasz 1992 for a cogent critique of the textbook (and professional) myth that Smith's references to an invisible hand were synonymous with a post-classical analysis of an `efficient allocation of resources'.

[8] For discussion of Smith's analysis of demand, noting the importance of Moral Sentiments, see Rosenberg 1968; Gram 1998.

WN differ in analytical sophistication, there is no marked `contradiction' between them as has sometimes been claimed. In the WN paragraph, Smith was referring to the long-period exchange value of water and diamonds. While he apparently regarded discussion of a market-period price for those commodities as irrelevant in his subsequent analysis, there is no warrant for the claim that by the time WN was written he had `forgotten' or `changed his mind' about the discussion of market prices in the Lectures.[9]

Although Smith wrote that the `things which have the greatest value in exchange have frequently little or no value in use', he provided only one example, so far as I am aware, of a commodity that appears to have no utility and even that had "sometimes ... some little use" [Smith 1979 (1759), p.180]. It is striking, however, that the complex theory of behaviour discussed in the Moral Sentiments, which allowed for the possibility of zero utility, was not examined, let alone followed, by economists in the nineteenth century, although Nassau Senior appears to have drawn on it in his Outline of 1836 [see Chapter 3 of this thesis]. Instead, a `thinner' and more mechanical approach to behaviour was adopted and Smith's approach was jettisoned. The discussion then concerned the meaning that could be attributed to a distinction between value in use and exchange in different theories of value and distribution.

2.2 Making Sense and Nonsense

In the context of this chapter, the most important aspect of the discussion from the early nineteenth century was the rejection of some of Smith's language and of his characterisation of utility. The phrase `value in use' was criticised because it led to analytical confusion [Malthus 1963 (1827), pp.234-5]. The term `utility' was preferred and it was here that the rejection of Smith was crucial. Following the early critiques of Smith in Bentham's True Alarm [Bentham 1954 (1801)] and Dugald Stewart's lectures of 1810-11 [Stewart 1855, pp.355-60], utility was used as a portmanteau term to cover all wants and desires. The dominant pattern was clear in the first edition of Jane Marcet's Conversations on Political Economy where, after citing Smith's water and diamonds paragraph, Mrs. B. informed Jane that she had followed the opinions of "[l]ater writers in political economy" who "have gone rather further than differed in opinion from Adam Smith, by tracing all value to the same source, utility, a doctrine which leads to the conclusion that it is the application of

[9] The differences between the two texts in this regard might also be explained, in part, by their different objects of analysis [Brown 1994, pp.149,152-3].

the labour of man to commodities which gives them exchangeable value" [Marcet 1816, p.275]. While this passage was compatible with a number of different approaches to value and minimised the break with Smith, it should be noted that, in the second edition of the Conversations, Marcet reverted to a more Smithian approach, arguing that utility was "the sole source of value in use, while value in exchange" depended on "utility ... beauty, curiosity, fashion, rarity, and many other qualities" [Marcet 1817, p.294]. William Whewell was later to cite Marcet in his Lectures [Whewell 1862, pp.47-8]. From a different perspective on value, Richard Whately also used Smithian language in arguing that the "great value" of a diamond was explained by it being "scarce ... very beautiful" and constituting "a sign of wealth", although it was "of no use but to make an ornament for a person" [Whately 1853, pp.27-30].[10] This language was unusual, however, and the general approach was that of Marcet's first edition.

The use of the portmanteau definition meant that almost all economists rejected Smith's statement that a commodity could have zero utility and a positive price. The significance of his paragraph was, however, construed in two different ways. The first was in the debates, following the publication of David Ricardo's Principles, regarding the commensurability of utility and value in exchange. In that context, the paragraph became virtually irrelevant by the 1830s. The second reading was that Smith's paragraph was incoherent. Each reading will be briefly considered in turn.

Much of the debate concerning the commensurability of utility and value in exchange hinged on the definition of value and the relevance of the distinction between long-period and market-period prices. Ricardo opened his discussion of value in the Principles by citing Smith's paragraph and indicating his general agreement. Utility was an "absolutely essential" pre-condition for, but could not be a `measure' of, value in exchange which was determined either by the "scarcity" or by "the quantity of labour required to obtain" commodities. He restricted the commodity domain in the Principles to the latter group, on the ground that "[b]y far the greater part of those goods which are the objects of desire, are procured by labour" [Ricardo 1951a (1817), pp. 11-12]. The restriction of the domain to such produced commodities can explain why there was no detailed discussion of the exchange value of water in the Principles, for Ricardo followed Smith in assuming that, "under ordinary circumstances", water had no price [ibid. pp.11,287] and, elsewhere, posed the rhetorical question, "Why is water without value, but because

[10] See also Whately 1832, pp.8-9 on the distinction between use and wealth.

of its abundance?" [Ricardo 1951c (1822), p.221]. The price for water was scarcity-determined and thus explained by the `proportion' between supply and demand. McCulloch clarified the point by arguing that the incommensurability between utility and value in exchange was valid only in a long period. Whether water had a long-period price depended on its cost of production. In a market-period, water could have a high price which was principally explained by its utility and the wealth of purchasers [McCulloch 1830, p.312].

Although Ricardo was well aware of Bentham's argument (see below) that Smith's paragraph was incoherent, he read the principal significance of the paragraph as an argument that utility could not be the `measure' of value. It was for that reason, as he made clear when he first read Bentham's critique, that he `liked' Smith's distinction between value in use and in exchange [Ricardo 1951b (1810-11), p.284]. With his acceptance of the Benthamite definition of utility, however, Ricardo's reading entailed that Smith's statement about zero utility was simply ignored. In keeping with that erasure of Smith's categorisation [Peach 1993, pp.242-4], direct citation and examination of Smith became virtually irrelevant in much of the discussion that followed. In the first edition of his Political Economy, McCulloch simply noted that Smith "did not always keep the distinction" between utility and exchange value "in view, and it has been very generally lost sight of by M. Say, Mr. Malthus, and other late writers" [McCulloch 1824, p.2]. It might be expected that there would be explicit references to, if not critiques of, Smith's paragraph in the work of the economists who argued that value could only be defined in terms of a Ricardian market-period and hence explained in terms of supply and demand. In that context, the distinction between utility and exchange value was irrelevant. There was, however, no mention of Smith in the treatment of those matters by, for example, Nassau Senior and Thomas Banfield [Senior 1951 (1836), pp.6-7,22-5; Banfield 1848, p.19].[11]

If it is clear that these economists, with their markedly different analyses of value, were not conceptual prisoners of Smith's paragraph, there was, as noted above, a second strand of commentary that can be traced to Bentham's True Alarm. The basic argument, which caricatured Smith's paragraph with a good deal of abuse, was that, with the portmanteau definition of utility, the WN paragraph was nonsense as it entailed that people would purchase commodities if they had no desire for

[11] Whately, however, continued to worry at Smith's paragraph [1834, p.606] and H.D. Macleod criticised it as "utterly destructive of all philosophical symmetry" [1858, p.52].

them [Bentham 1954 (1801), pp.87-8]. With the exception of Jean-Baptiste Say [1821, p.62] there was, however, little initial enthusiasm for, or acknowledgement of, the harrowing of Smith. Indeed, as noted above, Ricardo created the impression that Smith's definition was compatible with own. In 1844, however, the Benthamite reading was resurrected in Thomas De Quincey's Logic of Political Economy. In replicating the arguments and the vitriol heaped on Smith in the True Alarm (Smith's argument was "inconceivable and monstrous"), the opium eater illustrated the difference between value in use and exchange in a novel way by quoting the Roman author Plautus on the haggling between a brothel proprietor and customer [De Quincey 1897, pp.144-5,187-8]. John Stuart Mill then indicated general agreement with De Quincey in his Principles, arguing that Smith had employed value in use in the "sense in which use is opposed to pleasure. Political economy has nothing to do with the comparative estimation of different uses in the judgement of a philosopher or a moralist. The use of a thing, in political economy, means its capacity to satisfy a desire or serve a purpose" [Mill 1965 (1909), p.437]. The Principles shows that it was possible to argue within a framework of long-period and market-period prices that Smith's paragraph was incoherent.

Any suggestion that, before 1871, Smith's discussion of water and diamonds was understood as a paradox, which could not be explained, is simply a myth.[12] Nor was it the case that Smith's categorisation of utility dominated British political economy. On the contrary, utility was redefined and there was almost no acceptance of his zero utility argument. What is striking instead is the diverse readings of Smith's analysis.[13] For those who followed Ricardo's reading, there was nothing problematic about Smith's paragraph as J.E. Cairnes made clear in 1874 [Cairnes 1874, pp.16-7]. Nevertheless, it could be argued that, because Mill had accepted De Quincey's argument, the dominant reading of the paragraph by 1860 was one of incoherence. Two examples suggest that was the case. When Whewell's Lectures was published in 1862, citing the second edition of Marcet's Conversations (see above), a reviewer criticised Whewell's reference to Adam Smith on water and diamonds for failing to give "any warning of the important error which it is now acknowledged to contain" [Anonymous 1863]. In 1870, Alfred Marshall opened his unpublished `Essay on

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[12] A myth, moreover, that erases the detailed (non-marginalist) explanation of diamond or pearl prices, based on `vanity' and `caprice', provided by John Rae and Nassau Senior (see Chapter 3 of this thesis).

[13] The discussion here of the Classical treatment of utility has been necessarily abbreviated. See also Schefold 1999, which includes a helpful discussion of Marx on value in use and exchange.

Value' with a discussion of Smith's paragraph, repeating Mill's argument that, by making value in use depend on utility, Smith "makes himself the judge of what is useful to other people and introduces unnecessary confusion". In an aside Jevons was also to make, Marshall commented that Smith's paragraph "appeared paradoxical; but is really vague". Value in use should defined as "the amount of pleasure [a consumer] would derive from obtaining [a commodity] or the pain he would undergo from losing it" [Whitaker 1975, p.125].

Marshall's essay shows how the restatement, elaboration or reworking of Bentham's critique did not "clearly point in the direction of the marginal utility theory" [Hutchison 1956, p.291]. While Marshall explained value in use in terms of the `pleasure' and `pain' facing a consumer and his manuscript contains some indications of the subsequent analysis of consumer rent/surplus, he did not use a marginal utility theory to explain a downward-sloping market demand curve [Whitaker 1975, pp.122,130-1,145]. The use of that theory in that way came only after he had read Jevons' Theory in 1871.[14] As will be shown below, Jevons' discussion of Smith owed nothing to the claim that the WN paragraph was incoherent. This suggests that, rather than being "a step towards the later resolution of the [diamonds and water] paradox in terms of `total' and `marginal' utility" [Bharadwaj 1978, p.256], the Bentham/De Quincey/Mill critique reached a terminus in Marshall's 1870 non-marginalist discussion of value.

2.3 Jevonian Paradoxes

It was consistent with Jevons' highly critical evaluation of Mill's value theory that, in TPE, he produced a different assessment of Smith on value in use and exchange. Like Senior, Jevons argued that value could only be specified with reference to an exchange ratio. Within that framework, Smith's paragraph had been rendered meaningless, if not incoherent. Jevons' initial twist was to argue that that need not be the case. Read as a discussion of market-period prices, the paragraph could be made coherent within the new marginalist theory, although it required some criticism, clarification and emendation. In particular, like almost all economists, Smith had "failed to discriminate" between the final degree of (i.e. marginal) utility and total utility:

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[14] For references and discussion of this point, see Groenewegen 1995, pp.158-62,776-8; White 1996.

> From this confusion has arisen much perplexity. Many of those commodities which are the most useful to us are esteemed and desired the least. We cannot live a day without water, and yet in ordinary circumstances we set no value on it. Why is this? Simply because we usually have so much of it that its final degree of utility is reduced nearly to zero [Jevons 1871, p.62].

Here and elsewhere [Jevons 1905, p.61], 'perplexity' did not mean that economists were puzzled by Smith's statement, but rather that their arguments were confusing and confused. That confusion was particularly evident with the term 'value': "Adam Smith noted the extreme difference of meaning between value in use and value in exchange; and it is usual for the best writers on Economy to caution their readers against the confusion to which they are liable" [Jevons 1871, p.81]. Nevertheless, confusion still prevailed, which could only be solved by the marginalist theory:

> there is a certain sense of esteem, or desirableness, which we may have with regard to a thing apart from any distinct consciousness of the ratio in which it may exchange for other things . . . [T]his distinct feeling of value is probably identical with the final degree of utility. While Adam Smith's often quoted value in use is the total utility of a commodity to us, the value in exchange is defined by the terminal utility, the remaining desire which we or others have for possessing more [ibid. p.157].

Far from announcing the solution to a long-standing puzzle, the argument in TPE provided yet another reading of Smith so that his paragraph became explicable within the terms of the marginalist theory. A different angle emerged in 1876, however, when, discussing the distinction between value in use and exchange during a lecture at Owens College, Jevons was reported as telling his students that Smith "remarked that the most difficult paradox of the whole subject was: things which have the greatest value in use have little or no value in exchange. I have no doubt that remark contains the fundamental difficulty in political economy, because . . . value in one sense can be founded upon use . . . or what is the same, utility" [Black 1972-81, VI, pp.79-80]. As with Marshall's 1870 essay (see above), the formulation of this paradox followed defining value in use as a subjective estimate in the context of exchange. The attribution of a paradox to Smith was, however, shortlived. In his Political Economy primer, Jevons simply referred to an "apparent paradox" ("we do not pay for things in proportion to their usefulness") [Jevons 1878a, p.96]. As in TPE, the problem was sourced to the confusion which followed

the ambiguous meaning of the words `value' and `valuable'. In this sense, the paradox was a logical problem that could be solved by using words in the `correct' fashion and Jevons referred the reader to the discussion of the `correct use of words' in his Logic primer [Jevons 1878a, p.96; 1878c, pp.22-6]. These seem to be the only references Jevons made to a paradox. It played no role, for example, in the second edition of TPE when he added a long section expanding his argument that Smith had failed to distinguish between total and marginal utility although he "evidently means by value in use, the total utility of a substance" [Jevons 1970, p.129].[15] The context of the first appearance of the paradox and its later use in the primer (sans Smith recognising a paradox) suggest that it was formulated as a pedagogic device to illustrate the marginal utility theory.

Unlike subsequent commentators who relied on TPE, Jevons had second thoughts about his rational reconstruction of Smith's paragraph. In the unfinished Principles of Economics, he acknowledged that Smith's terminology made no sense in marginalist theory: "There is a confusion of ideas here between use in the common everyday meaning and utility in the economic sense. No one would call a diamond ring a very useful thing, but it is generally considered very ornamental, and it, therefore, has utility" [Jevons 1905, p.62]. Smith's discussion (Section 2.I above), of how the demand for gold and silver "arises partly from their utility, and partly from their beauty" [Smith 1976, (1776) p.189], indicated that he had used utility in the `common, everyday meaning'. He had, however, now become a puzzle. As Jevons noted elsewhere: "he should have said `Nothing is more useful than water when water is much wanted.' He could not possibly have meant that nothing was more useful than water in a wet mine, or a flooded meadow, or a leaky ship."[16]

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[15] See Jevons 1970, pp.128-31. The only substantive difference with the first edition was the criticism that, in the water and diamonds paragraph, Smith had not made clear that value in exchange should be depicted as a ratio, which depended on both the relative scarcities of commodities and their respective final degrees of utility. Jevons' attempt to clarify this matter was possibly prompted by Cairnes' critique of the utility theory in TPE, where he referred approvingly to both Smith and Ricardo on utility and value [Cairnes 1874, pp.16-17].

[16] Jevons Archive, John Rylands University Library of Manchester, JA 6/6/7. The quotation is taken from annotations on a copy of WN that Jevons made for a planned `Students Edition'. First discussed with the publisher Macmillan in late 1877, the edition was to include only one third of Smith's original text, accompanied by `supplementary notes' of commentary by other economists and an historical introduction by Jevons. Work proceeded slowly, with Jevons telling H.S. Foxwell in November 1879 that he was "a little out of heart" about the project, "owing partly I expect to your objections". Although a letter from H. Rylett to Jevons in October 1880 suggests the text had been advertised as forthcoming, it was never published [Black 1972-81, IV, pp.218-9,248-9,298; V, pp.81,115]. Jevons' annotations on the

Perhaps more remarkable, at least in the light of the eventual paradox story, Jevons also made clear in the Principles that the marginalist theory could not provide a determinate theoretical explanation for the diamond prices to which Smith referred. Previous references to diamonds had assumed they were rare, heterogeneous commodities purchased only by the very wealthy. Because of its reliance on the calculus, however, the analysis in TPE assumed that commodities were infinitely divisible and homogeneous. Jevons acknowledged that the market-period prices of indivisible and heterogeneous commodities, such as the Koh-i-noor diamond, were indeterminate within the terms of the marginalist theory and hence outside its domain (see Chapter 8 of this thesis). Having attempted to downplay the significance of this problem in TPE because it threatened the applicability of the theory, Jevons returned to the topic in the Principles, noting that, in cases such as the Koh-i-noor, "no consideration of cost of production or utility can apply; the arbitrary fancy of some monarch or wealthy person is the only rule". He then argued that, in the case of "more ordinary stones ... competition is possible ... so that something like a market price emerges". The following explanation, pivoting on the "traditional rule" that prices would vary directly with the square of the weight for a particular grade of stone, was, however, inconclusive. There was no discussion in that context of the marginal utility theory. It is evident, however, that the problems of heterogeneity and indivisibility remained and that the only case where the theory might apply was for "very small or imperfect diamonds which are bought to be reduced to diamond powder" [Jevons 1905, pp.150-1].

Jevons' discussion of how `something like a market price emerges' for the `more ordinary stones' referred to a mid-eighteenth-century treatise on diamonds and an entry in an early nineteenth-century encyclopedia. His commentary suggests that he had been searching for an explanation of such diamond prices when TPE was written.[17] Theoretically, however, the discussion in the Principles made no advance on William Petty's seventeenth-century "Dialogue on Diamonds", which discussed how prices were governed in the international diamond trade by agreements between specialist traders. A base price was set in terms of quantity and weight,

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WN text, when coupled with his notes on Smith and the WN [JA 6/6/8-13], suggest that little work had been done on the project by the time of his death, although some material may have been incorporated in the Principles.

[17] The two texts were Jeffries 1750, pp.7, 55-6; Rees 1819. Jevons noted that he had "corrected" the prices in a subsequent edition of Jeffries "to the present time (1871)" [Jevons 1905, p.151n].

which was then modified by secondary properties such as colour and quality [Petty 1899 (?)]. As Bertram Schefold [1999, p.135] has noted, Petty's Dialogue illustrated that a "social definition of homogeneity" is required if an explanation is to be given of a uniform price for heterogeneous commodities.[18] On the eve of the exploitation of the southern African reserves that was to change the face of diamond production and marketing, Jevons had, in effect, drawn attention to the importance of explaining how information was produced, transmitted and acted on in particular market structures when explaining diamond prices. Consideration of such matters was, however, precluded in TPE with the assumptions of infinite divisibility and homogeneity, coupled with the claim that brokers established a uniform price at any `moment' in a market-period. At the same time, Jevons had `deconstructed' his marginalist explanation of Smith's paragraph. Smith's characterisation of utility was incompatible with the marginalist approach and the latter's explanation of the diamond prices had become an empty set. It would require a highly selective reading of Jevons' commentary to create the fable of the paradox in the next century.

2.4 Stabilising The Paradox

The quite different assessments of Smith's water and diamonds paragraph made by Jevons were not all published during his lifetime. The account in the Principles, for example, did not appear until 1905, while the transcript of the Owens College lectures which reported his short-lived attribution of a paradox to Smith was not published until 1977. Hence, the only material available before the turn of the century was the reading of Smith in TPE and the mention of a logical paradox in the primer. In this regard, it is noteworthy that, while repeating the TPE argument that Smith's paragraph should be read in terms of a distinction between total and marginal utility, the first commentaries that reflected Jevons' work made no mention of a paradox [Marshall and Marshall 1879, p.68; editorial note by J.S. Nicholson in Smith 1886, p.407]. That absence is evident also in Marshall's Principles [Marshall 1961, p.61; see also pp.129-30].

Marshall's approach was in keeping with his attempts to minimise theoretical differences by constructing an unbroken historical skein of economic discourse that culminated in the Principles. A different agenda, however, became evident from the late 1880s in responses to the work on value and distribution analysis by the

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[18] See also Roncaglia 1985, pp.72-84.

second-generation Austrian marginalists. While Jevons' reading of Smith in terms of marginal and total utility remained a mainstay, his logical paradox was now also set in play. Driven in part by critical assessments of Austrian claims for originality and by the spectre of Karl Marx, the value theories of Smith and, by extension, Ricardo were now depicted as 'obstacles' to the development of the correct theory. Their focus on labour (whether in terms of labour commanded or a theory of value) also had deleterious analytical and political results since it had resulted in the exploitation theories of radicals, especially Marx [Menger 1899]. For most of the nineteenth century, the significance of Smith's paragraph was constructed in terms of the question: what relevance does a distinction between value in use and exchange have for a theory of value and distribution? From the 1890s, the question became: why did the Classical economists fail to produce a marginalist analysis? It was in this context that the basis for the paradox fable was to emerge by the 1920s and 1930s.[19]

In his 1888 examination of the Austrian approach, James Bonar wrote: "How, then, do we explain the paradox that indispensable things such as air and water have usually no value?" Although this might have been prompted by his reading of Friedrich von Wieser's 'paradox of value', Bonar apparently understood it to mean a logical paradox as he referred to Jevons' primer [Bonar 1888, pp.5,26].[20] Three years later, William Smart's 'Austrian' text criticised the WN for a "false or . . . unduly limited, conception of utility". Smith and the "older economists" had not clearly distinguished between utility and "so-called use value" (the latter was a "hermaphrodite" term) and had ignored the role of supply [Smart 1891, pp.18,24]. Subsequently, Wicksell argued that the failure to explain the "paradox" in Smith's paragraph meant that "science stood still . . . for almost a hundred years", since there was "practically no criticism, no examination of its obvious contradictions" [Wicksell 1934, p. 18]. If Smart erased the marked differences between Smith and his successors, and if there was some myth-making in Wicksell's claim about the lack of criticism, which was inconsistent with his citation of Mill's critique [ibid. p.29], these were also relatively careful accounts. Smart made clear that Smith's use of

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[19] See also the discussion by Sasan Fayazmanesh [1998, pp.140-47] who characterises the production of the fable as part of a "propaganda war waged against classical and Marxian political economy" (p.146).

[20] Smart's discussion of Wieser's paradox of value [Wieser (1893) 1971, ch.x] rightly presented it as a construction within the terms of Austrian marginalism which had no relationship with the WON [Smart 1891, pp.85-8]. See also Fayazmanesh 1998, pp.142-3.

utility took effect in a theoretical framework that was quite different from marginalism. Hence, he criticised Smith by arguing that commodities could not be ordered in a Classical hierarchy, the error of which was shown by Smith's suggestion that diamonds were of `trifling' importance: "the poorest savage, the worst paid mill-girl, the most refined woman, will put ornament second only to bare necessaries" [Smart 1891, pp.21,22].[21] Moreover, while Wicksell described Smith's paragraph as constituting a paradox, he made clear that this was a (Jevonian) logical problem that was not actually recognised by the Classical economists [Wicksell 1934, p.18].

Later commentary incorporated the argument that Smith's `incorrect' analysis was a conceptual barrier but began to slide toward the claim that the Classical economists were unable to "resolve the notorious `contradiction' between `exchange value' and `use value'" [Dmitriev (1904) 1974, p.184]. In a move replicated by later historians, V. K. Dmitriev argued that the analysis of Smith and Ricardo was an unnecessary detour as the resolution of the `contradiction' had been provided by Ferdinando Galiani's Della Moneta [Galiani (1751) 1977]. The detour had occurred because Galiani's solution went `unnoticed' [Dmitriev (1904) 1974, pp.187-9].[22] Smith's failure to follow the arguments or `hints' of his predecessors also figured in the paradox story that was firmly entrenched in the economics department at the University of Chicago by the mid-1920s. When Jacob Viner defended marginal utility theory against the "slashing criticisms" made in contemporary "scientific periodicals", he claimed that "the utility analysis ... has, for the first time, afforded a satisfactory explanation of the disparity between value in use and value in exchange which so puzzled the classical economists" [Viner 1925a, pp.371,387]. If Viner was restrained in referring to the "paradox of value" [Viner 1925b, p.643], Paul Douglas felt so no such compunction in his contribution to the sesquicentennial commemoration of the WN held at Chicago in the following year. Smith's "failure" to correctly analyse utility was attributed to his personality which, Douglas asserted, reflected a national stereotype. The inability to follow the `hints' of his predecessors (Locke, Law and Harris) was due to Smith's "moralistic sense ... In his thrifty

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[21] Indeed, to treat diamonds as `trifling' would "justify the reproach the economist has sometimes to bear, that `it is well seen that political economy was written by men!'" [Smart 1891, p.22].

[22] It is symptomatic of changing readings in this regard that, while Dmitriev presented Galiani as a fully fledged marginal utility theorist, McCulloch had objected to Say's claim that Galiani was the first author to state that labour was the only source of wealth [McCulloch 1830, p.72n].

Scottish manner with its opposition to ostentation as almost sinful he concluded that diamonds `have scarce any value in use'". The stingy Scot had thus managed to "divert" English (!) political economists "into a cul-de-sac from which they did not emerge ... for nearly a century" [Douglas 1928, p.80]. Smith on value and distribution was embarrassing: "it might seem to be the path of wisdom to pass these topics by in discreet silence". Indeed, the only real significance of his value theory was that, in dismissing utility (with the exception of market-period prices) and turning to labour as both a source and measure of value, it "inevitably gave rise to the doctrines of the post-Ricardian socialists and to the labour theory of value and exploitation of Karl Marx" [ibid. p.77]. Following this extraordinary performance, references to a "paradox" began to appear in histories of economics [Gray 1934, p.28][23] so that, by 1938, the paradox as an acknowledged problem to be solved was given a clear part to play in Eric Roll's History, where it was depicted as providing "the starting-point for the theorising . . . which finally led to the marginal utility doctrine" [Roll 1938, p.158]. A more detailed account followed in Edward Heimann's History, in which Galiani was given the key role in having "attacked and resolved" the paradox, although his analysis had been "overlooked by Smith" [Heimann 1945, pp.67-8,107-9].

If the principal elements of the paradox were now in place, it did not have a canonical status. It received no mention, for example, in Lorie Tarshis' textbook, Elements of Economics [Tarshis 1947], and played no role in the fourth edition of Lewis Haney's History [Haney 1949, pp.217-9]. It was, instead, the first edition of the textbook competitor to Tarshis, Samuelson's Economics, which tied the threads of the story and presented the paradox as "a famous question that troubled Adam Smith", a question that he "never did quite resolve" [Samuelson 1948, pp.482,483]. It is a reasonable conjecture that Samuelson's familiarity with the story can be traced to his time as a student at Chicago where he was first taught "Marshallian economics" by Douglas and then, in 1935, attended the "famous 301 graduate course in economic theory" taught by Viner, who "put considerable store on the historical development of the subject" [Samuelson 1972, pp.5,7]. In producing his own gloss on a story that had been circulating for some time, Samuelson stabilised

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[23] Gray [1934, pp.28,301-2] also provided two examples of what passed for learned wit: Marx's Capital "reveals very little knowledge of the real world ... He was too much in the British Museum, and too little on the Epsom Downs on Derby Day"; "as for Adam Smith, in the immortal words of Mr. Hubert Phillips

The wily bird
Had never heard
of marginal utility".

the meaning and significance of the paradox fable for future textbooks and the folklore of the profession. That the Economics was instrumental in creating the canonical version of the fable is suggested by another of Samuelson's excursions into the history of the subject – the linking of the Giffen good with the Irish famine. Although his Economics had identified Irish potatoes with an upward-sloping demand curve from the first edition, it was only in the fifth that the famine and "Sir Francis Giffen" were ushered onstage [Samuelson 1961, pp.444n,448n]. That story was subsequently replicated in other textbooks [McDonough and Eisenhauer 1995, p.753].

Conclusions

For nineteenth-century British political economy, the water and diamonds paragraph in the WN was a contested illustrative device that provided a focal point for arguments about the nature of price formation and the meaning and role of utility. The paragraph was thus read and its significance construed in different ways: as a valid statement about the difference between utility and value in exchange which required that some care be taken with the use of the word `value'; as an incoherent, moralistic melange; and, as a logical paradox that, with some clarification, could be explained by the correct theory. Any published suggestion of a paradox did not, however, exist before Jevons' primer.

Jevons' reading of Smith was then reworked to construct histories where the paradox had been a pivotal obstacle to the `advance' of economic theory. The important qualifications in the early accounts were afterwards erased so that Smith became puzzled by his own discussion along with his successors. TPE then appeared as the analytical circuit breaker. Since this story was stabilised by Samuelson's textbook, it is a notable irony that, in resurrecting a pedagogic device that Jevons had used but then interred, the fable has no place for the Jevons who acknowledged that the marginalist account could not be reconciled with its supposed point of origin in the WN and that he could not provide a determinate theoretical explanation for the diamond prices to which Smith referred .

That texts are both read and rewritten to construct historical figures who illustrate the virtues of a particular theoretical apparatus is not unusual. To take one example, which has resurfaced in recent macroeconomics textbooks [Barro 1997, ch.2; Mankiw 2000, pp.507-9], the construction of the marginalist economic Robinson Crusoe depended on the rewriting and a particular reading of Defoe's novel during

the nineteenth century [White 1982]. If such processes are not unusual, the wide circulation of the water and diamonds story is nevertheless striking because its basic premises can be so readily falsified. In particular, there has never been any evidence adduced to show one economist declaring the existence of an unsolved paradox or puzzle.

The significance of the paradox story is not simply that it is a self-congratulatory myth constructed within the profession. Like Samuelson's Giffen fable, it demonstrates how an analytically incoherent exemplar can circulate via the uncritical reproduction of textbook material. Putting to one side the pseudo-history on which the pertinence of the fable depends, it goes unnoticed that the marginalist theory cannot explain Smith's paragraph. It makes no sense within that theory to argue, as Smith did, that a commodity could have zero utility and a positive price. Much the same point could be made about Smith's reference to a `high' price and `low' utility. Nor can the presentation of the fable in the form of a purely competitive supply and demand `model' satisfactorily explain the prices of diamonds to which Smith referred. The model assumes commodities in the market are homogenous and infinitely divisible. At most this might be relevant for industrial (or synthetic) diamonds. It has no relevance for heterogeneous diamonds as in the WN. The student would also remain unaware that, for most of the twentieth century, diamond prices were set by a cartel [The Economist 1997; 2000]. The water and diamonds paradox fable exemplifies both the replication of mythical history and, within its own terms, remarkably poor analytics.

Chapter 3

DIAMONDS ARE FOREVER? NASSAU SENIOR AND UTILITY THEORY[1]

> In the development of the mental sciences exegesis has frequently played an important part. A change of doctrine has been justified, or supported, or commended for general acceptance, by the interpretation of an authoritative text.
>
> William .J. Ashley.

Nassau Senior's Outline Of The Science Of Political Economy (1836) has often been represented as containing a statement of the `law of diminishing marginal utility'. At the same time, Senior's analysis has been considered inadequate because he `failed' to link his discussion of the law with a marginalist analysis of demand and price formation. The principal purpose of this paper is to show that these assessments of the Outline are fundamentally misleading, since they depend on grid-reading Senior's text. That is, marginal utility theory is used as a reading grid to scan the Outline for statements which appear to be consistent with it. Statements or arguments inconsistent with the grid are either ignored or not carefully considered, although they explain why the Outline did not present arguments that are essential for the grid. The result of this treatment of Senior as a precursor of marginalism is an arbitrary reading of the text and a teleological history of economics which cannot register the possibility of different explanations of consumption demand in the nineteenth century.[2]

In a discussion of whether Keynes's General Theory produced a `revolution' in both economic theory and policy-making, Bernard Corry considered the problem of what constitutes "a revolutionary idea". He noted, in part, that the phrase usually entails some notion of `originality', particularly "the first statement of an idea, or an hypothesis or an explanation of something". However, Corry argued, originality does not consist of the first statement, but rather "the realisation that the idea changes our `vision' of how things operate or provides an explanation of an

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[2] For discussion of grid-reading, see Williams 1974, pp. 43-4, and, for the use of the term in writing histories of economics, see Peach 1986, p.104. For the notion of a precursor, see Barthelemy-Madaule 1982, pp. x-xv.

unhitherto unexplained event ... [I]t is the realisation of the impact of an idea, not the first statement per se, that makes it original." The `origin' of the `idea' of diminishing marginal utility, for example, does not lie in "the first statements of it (of which there were many!) but when it was first used to explain the empirical fact of a negative price-quantity relationship for most commodities" [Corry 1986, p.213].

This argument, which is similar to that of Stigler [1965, p.78], depends, in part, on the implicit assumption that a statement about the declining importance which consumers attach to successive units of a commodity has theoretical significance or coherence only within a marginalist economic framework. As Stigler explained, a statement such as Senior's "is a commonplace" in the historical literature. It is of "interest only when it is logically developed or explicitly applied to economic problems" [ibid.], where the `logical development' presupposes a marginalist framework. What is not considered, however, is whether the `uninteresting' statements took effect within an analytical framework that was quite different from marginalism. It will be argued here that what may appear to be a statement of the law of diminishing marginal utility can have a quite different analytical representation and significance, depending upon the discursive framework in which it is presented and from which it obtains its meaning.

There is no doubt that Senior argued in the Outline that "value" was to be explained by reference to `supply and demand'. In defining value as an exchange ratio, for instance, he wrote that it depended upon commodities' transferability (or exchangeability), utility, and limitation in supply. The state of supply was the most important of the three factors [Senior 1951 (1836), pp.11,13-16,95-7]. It will be shown below, however, that when discussing utility, Senior outlined a theory of consumption demand which was clearly `non-marginalist'. The parts of his analysis which have been read as a statement of the law of diminishing marginal utility took effect within a framework which gave the statement a different significance to that which it is ascribed in the grid-readings. After discussing Senior's analysis in section 3.1, section 3.2 shows why the grid-readings of the Outline are unsatisfactory and that Senior's analysis illustrates how consumption patterns could be explained without a marginalist theory. Section 3.3 then considers how Senior explained savings within that alternative framework.

3.1 Senior and Utility Theory

Senior's explanation of utility depended upon a depiction of human wants or desires for commodities, which he referred to when discussing the "general Propositions" of Political Economy. The first of these was that "every man desires to obtain additional wealth with as little sacrifice as possible" [Senior 1951 (1836), p.26].[3] This meant that "no person feels his whole wants to be adequately supplied; that every person has some unsatisfied desires which he believes that additional wealth would gratify" [ibid. p.27]. To satisfy those desires, a person used money ("abstract wealth" [ibid.]) to purchase commodities, which could be grouped into three general categories. Senior explained this when discussing his second `general proposition' - that population growth "is limited only by ... fear of a deficiency of those articles of wealth which the habits of the individual of each class ... lead them to require" [ibid. p.26]. Those habits could be explained by three categories of consumption:

> Necessaries - the commodities "requisite to keep a given individual in the health and strength essential to his going through his habitual occupations."
>
> Decencies - the commodities a person "must use in order to preserve his existing rank in society".
>
> Luxuries - all commodities which were not necessary for maintaining `health and strength' or preserving existing `rank' [ibid. p.36].

The designation of commodities in a hierarchy of essential and non-essential types clearly depicted consumption as a socially interdependent activity. Senior was dealing with `socialised' rather than `abstract' or `independent' individuals, because the identification of a commodity's position in the hierarchy depended upon "the place, the time, and the [socio-economic] rank of the individual".[4] Moreover, as noted above, the behaviour of these socialised individuals could be grouped and explained by examining the behaviour of "different classes" [ibid. p.37].

The focus on interdependent behaviour was clarified when Senior explained that the composition of the `necessaries' group changed only over a long period of time. In

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[3] It should be noted that, so far as the relevant quotations for this paper are concerned, Senior's text was unchanged from the first edition (Senior 1836).

[4] For discussion of the analytical differences between `abstract' and `social' individuals see Steedman 1989, ch. 11; Hodgson 1988, chapters 3 and 6.

that sense, necessaries were "more permanent and general". Moreover, the mass of the (English) population was not threatened by a reduction in the availability of necessaries,[5] so that the analysis of consumption patterns focussed on decencies and luxuries, the production of which were "continually varying". Hence, consumption behaviour was concerned predominantly with the pursuit of commodities whose principal role was to exhibit "social rank" [ibid. pp.37-8]. This argument played an important role in the discussion of utility.

For Senior, utility was defined as the capacity of a commodity to prevent pain or to produce pleasure, where pleasure included the "gratification of every kind" of desire which could be connected with wealth [ibid. p.6]. While the pursuit of wealth could be understood by referring to the first 'general principle' of political economy (see above), it required a more specific explanation in terms of "two of the most powerful principles of human nature" - the "desire for variety" and the "desire for distinction" [ibid. p.11]. The desire for variety was used to explain why there was a finite demand for any particular type of commodity. Senior illustrated this with the examples of: food; dress; buildings, ornaments and furnishings. Wants for the first two groups were limited, although a requirement of variety in dress was perhaps confined to "one sex at least". It was only with the third group that tastes were "insatiable ... and seem to increase with every improvement in civilization" [ibid].

The connection of this argument with the necessaries, decencies and luxuries hierarchy (see above) was that, while habitual standards of consumption for necessaries could change slowly over time, there were limits to the expansion of the wants for necessary food and dress, provided that people had the income to purchase the maximum amount. In a simplistic case, if all consumers had the same consumption patterns and had sufficient income to have reached the limit of demand for food and clothing, the analysis would focus on the demand for decencies and luxuries in the form of buildings, ornaments and furnishings. As suggested above, however, different consumption patterns for different social groups or classes played an important role in Senior's analysis.

Senior's discussion of the desire for variety was identified subsequently as a statement of the law of diminishing marginal utility (see below). In an oft-quoted passage, he explained the principle in these terms :

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[5] Of course there might be temporary exceptions to this - see Senior 1951 (1836), p.40.

> It is obvious ... that our desires do not aim so much at quantity as at diversity. Not only are there limits to the pleasure which commodities of any given class can afford, but the pleasure diminishes in a rapidly diminishing ratio long before those limits are reached. Two articles of the same kind will seldom afford twice the pleasure of one, and still less will give five times the pleasure of two. In proportion, therefore, as any article is abundant, the number of those who are provided with it, and do not wish, or wish but little, to increase their provision, is likely to be great; and, so far as they are concerned, the additional supply loses all, or nearly all, its utility. And in proportion to its scarcity the number of those who are in want of it, and the degree in which they want it, are likely to be increased; and its utility, or, in other words, the pleasure which the possession of a given quantity of it will afford, increases proportionally [Senior 1951 (1836), pp. 11-12].

For Senior, however, the desire for variety was "weak" in its effects as compared with the desire for distinction, which was "the most powerful of human passions". Consumption habits were thus driven primarily by the desire of actors "to seem more rich" or "to keep up a better appearance, than those within their own sphere of comparision". Given that they were placed "beyond the fear of actual want" (an assumption explained in the discussion of population growth - see above), it was the desire for distinction which explained why, in obtaining particular commodities, "almost all men" would "undergo toil which no pain or pleasure addressed to the senses would lead them to encounter" [ibid. p.12].

For a commodity to become an object of `distinctive' desire, it not only had to be limited in supply but have "some quality to which some person beside the owner annexes the notion of utility" [Senior 1951 (1836), p.12). And because this component of demand was dependent on `appearances', the desire for such commodities was often based on "trifling" and "capricious" factors. The most striking case of a commodity being an "unequivocal [proof] of wealth" was diamonds:

> as to appear rich is the ruling passion of the bulk of mankind, diamonds will probably continue the objects of eager competition while the obstacles that limit their supply are undiminished. If a Sinbad should discover a valley of diamonds, or we should succeed in manufacturing them from

> charcoal, they will probably be used only as ornaments for savages, playthings for children, and as affording tools and raw materials for some of the Arts; and we may send cargoes of diamonds to the coast of Guinea to be bartered for equal quantities of ivory or gum [ibid. p. 13].

Senior's discussion of utility thus had two components. The first, the desire for variety, was used to explain why there was a finite demand for any type or `class' of commodity, provided consumers had the income to purchase them. The second, the desire for distinction, was the more important since it was the "ruling principle of conduct" for "the bulk of mankind" [ibid. p.12]. It was this component which explained, given the desire for variety, how wants could be continuously multiplied in a hierarchy of desires. The explanation of consumption behaviour thus required a specific type of society to identify the habits of demand which could be classified in terms of necessaries, decencies and luxuries. Moreover, it required interdependent behaviour within and between classes (or ranks) of the society so as to explain why the focus of the consumption analysis was concerned with the pursuit of commodities which could not be explained by a `rational' comparision between pleasure and pain.

A number of Senior's arguments would have been familiar to his contemporaries. The discussion of the `insatiable' demand for buildings, ornaments and furnishings, for example, followed the Wealth of Nations [Smith 1976 (1776), pp.180-2]. The description of the desire for distinction was also similar to Adam Smith's explanation of consumption behaviour in terms of the imitation of other people's habits [cf. ibid. p.45n]. Even Senior's diamond example, used in discussing the desire for distinction, was not new. Two years before the Outline was published, John Rae had presented a similar argument, albeit with a more detailed analysis which described a dynamic interaction of `snob' and `bandwagon' effects. William Whewell subsequently outlined an argument which was similar to Rae's [Reisman 1976, pp.102-116; Mason 1981, ch.1; White 1987b].

Senior's analysis, however, contradicted the subsequent discussion of marginal utility theory as presented in W.S. Jevons's Theory of Political Economy (TPE). For example, the desire for variety, which Jevons equated with the law of diminishing marginal utility (see below), was of subordinate importance in the Outline and did not constitute the basic `law' of consumption demand as it did for Jevons. Moreover, Senior's focus on interdependent behaviour and his clear statement that

consumption could not be explained by a rational comparision of pleasure and pain, was in clear contradiction with the marginalist account.[6] What must now be considered is how the the marginalist grid-readings of the Outline dealt with these `anomalies'.

3.2 The Grid-Readings

Grid-readings can perform two roles. The first is to enhance the credibility of a new theory, to endow it with "impeccable historico-evolutionary credentials and authority that, in turn, may assuage, and commend the theory to, a potentially skeptical or even hostile audience" [Fausten 1979, p.656]. This role can be seen in TPE, the first text to identify the law of diminishing marginal utility with the Outline. When he introduced the marginalist distinction between total utility and the final degree of utility, Jevons argued that political economists, "generally speaking, have failed" to distinguish between them. Nevertheless, the law of "the ultimate decrease of the final degree of utility" was implicit in the work of "many economists, though seldom distinctly stated". For example, it formed "the basis of Senior's so-called `Law of Variety'" and Senior had stated "the law itself" [Jevons 1871, pp. 62-3]. In effectively representing Senior as a precursor of marginal utility theory, Jevons produced a highly selective and therefore arbitrary reading of the Outline. For while he cited extracts from Senior's discussion of the desire for variety, Jevons simply omitted any mention of the desire for distinction. The second, and subsequent, role of the grid-reading is in constructing histories of economics. The same reading technique has been used by a number of historians in that they have extracted quotations from the Outline with little regard for their context. Nevertheless, three quite different conclusions have been reached as to the significance of the Senior's analysis. Ironically, all three can be found, to some extent, in Jevons's work.

The first conclusion can be seen in Marian Bowley's 1937 argument that Senior's value theory was "a signpost on the route from Ricardo's theory to Jevons'". Hence, TPE made "no distinct break" with previous work, but rather "refined and completed theories that had been in the air for several decades" [Bowley 1937, pp. 66-7; see also pp. 115-6]. Other historians have followed Bowley in claiming that Senior

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[6] For Jevons' use of the independence assumption in his Theory, see White 1989, pp.430, 436, 439-40. It might be noted also that, unlike Senior, Jevons focussed on the demand for "the ordinary necessaries and conveniences of life" in the Theory [Jevons 1871, p.44], which helps explain the shape of most of his utility diagrams [White 1989, p.442].

discussed or `glimpsed' the principle of diminishing marginal utility, so that he is depicted as standing in a line which led to the marginalist insurrection of the 1870s [Roll 1966, p.342; Backhouse 1985, p.38; Campus 1987, p.6; de Marchi 1987, p.304]. These `continuist' histories rely on the type of reading which Jevons produced in 1871, since they arbitrarily exclude any reference to the desire for distinction.

If the simplistic presentation of Senior as a precursor is vulnerable to the criticism that it depends on omitting any statements which are incompatible with the marginalist grid, Senior's text becomes something of a puzzle once the discordant statements are acknowledged to exist. For example, a more recent assessment by Bowley concluded that, in part because of the role played by the desire for distinction, there is an "impression that Senior's statement of a law of diminishing utility was accidental" [Bowley 1973, pp.153-4]. Jevons seems also to have reached a similar conclusion. Although, in 1871, he declared that Senior had `stated' the law of diminishing final utility, by 1879, when the second edition of TPE was published, Jevons argued that Senior had only "incidentally" identified the law [Jevons 1970, p.112]. This second conclusion is a partial improvement on the first in that it acknowledges the existence of the desire for distinction. Nevertheless, it remains an arbitrary reading. This is because, since it has no place for the desire for distinction, the grid cannot explain the relevance of that category in Senior's argument. The appearance of the desire for variety in the text is then reduced to the status of an `accident', although no clear explanation is provided as to why this conclusion should be accepted.

In the unfinished Principles Of Economics, Jevons presented a slightly different account when he acknowledged that, so far as the law of diminishing marginal utility was concerned, Senior "may not have followed his own ideas to their ultimate result" [Jevons 1905, p.1]. Subsequent commentators have gone further in arguing that, because Senior's "statement of the principle" was "unconnected ... to a theory of demand" [Blaug 1986, p.220], he was `confused' analytically in that he "did not understand" the role of marginal utility theory in explaining demand and price formation [Ekelund, Forubotn and Gramm 1972, p.8n]. It was apparently on this basis that Stigler concluded that, although the Outline contained one of the "commonplace" statements of the law of diminishing marginal utility, it was of little historical relevance [Stigler 1965, p.78]. Relying on the simplistic grid-reading, this third conclusion depends on hauling the Outline before the full court of marginal

utility theory. Not surprisingly, since the text cannot present a satisfactory account of demand and price formation, it is found guilty of confusion and irrelevance. Once again, this is an arbitrary account since it is assumed, without argument, that the desire for variety could only have analytical significance within a marginalist framework.

Regardless of the specific conclusion reached as to the historical relevance of the Outline, the point which undermines all these accounts is that there is no explanation for the role of the desire for distinction in, and hence the structure of, Senior's analysis. It is possible, however, to explain the relevant statements in the Outline by considering them within the context of a lexicographic-type theory. This approach, which can be found in the work of other nineteenth century economists,[7] was quite different from the subsequent marginalist theory.

A lexicographic analysis is based on the argument that the demand for consumption commodities depends on a hierarchy of needs or `desires'. Commodities can be grouped in bundles and decisions are made between alternative consumption possibilities by ranking them in a step sequence. If two or more bundles are given equal weight on the most important criterion, they are assessed on the basis of the next criterion and so on. Consumers will not begin purchasing items from a lower priority bundle until they have obtained the requisite quantity of commodities from a higher priority bundle. This entails that there is a finite demand for the quantity of items in a particular bundle so that the theory can acknowledge that successive units within a bundle are given a lower ranking by consumers [cf. Canterbery 1979, p.83]. Nevertheless, with no trade-offs between bundles, the analysis does not, unlike the marginalist account, depend on substitutability between commodities, since it does not require the assumptions of continuity and indifference [Alter 1986, p.86].

The definition of `requisite' consumption will differ according to the aggregate wealth of the society, the distribution of wealth and income, and cultural standards. Moreover, as the material standard of living rises, commodities which were previously regarded as comforts or luxuries become necessities once their maximum consumption point is reached. This entails that consumption patterns change over time and that, as consumers reach the limits of the `lower reaches' of

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[7] See Georgescu-Roegen 1966, pp.190-204 and 1968, pp,262-4; Gowdy 1985; White 1987a and 1987b.

the hierarchy, they must be stimulated by some means if they are to purchase commodities in the `upper reaches'. A lexicographic-type analysis seems consistent with the both the arguments and the language in the Outline. For within that framework, it is possible to account for Senior's discussion of the hierarchy of wants and desires and the role of the desire for variety in explaining the limits to the demand for any particular type of commodity. At the same time, the desire for distinction explained why and how consumers were stimulated to obtain commodities and hence to move up the commodity hierarchy. Moreover, since the desire for variety was of subordinate importance in explaining consumption patterns, it should be clear why Senior did not attempt to use that category to explain a negative functional relationship between prices and quantities transacted. It has been suggested that Senior "formulated the principle of diminishing utility correctly though he did so somewhat misleadingly under the heading of `Limitation in Supply'" [O'Brien 1975, p.99]. However, with a lexicographic ordering of wants and the desire for distinction explained as the result of supply limitation and interdependence (see above), Senior's analysis appears misleading only when read with the marginalist grid.

A statement that economic actors attach less importance to successive units of a commodity has an analytical role within both the marginalist and lexicographic-type theories. The significance of the statement in a particular text thus depends on the framework in which it takes effect. Its meaning can be distorted if other components of the argument, which help to establish the place and significance of the statement, are ignored or not examined closely. It is the failure to consider this possibility which explains why the grid-readings of the Outline must either exclude any mention of the desire for distinction or conclude that Senior's discussion of the desire for variety was `accidental'. Since both of Senior's categories can be accounted for within a lexicographic-type theory, it is misleading to label the desire for variety as a discussion of the law (or principle) of diminishing marginal utility. For that terminology suggests that its analytical significance should be specified from within a subsequent and different theoretical framework.

3.3 Senior on Saving

The lexicographic-type theory described above assumed, for simplicity, that any savings are simply a residual of income. Senior, however, provided an explanation for saving that was also also grid-read by Jevons. In the second edition of TPE,

Jevons argued that interest could be depicted as the return for the deferment of utility, which was necessitated by saving to provide `capital'. Assuming that consumption was the sole end of economic activity, interest was the reward for "the endurance of want, the abstaining from the enjoyment of utility which might be enjoyed" [Jevons 1970, p.233]. According to Jevons, Senior had produced a similar argument, since he had defined "Abstinence" as "that temporary sacrifice of enjoyment which is essential to the existence of capital" [ibid. pp.232-3].

There is no doubt that Senior argued that profits were, in part, to be explained by personal sacrifice or pain, so that abstinence "stands in the same relation to Profits as Labour does to Wages" [Senior 1951 (1836), p.59; see also p.185]. In citing that passage, however, Jevons's account [Jevons 1970, p.233] was misleading, since he failed to mention that, for Senior, the motive for accumulation was not deferred consumption, but rather the desire for "power and pre-eminence". Driven by that desire, saving behavior could become "habitual" [Senior 1951 (1836), pp.187,192]. This argument was consistent with Senior's emphasis on the importance of interdependence in explaining consumption behaviour. Indeed, Senior linked both "distinction" (in relation to consumption) and "power" (in relation to wealth accumulation) when first explaining the `general desire' for wealth [ibid. p.27]. Jevons's attempt to assimilate the Outline's explanation for saving behaviour with the marginalist framework thus depended on omitting a key behavioural motive which Senior had clearly identified. Consistent with his treatment of Senior's discussion of consumption, Jevons had produced another arbitrary reading of the Outline.[8]

Conclusions

Recent critics of the explanation of aggregate consumption and saving patterns provided by the permanent income and life cycle theories have suggested that it is worth reconsidering Duesenberry's `relative income hypothesis', which is not even mentioned in some of today's macroeconomic textbooks [Kosicki 1987b]. A number of the critics[9] have argued that one of the reasons for the demise of Duesenberry's

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[8] Jevons's account of interest in terms of abstinence is arbitrary also because he simply assumed that saving could be explained by deferred consumption. However, as Steedman [1989, pp. 225-9, 232-3) has shown, other explanations were readily available and can be found in the work of prominent economists, including Senior, writing before 1871.

[9] Frank 1985, pp.35-8, 146-60; Green 1984; Kosicki 1987a.

analysis was his vigorous attack on the use of the independence assumption in orthodox consumption theory and his explanation of changing consumption patterns in terms of demonstration effects and "habit formation". These take effect in a society where, with differentiated social status, "maintenance of self-esteem" underlies a drive toward higher quality commodities, where the point of comparison is the social group with which a person "associates" [Duesenberry 1959 (1949), pp.25-32]. Consumption patterns were thus explained in part by hysteresis, rather than by reversibility as in the marginalist theory [Georgescu - Roegen 1966, pp.171-83]

That Duesenberry's emphasis on the interdependence of "preference systems" has a number of similarities with Senior's discussion should not be surprising since, as Duesenberry noted, interdependence "has been recognized since the earliest days of economics" [Duesenberry 1959 (1949), p.14).[10] However, one of his examples of the early use of the interdependence argument is not without some irony : "One can find discussion of emulation and the desire for distinction in the non-analytic parts of Jevons and Marshall ... But [their] remarks on this subject are mere obiter dicta and do not affect the formal analysis" [bid. p.14].

So far as Jevons is concerned, there is a discussion of emulation in the Principles of Economics [Jevons 1905, pp.44-7] although, as Duesenberry suggested, the analysis was not concerned with price theory. It is even possible to find a fleeting reference to a `snob effect' in TPE.[11] But the irony of Duesenberry's reference to Jevons is, of course, that it was TPE which inaugurated both the type of consumption analysis Duesenberry criticised and the attempt to assimilate Senior to a marginal utility `tradition' by excising the importance of interdependence in the Outline. What is not ironic, however, is that, by continuing to use Jevons's grid-reading of Senior, historians of economics have effectively erased the different explanations of consumption demand which can be found in nineteenth century

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[10] A parallel could be drawn also with the work of Fred Hirsch (1978), where Senior's desire for distinction is similar to Hirsch's concept of a positional good. In Hirsch's analysis, however, there is a key role for disappointment in the consumption of such commodities.

[11] Jevons acknowledged the possibility that, "if mutton became comparatively scarce, there would probably be some persons willing to pay a higher price merely because it would then be considered a delicacy" [Jevons 1871, p.128]. Although this smacks of the subsequent formalisation of a snob effect by Leibenstein,

political economy. This has facilitated an uncritical approach as to what, precisely, analysts such as Senior meant when they argued that all prices should be explained by reference to `supply and demand'. Such teleological histories thus distract attention away from careful examination of the differentia specifica of the 1870s marginalist insurrection.

Jevons argued that it would occur only in "extreme circumstances" and was thus of little practical relevance.

Chapter 4

THE MOMENT OF RICHARD JENNINGS: THE PRODUCTION OF THE MARGINALIST ECONOMIC AGENT[1]

> The effect of applying Physiology and Psychology to Political-economy will evidently remove this branch of learning from the condition of a political to the condition of a physical and a metaphysical science.
>
> Richard Jennings, 1856

Some years ago, George Katona argued that, while mainstream economic analysis generally "continues to disregard psychological studies, it is not devoid of psychological assumptions. Most commonly it proceeds on the premise that human beings behave mechanically", so that they are effectively depicted as "automatons". Hence, orthodox economics should be "described as `economics with mechanistic psychology', rather than as `economics without psychology'" [Katona 1975, pp.5,6]. This chapter provides an historical perspective on that mechanistic approach by explaining how it first appeared in postclassical (or marginalist) economic theory. Specifically, it is concerned with the depiction of economic behaviour in Jevons' Theory of Political Economy (TPE). This was the first postclassical English text which depicted the theoretical object of `scientific' political economy as a type of constrained optimisation and explained all economic actions in terms of a marginal utility theory, using the calculus and geometry. One reason for focusing on TPE is that its detailed treatment of the behavioural theory distinguished it from the work of the other postclassical pioneer, Leon Walras [Jaffé 1983, ch.17]. The representation of behaviour set out in TPE has remained fundamentally unchanged in orthodox theory, despite subsequent attempts to discard the notion of utility and to sever any connection with psychology [Wong 1978].

The principal argument of the chapter is that it is readily understandable why the orthodox theory is so mechanistic, once its basis is identified. That basis can be found in Richard Jennings Natural Elements of Political Economy (1855) which drew on the discourse of physiological psychology to present `natural laws' of

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[1] This Chapter was originally published in Philip Mirowski (ed.), Natural Images in Economics: Markets Read in Tooth and Claw, Cambridge University Press, New York, 1994, pp.197 – 230.

economic behaviour in functional terms. This was possible because most economic actions were explained as reflexes. Jevons was able to utilise this discourse in part because Jennings argued that the theory made behaviour analogous to a gravitational force. Drawing on his his previous training and work in aspects of physics, Jevons was then able to develop a theory of exchange based on the metaphor of a `balance' of forces. Jennings' approach, however, created a substantial problem because the existence of reflex actions raised the problem of `free will'. Since Jevons simply claimed in TPE that all economic activity was the result of free will, it is concluded that his explanation of economic action was incoherent.

The chapter is presented in five parts. Section 4.1 explains how Jennings provided the theory of economic behaviour for Jevons and why this inaugurated a new approach to the explanation of consumption behaviour. Section 4.2 considers the mechanical metaphors used by Jennings, explaining how Jevons was able to both use and modify them. Section 4.3 discusses the appearance of physiological psychology by the early 1850s and how it was used as a resource by Jennings to formulate his behavioural theory. Section 4.4 then explains how physiological psychology raised the problem of free will and how Jevons responded to this in TPE. Finally, since it has been argued that Jennings' work played a negligible role in the production of TPE, Section 4.5 shows how the problems raised by physiological psychology can explain a number of Jevons' comments when he was first formulating the marginalist theory.

4.1 The Natural Laws of Economic Action

Jevons argued in TPE that it was "the inevitable tendency of human nature" to "satisfy our wants to the utmost with the least effort - to procure the greatest amount of what is desirable at the expense of the least that is undesirable - in other words, to maximise comfort and pleasure" [Jevons 1871, pp. 44, 69]. Similar statements as to general behavioural motives can be found in the work of previous political economists such as Nassau Senior, J.S. Mill and J.E. Cairnes. It is important, however, to distinguish such general motives from the more specific "principles or axioms" of behaviour [Jevons 1871, p.24] which were the differentia specifica of the marginalist economic agent. The axioms were deemed to be universal laws as Jevons explained in 1876: "the laws of political economy treat of the relations between human wants and the available natural objects and human

labour by which they may be satisfied. These laws are so simple in their foundation that they would apply, more or less completely, to all human beings of whom we have any knowledge". Given that the behavioural laws "may be considered universally true as regards human nature" [Jevons 1905, pp.196,197], the utility theory could represent the actions of economic agents without reference to any social conditions of their existence. The marginalist principles of the science of political economy could thus be explained without reference to a particular type of society.[2]

There were two natural laws of behaviour. The first was that for consumption, where the final degree of utility "varies with the quantity of commodity, and ultimately decreases as that quantity increases" [Jevons 1871, p.62 ; cf. ibid. pp.53-8]. The second law was that for labour, defined as "any painful exertion of body or mind undergone with the view to future good" [ibid. p.164]. Its "law of variation" was that "as labour is prolonged the effort becomes rapidly more and more painful" [ibid. pp.166,168]. With the combination of the behavioural motive and specific laws, it was possible to set out the theory of "the mechanics of human interest" [ibid. p.24] or, as in the second edition, "the mechanics of utility and self-interest" [Jevons 1970, p.90]. One example of this mechanics was the equilibrium point where, at the margin, "the pleasure gained" from consuming a commodity was "exactly equal to the labour endured" in either directly producing, or working to indirectly obtain, the commodity through wages [Jevons 1871, p.169]. This analysis was represented [ibid. p.173] by Figure 1 below [see ibid. p.173].

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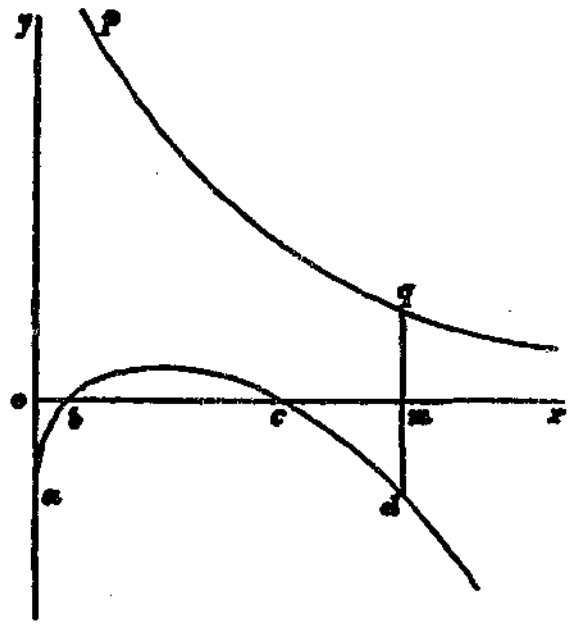
[2] While this chapter is concerned with Jevons' natural laws of behaviour, it should be noted that he did not claim that the laws became manifest in precisely the same ways in all situations, since they "may receive widely different applications in the concrete" [Jevons 1905, p.198]. Drawing on Quetelet's notion of l'homme moyen, Jevons claimed that the theory could be verified by using statistics of average prices and quantities transacted in markets. This assumed a normal distribution of behaviour, so that the theory could also explain the behaviour of different races and classes. For this reason, the analysis was not concerned with individuals per se (see Chapter 5 of this thesis). Jevons' use of the 'error law' was virtually a matter of faith [Jevons 1877, pp.383-4].

FIGURE 1



The diagram represents the work decision for a "free labourer" producing "enough to support himself". Units of marginal utility and disutility are represented along the ordinate. The marginal utility of the output produced is indicated along *pq*, with the marginal utility and disutility of work represented by *abcd*. The labour cease-point is then at *m*. The marginal productivity of labour is assumed constant so that units of labour correspond monotonically to the marginal product and *Ox* indicates units of labour. With the marginal return to labour reflecting its productivity, Jevons described *Ox* as representing the "amount of produce or the day's wages" [Jevons 1871, pp.166,169-72].[3]

This analysis was one of the "most important points of the theory" [Jevons 1871, p.38] in part because the theory of behaviour (or `action') played a crucial role in the initial production of Jevons' marginalist analysis in early 1860. His diary entries and some letters from that time indicate a remarkably rapid shift in his theoretical

[3] Jevons' formal treatment of the argument was as follows. With x representing a unit of output; l representing a unit of labour effort; and u representing the utility of a commodity, then dx/dt = the marginal rate of production; dl/dt = the degree of painfulness of labour; and, du/dx = the final degree of utility from the output, "whether [the labourer] consumes it himself, or exchange it". Labour's "reward" was thus equal to dx/dt.du/dx and labourers would work up to the point or "moment" where the marginal pain of work was equal to the marginal pleasure of the reward. The equilibrium condition dl/dt = dx/dt. du/dx would then represent "the length of time which will be naturally selected as the best term of labour". With a `constant rate of production', the equilibrium condition would become du/dx = dl/dx [Jevons 1871, pp.171-3].

approach. In early February, Jevons recorded that he was working on an aggregate distribution theory in a mathematical form, with "value to established on the basis of labour". Two weeks later, however, he wrote that he had "blundered" on the topic and now 'supposed' that he had arrived at "a true comprehension of Value" [Black 1973-81, VII, p.120]. Letters written in June and November indicate that Jevons was sketching a new theoretical approach, and that he was particularly concerned with the importance of his new explanation of utility [Black 1973-81, II, pp.410-11,422].

A reconstruction of the reasons for Jevons' dissatisfaction with the labour theory of value suggests that, in his initial distribution 'model', he was unable to explain ground rent with both capital and labour as inputs [White 1991b]. However, once he had the marginal utility theory of behaviour, he reformulated the rent analysis with labour as the only variable input. The different analytical orientation thus depended on the new theory of action. This was made more clear in Jevons' first public presentation of the theory [Jevons 1866b (1862)] than it was in TPE (see Chapter 6 of this thesis).

An attempt to explain how this theory was produced is hampered by contradictory statements from Jevons as to his sources. In the first edition of TPE, he claimed that he had "sketched out" the theory "almost irrespective of previous opinions" [Jevons 1871, p.vii]. In the second edition, however, he wrote that "I have carefully pointed out, both in the first edition and in this, certain passages of Bentham, Senior, Jennings and other authors, from whom my system was, more or less consciously, developed" [Jevons 1970, p.63]. Although it is customary to present Jevons as drawing on Bentham for the behavioural theory in TPE, it should be noted that Jevons did not attribute a marginal utility theory to the 'dry old Jeremy'. Only three analysts were presented as anticipating his approach in that regard - Nassau Senior, Thomas Banfield and Richard Jennings. So far as Senior is concerned, Jevons' account involved a grid-reading of Senior's analysis which is more akin to a lexicographic consumption theory (see Chapter 3 of this thesis). This suggests that Jevons read Senior in that misleading fashion after he had formulated the marginal utility theory. Much the same point can be made about Banfield's analysis which, as Jevons acknowledged, was inconsistent with the theory of action

in TPE [Jevons 1871, pp.49-51,54].[4] It is possible, however, to find a presentation of the marginalist behavioural theory in Jennings' Natural Elements (NE).

Jennings argued that political economy was a "science of human actions", founded on universal "laws of [human] nature" [Jennings 1855, pp. 41, 20], identified from the relation between body and mind: "As the human body is universally found to be framed after the same type ... so the human mind, whatever idiosyncrasies it may exhibit in particular instances, is universally found to offer to the philosophical observer the same general class of natural phenomena" [ibid. p.195]. Two universal laws were of fundamental importance in this regard. The first law concerned consumption:

> with respect to all Commodities, our feelings show that the degrees of satisfaction do not proceed para passu with the quantities consumed, - they do not advance equally with each instalment of the Commodity offered to the senses, and then suddenly stop, - but diminish gradually, until they ultimately disappear, and further instalments can produce no further satisfaction. In this progressive scale the increments of sensation resulting from equal increments of the Commodity are obviously less and less at each step [ibid. pp.98-9].

As Jevons noted in TPE, when he included a longer quotation from NE from which the above is taken [Jevons 1871, pp.65-8; cf. Jennings 1855, pp.96-9], Jennings was the "writer" who had "most clearly appreciated the nature and importance of the law of [diminishing marginal] utility" [Jevons 1871, pp.64-5].

Jennings second law of human behaviour, which also dealt with functional `increments of sensation', concerned labour. At first, any effort expended would produce "indifferent" or even "pleasurable" sensations, but, eventually, `pain' would be felt [Jennings 1855, p.116]. The nub of the law of labour variation, which Jevons cited in full [Jevons 1871, pp.166-8], was that:

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[4] For a brief comparison of the approaches of Banfield and Jennings, see section 4.3 below.

> Between these ... points ... of incipient effort and of painful suffering, it is quite evident that the degree of toilsome sensations endured does not vary directly as the quantity of work performed, but increases much more rapidly, like the resistance offered by an opposing medium to the velocity of a moving body.
>
> When this observation comes to be applied to the toilsome sensations endured by the working classes, it will be found convenient to fix ... the average amount of toilsome sensation attending the average amount of labour, and to measure from this point the degrees of variation. If, for the sake of illustration, this average amount be assumed to be of ten hours' duration, it would follow that, if at any period the amount were to be supposed to be reduced to five hours, the sensations of labour would be found, at least by the majority of mankind, to be almost merged in the pleasures of occupation and exercise, whilst the amount of work performed would only be diminished by one half; if, on the contrary, the amount were to be supposed to be increased to twenty hours, the quantity of work produced would only be doubled, whilst the amount of toilsome suffering would become unsupportable [Jennings 1855, pp. 119-20].

With the combination of the two behavioural laws, "the mystery of action is solved" [ibid. p.142] and Jennings emphasised that the explanation for any wage rate would have to be couched in terms of the interaction between the "positive value" attached to the "pecuniary reward" for work (which would follow the consumption sensation law) and the "Negative Value" accompanying the "toilsome feelings" of work [ibid. p.187]. Figure 1 shows how Jevons could have translated NE's account into an analysis and diagram of work effort and the labour `cease-point' for a representative labourer, since Jennings had argued that action would cease when a person became indifferent between sensations [Jennings 1855, p.85].

It should be noted here how Jenning's analysis signalled a new approach to consumption theory in political economy. Prior to the publication of NE, the dominant explanation had been presented in lexicographic terms, which allowed that there were two aspects to consumption. The first was that commodities were arranged in a hierarchy from necessaries to luxuries, while the second was that the degree of want felt for a particular commodity would decline with successive units of

it. In this account, the hierarchy was the most important component of the explanation and explicit allowance was made for interdependence in consumption (see Chapter 3 of this thesis). While Jennings' analysis allowed for a hierarchy, he effectively transformed the categories of the lexicographic framework.

To explain consumption, Jennings used a distinction between `common' and `special' sensations, the effects of which were made to correspond with the consumption of necessary (`primary') and luxury (`secondary') commodities [Jennings 1855, pp.81-102]. Nerves of common sensation conveyed sensations of resistance, temperature, gratification of appetite and stimulation. Special sensations were conveyed specifically by one of the five organs of the senses and included appreciation of colour, beauty of form and melody.

It was important to distinguish between `relative' and `absolute' effects so as to explain "the changes in the degree and duration of sensations" which followed changes in the quantities of commodities consumed. So far as the relative aspect was concerned, Jennings acknowledged that secondary commodities could not be appreciated without the primary wants first being met. Relative sensations thus depended upon the consumption of other commodities. This explained the hierarchy of consumption which was taken as effectively given and subject to change only over long periods of time [Jennings 1855, pp.93,94-6,104]. The second `absolute' aspect was concerned only with changes in sensations produced by successive units of a commodity. It was here that Jennings argued that "the increase of sensation resulting from equal increments of the Commodity are obviously less and less at each step" [ibid. p.99], an argument which Jevons cited subsequently as a statement of diminishing marginal utility (see above). Jennings then claimed that it was possible to posit a "law" for the "general variation of sensations" by noting that, "for equal changes in the quantity of Commodities, the change in the amount of satisfaction derived from Primary Commodities is greater than the change in the amount of satisfaction derived from Secondary Commodities" [ibid. p.102]. The analytical significance of the commodity hierarchy was thus reduced to differences in the `quantity of sensations' and hence to an illustration of the "law of the variation of sensations" [ibid. p.99]. It was Jennings' simultaneous inversion and transformation of the lexicographic approach which Jevons was to exploit by depicting utility as a single-valued function. Although he acknowledged that there was a hierarchy of consumption, this became a subordinate aspect of the marginalist analysis since luxury and necessary commodities could be represented

by utility diagrams with different slopes and were thus illustrations of the one law. The final step in Jevons' analysis was to treat all commodities in the analysis as capable of being exchanged at the margin, thus dissolving the significance of the hierarchy in the lexicographic account.

For Jennings, it was possible to explain `value' in political economy as a "complex mental conception" which consisted of ascribing an attribute to objects based on memory and the anticipation of services provided by an object. Exchangeable value was thus the value of objects which could be exchanged [Jennings 1855, pp.178,72]. Value had two aspects, static and dynamic. The static examined relative exchange value (i.e. relations of quantity in a particular space), and thus dealt with "phenomena of co-existence", measured by commodity prices. The dynamic, by contrast, examined the rate of change of exchange values through time and thus dealt with "phenomena of succession" or the manufacture of exchangeable objects. The link between the two aspects of value was that changes in consumption and price led to changes in value which induced changes in production [ibid. pp.28,30,72-3,135,204]. Jennings also provided a further suggestion which Jevons pursued in his quest to produce a `scientific' political economy.

At the outset of NE, Jennings explained that one "object" of his treatise was to attack an epistemological argument made by J.S. Mill and J.E. Cairnes. This was that political economy dealt with laws which were tendencies, so that their effects were never clear precisely in the "concrete" because of "disturbing causes". For Jennings, however, the argument was unsatisfactory because it could not establish the validity of theoretical propositions which, instead, had to be formulated so as "to represent observed facts". Nevertheless, "we are still far distant from that knowledge of numerical laws which is the characteristic of the higher branches of Science ... This is the field which now claims the attention, and will hereafter produce the laurels of the scientific political-economist" [Jennings 1855, pp.3-6,26].

Like Jennings, Jevons acknowledged that such numerical laws were difficult to produce and that the subject was not capable of `exact measurement'. However, in the early 1860s, he began to attempt to calculate statistical and mathematical price `laws' for particular commodities which would explain consumption in terms of marginal utility. This project was frustrated by computation problems, but one result can be seen in TPE with the formulation of a price law for the the King-D'Avenant price-quantity table [White 1989]. Jevons' formulation drew upon William Whewell's

treatment of the same topic in some early papers to the Cambridge Philosophical Society (1829;1830). In this regard, NE could have been something of a bibliographical goldmine for Jevons. Quite aside from the references to the exchange school of political economists (Senior, Whateley and Bastiat), Jennings quoted a passage from Whewell's early work in the Philosophical Society's Transactions on NE's title page.[5] In consulting the Transactions, Jevons could also have found Tozer's mathematical work on political economy which was mentioned in the first edition of TPE [Jevons 1871, pp.16-7].

4.2 Mechanics and Natural Forces

The attraction of Jennings' argument for Jevons was not simply that it provided a theoretical solution for his initial problem with a value and distribution theory. It was also that Jennings couched his explanation in terms of mechanical metaphors which Jevons could recognise because of his training and work in chemistry, meteorology and, therefore, mechanics.

In the unfinished Principles of Economics, Jevons noted that previous economists, such as J.S. Mill, had argued that "labour creates nothing, but merely draws from the crust of the globe the materials which are to be utilised." This was in keeping with the older "law ... in physics ... that man can neither create nor annihilate matter" [Jevons 1905, p.68]. Jennings also relied on this device, arguing that "matter receives improvement" in production, was "transferred" in commodity exchange and "absorbed, or resolved into other elements" in consumption. It was then the "universal relation of mind to matter" which explained a "large proportion" of sensations, emotions and actions in political economy. In particular, the analytical "field" of the discourse was that "betwixt mind and external matter which is offered by the organisation of the human body" [Jennings 1855, pp.10,18,27]. To explain the actions of the body, Jennings treated matter as a vehicle for `force', so that the "Natural laws [of behaviour] which are permanent and invariable" were akin to those of "mechanical force" and "may now be ... compared to the moving force of gravitation". Since "human action produces, or resists mechanical force, makes

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[5] "The most profitable and philosophical speculations of Political Economy are however of a different kind: they are those which are employed not in reasoning from principles, but to them" [Whewell 1831, p.43]. A member of the `landed gentry', Jennings (1814-1891) attended Trinity College, Cambridge, when Whewell was Master. Subsequently, Jennings entered the law and, by 1859, was High Sheriff of Carmarthenshire [Stark 1943, p.165n; Howey 1960, p.227].

durable impressions on matter, or causes motion", the natural laws of behaviour had the same veracity or "stability of other natural laws ... [such as] the gravitation or coherence of matter" [Jennings 1855, pp.17,136,141,148,159].

This analysis was given a more detailed treatment in TPE where Jevons made marginal utility analogous to a gravitational force. The dominant metaphor in the analysis was that of a `balance' of forces. The mind of the economic agent, for example, was represented as balancing the forces of pleasure and pain, so that exchange was depicted as a balance using the analogy of a lever in equilibrium [Jevons 1970, pp.144-7]. Consistent with this, the work decision for a labourer was explained as a balance between pleasure and pain [Jevons 1871, pp.163,169,174,180]. While the representation of the consumption utility curve in Figure 1 as a gravitational force is clear, the representation of labour in the same way may appear puzzling. However, this point can be clarified by examining how Jevons followed a suggestion by Jennings in an attempt to `verify' the marginalist project.

In the extract from Jenning's discussion of work effort which Jevons cited in TPE, it was argued that the "degree of toilsome sensation" increased rapidly with the work performed, "like the resistance offered by an opposing medium to the velocity of a moving body" [Jennings 1855, p.119; Jevons 1871, p.166]. If this was grist to Jevons' mechanistic mill, a few pages before, Jennings had offered the following suggestion to `test' the proposition:

> let any muscular effort be made, as, for example, let the arm be extended in a horizontal direction, and be held there, counteracting the force of gravitation: the first sensations may be the indifferent, or perhaps agreeable sensations of activity and of power, arising from the exercise of the muscular sense; but the sensations which succeed assume a different complexion, and progressively merge into sensations of resistance, of a necessity for effort, of a consciousness of a force equal or superior to our own, and ultimately of a painful reluctance to persist: such are the class of sensations which may be distinguished as the sensations of Physical Labour [Jennings 1855, pp.116-7].

In early 1870, Jevons reported three experiments which were designed to "throw some light upon the chemical and physiological conditions of muscular force" so as

to begin "defining the mathematical relations upon which the science of economy is founded" [Jevons 1870, p.158]. Two of the experiments were unsatisfactory in that they did not result in a mathematical law which could be explained by "mechanical principles". The third, however, was more satisfactory. It involved holding weights in the hand with an outstretched arm and recording the time for which the weights could be supported. In this case, work (the `useful effect') was calculated as the product of weight and time. First reported in Nature, the experiment was then described in TPE as illustrating the "laws forming the physical basis of Political Economy" [Jevons 1871, p.195]. Perhaps not surprisingly, a diagram of Jevons' results looks like the labour disutility curve in TPE [Haughton 1871, p.290]. As was noted above, in the early 1860s, Jevons had attempted to calculate mathematical price laws for a number of commodities which would provide statistical verification of the utility theory in consumption. It seems reasonable to suggest that Jevons' `work' experiment was suggested also by Jennings and dated from about the same time, with the aim of verifying the labour component of the utility theory.

The assumption of constant labour productivity, which Jevons used in the labour cease-point diagram was also consistent with Jennings' analysis. (In the long quotation from Jennings [1855, pp.119-20] which Jevons cited in TPE, it was argued that a doubling or halving of the work day would change output in the same proportion). The similarity was obscured, however, by Jevons' claim that the assumption applied also for cases of "machine labour" [Jevons 1871, p.172]. While Jennings drew upon the analysis of `labouring force' in Whewell's mechanics (see Chapter 6 of this thesis), Jevons' reference to machine labour was apparently taken from Babbage's Economy of Machinery and assumed a quite different set of means and relations of production to that of the `free labourer' case in TPE. In a similar manner, the debt to Jennings for the work experiment was obscured in TPE because Jennings received no mention. Instead, Jevons linked his experiments with the discussion of efficient work loads (the "economy of labour") by Babbage. Drawing on the work of Coulomb, Babbage discussed work in terms of the expenditure of force in moving matter [Babbage 1835, pp.18-20,30-37].[6]

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[6] Jevons' reference Coulomb's analysis in the first edition of TPE [Jevons 1871, pp.193-4] might suggest that he was familiar directly with the concept of work as developed in late eighteenth century French mechanics [cf. Grattan-Guinness 1984]. However, Jevons' discussion of Coulomb basically consisted of unacknowledged quotations from Babbage [1835, pp.30-1]. In the second edition of TPE, a long (acknowledged) quotation from Babbage on fatigue and work was added to the text [Jevons 1970, p.214].

It will be shown in Chapter 6 of this thesis that, by the time that Jevons came to write TPE, he considered that gravitational forces could be explained by the principle of the conservation of energy (or force). Hence he wrote that each labourer began the day with a given amount of "spontaneous energy" which "begins to be rapidly exhausted" with work.[7] With the pain of the intensity of labour indicated by the "amount of muscular force undergone in a certain time", it was necessary that "a workman ... [can] recover all fatigue and recommence with an undiminished store of energy" [Jevons 1871, pp.166,169,197]. When he described the relationship between the amount and the intensity of work, he claimed that "long experience has led men, by a sort of unconscious reasoning, to select that rate of work which is the most advantageous" [ibid. pp.191-2]. This Panglossian statement, with its reference to `unconscious reasoning', was remarkably similar to one previously made by Thomas Laycock [Danzinger 1982, p.126]. Laycock's work was instrumental in the formulation of the discourse of physiological psychology. It was that discourse which enabled Richard Jennings to first outline the mechanics of behaviour that Jevons subsequently explained with the energy conservation principle.

4.3 Physiological Psychology

In the early 1840s, the dominant English theory of wants, perception and behaviour which political economists could draw upon was associationist `psychology'. This discourse, which now appears as more an epistemology than a psychology,[8] considered that complex mental events, such as knowledge and experience, could be accounted for by a combination of sensations and perceptions felt by the body and registered in the mind. The formation of mental phenomena was dependent on the similarity and/or repeated juxtaposition of sensations and perceptions over space and time. These could then be `internalised', by memory for example, through an association of ideas so that behaviour subsequent to the initial stimulation could be explained by the mind's operation [Young 1973, p.111].

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[7] In the second edition, "spontaneous energy" was changed to "overflowing energy" [Jevons 1970, p.190].

[8] As Smith [1973, p. 76] has noted, while theories of the mind can be called `psychological', the term is somewhat anachronistic in this context.

In the early nineteenth century, Thomas Brown, whose work was cited by Jennings more than thirty years later, attempted to produce a theory of mind, reconciling associationism with the role of touch and muscle senses in revealing the external world in the mind. Still, the conceptual focus remained one of a `mental physiology' that was not carried out with any direct analysis of the nervous system. James Mill then used Brown's analysis in his theory of knowledge, albeit emphasising muscle sense to the exclusion of touch [Smith, 1973, p.92; Young 1970, p.97]. One crucial effect of the epistemological dominance in such discussion was that, while it was acknowledged that the mind had powers which organised units of knowledge, the characterisation of behaviour tended to be conducted in terms of responses to external stimuli, thus emphasising a "passive sensationalism" [Young 1970, p.114].

It would be misleading to characterise `the' eighteenth century conceptualisation of the mind-body relationship in terms of a simple Cartesian dualism, since by the mid-century two essential components of that dualism (the indivisibility of the mind and the notion of free will) had been challenged from within associationism [Young 1973, p.111]. By the early nineteenth century, however, a more decisive challenge to the previous century's conceptualisation of a mind-body hierarchy was made in Britain and on the Continent. Analysts such as Flourens, Muller, Bell and Hall argued for a division between types of reflex actions centred in the spinal cord, dealing with the lower/`automatic' regions of the body, and those actions ordered by the "soul", delineating the controlling regions of the brain [Jacyna 1981, p.111; Smith 1981, p.46]. The notion of the reflex was made more precise subsequently and applied to the "higher" regions of the nervous system, which could then be conceptualised in terms of sensory-motor connections and reflex mechanisms [Smith 1981, p.46; Danzinger 1982]. By the 1840s-50s, an important point in such analyses was that the essential unit of the nervous system was the ganglion - a nerve nucleus served by afferent and efferent nerves. A series of those units were understood to be "largely autonomous centres of reception and innervation" [Jacyna 1981, p.112]. The significance of the ganglia for analysis of the cerebrospinal column was that the notion of reflexion could be used to explain a number of cerebral functions. Although the continuity between various parts of the nervous system in terms of reflexes and sensory-motor connections was only "fully" established by the 1870s, it was possible by mid-century to explain human actions in such a way that the role of `the mind' was, to a significant extent, "epiphonomenal" [Smith 1981, pp.46,164].

During the 1850s, the conceptual basis and thrust of associationist psychology was shifted abruptly with the incorporation, in theories of behaviour, of the physiological analyses of sense organs and sensory processes which had been produced between the 1820s and 1840s. The significance of the physiological work is now apparent from the 1820s-30s with the formulation of the Bell-Magendie 'law' of spinal nerve roots which enabled a "structural localisation of sensory and motor functions" - i.e. the identification of nerves of sensation as contrasted with those stimulating muscles which moved parts of the body. The sensory-motor division of nervous function could be appropriated by a psychology, precisely because the division was "a nervous (structural or mechanical) analogue for the psychological events of sensation and reaction" [Smith 1973, pp.82,83].

By stressing the importance of relations between movement, the nervous system and 'in-born' patterns of co-ordination, it was also possible to provide an explanation for the body's spontaneous movements which were prior to, and independent of, previous external stimuli and consequently mental 'associations'. The organism became active, not simply reactive, in its own right since movement could precede sensation [Hearnshaw 1964, p.12]. To some extent, the nub of the explanation became the analysis of such spontaneous movements which were independent of and even opposed to those required by the 'will'. These were then linked to the experience of pleasure and pain, so that the organism could adapt its behaviour to the ends or purposes of avoiding pain and attracting pleasure. Motor impulses could then become purposive movements by the association of ideas with them even though there need be no voluntary activity on the part of the brain in bringing them about. It was necessary to incorporate 'willed' activity, which was both conscious and voluntary, in such an analysis, but with the emphasis on "activity as a primary psychological fact" and with the analytical means to delineate motion and purposive action, "association psychology had changed radically from an epistemological science to a psychological science of feeling, knowing and doing" [Young 1970, p.120].

The work of Thomas Bain, particularly in his The Senses of The Intellect (1855) and The Emotions and The Will (1856), has been considered to be "the meeting-point of experimental sensory-motor physiology and the association psychology" [ibid. p.101] to produce the new discourse of physiological psychology. While Jevons was to indicate the relevance of Bain's work in TPE (see below), W.B. Carpenter (1813-1885), a colleague of Bain's, provided the point of entry for political economy to first

appropriate the new discourse of behavioural action via Jennings' NE. Carpenter was the Professor of Physiology and of Forensic Medicine at University College of Hospital, London. As the author of the influential Principles of Human Physiology, first published in 1842, he "may be said to have played the same role from the physiological side that Bain did from the psychological side in uniting the two disciplines" [Young 1970, p. 212n]. For it was Carpenter, "drawing heavily from Bain before the publication of Bain's major work" [ibid.], who `combined' physiology and psychology by adding chapters on the latter to the fourth (1853) and fifth (1855) editions of his Principles.[9]

For Carpenter, organisms encountered matter, with its effects of resistance and `ponderosity', through sensations conveyed by the tactile senses of touch and muscular exertion as well as the mental sense of effort. The connection between "feelings of Pain and Pleasure" and sensations was explained as "the necessary associations of those feelings, by an original law of our nature, with the sensations in question". For human beings, the "springs of human actions" were to be found in `instinct', which produced automatic (reflex) actions, and `intelligence', which produced volitional or voluntary actions. Pleasure and pain were not the only feelings humans could have, but they were important since they were associated with reflex actions [Carpenter 1888, pp.10,16,85,100,171,173].

Jennings' discussion of the `natural laws' of human action which were relevant in political economy for the explanation of consumption, work and accumulation behaviour depended on Carpenter's delineation of reflex actions, which occurred without the "attention" of the will, some even taking place if the mind was unconscious [Jennings, 1855, p.136]. Such actions could be based in various parts of the nervous system, from the nerves of the limbs to the cerebral cortex, although it was necessary to distinguish between the body's "Automatic Mechanism which constitutes the fundamental and essential part of the nervous system" and the Cerebrum [Carpenter 1888, p.100]. The automatic apparatus was composed of the sensory ganglia and the thalamus. Figure 2 reproduces Carpenter's diagram of the general plan of the automatic apparatus in relation to the cerebral cortex. Jennings [1855, pp.136-41] closely and explicitly followed this account when detailing the natural laws of political economy.

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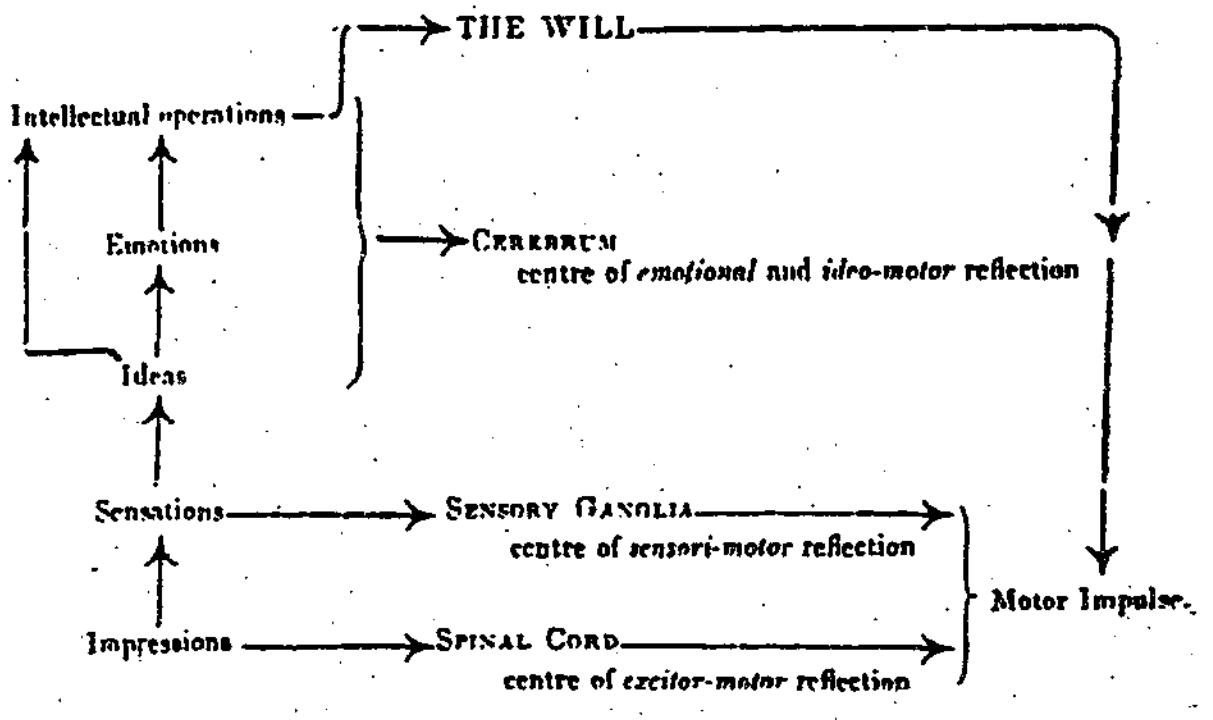
[9] For details of Carpenter, see Hearnshaw 1964, pp. 19-23; Young 1970, pp. 210-15.

FIGURE 2



Although Jennings referred in a number of places to economic actions which were governed by the will [Jennings 1855, pp.10,22,125,135], he noted that these occurred "much less frequently than is commonly supposed" [ibid. p.132]. Instead, a good deal of activity was lawed behaviour, consisting of actions which were "simply automatic or instinctive", performed "without the attention, or the intention, or even the excitement of consciousness in the mind of the agent". These reflex actions, which Carpenter had discussed, were "now universally recognised by psychologists" as resulting from the "involuntary education of the senses" through experience. The "two great branches of the subject", consumption and production (the latter was really an analysis of work types and 'effort'), could be explained in that manner. They were distinguished by their relation to different trunks of nerve fibres in the body. Consumption dealt with the effects of matter external to the body, producing "impressions" on the afferent fibre trunks, which led to the sensorium, resulting in mental `sensations'. Production, by contrast, involved the body acting on external matter. This produced impressions on the efferent trunks leading from the sensorium which, in turn, acted on muscles producing mechanical force. Such movements, which "originate" in the spinal column and not in the brain, constituted the "natural laws" of political economy which could be observed statistically by the method of averages [ibid. pp.46-9,81-2,136-8,143]. As Jennings summarised the argument:

> The laws ... of human action are, in the same sense in which other laws of Nature are so, fixed and invariable, - the conditions under which they operate are undoubtedly subject to the interposition of the human will, but their results are, in the absence of such interposition, certain, and therefore subject to provision where sufficient knowledge has been attained to determine the existing conditions of phenomena, and to trace their consequences. Of all the direct connections of cause and effect, this, perhaps, appears the most paradoxical - that our own organs should ever without our consciousness minister, like fairy hands, to our Desires, and even to our Ideas and our Sensations [Jennings, 1855, pp.140-1].

To a significant extent, then, behaviour could be depicted as a set of actions which were simultaneously purposive, automatic and could be either conscious or unconscious. It was the notion of the reflex which allowed this "reconciliation of purposiveness with automatism" so as to designate an individual "organism" in terms of neurophysiological organisation [Smith, 1973, p.85]. At the same time, it was possible to allow for the effects of the environment on the organism in a functional manner. In the case of human beings, this enabled a distinction between `individual' and socialised behaviour and depended on the notion of learned reflexes which incorporated environmental effects. The corollary was that, just as people could learn reflex actions by the replication of uncontrolled events, it would be possible to direct them into new action paths by changing their environment. For Jennings, most economic activities consisted of reflex actions and the mass of the population did not exercise free will to any significant extent.

Carpenter's analysis could have enabled Jennings to formulate his argument in terms of degrees of sensation by the manner in which the Principles of Human Physiology depicted feelings of pleasure and pain and stressed that they could be understood as `natural laws' of behaviour with empirical or statistical correlates. For Carpenter, "the vividness of Sensations usually depends on the degree of change which they produce in the [nervous] system, [rather] than on the absolute amount of the impressing force; and this is the case with regard alike to special sensations. Thus, our sensations of Heat and Cold are entirely governed by the previous condition of the parts affected" [Carpenter 1888, pp.153-4]. He also referred to "that diminution of the force of Sensations which is the ordinary consequence of their

habitual recurrence" [ibid. p. 155]. It had to be recognised, however, that the statistical laws, "in their primary sense, are simply expressions of phenomenal uniformities" or "comprehensive expressions of aggregates of particular facts ... giving no rationale of them whatever" [Carpenter 1888, pp.629,693]. This notion of statistical laws was common at the time and Jevons was to use it in TPE [White 1989].

In concluding this section, two points can be noted which show how, in using physiological psychology as a resource, NE marked a break with the work of previous analysts in British political economy. First, Jennings showed that it was possible to distinguish between `natural laws' of behaviour and the social manifestations of those laws. Such a distinction was not made clearly by preceding economists. To Thomas Banfield, for example, "Man is ... above all a free agent" with wants and aspirations, yet there was still some muted allowance made for the effects on people's behaviour of "the circumstances in which they are placed" [Banfield 1848, pp.5,11]. NE showed, however, that it was possible to first banish the `social' with the designation of a new theoretical object. Instead of an undifferentiated `man' there was the human body conceptualised as a neurophysiological system/organism. Social behaviour could then be accounted for by the organism's environment and could be observed with statistics.

The second point of note is the manner in which the new theoretical object of the body enabled a different conceptualisation of behaviour so as to explain the `system of action'. Whereas Banfield posited a fixed order of want fulfilment which, as Jevons noted, was incompatible with marginalism, NE showed that it was possible to posit a theory of action with a calculating neurophysiological organism. Combining the principles of consumption and production, Jennings could portray economic action in a way that was fundamentally the same as in the subsequent marginalist theory. In direct contrast with Banfield, the acquisition of commodities by an agent depended on

> whether the sensations of pleasure that are derived from the possession of objects which constitute property, and which are greater than, and prevail over, the sensations of toil that accompany the efforts by which alone they are commonly produced, or the consequent conception of value set upon these objects, or the will to

> labour for the purpose of producing, and to exercise self-denial for the purpose of calculating them [Jennings 1855, pp.195-6].

Given the behavioural motivation of pleasure "attraction" and pain "revulsion" [ibid. p.45] the agent learned to calculate and thus to act through replication.

4.4 The Citadel of the Will - The Bain of Jevons' Theory

The production of the discourse of physiological psychology by the early 1850's was the result of a series of analytical responses to problems which emerged "within the framework of contemporary social systems" [Smith 1973, p.79]. The social conditions of existence of the discourse included, at various times, the challenge posed by the "anti - establishment" and "popularist" movement of phrenology; the study of hypnosis and of diseases, especially "nervous disorder and mental illness", both of which were components of the reorganisation of hospitals and mental asylums in the nineteenth century; and, the acquisition of an institutional area of independence for psychology and physiology from medical studies [ibid. pp.79,81,86]. Because of its implications for child-rearing, the treatment of alcoholism and the legal defence of insanity [Daston 1978, p.192; Smith 1981], the discourse necessarily had significant political implications for the discussion of those issues.

The political impact of physiological psychology was actually much wider than the preceding paragraph suggests. Once human behaviour could be explained, to varying degrees, as predetermined by the body's neurophysiological organisation, it could be argued that human behaviour approximated a `materialist automatism' within the epistemological premises of scientific naturalism which "reached something of a high point in Britain in the 1860's and 1870's" [Smith 1981, p.9]. According to this approach, the rhetoric of which was "saturated with concepts and terminology from mechanics" [Porter 1986, p.196], scientific knowledge produced lawed or determined explanations of worldly phenomena which were thus "reduced to the parameters of matter and motion" in a deterministic or mechanistic fashion [Daston 1978, p.194]. In that respect, psychology could be viewed as simply one aspect of "a unified Science of Physics", as W.K. Clifford noted in 1874 [ibid. p.201].[10] This link had been made by Carpenter in 1857 when he claimed that

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[10] For discussion of scientific naturalism, see Turner 1974a, chapter 2.

mental events should be analysed in terms of the correlation of forces framework: "[There is] a `correlation' between nerve-force and mental agency, which is not less complete than that which has been shown to exist between nerve-force and electricity" [Carpenter 1857, pp.392-3]. Bain followed suit, arguing that it was possible to explain the correlation of mind and body (i.e. psycho-physiological parallelism) by `extending' the "doctrine" of the "Correlation ... [or] Equivalence ... [or] Indestructability of Force" to the "mind" [Bain 1867, p.373].

By making the notion of voluntary behaviour problematical, the concept of reflex action simultaneously called the evaluation of "value, purpose and ethical conduct" into doubt, precisely because such evaluation depended on behaviour being voluntarily undertaken so that a person was responsible for their actions. With the increasing circumscription of voluntary behaviour, the analytical area of moral philosophy was correspondingly circumscribed so that discussion of values and purpose, under the general heading of Ethics, was apparently only capable of analysis in terms of what Henry Sidgwick referred to in 1874 as "the mysterious citadel of the `Will'" [Daston 1978, pp.194,201].

The debate over scientific naturalism can, in part, be seen as an instrument of 'professionalisation' by a number of prominent scientists, promoting a `model' of knowledge production directed against "the religious beliefs of the clergy and other scientists [who] could and did directly influence evaluation of work, patronage of research, and appointments in scientific institutions, the universities, and the public schools" [Turner 1978, p.366]. As well as this particular context for the conflict between `science and religion', the physiological psychology of Bain and his confreres raised a further political danger for conservatives such as the Unitarian James Martineau (see Section 4.5). If that discourse obliterated the disjuncture between psychical and physical nature, between mind (the `spiritual') and matter (the `material'), then the claims Christians, based on the authority of the Scriptures, to lay down ethical prescriptions were under attack. This was held to threaten both the social position of the clergy and the stability of the social order. For just as the predominance of God/The Spirit over behaviour entailed a system of hierarchy and subordination, the ecclesiastical organization was an inherent component of the ordering of the social structure. Without an "external power" which could prescribe an ethical ordering for the world, the regulation of both individual behaviour and the existing set of social relations were threatened by the forces of `liberal radicalism'

[Jacyna 1981, pp.110,118,120,122-3].[11] That problem exercised W.B. Carpenter in his attempts to reconcile Christianity with physiological psychology [Smith 1977]. Carpenter's solution to the dilemma between automatism and free will was to argue that, while the will could only select and not cause actions (with volitional activity thus restricted within the choices available), it was capable of acting as a vehicle for "attention". Appropriate educational instruments would carry out the `riveting' of attention onto acceptable `ideas' so that the body's automatic apparatus would then determine behaviour.

Jennings relied on Carpenter's Human Physiology to delineate laws of behaviour but does not seem to have been particularly concerned by the `ethical'/political implications of that analysis in the terms described above. This may have been for three reasons: first, because of the political assumptions he made (the working classes, for instance, were to be `acted upon'); second, because the political furore over physiological psychology only became critical after the late 1850's; and, third, because he did not deem it politically necessary to demonstrate that market exchanges manifesting voluntary behaviour produced an economically optimal outcome. For Jevons in the early 1860's, neither the second nor the third of those reasons could be taken for granted.

While Jennings followed Carpenter, it was Alexander Bain's Emotions and the Will (1859) to which Jevons referred in TPE [Jevons 1871, pp.19,31,39,40].[12] Bain's work "profoundly changed" association psychology, integrating it with sensory-motor physiology and formulating an explanation of action, encompassing both perception and behaviour, by making the sense of activity fundamental to the human being [Smith 1973, p.95]. The crux of his work was the link between sensation and motor phenomena (ie. the nerves exciting muscular activity) [Young 1970, p.119]. Nevertheless, Bain argued that his theory was not `materialistic' - neural events did not cause mental events since both sets of events occurred in a direct correspondence. Aspects of consciousness correlated with motor nerve processes, so that there was a parallelism between the passive and active modes of consciousness and the sensory and motor delineation of neural processes [ibid.

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[11] See also Turner 1974b. Heyck 1982, Chapter 4 provides a useful overview of the `science' versus `religion' debates.

[12] For details of Bain's biography and his work see Hearnshaw 1964, pp. 1-4; Young 1970, Chapter 3.

pp.73,75; Daston 1978, p.197, n.123].[13] The private world of `the conscious' remained impenetrable but, because of psychophysical parallelism, behaviour could be studied as "the observable correlates of mental events" [Daston 1978, p.201; idem. 1982].

Bain argued also that the exercise of the will depended on the body's physiological organization. According to his account, since the nervous system was capable of `spontaneous' (ie. non-reflex) actions, it would experience muscular sensation. Such sensory experience amounted to the "experiential aspect" of the will so that knowledge of the latter was dependent on the experience of volition [Boring 1957, p.240]. The problem, however, with this account of the existence of free will was that spontaneous actions were inseparable from, indeed determined by, the body's physiological structure. `Free will' was thus dependent on the specific physical/material context in which actions occurred, so that it could be held to be illusory. Bain was thus only evading the problem when he also defended the traditional role of introspection being used in conjunction with the psycho-physiologists' experimental work [Smith 1973, p.117, n.35]. In that respect, he followed J.S. Mill who, while he greeted Bain's work enthusiastically, considered that the "ultimate facts of knowledge" corresponded to what were, in the last instance, "unanalysable states of consciousness" and that the development of knowledge was still fundamentally dependent on traditional introspective methods [ibid. p.120 n.130; Smith 1981, pp.59-60]. Bain's ambiguity on the role of the will and hence voluntary activity was replicated in TPE.

Arguing that individual feelings of pleasure and pain underlay all actions, Jevons followed Bain in arguing that "Every mind is ... inscrutable to every other mind, and no common denominator of feeling is possible". This meant it was impossible to compare directly the "amount of feeling in one mind with that in another" so that "We cannot weigh, or gauge, or test the feelings of the mind; there is no unit of labour, or suffering, or enjoyment" [Jevons 1871, pp.21,9]. Nevertheless, such feelings prompted economic activity so that "it is from the quantitative effects of the feelings that we must estimate their comparative amounts" [ibid. pp.13-14]. It was the will's role to act as the "final judge" on the "equality or inequality of feelings" which correspond to the events in the world `outside' the individual, so that its "oscillations are minutely registered in all the price lists of the markets". Drawing

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[13] For a summary of the argument, see Bain 1867.

also on Quételet's l'homme moyen, Jevons then claimed that the "general form of the laws of Economy is the same in the case of individuals and nations" and that statistics could be used to `verify' the utility theory [ibid. pp.14,21].

It is important to note that, in his Principles of Science, Jevons indicated that he was aware of the ethical issues raised by physiological psychology when, in discussing the arguments raised by scientific naturalism, he referred to the analysis of "mental phenomena". If such phenomena were "capable of treatment by the balance and the micrometer, can we any longer hold that mind is distinct from matter?" If not, "our boasted free will becomes a delusion". With "the uniform action of material causes" then explaining all events, it would be possible to "preclude the hypothesis of a benevolent Creator" [Jevons 1887 (1877), p.736].[14] While Jevons rejected that conclusion (see below), the shifting terminology he used in TPE to describe the nature of `individual' and aggregate decision-making provides further evidence that he was aware of the arguments about ethics which the physiological psychologists' work had raised. The designation of a mechanics of action suggests clearly the problem of automatism and scientific naturalism as it was understood by his contemporaries. Yet, in discussing the inevitable tendency of human nature to choose the `greater apparent good', Jevons, explicitly referring to Bain's work, initially argued that the resultant choices were manifestations of "voluntary activity", that is, "a manifest of the will" [Jevons 1871, pp.19,31]. Subsequently, however, the manifestation became that of the "will or inclination" [ibid. p.46], where the latter category is ambiguous since it could refer to either willed or reflex activity. The ambiguity was then thrown into sharp relief via an introductory comment to a long quotation from Jennings' Natural Elements, where Jevons noted that text "treats of the physiological groundwork of Economy, showing its dependence on physiological laws" [ibid. p.65]. (The reference to the `groundwork' was taken directly from Jennings [1855, p.18]).

Jevons seems to have been aware since 1860 of the ethical/political furore which accompanied the postulation of such reflex physiological laws (see Section 4.5). Yet, until the quotation from Jennings, there was no mention in TPE of the

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[14] Jevons also noted that there "are scientific men who assert that the interposition of Providence is impossible, and prayer an absurdity, because the laws of Nature are inductively proved to be invariable" [Jevons 1887 (1877), p. 736]. This was a reference to the `Prayer Gauge Debate" of 1872-3 [Turner 1974b].

`dependency' of the action theory on them. TPE thus maintained a theory of the mechanics of lawed action, which was simultaneously voluntary, only by confusion. At first, activity was manifestation of the `will', then `inclination', until it was finally acknowledged that it was dependent to some unspecified extent on the existence of reflexes. It might be argued that Jevons was drawing on the ambiguities over willed behaviour in Bain's account, but it is noteworthy that TPE made no attempt to acknowledge, let along confront, the problem of voluntary versus involuntary actions which Bain's exposition entailed. Indeed, in the "Introduction" to TPE's second edition, the conceptual fudging was ironically made clear with this statement: "The science of economics ... is in some degree peculiar, owing to the fact, pointed out by J.S. Mill and Cairnes, that its ultimate laws are known immediately to us by intuition, or at any rate, they are furnished to us ready- made by other mental or physical sciences" [Jevons 1970, p.88].

The fudging occurred because Jevons failed to mention that Cairnes explicitly rejected basing economic analysis on psycho-physiological laws as outlined by Jennings, and Jevons was well aware of Cairnes' objections. Jevons also failed to explain how an analysis based on `intuition' was reconcilable with one based on `laws' from other physical sciences since this was precisely what the opponents of physiological psychology argued was not possible (see Section 4.5). Jevons further confused matters when he cited Bain's The Emotions and the Will as follows: "No amount of complication is ever able to disguise the general fact, that our voluntary activity is moved by only two great classes of stimulants; either a pleasure or a pain, present or remote, must lurk in every situation that drives us into action" [Bain 1859, p.460; Jevons 1871, p.31]. The confusion resulted from citing Bain only on `voluntary action' and ignoring the problem of involuntary activity which, as noted above, Jevons subsequently acknowledged was the `groundwork' of the action theory. Without a satisfactory resolution of the problem, however, Jevons' account of the `mechanics of human interest' as voluntary activity was incoherent.

4.5 Jevons in 1860: Ruminating on Free Will

The remarkable similarities between the behavioural theory in NE and in TPE, when coupled with the speed with which Jevons switched to a marginalist theory in 1860, suggest that it is unlikely that Jevons "discovered" Jennings' text after he went to

Manchester in 1863 [Howey 1960, pp.12-3].[15] This section considers some further evidence which suggests that, in 1860, Jevons was familiar with and troubled by the issues raised by physiological psychology.

Since Jennings' text was not widely known and rarely referred to, how could Jevons have located it? In July 1860 he wrote to his brother that he had "studied the subject [of political economy] independently and originally ... and read some dozens of the best works in it" [Black 1973-81, II, p.416]. One possible candidate for his reading list would have been J.E. Cairnes' Character and Logical Method of Political Economy (1857) since, with its publication, Cairnes "had come to notice" in the late 1850s [Checkland 1951, p.161n; see also Gooch 1920, p.57]. If Jevons had read the Character, he could hardly have failed to notice the hostile treatment which Cairnes gave to Jenning's NE and to H.D. Macleod's Theory and Practice of Banking. Cairnes not only criticised Jennings and Macleod in long notes through the text, but also considered them important enough to discuss again in two Appendices [Cairnes 1857, pp.176-83]. As Jevons noted in TPE, Cairnes was the only exception to economists having failed to pay "the slightest attention" to NE [Jevons 1871, p.65].

That Jevons was considering the issues raised by Jennings at the time that he announced his break with a labour theory of value is indicated by a number of his diary entries in early 1860. At the beginning of February he recorded that he was working on his mathematical theory of political economy and, on the 19th, announced that he had previously `blundered' by using a labour theory of value. Two days before this, he recorded that he was "reading up the Nervous System".[16] This was possibly a reference to Marshall Hall's Memoirs of the Nervous System (1837), a discussion of reflex `sensori-motor' acts, which had influenced the early work of W.B. Carpenter [Jacyna 1981, p.111].[17]

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[15] For the reasons discussed above, I disagree with Howey's [1960, p.12] conclusion that Jevons' "early statements" on economic theory "do not show ... any similarity of form or expression that would hint that he had studied Jennings carefully".

[16] Jevons Archive, John Rylands University Library of Manchester, JA6/4/5.

[17] Alternatively, Jevons might have been referring to Charles Bell's The Nervous System of the Human Body (third edition 1836) [Jacyna 1982, p.235n].

It is noteworthy that, at the time that Jevons began to outline his marginal utility approach, he was particularly concerned with the free will question. The context and form of his comments provide further indirect support for the argument that Jennings' text was of crucial importance in Jevons' early work. In each of the two letters written in June and November of 1860, where Jevons outlined concepts which were to form the basis of his `true theory of Economy' (see above), the discussion of the theory was immediately followed or preceded by a reference to Metaphysics. This was not in itself remarkable since, at that time, Jevons was enrolled in a course on `Philosophy of Mind and Logic' at University College, London [Black 1972, p.123]. However, the terms of his comments are interesting. In the June letter, for instance, immediately following the claims for the theory ("so thorough-going and consistent, that I cannot now read other books on the subject without indignation"), Jevons wrote: "I am extremely interested in Metaphysics ... The ultimate question of philosophy that between idealism and materialism is necessarily an insoluble one, but one also on which we cannot avoid speculating with interest. Nor can I say that I yet feel bottom, I am somewhat ... out of my depth" [Black 1973-81, II, p.411]. If Jevons had relied on Jennings' Natural Elements and, therefore, the work of the physiological psychologists, in depicting behaviour in a mathematical functional manner, it would not be surprising if he was ruminating on the specific metaphysical problem of `idealism and materialism'. For by early 1860 a storm had broken over physiological psychology couched in precisely those terms.

The harbinger of the storm was James Martineau's review, in the April 1860 National Review, of Bain's The Senses and the Intellect (1855) and The Emotions and the Will (1859). In posing the question "What is `Psychology'?", Martineau launched a trenchant attack on the possibility of a physiological psychology. Bain's account of the nervous system was "lucid, exact and compendious" but, so far as psychology was concerned, it was "altogether foreign and intrusive". For it introduced "the language and methods" of the Natural Sciences into Mental and Moral Philosophy, a procedure which should be rejected. To connect a "physiological exposition" with a subsequent analysis of "intellectual" processes was to `tincture' psychology "with a language of materialistic description, at once unphilosophical and repulsive". Psychology was concerned with "self-consciousness" (introspection), to which the very language and methods of physiological description were foreign. It was as if an artist were "to paint his Madonna with the skin off. It is recommended neither by scientific precision, nor by illustrative good taste" [Martineau 1891, pp.538,542,543,545]. For Martineau, since

psychology required a reflecting subject, a knowing and willing self- conscious mind, it was primarily subjective and thus not a `natural' science [cf. Cardno 1955, pp.124-5].[18]

In TPE Jevons rejected this argument, of a complete divorce between the language and methods of the `natural' and `moral' sciences, when defending his approach to economic theory [Jevons 1871, p.3]. Nevertheless, his fudging over the voluntary nature of economic activity might suggest that he was worried by the type of criticism which Martineau had voiced. In June 1860, having announced his commitment to the mathematical behavioural approach, he acknowledged in the same letter that he was `out of his depth' in metaphysics, in terms which are consistent with the criticisms levelled at Bain's work in Martineau's review, published two months before.

Then, in the November 1860 letter containing further references to the marginalist economic theory and metaphysics, Jevons announced he was more interested in "moral philosophy" and was attending "Mr. Martineau's mental philosophy class in Manchester New College, which is close at hand in University Hall" [Black 1973-81, II, pp.421-2]. Jevons' brother thought that this was peculiar:

> It seems to me rather odd of you attending Martineau's metaphysical lectures ... The truth about Metaphysics is not to be put in a book or treatise. I am inclined to think that the tendency of the present age is to deprecate the importance of Metaphysical studies and stick to exact science and practical knowledge [ibid. p.424].

Yet, viewed in the sequence of events outlined above, Jevons' attendance at Martineau's lectures was not at all odd. Martineau was one of the two full-time professors at the New College, which was founded originally as "the principal institution of higher education in arts and theology for Unitarians" [Black 1973-81, II, p.421n]. Moved to London in 1853, the College was "established to supply the theological element omitted from University College's curriculum" [Woodfield 1986,

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[18] Jacyna [1981, pp. 120,123] argues that, in the 1860's, Martineau saw physiological psychology as synonymous with the views of the `radical' wing of the Liberal Party - a grouping identified with J.S. Mill, Henry Fawcett, Leslie Stephen and W.K. Clifford - and that Martineau was a "leading exponent" of a conservative response to that radicalism.

p.7]. The younger brother of Harriet Martineau, James was an influential intellectual force in the Northern Unitarian power bloc of intellectuals and businessmen, having previously been Professor of Moral and Mental Philosophy as well as Political Economy when the New College was at Manchester. Martineau was, in other words, part of the "social background in which Jevons had been reared and his return to University College had brought him back into it" [Black 1972, p.125].[19] While Jevons clearly disagreed with Martineau's attack on physiological psychology as such, he might well have been troubled by a fellow Unitarian's attack on that discourse as materialistic and to that extent `unethical'.

Jevons' attendance at Martineau's lectures can thus be explained by Jevons attempting to reconcile the behavioural basis for his new economic theory, drawn from Jennings' NE and the work of the English physiological psychologists,[20] with

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[19] Martineau's attack was first published as "Cerebral Physiology: Bain", in the National Review, Vol. X, 1860, pp.500-21. In the same year, that journal published a review article of the Poems and Essays by Jevons' cousin, W. Caldwell Roscoe (1823-59). The text had been edited posthumously by R.H. Hutton, another relative, who had been Principal of Manchester New College in 1852 [Woodfield 1986, p.7]. In July 1861, Jevons' review article on "Light and Sunlight", which had been commissioned by Hutton, was published in the National Review [Jevons 1861a].

[20] One other possible (non-English) influence on Jevons' formulation of the behavioural theory is suggested by Ekelund and Hebert [1975, p.250]. After noting that TPE's utility theory was "at least based ... partially on physiological theory", they argue that "In this connection Jevons specifically noted the Weber - Fechner studies of stimulus and response". No citation is provided to support the argument. I have found one reference by Jevons to "Fechner's law, Wundt's curve of pleasure and pain", but this was in a review of Edgeworth's Mathematical Psychics, where Jevons was citing Edgeworth's sources [Jevons 1881, p.581]. So far as Jevons' early work is concerned, it should be noted that Fechner's Elemente der Psychophysik was only published in 1860 [Boring 1957, Chapter 14]. Stigler [1965, pp.113-115] sketches the subsequent discussion of the Weber-Fechner `law' by economists, while Howey [1960, pp. 95-103] concentrates on Edgeworth, noting that the German work was known in England as `psychophysics' by the late 1870s. Howey suggests that the Weber - Fechner `law' can be considered analogous to marginal utility theory in that both argue that "the responses of the individual decrease in some way as the amount of stimulus increases". However, Howey argues, the two analyses were also quite different because psychophysics was concerned with "sensations associated with weight, distance, tones and the like" which could not be summed, unlike marginal utility. Moreover, psychophysics was concerned with measurement in laboratory experiments, an approach which was "shunned" initially by the marginal utility theorists who appealed instead to "common experience" [Howey 1960, pp.98-9]. Clearly, however, this was not the case for Jevons (see above). The basis for the similarities can be explained by psychophysics being the German variant of physiological psychology. Like its English counterpart, it began in the 1830s with work on reflex actions.

the terms of Martineau's attack.[21] As it turned out, that was not particularly difficult. In general, Jevons was unimpressed by Martineau's arguments, announcing near the end of the lecture series that he remained convinced of "the objective certainty of our knowledge". He was not "sorry" he had attended the lectures, "if only to know what out and out metaphysics is". Nevertheless, he told his brother that he had found the lectures " a great labour", complaining that Martineau "pursues a steady course through the clouds". Moreover, he was highly critical of the lecturer's knowledge of physiological psychology: "When he does become comprehensible he generally goes palpably wrong; thus a few days since he astonished me by asserting that the tactual & muscular feelings are all one - that you cannot feel unless your muscles are in play".[22]

In so far as Martineau's initial criticism had created something of a dilemma for Jevons, his experience was a specific example of the difficulties facing many scientists during that period in dealing with the conflict between `science' and `religion'. By 1870, however, that debate had been absorbed in the discussion of the relation(s) between `mind' and `matter' [Block 1986, p.380]. As was indicated above, Jevons referred to that issue in his Principles of Science, where he argued that science could not disprove the existence of the Creator. This was because of the incompleteness of scientific knowledge in the face of the "infinite ... extent and complexity" of the Universe. While science could posit the existence of various natural laws, knowledge of their causes was incomplete and the Creator's role was thus possible in both the "original conformation of the material universe" and in "sudden and unexpected changes" where the possibility of "sudden catastrophes"

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[21] Jevons seems to have maintained amicable relations with both Bain and Martineau since they provided testimonials for him which he used in his application for the Chair at Owens College in 1866 [Black 1973-81, III, pp.107,111]. Bain was an examiner at University College London when Jevons was a student there in the early 1860s.

[22] Letters to T.E. Jevons, April 4 and 28, 1861, Seton - Jevons Collection, Seton Hall University. In his discussion of the possible theoretical continuities between Bentham, Martineau and Jevons, Professor Black cites the following passage from Martineau's Types of Ethical Theory: "I carried into [my moral and metaphysical speculations] ... a store of exclusively scientific conceptions, rendered familiar in the elementary study of mathematics, mechanics and chemistry" [Martineau 1886, p. viii]. Black [1972, p.124 n. 3] considers this means "Martineau would certainly have appealed to Jevons". However, Martineau went on to point out that, while the above was his initial approach, he had rejected it by the late 1840s. To explain "human phenomena" in terms of "the maxims of mechanical causality" was to take the approach of a "tight-swathed logical prig" [Martineau 1886, pp. ix, x].

could not be precluded [Jevons 1887 (1877), pp.739-41,742,746]. Jevons' position thus seems to have been that it was possible to reconcile the claims of science and religion but analysis of them should be kept quite separate analytically. Such compartmentalisation of `knowledge' and `belief' was a common solution adopted in the disputes of the period.[23]

Conclusions

When J.E. Cairnes assessed Jennings' Natural Elements in 1857, he argued that a political economy based on such "laws of mind" was unnecessary (the basis for human behaviour was known already), too complicated (it required a detailed knowledge of both psychology and physiology) and misleading (a satisfactory political economy could not be based on universal "mental principles"). Cairnes concluded that, if political economy was "to be treated in this way, it is evident that it will soon become a wholly different study from that which the world has hitherto known" [Cairnes 1857, p.181]. The conceptualisation of the domain of political economy was indeed to change dramatically when Jevons appropriated Jennings' analysis in the next decade. By depicting human behaviour in mechanistic functional terms, however, Jevons both inherited and created for political economy a series of analytical problems. In particular, TPE became part of "a silly season", between roughly 1850 and the early 1870's, when "there was a zany intellectual ferment in discussion of determinism and free will" [Hacking 1983, p. 455].[24] Jevons' theory of the economic agent bears all the hallmarks of that `ferment' although his solution was to arbitrarily label the laws of action as voluntary in TPE. In this respect, Jevons provided a striking illustration of Ian Hacking's suggestion that "conceptual incoherence which creates philosophical perplexity is an historical incoherence between prior conditions that made a concept possible, and the concept made possible by those prior conditions" [Hacking 1981, p.17]. It should be noted, however, that Jevons' experience was not unique. For consideration of similar

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[23] For a summary of the various approaches taken by scientists on the question, see Brock and MacLeod 1976, p.59. An earlier statement of Jevons' position can be found in an 1864 letter to Sir John Herschel [Black 1973-81, III, p.60], after Herschel had rejected a request to sign the `Theological Declaration of Scientific Men'. For the Declaration and Herschel's reaction, see ibid. p.60n; Brock and MacLeod 1976, esp. p.47.

[24] See also Hacking 1981. Unfortunately, Hacking does not discuss the work of the English physiological psychologists.

problems flowing from the scientific naturalism associated with physiological psychology can be found also in the early work of that other English marginalist, Alfred Marshall [Raffaelli 1990a and 1990b].

Chapter 5

BRIDGING THE NATURAL AND THE SOCIAL: SCIENCE AND CHARACTER IN JEVONS' POLITICAL ECONOMY[1]

> As human knowledge and civilisation progress, these characteristic differences [in human behaviour] tend to develop and multiply themselves, rather than decrease. Character grows more many sided. Two well educated Englishmen are far better distinguished from each other than two common labourers, and these are better distinguished than two Australian aborigines.
>
> W. Stanley Jevons.

Much attention has been given in recent years to explaining the differences between the basic analytical frameworks of classical political economy and the marginalist supply and demand theories of Jevons and Leon Walras which were published during the 1860s and 1870s. While disagreeing over the precise form of the differences, historians of economics commonly describe the `marginalist revolution' by three interrelated aspects of its analytical domain. As summarised by Winch [1972], these aspects are: the type of problems considered to be within the domain, which effectively defines the theoretical object of `economic science'; the criteria used to designate the domain boundary so as to distinguish between `economic science' and other types of analysis; and, the conceptualisation of economic actors within the domain. More specifically, Winch argues that the theoretical object of marginalism was distinguished by "recognizing scarcity of given means in relation to alternative uses as the economic problem" and explaining this in terms of the "universal application of the laws of human choice". With activity in the domain of the science "explicitly including both material and immaterial goods and services, moral and immoral", its boundary was set by drawing a clear distinction between "pure and applied science" which corresponded to the distinction between positive and normative propositions. Finally, the depiction of economic actors entailed a "thorough going individualism

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... which placed the rational maximizer at the centre of things" [Winch 1972, pp.328,335]. In keeping with this account, Cohen and Cohen [1983, pp.195-197] have argued that, while the concept of social class was a "fundamental aspect" of classical political economy, it was "irrelevant" in marginalism because "individuals form the basic unit of analysis, and individual demand is the driving force of the system. These aspects can be seen most clearly in Jevons's work".[2]

It will be argued here that this characterisation of the economic domain in Jevons' marginalism is misleading and that it erases a number of important differences between his Theory of Political Economy (TPE) and later versions of supply and demand theory. Using the discussion of reduced working hours in TPE to illustrate the analysis, it will be shown that the theoretical object of TPE cannot be reduced to an analysis of 'rational behaviour' per se and that Jevons did not rely on a distinction between positive and normative propositions. Indeed, he argued that the domain of 'economic science' provided the means to advocate or reject particular government policies. Moreover, while there was an important analytical difference between the social individuals of the classical framework and the abstract economic actors of marginalism, references to Jevons' individualism do not explain the significance of the discussion of class and race behaviour which pervades his work.

The chapter is presented in four sections. The first discusses how Jevons specified the domain of 'scientific' political economy with a particular Utilitarian theory of ethics. This enabled him to make a distinction between policy questions which could be decided within the domain and those which could not because they raised questions of ethics and duty. One policy question which fell outside the domain was legislation to reduce working hours and the next two sections show why that was the case. Section 5.2 considers the 'scientific' analysis of work hours in TPE where Jevons explained different work patterns in terms of class and race behaviour. While the general policy stance which Jevons adopted on reduced working hours could be predicted from that account, Section 5.3 identifies the ethical issues raised by the topic which explain why he stopped short

[2] Similar comments have been made by Dobb 1973, p.75; Mazlish 1986, p.142; Paul 1979, p.271; Schabas 1990, p.50; and Walsh and Gram 1980, pp.124-27.

of making an explicit policy recommendation in TPE. Finally, Section 5.4 shows that Jevons linked his marginalist behavioural theory to class and race behaviour by using the Victorian notion of `character' which provided the analytical link between the universal `natural' laws of behaviour of the marginal utility which verified those laws.

5.1 The Domain of Scientific Political Economy

Black [1970, pp.21,37,38] has argued that "questions of economic policy are entirely excluded" from TPE which "carried with it no implications for policy. It was an exercise in what today would be called positive economics, concerned to analyse and not to prescribe, to bring light rather than bear fruit". According to this epistemological framework, an analyst is precluded from making explicit statements for or against a particular policy within a scientific discourse. Regardless of the subject-matter, the boundary between a scientific (neutral) and a non-scientific (value laden) analysis is set by a distinction between `facts' and `value judgements', between a descriptive and an evaluative language. While it can be acknowledged that explicit consideration of policy questions does not play a predominant role in TPE, any attempt to herd that text into the epistemological pound of a `positive' discourse faces substantial problems. So far as direct policy prescription is concerned, it is difficult to reconcile with Jevons' dogmatic pronouncements in favour of a free trade policy [Jevons 1871, pp.134-39; 1970, 88-89,171-74]. Moreover, the implications of the following statements on income distribution seem clear: "the wages of a working man are ultimately coincident with what he produces ... Every labourer ultimately receives the due value of his produce after paying a proper fraction to the capitalist". [ibid, pp.259,262]

If Jevons' approach appears anomalous when read within the categories of the positive/normative dichotomy, the reason is that he was using a different framework of ethics or moral evaluation. As John Davis [1990] has explained, the positive/normative dichotomy used by economists relies on an emotive theory of

ethics which was developed during the 1920s and 1930s.[3] In that account, positive statements or propositions are objective because they can be empirically confirmed or rejected. Normative statements, on the other hand, are "subjective expressions of attitudes used persuasively to affect opinion or belief in a non-cognitive manner" [Davis 1990, p.141]. The advocacy of a particular policy is thus emotive or subjective because it depends on value judgements. Urmson [1968, p.11] has noted that the emotive theory could, therefore, be more accurately termed an "emotive theory of value judgements". By contrast, Jevons was using what G.E. Moore termed a `naturalistic' theory of ethics, where what was good or ethical could be characterised in terms of `sensible' properties of the world and hence could be discussed and identified in empirically meaningful terms. Since this account claimed, in effect, that it did not rely on reports of individuals' intuition or consciousness to designate what was ethical, the terminology and category of value judgement had no place in the analysis. However, if such an account is read within the terms of the emotive theory, it appears as if it is being argued that value judgements can "be scientific, cognitive or descriptive" and hence a "matter of fact" [ibid. pp.12,20].

Jevons' naturalistic analysis of ethics and government legislation was based on a version of Utilitarianism, a doctrine which he regarded [Jevons 1890, p.269] as "the foundation of all moral and legislative progress". His basic approach was sketched in an article, first published in 1879, where he considered aspects of J.S. Mill's Utilitarianism. Jevons criticised Mill's answer to the following question: "Do pleasures differ in quality as well as in quantity? Can a small pleasure of very elevated character outweigh a large amount of pleasure of low quality?" [ibid. p.274]. In criticising Mill, Jevons made clear that he was not "denying the moral superiority of some pleasures and courses of life over others". His objection was rather that, in attempting to assign weights to different `pleasures', Mill had relied on `feelings' or `emotions'. Jevons was apparently referring to those categories

[3] Accounts of the emotive theory at this time have been given by Urmson 1968, chapter 2, and Warnock 1978, chapter 3.

when he rejected Utilitarian arguments based on "the intrinsic superiority of one pleasure to another" [ibid. pp.277,278].[4]

While arguing that Mill had confused "fact and feeling" when explaining the importance of the "difference of high and low" pleasures for theories of ethics and legislation, Jevons relied on Bentham's `model of inquiry' which followed Paley's argument that there was no "difference between pleasures, except in continuance and intensity". All feelings could thus be "reduced to the same denomination of value" (ie. the "quantities or forces" of pleasures and pains), which could be identified by the effects and consequences of any actions [Jevons 1890, pp.276,277,285]. Mill's juxtaposition of quality and quantity was thus both wrong and unnecessary since quality and quantity could be reconciled by measurement. The ethical superiority of a higher pleasure could then be identified in terms of the greatest happiness principle:

> that is, fruitful of pleasure and devoid of evil to great numbers of people. It is a higher pleasure to build a Free Library than to establish a Race Course; not because there is a Free-Library-building emotion, which is essentially better than a Race course-building emotion, each being a simple unanalysable feeling; but because we may, after the model of inquiry given by Bentham, resolve into its elements the effect of one action and the other upon the happiness of the community ... Mill proposed to give `geniality' to the Utilitarian philosophy by throwing into confusion what it was the very merit of Bentham to have distinguished scientifically. We must hold to the dry old Jeremy, if we are to have any chance of progress in Ethics [ibid. p.286].

In sum, Jevons argued that it was possible to distinguish higher pleasures from lower ones and that the distinction could be used for practical purposes because the effects of different pleasures could be quantified. As Peart [1990, pp.286-87] has noted, he could not explain precisely how the different quantities were to be

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[4] I am concerned here with identifying Jevons' argument. Questions of the accuracy of his treatment of Mill are put to one side, although it should be noted that Mill's use of the term `intrinsic' was ambiguous [cf. Mill 1978 (1861), pp.258-59].

measured and weighted. Nor was his critique of Mill particularly original since, as Jevons acknowledged, he was following the path of previous critics [cf. Schneewind 1977, pp.185-86]. However, the discussion of Utilitarianism is important here because it indicates that Jevons thought that it was possible to rank a series of analytical domains, corresponding to different types of `pleasures', in a hierarchy of social importance. It was that argument which was used to specify the domain of scientific political economy in TPE.

For Jevons, "Moral Philosophy" considered "the character of men and the effects of action on their characters" [Black 1973-81, VI, p.8]. When he summarised the relation between political economy and moral philosophy or "ethics" in TPE, Jevons [1871, pp.27-32; 1970, 91-93] made clear that he accepted the (tautological) Utilitarian proposition that all human behaviour was driven by the `forces' of pleasure and pain: "Call any motive which attracts to a certain action pleasure, and that which deters pain, and it becomes impossible to deny that all actions are prompted by pleasure or by pain". Those forces "form the ultimate quantities to be treated in all the moral sciences" such as political economy. Nevertheless, it was crucial to delineate a `hierarchy of feeling' because feelings were of `different grades'. The "mere physical pleasures or pain arising from . . . bodily wants and susceptibilities" should be contrasted with "mental and moral feelings of several degrees of elevation". It was quite possible that a person would not be driven solely by feelings of a `gross kind' because a "higher motive may rightly overbalance all considerations belonging even to the next lower range of feelings" [Jevons 1871, pp.27-31].

Using the quotations from Bentham and Paley which appeared subsequently in his Contemporary Review article, Jevons [1871, p.29] linked Bentham's discussion of pleasure and pain with Paley's dictum that "pleasures differ in nothing but in continuity and intensity". But Jevons made clear here that, in taking explicit account of the higher pleasures, he disagreed with Paley: "It seems hardly possible to admit Paley's statement, except with an interpretation that would probably reverse his original meaning. Motives and feelings are certainly of the same kind to the extent that we are able to weigh them against each other; but they are, nevertheless, almost incomparable in power and authority" [ibid.

pp.31-32]. This argument was used to specify the domain of the `science of Economy' which dealt only with "the lowest rank of feelings". The economic "calculus of utility aims at supplying the ordinary wants of man at the least cost of labour. Each labourer, in the absence of other motives, is supposed to devote his energy to the accumulation of wealth". Within this domain, where `a man' sought to "earn sufficient food and whatever else may best satisfy his proper and moderate desires", it was possible to ignore any issues raised by the "higher calculus of right and wrong". This meant that the discourse could not explain all human actions, for people would not necessarily behave according to the dictates of the lower calculus. Questions of duty, for example, could mean that it was "desirable that [`a man'] should deny his own desires and even his physical needs their customary gratification" [ibid. pp.30,32].

The distinction between the discourses of political economy and moral philosophy enabled Jevons to make explicit statements on some policy issues in TPE. Provided that a policy question could be examined simply in terms of its effects on the accumulation of wealth, a policy recommendation could be made within a scientific analysis. Such was the case for free trade. If, however, the policy involved ethical issues, such as feelings of "justice or kindliness" which were "motives altogether extraneous to a theory of Economy" [Jevons 1871, p.124], it fell outside the domain because it had to be discussed with reference to the `higher calculus of moral right and wrong'.[5]

In the closing pages of TPE, Jevons described the theoretical object of the marginalist project by defining the "problem of Economy" as follows: "Given, a certain population, with various needs and powers of production, in possession of certain lands and other sources of material: required, the mode of employing their labour so as to maximise the utility of the produce" [Jevons 1871, p.255]. This domain, which focussed on the maximisation of "material welfare" [ibid. p.262], was quite different to that encapsulated in Lionel Robbins' subsequent argument [1947 (1935), p.16] that economics was "the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses". Here, the focus was on a theory of human behaviour in

[5] For a similar, though not identical, argument see Mill 1974, pp.139-40.

general, where the economist was agnostic as between `ends'. Within that domain, a tradeoff between the pursuit of pleasure and the fulfilment of duty became an economic decision [cf. ibid. pp.17,25]. While Jevons' discussion of political economy in TPE can be characterised as a type of constrained maximization, it is important to recognise that, because of the way he designated the domain, its analytical focus was restricted to the maximization of utility arising from the satisfaction of the `lower pleasures' in material welfare. For Jevons, then, economics was not a theory of rational behaviour per se.

Some further ramifications of this difference can be illustrated by Jevons' discussion in TPE of reduced working hours. There was a "general and comprehensive reduction" in hours worked in England between 1862-74. With the 1870 Factory Act setting a `normal' working week of 60 hours (less for textile factories), the reduction occurred mainly in the boom years of 1871-73, although pressure for change began in 1870 as the economy moved into an upturn of the trade cycle [Bienefeld 1972, pp.82-83,106-107]. It was in that context that Jevons, who took a keen interest in labour and trade union issues and who had publicly argued against the reduction of work hours for adult males in 1868 (see below), discussed the issue in Chapter V of TPE [Jevons 1871, pp.174-81]. The analysis illustrates how Jevons considered a question of economic `science' where it was necessary to distinguish the behaviour of different groups in the economy. It shows also that, while he produced a marginalist explanation for the "general tendency to reduce the hours of labour at the present day" [ibid. p.176], Jevons did not discuss explicitly work hours legislation in TPE because it involved consideration of leisure time, a subject which fell outside the domain of economic `science'.

5.2 Working Hours: The `Scientific' Analysis

Jevons [1970, p.90] described the marginalist theory as "the mechanics of utility and self interest". Two steps were required in using this designation of human action to explain `actual' events. The first was to claim that the theory was based on `natural' laws of economic behaviour which were "universally true as regards human nature". Hence the theory could be used to analyse activity in any type of economy: "the laws of political economy treat of the relations between human

wants and the available natural objects and human labour by which they may be satisfied. These laws are so simple in their foundation that they would apply, more or less completely, to all human beings of whom we have any knowledge" [Jevons 1905, pp.196,197].

The second step was to acknowledge that the laws would not become manifest in precisely the same way in all situations, so that they "may receive widely different applications in the concrete" [ibid. p.198]. As Jevons [1871, pp.22-23] explained in TPE, not all economic actors would behave in exactly the way that the theory required. Because of the vagaries of individual behaviour, "it is quite impossible to detect the operation of general laws ... in the actions of one or a few individuals". Nevertheless, a "regular law" could be observed in average behaviour because there was a "high direction as the other, so as to neutralise each other ... [Q]uestions which appear ... indeterminate as regards individuals, may be capable of exact investigation and solution in regard to great masses and wide averages". This argument, that `accidental and disturbing causes' of human behaviour would `neutralise' each other, was based on A.J. Quetelet's concept of l'homme moyen which argued that human behaviour was normally distributed.[6]

Strictly speaking, then, Jevons' analysis was not concerned with individuals per se. The laws of supply and demand which applied to average transactions would not represent the behaviour of any particular "individual" unless all the actors in the market were of a "perfectly uniform character". While the theory "presumes to investigate the condition of a mind, and bases upon this investigation the whole of Political Economy", so that the "general form of the laws of Economy is the same in the case of individuals and nations", this was the case only in the aggregate and for an average actor [Jevons 1871, pp.21,90]. Hence it was necessary to introduce statistics or other observations on the average behaviour of particular groups in the economy which could then be used to verify the theory. The analysis of work hours in TPE illustrates this procedure.

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[6] Porter 1985 and 1986 has provided a clear account of the importance of Quételet at that time.

To explain the determination of work hours, Jevons first considered the `universal' relation between wants and human labour. A person would work until the increasing marginal disutility of pain or effort was considered equal to the declining marginal utility of successive units of commodities obtained from working. At the "cease" or equilibrium position, "what he produces must be considered ... the exact equivalent of what he gives for it", although before that point the labourer received "an excess of utility" and thus made a net gain from working [Jevons 1871, pp.166-69,173].[7] Figure 1 shows Jevons' diagram of the work decision as it appears in Chapter V of TPE, with the addition of the dashed curve *ab'c'd'* which is explained below. The diagram represents the work decision for a "free labourer" producing and consuming the output, or exchanging the latter for another consumption good [ibid., pp.168,172]. Labour is the only input directly accounted for in production. Marginal utility and disutility are indicated on the vertical axis. Marginal utility from consuming the output is represented along *pq*, with marginal utility and disutility from work represented along *abcd*. The initial equilibrium point is at *m*, where the vertical distance from *m* to *q* is the same as the distance from *m* to *d*.

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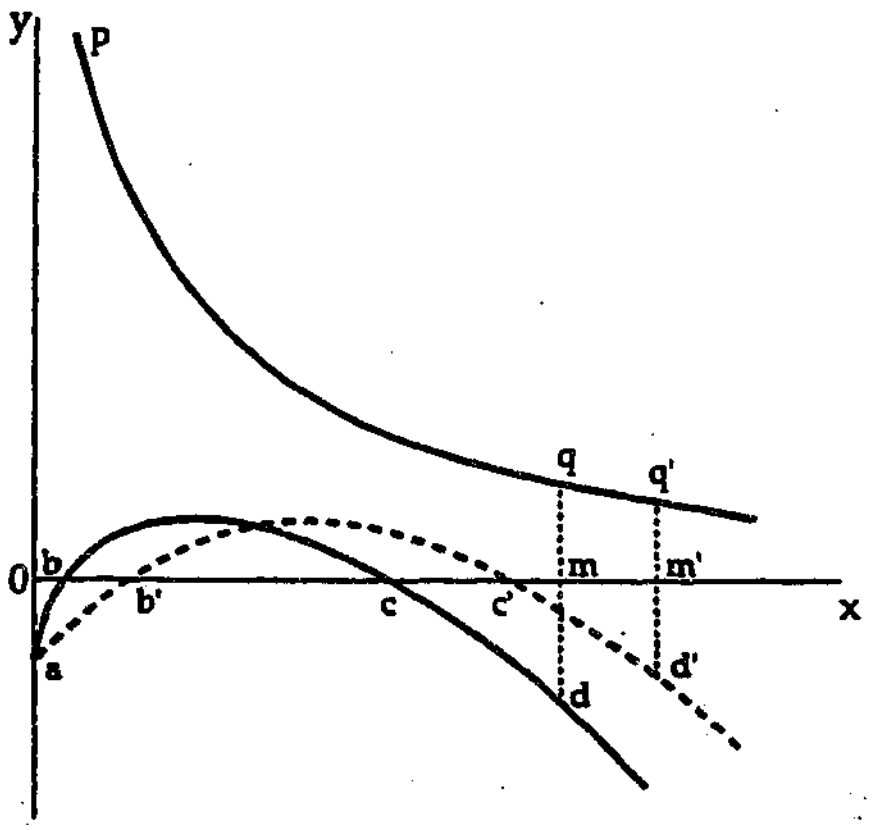
[7] Jevons claimed that, like all other economic activity in TPE, the work decision was a `voluntary' act of `free exchange'. This required the existence condition that economic actors had a source of subsistence apart from market income, an issue which has been discussed by McPherson 1973, pp.145-47; Walsh and Gram 1980, pp.175,247; and Rizvi 1991.

Figure 1



Jevons [1877, p.169] described points on Ox as "represent[ing] the amount of produce or the day's wages". Since the real wage is assumed to be equal to the marginal product of labour, an evenly calibrated scale along the horizontal axis implies that the marginal product of labour is constant, and equal to the average product of labour. While Jevons acknowledged that the "rate of production" could be "uniform or variable", he argued that constant marginal productivity applied in "many cases", such as industries using "machine labour". He explained also that the "variation of produce will be treated in the next chapter", which depicted ground rent as the result of diminishing returns [ibid. pp.171,173,166]. When the assumption of constant marginal productivity is coupled with the further assumption that the real wage rate reflects the marginal productivity of labour, a unit along *Ox* will represent simultaneously the incremental amount of effort (in terms of output equivalents), marginal labour productivity, and the real return to labour per unit of time.

As will be explained below, Jevons argued that, with increases in labour productivity and real wage rates, English workers reduced their work hours because they preferred "greater ease to greater wealth". In that particular case, "the degree of utility varies more rapidly than the degree of painfulness of labour"

[Jevons 1871, p.176]. Compared with Figure 1, this argument assumes that the slope of the marginal utility consumption curve is much greater than that of the labour disutility curve in the neighbourhood of equilibrium. The diagram, however, is not well suited for representing Jevons' discussion of a reduction in hours of work following an increase in labour productivity and the wage rate. A proportionate productivity increase for each unit of effort can be represented by a shift to the right of the disutility curve to *ab'c'd'*, with a new equilibrium point at *m'*. Each unit of effort now corresponds to a higher point of marginal productivity. Real income and consumption have increased as indicated by a movement along the consumption utility curve to *q'*. The reduction in hours of work is indicated by the new equilibrium position corresponding to a point of less marginal disutility than before (*d'* cf. *d*). The diagram is thus rather clumsy in that the reduction in hours is not shown clearly. The problem now, however, is that along *Ox*, with the same scale, there can no longer be a monotonic identity between units of labour effort (in terms of output equivalents) and the real return to labour. That Jevons subsequently recognised, but did not directly acknowledge, this problem is suggested in the second edition of TPE, where he simply described *Ox* as indicating the "amount of produce" and omitted the reference to the wage rate [Jevons 1970, p.191].[8] It should be noted also that, although Jevons' references to wages and machine labour indicate that he considered his analysis could be generalized to explain factory working hours in a capitalist economy, this claim cannot be sustained. Since the marginal disutility curve intersects the vertical axis, marginal and average labour productivity are equal at all points along *Ox*. If, as Jevons assumed, the wage rate is equal to marginal labour productivity, the labourers receive the average product so that there can be no non-labour income to be distributed. The system cannot be viable so that the analysis is incoherent once it is taken beyond the free labourer case. Analogous to his capital theory discussed by Steedman [1972], Jevons' representation of changes in work hours was restricted to a special case.

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[8] Alternatively, the reduction in hours could be depicted by shifting the marginal consumption utility curve down to the left, with the new equilibrium point to the left of *m*. The problem remains, however, in that the same scale along *Ox* can no longer represent the relationship between units of labour effort on the one hand, and marginal productivity and the real return to labour on the other.

Jevons did acknowledge that the theory could not predict an unambiguous outcome following an increase in the real wage rate proportionate to an increase in labour productivity. While there would be a tendency to increased hours of work, the opposite effect could occur if the "irksomeness of labour" had reached a "high point". Since the theory could not predict a determinate result, a `few facts' would show which effect would dominate [Jevons 1871, p.175]. One possible source of `facts' in this regard followed from Jevons' argument that it would be possible to undertake experiments on muscular effort and fatigue so as to calculate how much time workers required to "recover all fatigue" and recommence work with an "undiminished store of energy". This was particularly important in industry where there was "regular and constant employment" [ibid. pp.173,197]. It might then be expected that he would explain the contemporary reduction in work hours as the result of the increasing intensity of work. That, however, was not the case. For Jevons introduced a set of `facts' which consisted of some observations on the work patterns of different groups. In part, this necessitated reference to racial characteristics:

> It is evident that questions of this kind will depend greatly upon the character of the race. Persons of an energetic disposition feel labour less painful than they otherwise would, and, if they happen to be endowed with various and acute sensibilities, their desire of further acquisition never ceases. A man of lower race, a negro for instance, enjoys possession less, and loathes labour more; his exertions, therefore, soon stop. A poor savage would be content to gather the almost gratuitous fruits of nature, if they were sufficient to give sustenance; it is only physical want that drives him to exertion [ibid. pp.177-78].

To a significant extent, though to a lesser degree, it was a similar behavioural characteristic of English labourers, artisans, and white-collar employees which explained the "general tendency to reduce the hours of labour at the present day". Jevons considered that those workers aimed for a target standard of living ("the necessaries of life") and that, once it was achieved and with real wages rising over time, they preferred greater "ease" to the effort involved in obtaining greater wealth by working the same hours as before. This was particularly important for

those in mercantile offices with their "increased comfort and opulence".[9] There were, however, important exceptions to the general trend. The "learned professions" (solicitors, barristers, physicians, architects, engineers), for instance, generally worked "more severely" as their income increased. Indeed, the "rich man in modern society is supplied apparently with all he can desire, and yet he labours unceasingly for more" [Jevons 1871, pp.176-78]. Although Jevons acknowledged that this was partly because the professionals' work was "more interesting and exciting", by explaining reduced work hours in terms of a preference for `greater ease over greater wealth' and by equating those who `loathe labour' with members of a `lower race', his `scientific' analysis was loaded with a particular rhetoric of race and character.

5.3 Working Hours: The Policy Analysis

Nyland [1986, p.527] has suggested that Jevons' analysis "contains all the essential elements e contemporary marginalist theory of worktime" by effectively distinguishing between the substitution and income effects of a change in the real wage rate.[10] There were, however, important differences between TPE and the version of supply and demand theory published during the 1930s[11] because there was no concept of an opportunity cost of leisure in TPE, so that there could be no identification of a substitution effect. Leisure was not treated as if it was another commodity and hence considered as being within the domain boundary of political economy. The ways in which leisure time was used could affect the economy. However, because these effects raised questions of duty or morals, they could not be considered within the domain of economic science. This was made clear when Jevons discussed legislation to control working hours.

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[9] This statement is rather ambiguous if it is to be represented by a neoclassical labour market diagram. It might correspond to a rectangular hyperbola labour supply curve, although Jevons' discussion seems more consistent with a backward-sloping supply curve as analysed by Vatter [1961; 1962].

[10] See also Nyland 1989, chapter 1; Kerton 1971, p.227n; Black 1970, p.24, and 1987, p.1010.

[11] See Morgan 1981, pp.108-15 for a useful summary.

Although Jevons assumed constant marginal labour productivity when discussing the work decision by a `free labourer' in TPE (see above), he acknowledged that the assumption might require some modification: "the last two hours of work in the day may give less reward, both because less produce is then created, and because that produce is less necessary and useful to one who makes enough to support himself in the other ten hours" [Jevons 1871, p.172]. Jevons had used a similar argument when he addressed the Manchester Trades Unionists' Political Association in 1868. He noted that reducing the work day from twelve to ten hours could lead to an increase in labour productivity because "the workman is fresher and more careful". The increase in productivity, however, would not be sufficient to produce the same total output as before. Unionists should, therefore, argue for reduced hours only if they were prepared to accept a decline in total money wages commensurate with the decline in production and total revenue. But even this measure was not completely acceptable. The "working-classes" should "abstain" from agitation for an Eight Hours Bill until legislation was adopted for restricting the employment of children and for compulsory education [Jevons 1883, pp.106-10]. Duty to their children should thus override adult males' pursuit of self-interest through the reduction of work time.

Jevons made clear why this analysis could not be included within TPE when he discussed the domain of the science: "Each labourer, in the absence of other motives, is supposed to devote his energy to the accumulation of wealth" [Jevons 1871, p.32]. However, this was not to claim that other considerations from the "higher calculus of right and wrong" were irrelevant within a broader domain:

> it is a man's duty, as it is his natural inclination, to earn sufficient food and whatever else may best satisfy his proper and moderate desires. If the claims of a family or friends fall upon him, it may be desirable that he should deny his own desires and even his physical needs their customary gratification. But the claims of a family are only a step to a higher grade of duties [ibid. p.30].

Hence, the question of legislation to control male work hours could not be considered within the domain of TPE.

Although the requisite legislation for compulsory schooling was in place by 1871, Jevons continued to criticise reductions in male labourers' work hours and to oppose any legislation in that regard. In The State In Relation To Labour, for example, he argued that there was "no ground whatever" for legislation to limit the work hours of adult male labour. This was because of the loss of production and because it was "an economic fallacy" to argue that there were any positive counter-balancing effects, "except of course the recreative, sanitary or intellectual advantages (if any) to the workman from his enjoyment of more leisure time" [Jevons 1882a, p.66].

Jevons' explanation and evaluation of legislation for reduced working hours hinged on his view that, in general, the working classes `preferred' leisure to the accumulation of wealth and used their `high' wages and leisure time in a wasteful or destructive fashion. So far as the waste of wages was concerned, Jevons argued in 1869 and 1870 that most poverty was due to lack of education and thrift as well as intemperance. Although the "poorer classes" were supplied with "easily earned wealth", they remained "too ignorant, careless, improvident or vicious, to appreciate or accumulate the wealth which science brings". Any further increase in the real wages of the "working classes" through remittance of their taxation would thus be wasted because it would be spent merely on a "higher scale of living ... It is only with an increase of education and temperance, that the increase of wages will prove a solid advantage" [Jevons 1883, pp.196-200,205-6]. A similar argument was used in The Coal Question where Jevons referred [1865, pp.339-43; 1866a, xiix] to increased working class consumption as "luxury, ostentation and corruption".

So far as the use of leisure was concerned, Jevons explained in 1878 that when "our English masses try to amuse themselves, they do it in such a clumsy and vulgar way as to disgust one with the very name of amusement". Instead of attending libraries, reading rooms and concerts, they drank to excess and frequented music-halls, "a nightly exhibition of all that is degraded in taste". There were even problems with uplifting public concerts, which required the presence of the "upper and middle classes" to "raise their tone" and of the police

to banish the "demi-monde": "Why should we continue the perverse and legislatively insane practice of allowing our most public places to be turned into the markets of vice? Why do we tolerate a state of things under which a young man cannot seek an hour's recreation without meeting an evil magnet at every turn?" [Jevons 1883, pp.4,24-25].

Jevons continued this theme in early 1882 when he argued that women with children under three years of age and who were working in factories and workshops should ultimately be forced back into the home because their absence resulted in "shocking infantile mortality ... much immorality and intemperance not unnaturally produced by the destruction of home influences" [Jevons 1882a, pp.74-5]. The intemperance followed because males reduced their work hours and spent the time drinking away the increase in the family income. Hence it would be a positive social benefit to reduce such family incomes by preventing mothers with young children from working outside the home. As Jevons explained in a letter to the Manchester Guardian, it "is easy to declaim about the poverty of the people", but "facts" revealed that lower earnings corresponded to "healthy children and less drunkenness. The inference is that high wages are not conducive to the good of a certain part of the manufacturing population while their state of civilisation is of its present standard" [Black 1973 81, V, p.166].[12]

Jevons' discussion of reduced work hours illustrates the way in which he linked the universal/natural behavioural laws and their `concrete application'.[13] At the same time, it illustrates how he distinguished between the domains of scientific political economy and moral philosophy, or `ethics'. An explicit policy statement on hours of work was omitted from TPE because it involved questions which had

[12] See White 1994a for detailed discussion of this argument.

[13] As Wisman 1989 has explained, the claim that the behavioural premises of the marginalist explanation of work time were `natural' and thus universally applicable was an historical fantasy. When he referred to the work decision in an agricultural economy in Chapter VI of TPE, Jevons argued [1871, pp.201-10] that hours worked would be the same, regardless of whether the labourers or landlords owned the land. Even within the terms of a supply and demand theory, Prieser 1971 shows that this attempt to efface the effects of property relations so as to establish a `natural' result was unsuccessful.

to be analysed in terms of 'the higher calculus'. This was indicated by the way in which Jevons focussed on a labourer's duty to his family when delineating actions which could and could not be included within a strict scientific analysis. For it was partly by referring to labourers' duties that Jevons elsewhere opposed the regulation of hours for adult males. While Jevons' 'scientific' analysis used the categories of race and class, it should be noted that TPE was also a gendered discourse. For he clearly assumed that it was the male who made the labour supply decisions in working class households.

5.4 Class, Race and Character

To the extent that "social structure" and "culture" are considered in neoclassical explanations of labour markets, Friedman [1984, p.178] has noted, they are depicted as "factors that condition utility functions or the options open to individual endeavour". Despite the differences between Jevons and later neoclassical theorists, the basis for this analytical representation can be found in TPE, where supposed differences in class and race behaviour were effectively represented by utility functions with different slopes so as to explain how the 'natural' laws of action became manifest in social behaviour. What needs to be explained, however, is the way in which Jevons linked the universal behavioural laws of the marginalist theory with the categories of race and class.

Because of its subject-matter, TPE identified classes in terms of their roles in a rudimentary (Smithian) social division of labour. (Labourers supplied labour, capitalists invested capital and landowners received ground rent). Apart from this, however, the discussion of classes had little to do with the places which actors occupied in the system of commodity production and distribution. Instead, like races, classes were identified principally in terms of their behaviour, which was characterized and evaluated by the Victorian yardstick of 'civilised' actions. It was this term (rather than 'rational') which Jevons used to describe utility-maximising behaviour in TPE. Hence, he referred to his exchange equations applying "in a civilized country", arguing that, in a "state of civilization", behaviour pivoted on the application of "intelligence and foresight" and hence the ability to reason in particular ways [Jevons 1871, pp.40,41,132]. For Jevons, the clearest

manifestation of civilised behaviour in political economy concerned the foresight necessary for the accumulation of wealth through work and saving. There was some "natural relation" lying behind wealth accumulation which meant that civilised behaviour would differ:

> according to the circumstances, according to the intellectual standing of the race, or the character of the individual ... That class or race of men who have the most foresight will work most for the future. The untutored savage is wholly occupied with the troubles of the moment; the morrow is dimly felt; the limit of his horizon is but a few days off. The wants of a future year, or of a lifetime, are wholly unforseen. But, in a state of civilisation, a vague though powerful feeling of the future is the main incentive to industry and saving [ibid. pp.41-42].

As Jevons's discussion of reduced working hours indicates, the civilised professional was able to calculate, work and save so as to accumulate for the future. However, that was not the case for the `untutored savage', nor for a significant section of the English working class.

The explanation for these different types of behaviour drew on the prevalent Victorian language of `character'. Collini [1980, p.217] has explained that prominent Liberals of the 1860s, such as Leslie Stephen, Henry Sidgwick and John Morley, "perceived the behaviour of different social groups through the same grid in terms of which they judged the moral capacity of the individual". Although this analysis of human `dispositions' and `moral qualities' could take a number of forms, it hinged on the approval of behaviour which `restrained the impulses' towards "random", "feckless" or `impulsive' actions. Such manifestations of the `lower self' or habitual behaviour had to be controlled by the exercise of the will, so as to produce self restraint, perseverance, strenuous effort and courage in the face of adversity [Collini 1985, pp.33-34; 1991, pp.97-100]. The language of character could thus become part of "the protest against the politics of patronage", part of "a wider reaction against the alleged vices and indulgences of the territorial aristocracy, especially in their metropolitan form" [Collini 1991, p.106; see Jevons 1862d]. As Curtis [1968, p.53] has shown, the same language

could be used to differentiate race behaviour as, for example, between Anglo-Saxons and Irish Celts. The former were mature, able to exercise self-control, energetic, civilised (or rational) and clean. By contrast, the Irish were child-like, emotionally unstable, lazy, superstitious, primitive and dirty. Jevons used this frame of reference when he claimed [1883, pp.213-16] that the excessive mortality rates of large cities such as Liverpool could be explained in large part by their high proportion of Irish inhabitants.[14]

In a helpful discussion of the importance of character in Alfred Marshall's early writings, Rafaelli [1990b] has noted that the principal role for character in political economy was in the perception of time which was attributed to different classes and races. It was made "explicit, precise and quasi-measurable, at least theoretically" in the act of saving. Because it indicated foresight, saving could then become a 'test' of character as Jevons explained in TPE (see above). Rafaelli suggests also that other aspects of Marshall's early manuscripts indicate the importance of character as represented by the time perspective. For example, by facilitating personal saving, the banks were "the chief trainer of ... [working class] character" for Marshall. His support for teetotalism, or at least a marked degree of temperance, can also be explained in this framework because temperance necessitated the sacrifice of immediate for future pleasures [Rafaelli 1990, pp.42-43]. Similarly, the use of libraries involved the anticipation of future benefits through study time. As was indicated in Section 5.3 similar arguments can be found in Jevons's analysis of the necessity to change the character of working class behaviour by redirecting the uses made of leisure time. This required compulsory education for children, legislation to control intemperance and the public provision of concerts, libraries, reading rooms, museums and savings banks. Just as Post Office savings banks were an 'engine' for teaching thrift (and hence for reducing gambling and drinking), public libraries would endow the poor with the virtues of "civilization" through their reading "high class literature", which would complement the work of the schools. Libraries were thus to be "classed with town-halls, police-courts, prisons and poor-houses as necessary adjuncts of our state of civilization" [Jevons 1883, pp.28,32].

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[14] See White 1994a and 1994c for analysis of this and other references by Jevons to Irish and English mortality statistics.

It must be emphasised, however, that, for Jevons, much of this policy analysis fell outside the domain of the science of political economy because it involved questions of ethics and duty. Within the language of character, a distinction was made between two types of `selfish' actions - those which involved the pursuit of a person's self interest (as in political economy) and those which harmed others or neglected obligations and duties. To a significant extent, that "polarity" of actions was regarded as "exhaustive of the moral possibilities" [Collini 1991, p.66]. It was Jevons's resolution of that polarity with a Utilitarian theory of ethics which enabled him to both discuss and separate the effects of character in different discursive domains.

Conclusions

Jevons's apparently puzzling treatment of legislative policies in TPE can be resolved once it is recognised that his domain of scientific analysis was quite different from that specified by later versions of supply and demand economics. Inscribed within a `naturalistic' Utilitarian theory of ethics, Jevons's domain boundary was determined by the theoretical object of the discourse and not by the value judgements of the analyst. The representation of behaviour within the domain was quite different also because of the way that Jevons linked the representative actor of the marginalist theory with class and race behaviour. While classes were identified by their place in the social division of labour, their actions were explained in terms of their character, where the yardstick for evaluation was the civilised middle-class of Victorian England.

Although the language of civilisation and character can be found in virtually all aspects of Jevons' work, its role and relevance has not been explored by historians of economics. Harrod provided a possible and partial explanation for this when recounting the story of a student who refused to read the "drivel" of Marshall's Principles. It "was not the economic aspects with which he was quarrelling, but the background of Victorian morality" so that "other means" had to be found for the student to "acquire economic wisdom". By contrast, Harrod

suggested, an "economic student, who gets to know Marshall's economic writings well, soon becomes unconscious of their intensely Victorian moral outlook" [Harrod 1972, p.136n]. Such filtering would presumably apply to Marshall's discussion of the relationship between race and effort (referred to by Levitt [1976, p.436]) and of working class character (considered by Reisman [1986, pp.30-33]) which were similar to, though not identical with, that of Jevons'. As was shown above, however, the `Victorian morality' was not simply an embarrassing dross which can be separated from the `pure' economics of TPE. For it was precisely because Jevons worked with a series of analytical levels, moving from the `natural' laws of the utility theory to their `concrete' manifestation in social behaviour, that it was necessary for him to refer to the language of character to describe class and race behaviour. Without that language, he could not explain how the marginalist theory could be used to assess a number of issues which were important in `the present day'.

Chapter 6

IN THE LOBBY OF THE ENERGY HOTEL: JEVONS' FORMULATION OF THE POST-CLASSICAL ECONOMIC PROBLEM

In the closing chapter of the first edition of his Theory of Political Economy (TPE), Jevons argued that, within the terms of his marginalist theory of value and distribution, the "great problem of Economy" could be summarised as follows: "Given, a certain population, with various needs and powers of production, in possession of certain lands and other sources of material: required, the mode of employing their labour so as to maximise the utility of the produce" [Jevons 1871, p.254].[1] Historians of economics have noted that this summary marked an analytical break with the work of his predecessors, such as John Stuart Mill and John Elliott Cairnes, in two ways. The first was to remove the (Malthusian) "doctrine of population" from the domain of a theory of value and distribution. Although Jevons did not "in the least doubt its truth and vast importance", the doctrine was "conspicuously absent" from TPE because "it forms no part of the direct problem of Economy". Population size, like the quantity of natural resources and capital, was simply a parameter because "we originally start with labour as the first element of production, and aim at the most economical employment of that labour" [ibid. p.255].[2] The second aspect of the break, it has been suggested, was that "[f]or the first time, economics truly became the science that studies the relation between given ends and given scarce means that have alternative uses for the achievement of those ends" [Blaug 1997, p.278; see also Winch 1972, pp.328,335.]. The summary is thus depicted as inaugurating the analytical framework of marginalism or post-classical economics which Lionel Robbins subsequently characterised as the science of "Modern Economics" [Robbins 1949 (1935), pp.2,16]. Given the historical importance of Jevons' summary, the principal purpose of this chapter is to explain how it came to be produced and its significance for understanding the analysis in TPE. It will be shown that the summary served as an index of Jevons' attempts to situate political economy in terms of contemporary debates in physics (or `natural philosophy') regarding the

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[1] The statement was basically unchanged in the second edition although `economics' was substituted for `economy' [Jevons 1970, p.254].

[2] The second edition of Cairnes' Character and Method of Political Economy, published after TPE, made clear that for Cairnes, as for Mill, the `principles of population' were an integral component of the domain of a theory of value and distribution [Cairnes 1875, p.73].

conservation of force or, subsequently, energy. Since the resources for the formulation of the summary became available to him when writing the two editions of The Coal Question (CQ) which were published during his lifetime [Jevons 1865; 1866a], the chapter shows how Jevons reworked his first version of the marginalist theory, the "Brief Account" of 1862 [Jevons 1866b (1862)], to produce TPE in 1871.

The analysis has a thematic congruity with Philip Mirowski's argument in More Heat than Light that the genesis of post-classical economic theory can be found in the production of the conservation of energy framework after the mid-nineteenth century [Mirowski 1989, chs.5-6]. Indeed, Jevons' summary of his program neatly combines variants of the `conservation' and `variational' principles that Mirowski uses to structure his account.[3] It is, however, difficult to register this from the discussion in More Heat for two reasons. The first is a matter of omission. Mirowski makes no mention of Jevons' summary and hence the terms in which he referred to the `conservation' and `variational' principles. The second is a problem of commission. Mirowski argues that Jevons was a poor mathematician and had a deficient understanding of energy physics. Hence there was little in the formal analysis of TPE which can be compared with Mirowski's `canonical neoclassical model' which is used to show the `full implications' for post-classical economic theory of adopting the energy framework [Mirowski 1989, pp.222-41]. If that `model' has been criticised as a Whig construction [Wise 1992], it is now clear that, in the mid-1860s, which is the relevant period for assessing Jevons' `conversion', there was no accepted framework that he could appropriate. Physicists and others were deeply divided as to the meaning and representation of the new conservation principle(s). Indeed, for a number of Jevons' sources, focussing on the interrelationship between chemistry and physiology, a conservation principle was, initially at least, a subsidiary concern. Regardless of what we now make of Jevons' analytical abilities, his arguments need to placed in the rather confusing set of arguments on conservation principles in the early to mid-1860s. Despite a number of important qualifications in Mirowski's story, his

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[3] A conservation principle: "the rule that some particular aspect of a phenomenon remains invariant or unaltered while the greater phenomenon undergoes certain specified transformations". A variational principle: "an analytical method whereby, given a situation where some quantity or function is conserved, the description of the physical outcome is expressed mathematically by finding the maximum or minimum of a function of the conserved quantity" [Mirowski 1989, pp.5,17]. As Mirowski stresses, however, Jevons did not produce a mathematical formulation of these arguments.

canonical neoclassical model obscures an understanding of the ways in which Jevons thought about conservation principles.

The analysis in this chapter is presented in five sections. The first considers the place of Jevons' summary and its relation to the arguments in TPE, showing that the summary was closely connected with Jevons' analysis of labour and the specification of a long-period equilibrium position in Chapter V. In equilibrium, commodities would exchange in direct proportion to their marginal utility and cost of production ratios. Jevons defined cost of production in terms of labour costs alone, which was consistent with his reference, when summarising the program, to privileging labour as `the first element of production'. As shown in Section 6.2, however, the organisation of the argument in TPE was quite different to that in the Brief Account. To formulate the summary of the program required different organising principles from those used in 1862. Jevons had produced the Brief Account by depicting economic actors as machines; a representative actor in the theory behaved like a balance in mechanics. Behaviour, including that of labour, was thus made equivalent to a `force' such as gravity. By the time that TPE was written, however, Jevons claimed that an `indefinitely small' increment of pleasure or pain was analogous to an `indefinitely small amount of energy' [Jevons 1871, p.viii]. This reflected a significant change in his approach in that he now regarded his analysis as consistent with the general theoretical framework of the conservation of energy. In providing a theoretical binding for the original analysis, a conservation principle also provided the means for Jevons to formulate the summary which appeared in TPE.

As is shown in Section 6.3, those crucial changes took some time to work through. It is evident that when Jevons began writing CQ in 1864, he was familiar with, and indeed argued that his analysis depended on, the principle of the conservation of force. By early 1866, however, he had been convinced that this was the same framework as the conservation of energy. The analysis in this section also provides a context for examining the materials Jevons used to formulate the summary of his marginalist program. There is no evidence that he had formulated the summary when the Brief Account was written in 1862. Section 6.4 shows how the process of formulation began in early 1864 and that the material which provided the nub of the summary can be traced to a discussion of the conservation of force he used when writing CQ. In that framework, the human body was represented as a steam engine and the least action principle, long familiar in mechanics, was now applied to human behaviour. Modern or 'civilised'

behaviour was characterised as the use of given means to produce a maximum of force or power, with a concomitant minimisation of wasted power. The process of reworking the initial analysis of 1862, which enabled Jevons to formulate the summary of the program in 1871, was thus critically dependent on his interactions with developments in natural philosophy. Section 6.5 further demonstrates the importance of that context by showing how Jevons subsequently explained the privileging of labour in the TPE summary by referring to the conservation of energy.

6.1 The Summary and TPE

The relation between Jevons' concluding statement of 'the problem of Economy' and the preceding analysis in TPE can be shown by briefly considering the ordering of the argument in that text. After a defence of Jevons' general approach in the Introduction, chapter II set out the explanation of behaviour in terms of the utilitarian calculus of the maximisation of pleasure and the avoidance of pain. Chapter III then discussed the marginal utility theory of consumption, which provided the basis for the next chapter's discussion of trading in a market period, where the stock of commodities was given. With a uniform price ratio at any 'moment', the basic equilibrium condition entailed that commodities would exchange in (inverse) proportion to the ratio of their final degrees of utility. Chapter V then considered a long-period equilibrium position, toward which prices would tend in consecutive market-periods with changes in production levels, where the price ratio was directly proportional to the cost of production ratio. Labour was the only production input explicitly considered, although it is evident that the labourers were working with a stock of raw materials. The cost of production for each commodity was equal to the inverse of the marginal product of labour multiplied by a given uniform wage rate and was thus defined in terms of unit labour costs alone [Jevons 1970, pp.203-5]. Having set out his theory of value and cost of production, Jevons turned to the long-period theory of distribution, consisting of rent which was price-determined (VI), a uniform interest rate on capital (VII) and a brief discussion of differential wage rates (VIII).

The analysis of production and cost of production is of principal concern here because it provided the terms of reference for the summary of the program. As Jevons put it immediately before stating the summary, "we originally start with labour as the first element of production, and aim at the most economical employment of that labour". The link had also been made in Chapter V when

Jevons noted that, in long-period equilibrium, "there can be no motive for altering or regretting the division of labour, and the utility produced is at its maximum" [Jevons 1871, pp.255,180]. The summary thus referred to a long-period equilibrium outcome, as discussed in Chapter V, and was based on a `model' of a representative labourer who `balanced' the marginal disutility of work with the marginal utility of the commodity obtained from that work (see Chapters 4 and 5 of this thesis). The depiction of the long-period equilibrium condition is difficult to understand if only because Jevons failed to clearly explain the meaning and significance of his particular definitions of production and cost of production. As was explained in Chapter 1 of this thesis, Jevons elliptically noted that, "[f]or the sake of accuracy", the phrase cost of production was "conspicuous by its absence" from TPE because there was some difficulty in `interpreting' its meaning [Jevons 1970, pp.200-1, 203-5]. Although no explanation was given for this difficulty, Jevons complained elsewhere that "manufacturers" conflated wages with the cost of production in claiming that the higher `general' rate of wages in Britain was a barrier to exports. Perhaps more puzzling, Jevons did not include a return to capital when defining cost of production. Again, no explanation was given in TPE. Elsewhere, however, Jevons explained that his approach depended on the meaning he attributed to `production' and the `requisites of production'.

The clearest statement of the relative importance of labour can be found in Jevons' primer on Political Economy, where he argued that there were "three requisites of production" - natural resources, labour and capital. Of natural resources, land was the most important: "from the earth, or, as we say, from Nature we obtain both the materials [such as corn and minerals] of wealth and the force [for powering wind-mills and steam engines] which help us to turn the materials into wealth". Labour, however, was more critical in that wealth depended "far more" on "activity and skill" than on "abundance and materials". The role of capital, defined as "a stock of food", was to support "labourers while they are engaged in work" [Jevons 1878, pp.24, 25-6,27].[4] Labour and natural resources were the "Primary requisites" of production, while capital was a "Secondary requisite": "We can hardly say that capital is as requisite to production as land and labour, for the reason that capital must have been the produce of land and labour ... [T]here is no good attempting to say exactly how capital began to be collected, because it began in the childhood of the world ... Capital is requisite ... not so

[4] This was consistent with the definition of capital in TPE as discussed in Chapter 1 above.

much that we shall labour, but that we shall labour economically and with great success" [ibid. p.28]. It was for this reason that the analysis of capital was introduced after the discussion of labour and why labour was depicted as working with raw materials in chapter V of TPE. It will be shown below that Jevons explained the more general significance of his analysis of the `requisites of production' by conservation principles from natural philosophy.

The maximisation of output from a given labour force required an extensive division of labour, encompassing comparative advantage in international trade as suggested in Chapter V. Given the available resources, technology and the division of labour, maximisation of output would depend on the "duration" and the "intensity" of work. Duration, or the number of hours worked, depended on the desire to accumulate wealth and was principally a matter of race and class (see Chapter 5 of this thesis). Intensity was a question of the conditions required and the most efficient instruments used to calculate the physiological limits of the rate at which people could work [Jevons 1871, pp.191-7]. The point was to ensure that the energy of the workforce, which was depleted during a work period and evident in fatigue, was replaced for a subsequent period: "In a regular and constant employment the greatest result will always be gained by such a rate [of work] as allows a workman each day, or each week at the most, to recover all fatigue and recommence with an undiminished store of energy" [ibid. p.197]. In that sense, it was necessary to conserve the energy of the `first element of production'.

If the analytical basis for Jevons' discussion of production and cost of production was not explained in TPE, the organisation of the argument in terms of a market-period (Chapter IV) and long-period (Chapter V et. seq.) analysis adopted the same `classical method' as his predecessors such as Mill and Cairnes. That method was, however, not evident in his first summary of the project in the Brief Account. Its use in TPE reflected a substantive reassessment of Jevons' initial approach.

6.2 The Force of Argument

In 1862, Jevons attempted, unsuccessfully, to publish a more detailed version of the Brief Account in the London, Edinburgh, and Dublin Philosophical Magazine And Journal Of Science [Grattan-Guinness 2002]. A leading science journal of the time, the Magazine had previously published articles by Jevons on hygrometry, meteorology and spectroscopy [Inoue and White 2002, pp.353-8]. The choice of

the Magazine should not be surprising in that, from the outset of the marginalist project in 1860, Jevons had depicted economic activity in terms of mechanical metaphors and principles. TPE was not, however, simply an expanded version of the Brief Account. By 1871, Jevons had changed the ordering and explanation of his argument and now referred to the mechanical metaphors with reference to the language of `energy' physics.[5] Those changes will be discussed in this section as they help explain the terms of reference for the formulation of his program summary.

As was explained in Chapter 4 above, the depiction of behaviour used to derive the long-period equilibrium position in Chapter V of TPE was adapted from Richard Jenning's Natural Elements of Political Economy (1855) which introduced a new conceptualisation of the human body to British political economy. Behaviour was made analogous to a `force' in mechanics (and natural philosophy more generally) with particular attention paid to gravitational force to explain the work decision. That account drew on the new discourse of physiological psychology, as set out in William Carpenter's Principles of Human Physiology (1853), and on William Whewell's treatment of mechanics. Carpenter's explanation of behaviour in functional terms relied, to a significant extent, on the role of reflex actions which Jennings used to characterise the behaviour of the workforce in the Natural Elements. While Whewell had discussed the importance of reflex actions for physiology in his Philosophy of the Inductive Sciences [Whewell 1847, pp.600-18], his mechanics had represented people as akin to machines or engines, which required a "precise and universal unit" of measurement for their comparision. For Whewell, that unit was `labouring force', defined as force multiplied by distance or as a specified amount of pounds (weight) descending a specified number of feet. With a common unit of measurement for the labouring force of humans, animals, water, wind and steam, force could be expressed in monetary terms. As Whewell put it in his Mechanics of Engineering (1841), "Labouring force is the labour that we pay for" [Smith and Wise 1989, pp.286-87; Wise 1989b, pp.418-20]. Jennings'

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[5] These were not, of course, the only changes made between 1862 and 1871. For example, the project envisaged in the Brief Account was more ambitious than that published in 1871. In 1862 Jevons indicated that the theory was to be linked with "the higher complications of the subject where the effects of money, of credit, of combinations of labour, of the risk or uncertainty of undertakings and of bankruptcy are taken into account" [Jevons 1866b (1862), p.287]. It is difficult to see any systematic trace of those links in TPE. The analysis of market-period trading in TPE also showed the effects of the debate following William Thornton's critique of 'the laws of supply and demand' in the late 1860s (see Chapters 7 and 8 of this thesis).

conceptualisation of behaviour as a stimulus-response mechanism combined the depiction of the body as a machine, governed largely by gravitational force, with an explanation of responses as reflex actions. As Jennings explained to Whewell when presenting him with a copy of the Natural Elements, "Assuming the `terra firma' of political-economy to be in fact a `terra incognito' I have endeavoured to discover its true position & principles by abandoning the consideration of what I believe to be arbitrary assumptions & by tracing the consequences of known laws of nature".[6]

Jevons began reworking that analysis in 1860 and the importance of the work decision analysis was evident when the Brief Account was read to the British Association for the Advancement of Science meeting at Cambridge two years later. As shown in Table 1, however, the organisation of the analysis was quite different to that in TPE.

Table 1

Subject	1862/1866 Sections	1871/1879 Chapters
Role of mathematics; behavioural motives; marginal utility consumption theory	1-9	1-3
Work decision analysis (utility and disutility theory)	10-11	5
Rent	12	6
Exchange with parametric stocks in each trading period	13-19	4
Exchange with production (labour the only variable input)	20	5
Capital Theory	21-6	7
Wages	27	8

[6] Jennings to Whewell, 22 May 1855, Add.MS.c.75/50, Trinity College Library, University of Cambridge. It has not been possible to trace some earlier correspondence regarding political economy between Jennings and Whewell to which Jennings referred in his letter.

In 1862, the work decision analysis and the discussion of rent preceded the discussion of exchange with a parametric stock, which was followed by a description of how the exchange theory could be combined with the analysis of "labour and production" in an "equation ... between the utility of the last increment of produce and the increment of labour necessary to produce it" [Jevons 1866b (1862), pp.284-5]. In 1871, however, the work decision analysis, now coupled with the discussion of the long-period equilibrium condition, appeared in Chapter V, following the previous chapter's analysis of market-period exchange. Rent was shifted to Chapter VI. The reordering made the analysis more consistent with prevailing conventions in political economy as it was now organised in terms of a market-period (Chapter IV) and a long-period (Chapter V et. seq.) analysis. At the same time, TPE discussed value and cost of production (Chapters IV and V) and then outlined a theory of distribution (Chapters VI-VIII). When coupled with the peculiar placement of the rent analysis, the separation in 1862 of the work-decision analysis from that of exchange and production indicates that Jevons' initial analysis was not cast in terms of the distinction between market- and long-period outcomes. (This possibly reflected the approach of Jennings' Natural Elements). The framing of TPE's long-period cost of production analysis, which was essential for understanding the summary of the program, thus occurred between 1862 and 1871.

The reorganisation of the analysis obscured the particular importance that Jevons attached to the work decision analysis and the key analytical role of the Natural Elements when he began formulating the marginalist project. That role was further obscured by another argument in TPE. Jennings used his discussion of the increasing "degree of toilsome work endured ... by the working classes" to support legislation limiting the length of the working day [Jennings 1855, pp.119, 214-5]. Jevons opposed such legislation for adult males, remarking in his discussion of the intensity of labour that "long experience has led men, by a sort of unconscious reasoning, to select that rate of work which is most advantageous".[7] He then summarised a series of experiments, first reported in Nature [Jevons 1870], to "approximately measure the intensity of labour by the amount of physical force undergone in a certain time". The specific purpose of the experiments was to provide a statistical estimate of his work (disutility) function, showing "the relation

[7] For Jevons' complex position on work hours legislation and its relation to the analysis in TPE, see Chapter 5 of this thesis and White 1994a.

between the work done ... and the rate of fatigue" [Jevons 1871, pp.191, 192, 194]. While the most successful of the experiments echo a suggestion made by Jennings, Jevons attributed the motivation for the experiments to his reading of the discussion of work and fatigue in Charles Babbage's Economy of Machinery and Manufactures (1835) (see Chapter 4 of this thesis). It will be shown in section 6.4 that Jevons probably read the Economy after the Brief Account was published. The discussion in TPE was in keeping with his initial approach, in that the human body was represented as a machine which converted muscular effort into 'useful' effects which were offset by fatigue. Section 6.4 also shows, however, that Jevons' reference to Babbage indicated he was now thinking of 'work' in terms of a conservation principle from physics. It was that principle which underpinned his reconceptualisation and reordering of the analysis of labour "power" in the Brief Account [Jevons 1866b (1862), p.284].

Jevons reworked and extended Jennings' analysis by using the metaphor of 'the balance' as the motif of his project which he described in TPE as the "mechanics of human interest" [Jevons 1871, p. 24].[8] With the human mind and body depicted as a balance [Jevons 1871, pp.8-14], the analysis of exchange in a market-period made the final degree of utility for a commodity analogous to a gravitational force. As Jevons put it in 1874: "just as the gravitating force of a material body depends not alone upon the mass of that body, but upon the masses and relative positions and distances of the surrounding material bodies, so utility is an attraction between a wanting body and what is wanted" [Black 1973-81, VII, p.80]. This was a reference to his analysis of exchange in a market period where the fundamental equilibrium condition specified that, at any moment, the ratio of marginal utilities for any two commodities was inversely proportional to the marginal exchange ratio which prevailed in the market. As Jevons noted in the first edition and explained in the second, the equilibrium condition was taken from that for a lever in static equilibrium, which provided the theoretical explanation for a 'balance' [Jevons 1871, p.viii; 1970, pp.144-8,165].

Jevons' initial formulation of the lever analogy, which will be considered in Chapter 7, drew on two principal theoretical sources. The first was the treatment of the calculus by Augustus De Morgan, whose classes Jevons had attended at University College, London, when he returned from Australia in 1859 [Black 1973-

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[8] In the second edition this became "the mechanics of utility and self-interest" [Jevons 1970, p.90].

81, II, p.403]. The second was S.D. Poisson's Treatise on Mechanics [1842 (1833)], an influential exposition of the French tradition of 'variational' mechanics which, in referring to the work of d'Alembert and Lagrange, stressed the principle of virtual velocities. The principle argued that all 'dynamic' problems in a system could be explained in terms of 'statics' and hence in terms of equilibrium outcomes [Grattan-Guinness 1990, pp.318,325-7]. In the second edition of TPE, Jevons referred to Poisson when justifying his use of the lever analogy by referring to virtual velocities, claiming that the principle was "the real foundation of the science" of mechanics [Jevons 1970, pp.144,147]. He attempted to reconcile his initial treatment of the lever from Poisson with subsequent work by arguing that the principle was 'disguised' in the "best modern elementary" treatments of mechanics, such as Philip Magnus' Lessons in Elementary Mechanics [Jevons 1970, p.144]. Magnus' account, which Jevons used in TPE when explaining the relation between the equilibrium conditions for a lever and economic exchange, discussed the analysis of the lever in terms of the conservation of energy [Magnus 1875, pp.120-33].

Jevons was familiar with that conservation principle before TPE was published, using the language of both forces and energy in the first edition. After explaining that he had "attempted to treat Economy as a Calculus of Pleasure and Pain" with "accurate quantitative notions concerning Utility, Value, Labour, Capital, &c.", he observed:

> The theory of Economy thus treated presents a close analogy to the science of Statical Mechanics, and the Laws of Exchange are found to resemble the Laws of Equilibrium of a lever as determined by the principle of virtual velocities. The nature of Wealth and Value is explained by the consideration of indefinitely small amounts of pleasure and pain, just as the Theory of Statics is made to rest upon the equality of indefinitely small amounts of energy [Jevons 1871, p.viii].

This was consistent with his argument in the unfinished Principles of Economics that "the notion of value is to our science as that of energy is to mechanics" [Jevons 1905, p.50]. Indeed, Jevons gave the impression that TPE was consistent with the approach to energy physics of the 'North British scientific network', consisting of William Thomson (Lord Kelvin), Peter G. Tait, James Joule, William Rankine, James C. Maxwell, H.C. Fleeming Jenkin and Balfour Stewart [Smith 1998]. In the first edition, he referred to Thomson and Tait's Treatise on Natural

Philosophy (1867), which had reworked the principles of virtual velocities and least action in their energy framework [Smith and Wise 1989, ch.11; Smith 1998, pp.205-10]. He followed this in the second edition with references to Maxwell's Theory of Heat (1871) and Treatise on Electricity (1873), as well as Jenkin's Textbook of Electricity and Magnetism (1873) [Jevons 1970, pp.79,80,117]. In 1873, George Darwin suggested that, when compared with the analysis of his predecessors such as Mill, Jevons' treatment of capital was more consistent with energy physics [Darwin 1873]. The sixth member of the northern network, Balfour Stewart, who had joined Jevons at Owens College, Manchester as professor of natural philosophy in 1870, reversed the circuit in his Conservation of Energy. Drawing analogies between energy and `capital' as money in a bank ("energy of position") or money being spent ("energy of motion"), Stewart explained the principle of virtual velocities in terms of market trading and referred to CQ in terms of energy physics [Stewart 1874, pp.26,33-5, 144-5].

If the references by Stewart and Darwin indicate that a number of Jevons' contemporaries saw a congruity between TPE and an energy framework, the actual theoretical connections and their relevance for explaining the marginalist project appear puzzling today. Jevons had produced an outline of the project before he was conversant with the work, or at least had contact with members, of the North British network, a contact symbolised by his exchange regarding the marginalist theory with Jenkin in 1868.[9] There is no evidence of him referring explicitly to an energy framework before 1866 and his subsequent references to that framework left no mark on the formal mathematics (ie. the calculus and geometry) of TPE. If those absences make the connection with the energy framework appear problematic, they also make it difficult to explain how Jevons arrived at the conservation principle used in the summary of the marginalist project. As will be shown in Section 6.3, however, the basis of an explanation for the puzzles can be found by considering how, in the 1860s, Jevons became convinced of the validity of the principle of the conservation of force and, subsequently, the conservation of energy. Those changes were critically dependent on a particular argument, incorporating references to 'muscular force',

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[9] Black 1973-81, III, pp.167-78. The exchange was triggered by Jenkin sending Jevons a copy of his 1868 paper on trade unions. Although it is not clear why, precisely, Jenkin sent that paper to Jevons, he apparently knew that Jevons was interested in the topic of energy as he drew Jevons' attention to his paper, "Lucretius and the Atomic Theory" (1868), a defence of the compatibility of energy physics and free will [ibid. p.172]. For the context of Jenkin's paper see Smith and Wise 1989, ch.18.

which claimed that the two conservation principles were equivalent. In the context of an extensive, confusing and sometimes bitter debate regarding the meaning and significance of different conservation principles at the time, Jevons felt able to switch from the language of (the conservation of) force to that of energy. It was in that context and during Jevons' period of conversion that he found the resources which were to serve as the basis for the formulation of the summary of his marginalist program (Section 6.4).

6.3 Hunting Conservation Principles

Simon Schaffer has noted that, today, "sciences are publicised through hands-on exhibitions, press conferences, chat shows and interactive CD-Roms. The Victorians had a different system and, as usual, painstakingly classified it. There was the conversazione and the soiree; the grand lecture and the subscription dinner; the amateur society and the private clubs; above all, there were periodicals and public museums" [Schaffer 1999, p.31]. The meetings of the British Association for the Advancement of Science (BAAS) combined the presentation of learned papers to the various sections with soirees and the public lecture in the form of the Presidential Address. Jevons was familiar with the routine of a BAAS meeting, having acted as a correspondent for the Manchester Examiner and Times when the BAAS met in that city in 1861.[10] The 1863 meeting was held at Newcastle with Sir William Armstrong, the engineer and armaments manufacturer, as President. Reporting on the meeting, The Illustrated London News gave Armstrong an iconic status, adorning a laudatory biographical piece with a reproduction of a marble bust, and subsequently printing an engraving depicting the presentation of his Address. The News also reported that "The probable continuance of the supply of that most essential article of fuel, coal, has occupied a considerable share of the attention of the members of the association, the prominence given to the subject in the address of the president, Sir William Armstrong, having given an impulse to the inquiry in that direction."[11]

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[10] Black 1973-81, II, pp.434-6. One of Jevons' meteorological papers [Jevons 1861b] was read to the meeting although, as was usual for him at the time, he did not present it.

[11] "The British Association", The Illustrated London News, 5 September 1863, pp.231, 233; 12 September 1863, p.269.

The debate over the supply of coal had followed the signing of the Cobden-Chevalier Treaty in 1860. Initially discussed in terms of the exhaustion of coal reserves, the terms of the debate were then shifted to the question of the cost of coal extraction. Reflecting that shift, Armstrong's address was important not just as an occasion, but also because it provided two basic terms of reference for the subsequent analysis in CQ [White 1991c, p.291]. First, Armstrong argued that the relevant question was not the size of coal reserves (or the possibility of an absolute scarcity), but rather the threat posed to British manufacturing "supremacy" by increasing coal costs as deeper seams were mined [Armstrong 1864, pp. lii-liv]. Second, there were no conceivable alternatives to coal as the basic source of power, a point which could be explained by the principle of the conservation of force where the theory of heat was given a key role.[12] Describing coal deposits as "vast magazines" of "embodied ... power" derived from the sun, Armstrong linked the discussion of coal with the dynamical theory of heat. The theory, which he attributed to the work of Julius Mayer, Joule, Thomson and Rankine, was "probably the most important discovery of the present century". With the interconvertibility of work (or mechanical effect) and heat demonstrated by the theory, the formation of coal could be explained by the "principle of conservation of force and the relationship now established between heat and motion". The "mechanical energy resident ... in coal" could then be expressed as the numerical equivalent of lifting a weight through a particular height. Or, in an example closer to Armstrong's own interests, it was possible to calculate the "number of dynamical units of heat representing the whole mechanical power of the projectile" in the "science of gunnery". The heat theory could also be used to explain that, although the conditions for coal formation had "passed away for ever", coal was the only feasible source of power in the future. The use of heat or electricity required "chemical affinity as the source of supply". This necessitated the use of oxygen and the only feasible "oxidizable substance" available was coal. At the same time, it was alarming that the heat theory showed that steam engines used in industry "realise ... only a small part of the thermic effect of the fuel", where the point of comparision was a "perfect heat-engine". It was thus crucial to reduce waste by improving the rate of the conversion of "heat of combustion into available power" [ibid. pp.lii-lv,lx].

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[12] For the importance of heat theory in the formulation of the conservation of force and energy frameworks, see Harman 1982.

Although physicists such as John Tyndall, Thomson and Tait had referred to recent experiments with the `12-ton Armstrong gun' in their popular explanations of the theory of heat and of the conservation of force or energy,[13] the terms of Armstrong's discussion referred to a bitter argument between them. In June 1862, Tyndall delivered a lecture, "On Force", to the Royal Institution, where he held the chair of natural philosophy [Tyndall 1862]. The lecture was one of a series devoted to the topic of heat analysis. Ostensibly concerned with the role of Mayer, a German physician, in formulating the theory of the interconvertibility of heat and work, Tyndall's lecture was a "calculated rhetorical move" directed against the North British network in "a contest for scientific authority" or 'truth' regarding the significance of conservation principles [Smith 1998, pp.180,171].[14] The effect of stressing the role of Mayer was to downplay the experimental work of Joule, identified with the Northern group. More generally, Tyndall was defending a 'scientific naturalism' which, in referring to the work of Hermann Helmholtz, stressed determinism, hostility to Christian doctrines and support for Darwinian evolution, in opposition to the northern stress on `free will', the depiction of natural philosophy as harmonising with Christian doctrine and hostility to Darwin. Not surprisingly, the counterattack by Thomson and Tait claimed analytical priority for Joule. They also criticised Tyndall's more general representation of heat theory. While Tyndall discussed it in his lecture with the title of "On Force", Thomson and Tait drove a wedge between the force and energy frameworks, referring, for example, to the "host of errors which are due to confounding Force with Energy", while characterising the notion of the conservation of force as an "error" [Thomson and Tait 1862, p.601].[15] This particular debate, conducted in an increasingly bitter tone, continued into 1863 when Tyndall's lectures were published as Heat Considered as a Mode of Motion [Tyndall 1863].

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[13] Tyndall 1862, p.59; Thomson and Tait 1862, p.602. For Armstrong and armaments, see Bastable 1992.

[14] The following account is based on Smith 1998, esp. Chapter 9.

[15] As defined by Tyndall: "The principle of the conservation of force, broadly enunciated, asserts that the quantity of force in the universe is as unalterable as the quantity of matter; that it is alike impossible to create force and to annihilate it" [Tyndall 1865, p.138]. In 1850, Thomson had neatly summarised the subordinate role that force was to play in his energy framework: "The action of a force ... is ... a transformation ... of Energy" [Wise 1990, p.254].

In his Address of the same year, apart from referring to the importance of Tyndall's analysis of heat [Armstrong 1864, p.lxi], Armstrong linked Mayer with the British physicists and referred explicitly to the heat theory within a conservation of force framework. This effectively indicated his support for Tyndall. Jevons followed suit when amplifying Armstrong's arguments in chapters VI ("The Economy of Fuel") and VII ("Of Supposed Substitutes for Coal") of CQ. For Jevons placed the analysis firmly within a conservation of force framework:

> The great advances which have been achieved in the mechanical theory of nature, during the last twenty or thirty years, have greatly cleared up our notions of force ... [T]he universe ... is one great manifestation of a constant whole of force. The motion of falling bodies, the motions of magnetic or electric attractions, the unseen agitation of heat, the vibration of light, the molecular changes of chemical action, and even the mysterious life-motions of plants and animals, are all but the several modes of greater or lesser motion, and their cause one general living force [vis viva].
>
> These views lead us at once to look upon all machines and processes of manufacture as but the more or less efficient modes of transmuting and using force. If we have force in any one of its forms, as heat, light, chemical change, or mechanical motion, we can turn it, or may fairly hope to turn it, into any other of its forms. But to think of getting force, except from some natural source, is as absurd as to think of making iron or gold out of vacant space [Jevons 1865, pp.119-20].

A number of important changes were made to this summary in the third edition of CQ which was published in 1906. (The alterations were made by the editor, A.W. Flux, working from Jevons' notes in his copy of the second edition [Jevons 1906, pp.xxvii-xxviii]). In the first paragraph of the quotation above, "constant whole of force" was changed to "constant aggregate of energy"; the words "and energy" were added after "force" at the end of the first sentence; and the section of the last sentence after `motion' was omitted [ibid. p.161]. In the second paragraph, `force' was changed to `energy'. Throughout the text, references to `force' were changed to `energy' or `motive power', indicating a shift from the language of the conservation of force to that of energy.[16]

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[16] In the Principles of Economics, Jevons noted that "within the last forty years ... Joule and other physicists have demonstrated that even in all the transmutations of heat and electric force there is neither creation nor destruction of energy". He

To explain the shift, it should be noted that Jevons had understood the significance of the conservation of force argument well before Armstrong's address had been delivered. His earlier work in chemistry and meteorology (see, for example, Jevons 1858) had enabled him to publish review articles on developments in spectroscopy, which brought together the topics of heat, `magnetic or electric attractions', the `vibration of light', and the `molecular changes of chemical action' mentioned in CQ.[17] The review articles concerned the spectrum experiments of Kirchoff and Bunsen [Jevons 1861a; 1862a; 1862b; 1862c; 1864b]. Providing a detailed discussion of the experiments in 1861, Jevons indicated the more general significance of the analysis:

> At the present time, mathematicians, electricians, opticians, chemists, and even physiologists, are united in one immense confederation, irrespective of nation or language, for the purpose of solving the great remaining problem of natural science, - that of the molecular constitution of matter, and the mutual relations of the physical forces ... The second great step in our knowledge of the world will then have been made, comparable in importance and difficulty to the discovery of the differential calculus and law of universal gravitation, achieved, however, by a whole army of thinkers and workers, not by a single intellect [Jevons 1861a, p.26].

The reference here to the `mutual relations of the physical forces' sounds similar to Jevons' subsequent reference in CQ to the conservation of force as the "modern doctrines of the relations of the natural forces" [Jevons 1866a, p.143n]. That it had the same meaning in 1861 is indicated by a letter to his cousin Henry Roscoe, professor of chemistry at Owens College, Manchester, a former student of Bunsen's and the author of an article on spectroscopy which Jevons reviewed. Discussing some aspects of the spectrum analysis in October 1861, Jevons observed to Roscoe: "It is obvious that Newton was quite up to the Undulatory theory but it is plain also ... that he did not dream of the conservation of forces[,] the doctrine now so prevalent."[18]

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then referred to chapter VIII of the second edition of CQ for an illustration of the argument [Jevons 1906, pp.93-4].

[17] Some notes, dated early 1853, report Jevons' (frustrated) experiments with a `vibratory' theory of heat [JA 6/22/3].

[18] Jevons to Henry Roscoe, 30 October 1861 [JA 16/1/11].

Today, historians would argue that the force and energy frameworks were different analytically. For the conservation of energy, force was no longer understood as a cause of, or even essential for, conversion, since it was "merely a theoretical intermediary between energy states ... [P]hysical reality was based not in the possession of forces as active powers, but in the possession of energy by inert, material systems" [Gooding 1980, p.8]. Nevertheless, as noted above, the characteristics, properties and more general significance of the two frameworks were subject to some dispute in the mid-1860s. It seems likely that Jevons was aware of Tyndall's 1862 argument and the subsequent dispute with Thomson and Tait as one of his spectroscopy articles [Jevons 1862c] immediately preceded the printing of Tyndall's paper in the Philosophical Magazine.[19] Jevons' subsequent switch of language, which indicates he thought the energy and force frameworks were equivalent, took place by early 1866 and was also based on an argument of Tyndall's.

In the Preface to the second edition of CQ, Jevons cited some correspondence from Tyndall. He then used a long quotation from Tyndall's 1865 article, "The Constitution of the Universe", noting that, regarding the "impossibility" of finding a substitute for coal "as a source of heat and power ... I have ... only interpreted the opinions of Professor Tyndall" [Jevons 1866a, p.xvi].[20] The relevance of the long quotation which followed from Tyndall's article [ibid. pp.xvii-xviii; Tyndall 1865, p.143] was that the argument for the formation of coal and the lack of a substitute was no longer explained by reference to the conservation of force (as it was in the text), but rather in terms of `potential' and `actual' (subsequently, kinetic) energy. While he was in Australia, Jevons had been effusive about some of Tyndall's earlier work [Black 1973-81, II, p.250]. But the attraction of the physicist's 1865 article was that it provided a clear (albeit rather glib) argument for the reconciliation of the forces and energy frameworks, incorporating the troublesome case of gravity [cf. Gilchrist 1862, pp.341-2]. As Jevons noted in his Principles of

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[19] Indeed, Jevons' article concluded and Tyndall's began on the same page. The first attack on Tyndall by Thomson and Tait was published in Good Words. Jevons cited another article [Rogers 1864] from the same journal in CQ [Jevons 1865, p.47]. His reading of the debates over conservation principles could explain why the Unitarian Jevons consulted Good Words, the magazine of the `latitudinarian' Church of Scotland [Smith 1998, pp.26,184].

[20] Although Jevons has been criticised for arguing there could be no principal power source other than coal, the statements of Armstrong, Tyndall and Michael Faraday (see below) show that it was not an unusual argument at the time.

Science: "the force of gravity stands apart from all the other forces and phenomena of nature, and has not yet been brought into any relation with them except through the general principle of the conservation of energy" [Jevons 1887 (1877), p.605]. "Following" the approach of Helmholtz, whose 1847 essay on the conservation of force he had translated in 1853, Tyndall provided an account of that 'relation'. After explaining how "gravity and chemical affinity stand on precisely the same footing" in terms of convertibility into heat, he turned to the question of gravity, discussing the statics and dynamics of the attraction between two particles in terms of gravitational forces [Tyndall 1865, pp. 134-5, 138-41]. Tyndall now suggested, however, that the language of 'forces' had become confused, if not partially redundant, so that it was better to couch the analysis in the terminology of energy as discussed by Rankine.[21] Helmholtz's vis viva (the velocity of a body [Helmholtz 1861, p.322]) and 'tensions' would become, respectively, 'actual' and 'potential' energy. The new framework could be used as a general mechanical explanation for gravity, light, heat, magnetism, electricity, chemical affinity and "muscular force". Given the generality of the explanation, it followed that "the energy of the universe is as constant as its matter" [ibid. pp.141-3].

While the significance of Helmholtz's analysis was to be reworked in a different way by the Northern network [Smith 1998, pp.126-40], he had previously explained the basis for Tyndall's reference to 'muscular force' in the context of heat theory. Addressing the Royal Institution in May 1861 as a physiologist, Helmholtz argued "it was extremely probable that the law of the conservation of force holds good for living bodies". The human body was equated with a steam engine in that both produced work and heat [Helmholtz 1861, pp.324,326]. To illustrate this, Helmholtz referred, in part, to the work of Edward Smith, the English physiologist concerned with the debilitating effects of diet, working conditions and fatigue of factory workers and prisoners on treadmills [Chapman 1967]. For Helmholtz, the experiments of Smith and other European researchers had "proven that the best method of getting the greatest amount of work from a human being is by the treadmill".[22] The experiments showed that, on a treadmill (equivalent to

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[21] See Rankine 1859. For Tyndall's previous use of this argument, see Tyndall 1863, pp.136-7; see also Helmholtz 1861, p.322.

[22] It should be noted that Smith wanted to abolish the use of treadmills in prisons. A summary of his work on diet and fatigue was presented in a commissioned paper to the BAAS meeting at Manchester in 1861 [Smith and Milner 1861] where, as noted above, Jevons acted as a newspaper correspondent.

walking uphill), one quarter of the effort resulted in work, while the remainder was spent in heat. This meant that "the human body is ... a better engine than the steam engine only its food is more expensive than the fuel of steam engines" [Helmholtz 1861, p.325].[23]

The discussion in the 1865 and 1866 editions of CQ explain why there are no references to 'energy' physics in Jevons' work before 1866. Following Armstrong's address of late 1863, Jevons began work on CQ in early 1864 using the conservation of force principle as a linchpin for his argument. This placed the terms of his argument in line with Tyndall, rather than Thomson and Tait. His subsequent endorsement of Tyndall's analysis explains why he switched to the language of the conservation of energy in his later published work although, by the time that TPE was published, Jevons referred to the work of the North British network. It was, however, the language of the conservation of force and the equating of the body with a steam engine which was crucial in 1864 and the next section will show how that coupling provided the context for the materials Jevons used to formulate the summary of the marginalist program.

6.4 The Economy of Force

Jevons had produced the `Brief Account' of his marginalist theory by September 1862. While this presented a summary of much of the theory eventually published as TPE, there were, as noted above, significant differences between the two texts with regard to the organisation and the analysis of the arguments. It is evident also that the Account was unfinished as Jevons acknowledged he had yet to complete an explanation for wage rates [Jevons 1866b (1862), p.287]. Of particular relevance for this chapter, there was no indication in 1862 that Jevons had arrived at the summary statement of the program that was to appear in TPE. Indeed, the earliest published approximation to that summary, of which I am aware, came in a lecture in 1869 when Jevons was reported as saying that, in political economy,

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[23] Helmholtz's address was printed in the Chemical News in May. Jevons' article on spectroscopy where he noted that `even physiologists' were concerned with the conservation of force (see above) was published in July. Jevons' first article for the Chemical News appeared in the following year [Jevons 1862b].

> We consider men as governed by ... or as actuated by a greater or less desire for possessions ... To obtain these commodities he is endowed with the muscular power of his body, the intellectual powers of his mind, and the possession of the land with its materials and forces. We have to consider how he may best apply his labour to satisfy his wants. How, in short, he may acquire most wealth at the expense of the least labour. Thus Political Economy treats only of wealth [Black 1973-81, VII, p.56].

It is possible that Jevons had formulated the summary when the Brief Account was written and that it was omitted because the Account had to be presented in an abbreviated form. The available textual evidence suggests, however, that the 1869 summary and the more precise statement in TPE depended on a number of resources which became available to Jevons in 1864.[24]

As Jevons began working on CQ, he obtained a copy of Plutology: or the Theory of the Efforts to Satisfy Human Wants by William Hearn, the first professor of Modern History and Political Economy at the University of Melbourne. He then wrote a laudatory brief review (or 'notice'), which was published in the Spectator. Referring also to the Traité Théorique et Pratique d'Economie Politique (1858) by J.G. Courcelle-Seneuil, from which Hearn had taken the title of his book [Hearn 1864, p.7],[25] Jevons wrote that Plutology was "in many respects in advance of the treatises of the day, including on certain points even Mr. J.S. Mill's great work." In particular, Hearn "begins with a review of the kinds and degrees of human want, a subject which John Mill professedly but not really banishes from the science".[26] He was thus taken with "Hearn's view of economy as the balancing of effort against want" [Jevons 1864a]. The praise was ratcheted up in CQ, where Plutology was described as "both in soundness and originality the most advanced treatise on political economy which has appeared, and should be familiar to every student of the science" [Jevons 1865, p.126n]. Similar statements appeared in TPE [Jevons 1871, pp.263-5], where Jevons appears to have relied to some extent on Hearn when producing his account of how wage rates adjusted to a long-period position [ibid. p.263; Black 1973-81, III, p.255]. (This was, as noted above, an unfinished

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[24] The extended version of the Brief Account [Grattan-Guinness 2002] contains no discernible reference to the 1871 summary.

[25] On the etymology of plutology, see Treloar and Pullen 1998; Forget 1999.

[26] The reference was to Mill's 1836 essay on "The Definition of Political Economy" [Mill 1874, p.132n].

topic in the Brief Account). Jevons also included a long extract from Hearn's discussion of capital [Jevons 1871, pp.215-6]. Of particular note here, however, is that he repeated the points made in his 1864 notice. Mill was again criticised for failing to provide "a theory of the consumption of wealth" [ibid. pp.46-7], while the approach of Courcelle-Seneuil and Hearn was given a prominent place. Jevons noted that, "To satisfy our wants to the utmost with the least effort - to procure the greatest amount of what is desirable at the expense of the least that is undesirable - in other words, to maximize comfort and pleasure, is the problem of Economy", a formulation which was attributed to Hearn and Courcelle-Seneuil [ibid. pp.44,49]. At the opening of Chapter V, he argued that "Labour is the beginning of the process treated by economists, as consumption is the end and purpose. Labour is the painful exertion which we undergo to ward off pains of greater amount, or to procure pleasures which leave a balance in our favour. Courcelle-Seneuil and Hearn have stated the problem of Economy with the utmost truth and brevity in saying, that it is to satisfy our wants with the least sum of labour" [ibid. pp.162-3].[27]

It is evident that the Hearn/Courcelle-Seneuil definition of the object of political economy was instrumental in Jevons formulating the summary of the marginalist program. He had produced the marginalist theory, as summarised in the Brief Account, using Jennings' analysis of behaviour in functional terms. The work-decision equililibrium condition was constructed using Jennings' depiction of a labourer `balancing' the incremental effort of pain in work against the incremental pleasure from the commodity produced by that work. This focus on the behaviour of a representative actor was neatly encapsulated in the Hearn/Courcelle-Seneuil discussion of the relation between satisfaction and effort. As Jevons put it in TPE, referring to Courcelle-Seneuil's Traite, "I conceive that he gives the best possible statement of the problem of Economy when he expresses its object as `to satisfy our wants with the least amount of work possible'" [Jevons 1871, p.49].

The general behavioural motives (though not the theoretical representation of behaviour) assumed here were not markedly different from those discussed by Mill and Cairnes. For Cairnes, the basic "mental principles" assumed in political

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[27] The specification of the object of political economy in terms of `wants, efforts, satisfactions' also owed a good deal to Bastiat's Economic Harmonies, as Jevons indicated in TPE [Jevons 1871, p.48]. See the discussion of this by La Nauze [1949, chapter III], where he accuses Hearn of plagiarism.

economy were a desire for wealth and an aversion to labour, so that wealth was sought at the least possible sacrifice. That objective entailed the exercise of "the intellectual power of judging the efficacy of means to an end" [Cairnes 1857, p.33; see also p.135]. This replicated the discussion by Mill in his essay on the "Definition of Political Economy" and his Logic [Mill 1874, pp.137,144; 1974, pp. 901-3]. Nevertheless, the argument that these motives encapsulated the object of a theory of value and distribution in political economy was quite foreign to both Mill and Cairnes who expressed some irritation with Jevons' notice of Plutology.[28] Cairnes had also previously rejected the representation of political economy and of behaviour in Jennings' Natural Elements, observing that, "if Political Economy is to be treated in this way, it is evident it will soon become a wholly different study from that which the world has hitherto known it" [Cairnes 1857, p.181].

While Cairnes and Mill rejected that conceptualisation of political economy, it should also be noted that the Hearn/Courcelle-Seneuil aphorism does not capture adequately Jevons' summary in TPE. In discussing the relation between want and effort, Hearn argued that "men always strive either to reduce the amount of any particular effort, or to obtain for the same amount a larger quantity of satisfaction" [Hearn 1864, p.8]. In Jevons' case, however, the problem was expressed specifically as maximising the amount of output (utility) for a given population and set of `materials'. The basis for that particular conceptualisation can be traced to one of Hearn's resources.

In a chapter on `invention' in Plutology, to which Jevons approvingly referred in CQ, Hearn had cited Justus von Liebig's Familiar Letters on Chemistry [Jevons 1865, pp.93,152; Hearn 1864, pp.191,192,195]. Translated into a number of languages, the Letters, or popular essays, were "responsible for much of [Liebig's] world-wide fame and adulation", cemented in the British case by a number of visits between 1837 and 1855 with "charismatic" appearances by Liebig at the BAAS [Brock 1997, pp.113,274]. Focussing on the relation between chemistry, physiology and physics, a combination which had a marked effect on the physiological psychology of William Carpenter [Hall 1979], the Letters "served the gatekeeping function of demonstrating that chemistry was essential knowledge for understanding plant and human physiology and for solving problems of health and

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[28] Although Mill had not read Plutology, apparently following an irritated letter from Cairnes in March 1864, he wrote that he would "ascribe the opinions given of it by the Spectator ... not to defects of honesty, but to sheer ignorance and incompetence on the subject" [Mill 1972, p.930].

nutrition, as well as saving the world from Malthusian agricultural damnation and misery" [Brock 1997, p.275]. Jevons was familiar with the third edition of the Letters (1845) when he was a student at University College, London, during the early 1850s [Black 1973-81, II, p.87]. This was a rather slim volume when compared with the fourth edition (1859) to which Hearn referred. Three of the letters from that edition (xii,xiii and xxxii) were a crucial resource for Jevons in 1864.

Letter xii drew on Michael Faraday's work in electricity to argue that 'electro-magnetic' motors could not replace coal as a power source because of the relative costs in their use. Jevons discussed this Letter twice in CQ where he also referred to Faraday to support his argument regarding the impossibility of replacing coal as a power source: "it is impossible that electricity should be the cheapest source of force" [Jevons 1865, pp.137-8,144; cf. Liebig 1859, pp.154-8].[29] Letter xii served as a prelude for the discussion in the following Letter of the convertibility of force (electrical, magnetic, gravitational) in machines in terms of the theory of heat, where Liebig referred to the work of his former student Mayer for the "more correct view of the natural forces" [Liebig 1859, pp. 167-71]. Liebig characterised the analysis in Letter xiii, which was based on a lecture given in 1858, as a discussion of "the Correlation of the Forces of Inorganic Nature" [ibid. p.v]. While correlation was not necessarily identical with the conservation of force,[30] Liebig's discussion could have been read as enunciating a conservation principle: "forces are causes ... [and] these causes, as far as relates to their quantity, possess the power of indestructibility, and to their quality that of convertibility ... If, according to the materialists, matter is indestructible, the same holds good with regard to force. It is not extinguished; its apparent annihilation, its disappearance, is only a conversion to some other form" [ibid. pp.167,172]. Liebig went on to treat the human body as analogous to a steam engine, whose "power and heat" from food were ultimately derived from the sun: "In the production of heat by blows or concussion, for example, by hammering a bar of steel ... the motion of the mass (the hammer) is transformed into a molecular movement (into heat), and in a similar way a body by

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[29] Jevons used Faraday's publications on chemistry and electricity in his Australian work on meteorology [Jevons 1858]; numerous references in his Principles of Science confirm his close reading of Faraday.

[30] In the correlation of force argument, while no force could be destroyed totally, this did not necessitate that the quantity of force remained conserved at the phenomenal level [Heimann 1974; Cantor 1976, pp.284-6].

being heated (by molecular action), exercises on surrounding objects a pressure or force (a motion of the mass)" [ibid. p.175].

In a subsequent Letter (xxxii), Liebig described in exhaustive detail different types of food in terms of their chemical properties [ibid. pp.433-75] and then drew some conclusions for the analysis for political economy. Much of this consisted of trite metaphors, such as between gold and silver in the economy and blood corpuscles in the human body, and fatuous statements regarding unregulated markets [ibid. pp.480-2]. Of more interest is the general conclusion drawn in arguing that "Life is a continual struggle with the forces of nature, a constant alternate disturbance and restoration of the state of equililibrium" [ibid. p.474]. Liebig observed that "A ::ation of hunters, on a limited space, is utterly incapable of increasing its number beyond a certain point, which is soon attained" [ibid. p.477]. After reporting a "speech" by a "North American Indian chief" on the greater relative effort and lesser output of a meat-eating (Indian) diet as compared with a corn-eating diet of "whites", he concluded:

> In his difficult and laborious life of the chase, the Indian consumes in his limbs a large sum of force; but the effect produced is very trifling, and bears little proportion to the expense.
> Cultivation is the economy of force. Science teaches us the simplest means of obtaining the greatest effect with the smallest expenditure of organic power, and with given means to produce a maximum of force. The unprofitable exertion of power, the waste of force in agriculture, in other branches of industry, in science, or in social economy, is characteristic of the savage state, or of the want of true civilisation.
> Herein consists, in fact, the extraordinary superiority of power, which distinguishes our period from all earlier times; in this, namely, that the development of the natural sciences and of mechanics, and the study of all the causes which produce mechanical motion and change of place, have led to the more accurate acquaintance with the laws which enable men to convert into willing and obedient servants those natural forces which formerly exerted fear and terror.
> Like a Prometheus, man, with the aid of the divine spark from above, which, when fed by religion and morality, is the foundation of all mental improvement, has infused life into the elements of the globe.
> The steam engine receives food and drink, and breathes like an animal; in its body there exists a source of heat and a source of power, by means of

> which internal and external effects of motion are produced; the most perfectly trained horse does not more patiently obey man's will, than the locomotive of our railways, which goes fast or slow, stands still and obeys the slightest touch of his fingers [ibid. pp.477-8].

This quotation is essentially an adaption of the principle of least action to the political economy of human behaviour.[31] Jevons was very taken with it. He referred to it twice in CQ [Jevons 1865, pp.105,122], having copied it in a note which can be found in the Jevons Archive.[32] I suggest that, in conjunction with the object of political economy from Courcelle-Seneuil/Hearn, the second paragraph in particular provided the basis for the conservation principle which Jevons used for his summary of the marginalist program. While A.J. Quételet had gestured towards adapting the principle of least action to human behaviour in the 1830s [Wise 1989a, p.289], it can be reasonably assumed that Jevons could recognise the principle from the work of De Morgan [1842, p.517] or Faraday who used the teleological principle of 'an economy of nature' in postulating that it was "the final condition sought by bodies in a field" [Gooding 1980, p.10].

The analysis in CQ pivoted on the use of steam-engines in the economy and the importance of `economy' in coal use. Coal was "the best natural source of motive power" and Jevons referred to an early paper by Rankine on the "economy" of coal use in engines.[33] In that context he seized on Liebig's anthropomorphisation of the steam engine and adaption of the principle of least action. The use of the principle in that manner was a product of the mid-nineteenth century. While it is possible to represent and derive least action by integrating the path of a conservative system from one configuration to another, there could be little relevance in that procedure if, as in the early nineteenth century, it was not clear

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[31] In basic terms, the principle as developed from the work of Maupertuis and Euler, stated that "for systems in which vis viva is conserved, the total vis viva averaged at any time will be a minimum" [Wise 1989a, p.289].

[32] JA 6/6/165. The first sentence of Liebig's quotation in the text above is summarised in the note which, in typical Jevons fashion, was made on the back of a notice, dated 19 November 1863, advertising a meeting of the Salford Working Men's College. While this provides the earliest possible dating of the note, it seems likely it was made in 1864 after reading Plutology. A further lengthy quotation from Letter xii [Liebig 1857, pp.161-2], written on the back of an April 1864 letter to Jevons, is also in the Archive [JA 6/26/1].

[33] Jevons 1865, pp.133,141; see, in general, chapters v-vii. Jevons referred to Rankine 1855.

what was meant by the conservation of vis viva [Wise 1989a, pp.290-3]. That situation changed with the introduction of general conservation principles incorporating the human body. Indeed, the basis for Liebig's metaphors had previously appeared in the work of Helmholtz discussing the conservation of force (see above), where `labour power' was now the "quantitative equivalent of work produced" regardless of the source of the power transformation. In particular for Helmholtz, "Nature ... is best served by utility or economy of design insofar as the most efficient social use of energy is one in which the greatest amount of labour power is generated with the least amount of waste" [Rabinbach 1992, pp.57, 60]. If Liebig lacked the theoretical sophistication of Helmholtz, his rendition of those arguments in the Chemical Letters enabled Jevons to crystallise the significance of the marginalist project and to rework the significance of his analysis of labour in the Brief Account.

In the second edition of CQ, Jevons added two references to Babbage's Economy of Machinery and Manufactures [Jevons 1866a, pp.143n, 167-8] which suggest he read that text between December 1865, when CQ was first submitted for publication, and mid-1866 when the second edition was published. One of the references followed his discussion of the conservation of force and immediately preceded a reference to Liebig on `the economy of power'. In the first edition, Jevons wrote: "The power we employ in the greatest engine is but an infinitesimal portion, withdrawn from the immeasurable expense of natural forces" [Jevons 1865, p.122]. In the second edition he added a footnote to that sentence, referring to Babbage's Economy as an "exquisite work" which "anticipates the modern doctrines of the relations of natural forces" [Jevons 1866a, p.143n]. The reference given was to Babbage's discussion of machines and work, where "Man ... does not ... create power" but rather `diverts' a "small ... portion of [nature's] energies to his own wants", which was followed by the discussion of fatigue to which Jevons referred in TPE.[34] It was noted in section 6.2 that, by 1871, Jevons had changed the ordering and organisation of his argument in the Brief Account. The previously separated sections on the work decision analysis and a long-period

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[34] Jevons [1866a, p.143n] referred cryptically to section "17, et. passim" of Babbage – see Babbage 1835, esp. pp.18-20, 30-37. In a helpful discussion of the Economy, Norton Wise has suggested that Babbage's analysis "implies that the manufacturer ought to divide the labour [in a factory] in such a way that the product of force, skill, time, summed over all workers, is minimum", an adaption of the principle of least action [Wise 1989b, p.412]. Jevons' reference to Babbage suggests how such a reading was possible although only, as Wise indicates, after the mid-nineteenth century.

equilibrium now both appeared in Chapter V of TPE which made the analysis more consistent with the prevailing distinction between a market-period (Chapter IV) and a long-period analysis (Chapter V et. seq.) The analytical binding for Chapter V, however, using Jevons' concept of production with the discussion of effort and fatigue linked to the summary of the project, was provided by the principle of the conservation of force (energy). Read in the context of Liebig's argument and the analysis in CQ, the 1866 reference to Babbage's Economy indicates how Jevons was able to produce the argument of 1871.[35]

Jevons had begun work on the marginalist project in 1860 using Jenning's depiction of the human body to formulate the functionalist theory of consumption and work. While the Natural Elements showed some awareness of the interconvertibility of force [Jennings 1855, p.151], there was no reference to conservation of force presumably because it played no role in the fourth edition (1853) of Carpenter's Principles of Human Physiology which Jennings read. Like Liebig, Carpenter regarded the correlation of force to be "the primary principle ... with conservation only a special aspect of it", so that the explicit introduction of the

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[35] In May 1866, Jevons' brother wrote to him, remarking "I was very much interested in the account of your visit to Babbage" [letter from Thomas Jevons, 1 May 1866, Box 14, Seton-Jevons Collection, Seton Hall University]. Although Jevons' letter describing the visit has apparently been lost, the basis for the visit can be readily discerned. In chapter xx of the Economy, Babbage described how "the division of labour can be applied to mental as well as mechanical operations", illustrating this in part by referring to his Analytic and Difference "calculating-engine[s]" [Babbage 1835, pp.191,201]. In 1865, Jevons had first referred to his 'logical abacus', a mechanical device for producing deductively a (limited) set of propositions. Jevons referred to Babbage's engines in that context. The abacus was followed by the 'logical machine' or 'piano', where 'the mind' was represented by a series of levers and pulleys [Maas 1999; see also Mosselmans 1998]. As Maas [1999, p.612] notes, for Jevons, "there was no essential difference between the routine labour of a workman, the cramming of a student, and the working of a machine". Two points should be added to this account. First, as the reference to a piano suggests, Jevons' work on logic machines also depended on his training and practice as a musician [Kassler 1996; see also Mosselmans and Mathijs 1999]. Second, I know of no textual evidence to support the claim that Jevons' mechanisation of logic project provided an analytical basis for the marginalist project [Maas 1999, pp.589, 616,617]. Jevons' first written reference to the abacus occurred in 1865 while he had summarised the marginalist project with the use of the lever in 1862. As Harro Maas has since noted in a personal communication, it would be more accurate to say that the projects were linked in that both assumed the mind could be represented in terms of mechanics.

conservation principle only appeared in the sixth edition (1864) of Human Physiology [Hall 1979, pp.153,154]. While Jevons had read the fifth edition of that text by 1862, which he cited in one of his spectroscopy articles [Jevons 1862a, p.86n], he could have seen a discussion of the conservation principle by Carpenter when he began work on CQ. In January 1864, the first number of the Quarterly Journal of Science published an article by Carpenter where, after referring to Armstrong's "recent admirable address", he argued that the conservation of force "is now amongst the best established generalizations of Physical Science" and explained its significance for physiology [Carpenter 1864, p.78]. That article appeared in the same number of the Journal as an analysis of coal reserves by Edward Hull which Jevons cited in CQ [Jevons 1865, p.14]. It may be concluded that, by 1864, Jevons' various analytical paths to the marginalist project had converged at the crossroads of a conservation principle.

6.5 Labour and the Conservation of Energy

The significance for TPE of Jevons reworking his initial analysis in terms of conservation principles can be inferred from his 1866 linking of Babbage on work and fatigue to Liebig on 'cultivation as the economy of force'. If that new framework was not clearly explained in TPE, Jevons did refer to it elsewhere. Drawing on previous arguments in political economy which explained the meaning of 'production' and the role of labour by referring to the principle of the indestructibility of matter from physics, Jevons reworked those arguments in terms of the conservation of energy.

It was noted in Section 6.1 that Jevons described the hierarchy of the 'requisites of production' in his primer where labor and natural agents were the primary requisites of production. To explain how "the amount of wealth which people can obtain depends far more upon their activity and skill in labouring than upon the abundance of materials around them", he used a similar example to Liebig. Although North America was 'rich' in raw materials, "the North American Indians lived in the land for thousands of years in great poverty, because they had not the knowledge and perseverance to enable them to labour properly and produce wealth out of natural agents". The analysis of capital as the secondary requisite of production made the related point that, without capital, "Australian natives ... usually spend a good deal of labour for very little result" [Jevons 1878, pp.26-7]. Although Jevons, initially at least, probably followed Jennings in treating capital as necessary for setting labour 'in motion', the earliest textual evidence, which I have

been able to find, of him explicitly considering capital and production dates from his reading of Hearn. A bundle of notes on `capital' in the Jevons Archive [JA 6/8/1-67] includes the quotations from various economists on the topic which appeared in TPE [Jevons 1871, pp.213-4].[36] The bundle also contains a note from Plutology, regarding the `origin' and the subordinate role of capital, which is similar to the discussion in the primer.[37] While Jevons was considering this matter as he began writing CQ with its discussion of the conservation of force, his subsequent published commentary referred to the conservation of energy.

In his 1881 article on Richard Cantillon's Essai, Jevons provided a historical gloss on the `requisites of production' when commenting on the opening paragraph of Cantillon's first chapter. Cantillon argued that "The Land is the Source or Matter from whence all Wealth is produced. The Labour of man is the Form which produces it: and Wealth in itself is nothing but Maintenance, Conveniences, and Superfluities of Life" [Cantillon 1931, p.3]. Jevons' assessment of the relevance of this statement was in keeping with his general "effusive" assessment of the Essai [Aspromourgos 1989, p.356]. The passage "strikes ... the leading chord of the science of economics ... [and] holds the balance between the elements of production more evenly than any subsequent treatise". Quesnay, for example, was "entirely one-sided" with his focus on land. Adam Smith, for all his "harping" on the phrase `land and labour of the country', identified `annual labour' as "the fund which supplies ... [the nation] with all the necessaries and conveniences of life. Properly interpreted Cantillon's statement is probably the truest which has yet been given" [Jevons 1905, p.165]. The last elliptical sentence was clarified in the Principles of Economics where Jevons returned to the summary of the marginalist program, noting that the "purpose" of production was to "obtain the greatest hedonic result at the cost of the least amount of painful labour" [Jevons 1905, p.67]. He again referred to Cantillon's statement and to the discussion by early-nineteenth century economists of the role of labour. The `proper interpretation' of that discussion and of Cantillon depended on understanding the meaning of `production' which, Jevons observed,

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[36] That is, James Mill, McCulloch and Fawcett [JA 6/8/32,62,63].

[37] The quotation in the note [JA 6/8/60] is from Hearn 1864, pp.135-6, citing Bentham's Manual of Political Economy [Bentham 1962 (1838-1842), pp.36n-37n]. In Plutology, the quotation was preceded by Hearn's discussion of how `capitals' were "the products of labour and natural agents" [Hearn 1864, p.134] and was followed a few pages later by the analysis of capital from which Jevons cited a long extract in TPE [Hearn 1864, pp.139-40; Jevons 1871, pp.215-6.

> is one of the very few happily chosen terms which the economist possesses. Etymologically the term implies that we draw wealth forth, and this is the correct idea of production. Labour creates nothing, but merely draws from the crust of the globe the materials which are to be utilised. It is, with but slight exception, only the natural properties of the matter which allow it to be utilised ... Our labour ... only appropriates things, and by changes of form and place renders them useful for the satisfaction of our wants [ibid. pp.68,69].

This was, as Jevons acknowledged, an argument made by J.B. Say and Destutt de Tracy [Say 1821, p.3; Tracy 1817, pp.19-20 ('Treatise of the Will').[38] Perhaps the clearest statements, however, came from G.P. Scrope [1833, p.65] and Nassau Senior:

> To produce, as far as Political Economy is concerned, is to occasion an alteration in the conditions of existing matter, for the occasioning of which alteration, or for the things thence resulting, something may be obtained in exchange. This alteration is a product. It is scarcely necessary to remind our readers that matter is susceptible neither of increase nor diminuition, and that all which man, or any other agent of which we have experience, can effect, is to alter the condition of its existing particles [Senior 1951 (1836), p.51].

Senior followed Say in using the argument to criticise Adam Smith's discussion of productive and unproductive labour [ibid. pp.53-7]. The argument was used also by John Stuart Mill to explain his distinction between productive and unproductive labour [Mill 1965 (1909), pp.23-5,45-53]. For Jevons, economists such as Say and Mill were correct to draw on the "law ... in physics ... that man can neither create nor annihilate matter", so that "creating wealth" really meant "creating utility" [Jevons 1905, p.68]. That `older' principle of indestructibility was, however, quite different from the conservation principle which now prevailed:

> Since most of these economists wrote, the truth of their remarks has been extended by the establishment of the principle of the conservation of

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[38] For discussion of the relevance of this and other arguments from physics for early nineteenth century theories of value, see Mirowski 1989, ch.4.

> energy. Not only of matter, but of energy we may say that it can neither be created nor annihilated. All change, then, is apparent rather than real change; motion, visible or invisible, is the sole real change, and that changes not, but is itself a constant change. Without, however, pursuing the physical aspects of this subject, we may easily see that the properly directed muscular energy of his body is almost the only agent of production which man can apply ... Science makes muscular energy the key to the vast stores of material energy existing in the things around us ... [ibid. pp.69-70].

As was suggested above, Jevons had formulated the summary of the marginalist program using Liebig's argument that `Cultivation is the economy of force. Science teaches us the simplest means of obtaining the greatest effect with the smallest expenditure of organic power, and with given means to produce a maximum of force'. Near the end of his life Jevons provided his own version of this argument by restating it in terms of the conservation of energy.

Conclusions

The significance of the specificity of Jevons' summary and the means by which he produced it is obscured by suggestions that the publication of TPE, Carl Menger's Principles (1871) and Leon Walras' Elements (1874-77) inaugurated the analytical framework which Lionel Robbins subsequently characterised as the science of "Modern Economics" [Robbins 1949 (1935), p.2]. It has been argued that with the publication of the three post-classical texts, "[f]or the first time, economics truly became the science that studies the relation between given ends and given scarce means that have alternative uses for the achievement of those ends" [Blaug 1997, p.278]. That neat linear account is, however, misleading.[39] So far as I am aware, no Robbins-type statement can be found in Walras' Elements. With regard to Menger's Principles, although Robbins' account was understood at the time to be a summary of contemporary Austrian theory and Robbins did refer to the Principles when stating his definition, subsequent commentary has noted that

[39] It is difficult, for example, to envisage Alfred Marshall agreeing with Robbins' definition [Groenewegen 1995, p.788].

the link to Menger appears `distant and diffuse'.[40] It is only in TPE that the later definition of economics can find a clear precedent.

It should also be noted that, while Jevons' summary bore a family resemblance to the later definition because both used a mechanical analogue of maximisation subject to given means, there was a substantive analytical distance between them on at least four counts. First, the domains of economics were different For Jevons, the domain of political economy (`economics' by the second edition of 1879) was wealth, rather than a theory of logic of choice. Second, two quite distinct epistemological frameworks were employed. For Jevons, it was possible for the economist to declare in favour of (some) economic policies within the domain of science, a possibility precluded by the later designation of economics as a `value-free science'.[41] Third, as was emphasised above, Jevons' summary specifically referred to a long-period equilibrium discussed in Chapter V of TPE, rather than to the market-period analysis of exchange in Chapter IV which Robbins and subsequent commentators regarded as the core of Jevons' contribution [Robbins 1982 (1936), pp.313-7]. Fourth, labour was privileged as `the first element of production' in Jevons' summary, whereas later theory did not depict a particular `factor of production' as having any special significance. Given those differences, the purpose of this chapter has been to identify the particular theoretical framework with which Jevons produced his mechanical analogue.

Treating population as a parameter was implicit in Jevons' use of Jennings' Natural Elements when he began work on the marginalist project in 1860. Working from Carpenter's exposition of physiological psychology and Whewell's mechanics with its discussion of `labouring force', Jennings provided an account of how the level of output depended on the work decision by the labour force in a stimulus-response behavioural framework. Maximisation of output occurred where there was a `balance' of pleasure and pain. Jevons initially reworked that analysis as

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[40] Robbins [1949 (1935), p.16n] referred to the original edition of Menger's Principles. Peter Groenewegen has informed me that the pages cited correspond to Chapter II of the English translation [Menger 1950 (1871)]. Menger, however, limited `economic' phenomena far more than Robbins and did not use a marginal utility theory nor, consequently, a maximisation principle in terms of a marginalist equilibrium condition. Moreover, the depiction of the object of economics as "exclusively a study of the pure-logic-of-choice" reflects the approach of later Austrian theory. The link to Menger thus appears "distant and diffuse" [Endres 1997, pp.24,29-30,36].

[41] See the discussion of both these points in Chapter 5 of this thesis.

'the mechanics of self-interest' with De Morgan's calculus and Poisson's variational mechanics. Subsequently, he was able to rethink the significance, and thus produce the summary, of the project using the binding of the general principle of the conservation of force. Although Hearn's Plutology helped clarify the issues, the more important use of the principle of least action from Liebig's Chemical Letters followed Jevons' familiarity with the significance of the conservation of force by the early 1860s. In the context of writing CQ, following Armstrong's reference points of the conservation of force, heat theory and engines, Liebig's discussion of the body and labour in similar terms provided both the binding and organisation for Jevons' summary. The terms of Jevons' argument then underwent a further terminological change when he adopted Tyndall's argument that the force and energy frameworks were equivalent. Many traces of the uneven path to 1871 had disappeared when TPE was published, however, as Jevons now referred to the work of the North British energy physicists. His summary of the marginalist program thus depended on a series of interlocking changes in physics and other discourses. To depict behaviour in a functional form, which was equivalent to a force (or an increment of energy), commensurate with other 'natural forces' bound together in a conservation principle with an adoption of the principle of least action, was only possible after the mid-nineteenth century.

Jevons' attempt to rework his initial argument by reference to a physics of energy was not unique. From the late 1850s, Karl Marx was also reworking his analysis of political economy in terms of 'labour power', with its reference points located in the new conservation principles [Rabinbach 1990, ch. 3].[42] The two analyses were, of course, quite different, a neat point of contrast being Jevons' discussion of the 'duration' and 'intensity' of work compared with Marx's detailed analysis of absolute and relative surplus value [Marx 1974, Parts III-IV]. Analogous to Marx, Jevons' analysis of labour as the 'first element of production' provided an underlying rationale for his discussion elsewhere of wage determination, trade unions and the policies necessary to change behaviour so as to produce an efficient or 'civilised' labour force. It should be emphasised, however, that, although a conservation principle was crucial for Jevons rethinking the terms of his initial project, it made little difference to the formal presentation of his 'model' of exchange and production in chapters IV and V of TPE. In particular, the representation of market-period trading in Chapter IV retained the essential

[42] Marx also drew on Liebig for his analysis of the adverse ecological consequences of the expansion of agricultural output [Foster 1999].

characteristics of the mechanics Jevons had used to formulate it in the early 1860s. It was the attempt to represent political economy as a form of mechanics that generated a major and, for Jevons, an irresolvable problem. By the time that TPE was published, he realised that he could not explain and depict market-period trading in terms of an equilibrium outcome as required by the mechanics 'model' based on the calculus. This equilibrium problem and Jevons' response to it will be examined in the following two chapters.

Chapter 7

'THE CARDINAL DIFFICULTY OF THE WHOLE THEORY': JEVONS' ELUSIVE EQUILIBRIUM

> The notion of getting into equilibrium is a metaphor based on space to explain a process which takes place in time.
>
> Joan Robinson

> There are hardly any of the processes of industry which do not partly depend upon the properties of the lever; but it would be a strange classification which included those properties among the truths of Political Economy.
>
> John Stuart Mill

In the Preface to the first edition of his Theory of Political Economy (TPE), Jevons noted that, in chapter IV, he had "alluded" to the "cardinal difficulty with the whole theory" [Jevons 1871, p.x; 1970, p.45]. As Jevons did not make a habit of advertising the problems he recognised with the marginalist theory (see Chapter 8 of this thesis), the reference indicates that he considered 'the cardinal difficulty' a matter of substantive concern. Because it was only 'alluded' to, however, it was not clearly identified. The purpose of the present chapter is twofold. The first is to argue that the difficulty consisted in explaining how an equilibrium is attained in a market period and that Jevons was unable to do so. The second is to show how he then obscured both the presence and the significance of the problem with a series of rhetorical devices in TPE.

The basis of the difficulty turned on the relationship between the marginal utility theory and 'the laws of supply and demand'. One of Jevons' principal arguments in TPE was that, with the utility theory, he had, for the first time, provided a rigorous theoretical explanation for the laws that, as 'facts', described 'concrete' market phenomena. This meant, in turn, Jevons claimed, that the theory was 'verified' in the functioning of actual markets. To explain the attainment of equilibrium with the theory, Jevons depicted a representative transactor adjusting purchases in a sequence of disequilibrium transactions with a given exchange ratio (or market price). The problem was that Jevons' representation of the laws of supply and demand entailed that every transaction would change the price. The attainment of equilibrium could not, therefore, occur as any transaction would change one of the 'data' of the equilibrium position. The problem was compounded when Jevons also argued that trading was affected by stochastic

shocks in the form of `news'. This required continual adjustments to, and revisions of, expectations as transactors could not predict the arrival of news nor the precise way(s) in which other transactors would respond to it. The utility schedules representing transactors' actions would, therefore, be subject to continual shifts. This point was, however, analytically separate from Jevons' `cardinal difficulty' of explaining how equilbrium could be attained with a given set of utility functions.

Unable to solve the problem, Jevons produced a confusing account of market-period trading in TPE. On the one hand, he gave the impression at a number of places that he could explain how equilibrium was attained through adjustments with disequilibrium transactions. At the same time, he `alluded' to the problem, but failed to clearly identify it. He did not make clear, therefore, that his account was restricted to the depiction of equilibrium outcomes, the attainment of which he could not explain. He then resorted to the argument that all market transactions could be depicted as occurring at equilibrium and attempted to defend that result, principally by drawing on a number of arguments from mechanics and natural philosophy (physics). As was explained in previous chapters, he had developed his marginalist analysis using a series of mechanical metaphors. The basic exchange equilibrium condition, for example, was derived from that for a lever in static equilibrium. In explaining that derivation, Jevons defended his analysis by referring to the `principle of virtual velocities' from (variational) mechanics, which argued that all outcomes in a system could be explained in terms of equilibrium. It was consistent with his only alluding to the attainment problem, however, that the significance of the principle of virtual velocities was not clearly explained.

The analysis is presented in five sections. The first considers Jevons' discussion of market-period trading in Chapter IV, where he argued that the marginalist theory was `practically verified' in `actual' markets. Section 7.2 then explains his `difficulty' with equilibrium. The following section discusses the passages where Jevons `alluded' to the problem, while section 7.4 considers the lever analogy and the reference to the principle of virtual velocities. It is concluded that Jevons' confusing discussion of his theory and its relevance for explaining events in `actual' markets was a deliberate rhetorical strategy, designed to avoid a clear discussion of his equilibrium problem. Section 7.5 shows how the context in which TPE was written explains why Jevons adopted that strategy.

7.1 Market-Period Trading

Jevons' discussion of trading (or exchange) in a market period in Chapter IV of TPE assumed a "theoretically perfect" market which was characterised by six conditions:

(i) the ratio of exchange "between any two persons should be known to all the others";
(ii) transactions were motivated purely by self-interest and the maximisation of utility;
(iii) "perfectly free competition" prevailed so that "anyone will exchange with anyone else";
(iv) there were no conspiracies for withholding supplies to increase prices;
(v) commodities were homogenous;
(vi) there was a singie price (or ratio of exchange) "at any moment"

[Jevons 1970, 133-4,136,137].[1]

The uniform price was "a general law of the utmost importance in economics", which, in the second edition, was labelled "the law of indifference ... in the same open market, at any moment, there cannot be two prices for the same kind of article" [Jevons 1970, p.137].[2] The archetypal market used to illustrate the argument was that for wholesale commodities, such cotton and coal, or for financial instruments, such as stocks [ibid. p.132]. In those markets, Jevons asserted, brokers established the prevailing price: "The theoretical conception of a perfect market is more or less completely carried out in practice. It is the work of brokers in any extensive market to organize exchange, so that every purchase shall be made with the most thorough acquaintance with the conditions of the trade ... It is only thus that a definite market price can be ascertained at every moment, and varied according to the frequent news capable of affecting buyers

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[1] Jevons' use of the calculus also required that commodities were infinitely divisible. The difficulties this created for his analysis, put to one side here, are considered in Chapter 8.

[2] In the first edition, the law was referred to as the `principle of uniformity' [Jevons 1871, p.99].

and sellers" [ibid. pp.133,134].[3] This meant that constantly changing prices were consistent with the law of indifference: "Though the price of the same commodity must be uniform at any one moment, it may vary from moment to moment, and must be conceived as in a state of continual change" [ibid. p.137]. The key analytical role attributed to brokers was further illustrated when Jevons, in effect, defined a market in terms of the law:

> By a market I shall mean two or more persons dealing in two or more commodities, whose stocks of those commodities and intentions of exchanging are known to all ... It is only so far as this community of knowledge extends that the market extends. Any persons who are not acquainted at the moment with the prevailing ratio of exchange, or whose stocks are not available for want of communication, must not be considered part of the market [Jevons 1970, p.133].

It was a peculiar argument. With no trading within a spread of buy and sell offers by transactors, the maximisation assumption entailed that all trades took place at equilibrium. Yet there was no explanation for how brokers would establish a uniform price and certainly not at `every moment' of trading [Fusfeld 1990].[4] The figure of `brokers' thus acted as a deus ex machina, analogous to that of `the auctioneer' in later post-classical theory. It should be noted, however, that Jevons' notion of `perfect competition' was quite different from that of the later theory in two important respects. The first was that, contrary to some accounts,[5] he did not depict all transactors as price-takers in TPE. Attributing a price-taking `model' to TPE ignores the role of brokers and Jevons' clear statement that, with continuous trading in a market period, any set of trades would change the price: "In theory, this effect of exchange upon the ratio of exchange must be conceived to exist in some degree, however small may be the purchases concerned" [ibid. p.138]. The second difference with the later theory concerned the knowledge of transactors. Jevons

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[3] It has been argued that Jevons regarded the law of indifference as "an abstraction from reality. In reality, differences in observed prices arose all the time in practice..." [Peart 1998, p.310]. This depends, in part, on reading Jevons' statement that theoretically perfect markets existed `more or less completely in practice' to mean that perfect markets rarely occurred `in reality' [ibid. p.316].

[4] The analysis also erased the important role in British stock exchanges of `jobbers', the market makers (or `dealers') who carried out brokers' orders for buying and selling [Attard 2000].

[5] Creedy 1980, p.268; Schabas 1990, p.33; Peart 1998, pp.308, 309.

defined a market as "theoretically perfect only when all traders have perfect knowledge of the conditions of supply and demand and the consequent ratio of exchange" [Jevons 1970, p.134]. This `perfect knowledge', however, entailed that participants had that information `at any moment' and not that they had complete knowledge of future events, even on the same day.[6] Jevons made this clear in a note added to the second edition when, discussing the law of indifference and how the theory was "verified in practice", he referred to

> New York stock markets, where it is the practice to sell stocks by auction in successive lots, without disclosing the total amount to be put up. When the amount offered begins to exceed what was expected, then each successive lot brings a less price, and those who bought the earlier lots suffer. But if the amount offered is small, the early buyers have the advantage. Such an auction sale only exhibits in miniature what is constantly going on in the markets generally on a large scale [Jevons 1970, p.137n].

Jevons' statement that perfect markets were to be found `more or less completely carried out in practice', indicates that he acknowledged there were some exceptions. Three can be identified in TPE, two of which concerned traders in specialised commodity or financial markets. The first was that speculators could manipulate market outcomes through, for example, the use of `corners'. Changes in prices would then bear "no proper relation to the existing supplies", producing "unnatural ratios of exchange". The solution was state intervention in the form, for example, of regulations requiring information to be posted regarding the amount of stocks to be traded on a particular day [Jevons 1970, pp.133,134].[7] The second exception concerned the law of indifference when Jevons referred to "Such differences as may practically occur arise from extraneous circumstances such as the defective credit of purchasers, their imperfect knowledge of the markets, and so on" [1970, p.137]. This was, however, the only acknowledgement Jevons made in TPE regarding such divergences. While John Stuart Mill and J.E. Cairnes

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[6] Cf. the unqualified assertion that Jevons' theory assumed "perfect competition and perfect information" [Schabas 1990, p. 40].

[7] It has been suggested that Jevons' reference to speculators "meant that trades would occur that violate his equilibrium conditions for exchanges" [Peart 1998, p.316]. The `violation', however, concerned one of the conditions for a perfect market. The equilibrium conditions for exchange would still apply, as they simply entailed that purchases were made at the price at any `moment'. Such prices would be `unnatural' or `artificial' because they would be higher than those in a perfect market.

regarded price dispersion as the rule in retail (but not wholesale) markets,[6] Jevons treated dispersion as an exception which required little attention.

The third exception to the conditions required by the theory concerned the behaviour of final consumers. At a number of points in TPE, Jevons discussed whether `actual' individuals would behave as required by the theory in adjusting their purchases in a continuous (marginalist) maximising manner as prices changed [Jevons 1970, pp.86,108-9,119,135-6]. He acknowledged that some ("many" at one point [ibid. p.86], although he usually referred to one or a few individuals) would not do so: "We cannot usually observe any precise and continuous variation in the wants and deeds of an individual, because the actions of extraneous motives, or what would seem to be caprice, overwhelms minute tendencies" [ibid. p.135]. However, because he assumed that behaviour was normally distributed (according to `the law of error') purchasers would, on average, behave in the requisite manner. So, for example, if the price of a commodity increased,

> a single individual ... probably continues his ordinary consumption until accident directs his attention to a rise in price, and he then, perhaps, discontinues the use of the article altogether for a time. But the aggregate or what is the same, the average consumption of a large community will be found to vary continuously or nearly so. The most minute tendencies make themselves apparent in a wide average. Thus, our laws of economics will be theoretically true in the case of individuals, and practically true in the case of large aggregates; but the general principles will be the same, whatever the extent of the trading body considered [ibid. p.135].

Indeed, the way in which particular `actual' individuals behaved was virtually irrelevant: "the movement of trade and industry depends on averages and aggregates, not on the whims of individuals" [ibid. p.136]. Due to the law of error, "accidental and disturbing causes will operate, in the long run, as often in one direction as the other, so as to neutralise each other" [ibid. p.86]. The use of that assumption entailed that consumers' behaviour was independent, which marked a significant break with the interdependent behaviour assumed by earlier

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[6] See the discussion and references in White 1994b, p.152.

economists such as Adam Smith and Nassau Senior (see Chapters 2 and 3 of this thesis).[9]

The effect of Jevons' discussion of possible exceptions to perfect markets was to reinforce his claim that such markets could be taken as the rule. The law of indifference was crucial because it governed the possibility of equilibrium trades and hence the material welfare maximisation results that, Jevons claimed, followed from `perfect freedom of exchange':

> so far as is consistent with the inequality of wealth in every community, all commodities are distributed by exchange so as to produce the maximum of benefit ... No one is ever required to give what he more desires for what he less desires, so that perfect freedom of exchange must be to the advantage of all [Jevons 1970, p.171; see also p.173].

It was, however, in explaining the attainment of an equilibrium position that Jevons realised he faced the `cardinal difficulty with the whole theory'.

7.2 The Equilibrium Problem

As discussed in Chapter 1 of this thesis, the analysis of market-period trading in chapter IV was designed to show that the `facts' of the `laws of supply and demand' could be explained by the marginal utility theory. For two representative transactors trading commodities x and y, the basic equilibrium exchange condition was $\phi x/\psi y = dy/dx = y/x$, where: $\phi x/\psi y$ is the ratio of the final degree of utility for the two commodities; dy/dx is the marginal exchange ratio; y/x is the market exchange ratio. With the market exchange ratio given at any `moment' by the law of indifference, the theory depicted an equilibrium between supply and demand:

> We may regard *x* as the quantity demanded on the one side and supplied on the other; similarly, *y* is the quantity supplied on the one side and demanded on the other. Now, when we hold the two equations to be

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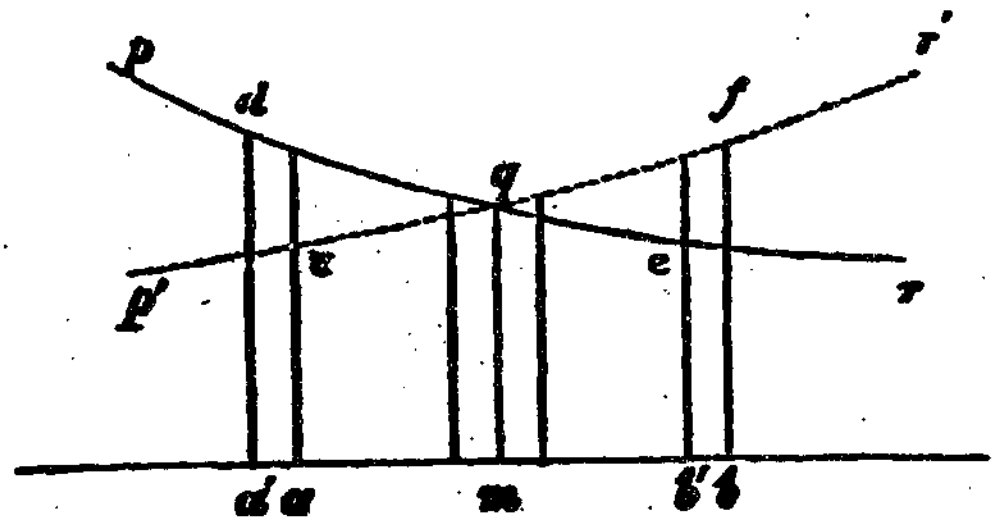
[9] It has been claimed that "Jevons sometimes presumed that the effects of `caprice' would balance across individuals, so that on average, an aggregate specification will be correct" [Peart 1998, p.321, n.10; see also p.319]. The point, however, is not that Jevons `sometimes presumed' this, but rather that it was at the core of his argument for the validity of the theory. Milgate [1987, p.180] confuses Jevons' reference to "the long run" in that context [Jevons 1970, p.86] with a discussion of long-period equilibrium, involving production.

true, we assume that the *x* and *y* of one equation equal those of the other. The laws of supply and demand are thus a result of what seems to me the true theory of value or exchange [Jevons 1970, p.144].

In the section of the chapter immediately preceding that analysis, Jevons had discussed how the equilibrium maximisation point could be reached, using a utility diagram for a representative transactor [Jevons 1970, p.140].

Figure 1



The transactor held a stock of commodity b (the supply), exchanging units of it for those of commodity a (the demand). The final degree of utility function for a (*pr*), was 'measured' from left to right. The corresponding function for b (*p'r'*), reversed and superimposed on that for a, was 'measured' from right to left. Acquisition of the unit *aa'* would produce a net utility gain (*a'd* > *ac*) and exchange would continue until the equilibrium point *q*. Transactions would not persistently take place to the right of *q* as there would be a net utility loss (*eb'* < *fb*). In representing disequilibrium transactions, the diagram showed how utility was maximised at equilibrium: "Exchange will thus go on until each party has obtained all the benefit that is possible, and loss of utility would result if more were exchanged. Both parties, then, rest in satisfaction and equilibrium, and the degrees of utility have come to their level, as it were." It is important for the analysis below to note that, although Jevons acknowledged that the theory dealt with "infinitely small quantities" of commodities,

his discussion also referred to `finite' quantities, such as ten pounds of corn [Jevons 1970, p.140]. [10]

The depiction of adjustment to equilibrium with a given exchange ratio appears, at first sight, to be consistent with references, elsewhere in the same chapter, to "the conditions of a great market where vast quantities of some stock are available, so that any one small trader will not appreciably affect the ratio of exchange" [ibid. p.150]. In such cases, the equilibrium condition "accurately represents the position of an individual consumer with regard to the aggregate trade of a large community, since he must buy at the current prices, which he cannot in any appreciable degree affect" [ibid. p.151]. The argument was, however, misleading. As was noted above, Jevons made clear that any set of trades, represented by the behaviour of a representative transactor, would change the ratio and, therefore, "the conditions of utility" [Jevons 1970, p.137]. This resulted in Jevons' `difficulty': adjustment towards an equilibrium in a series of disequilibrium transactions would induce a parameter shift (the price) and hence a new equilibrium position. Any convergence to an equilibrium through disequilibrium transactions would be akin to chasing a will o' the wisp. Nor was the problem restricted to transactions by a group of traders. As was noted above, Jevons argued that, in theory, any trade would change the ratio. Even when he referred to an `individual consumer' whose transactions could not `appreciably affect' the price (see above), he acknowledged in the same paragraph that "the smallest purchasers do affect the market in some degree" [Jevons 1970, p.151].

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[10] The single diagram in TPE can be compared with the more complicated series used in 1868 when Jevons discussed the exchange theory with H.C. Fleeming Jenkin [Black 1973-81, III, pp.166-78]. If the diagrams in Jenkin's letters are a reliable guide, Jevons drew intersecting utility curves for different transactors. This would help explain his subsequent comments about priority over Jenkin in using `intersecting curves to illustrate the determination of market price' (see the discussion and references in White 1989, pp.443-8). The single-transactor diagram in TPE appears to have been used for simplicity of exposition. In Jenkin's letters, a single diagram for two transactors could only represent trade in one commodity. Trade with two commodities, as required by the exchange theory, would necessitate at least one other diagram or a series of diagrams. The single-transactor diagram in TPE could show two commodities and hence illustrate the basic equilibrium exchange condition. It was, however, limited, which could explain Jevons' comment that the theory could not be "completely" represented by the diagram [Jevons 1970, p.141]. Jevons' subsequent claim that he had drawn diagrams to illustrate the `determination of market price' was misleading, as he assumed a given price for each set of transactions.

One possible 'solution' to the problem can be found in Jevons' discussion, elsewhere, of the properties of the laws of supply and demand. As was noted in Chapter 1, although Jevons insisted that the marginalist theory underpinned the laws, he did not explain the meaning of the latter in TPE. An account can be found, however, in the record of his mid-1870s lectures at Owens College [Black 1973-81, VI, pp.81-2], the Political Economy primer [Jevons 1878a, pp.99-100] and the unfinished Principles of Economics [Jevons 1905, ch.9]. For Jevons, the laws of supply and demand were empirical phenomena or 'facts' that were the result of a complex of causal factors in market trading. Because of that complexity, supply and demand could not be represented in a functional form. It was, however, possible, in principle, to explain the primary factors driving transactors' behaviour by the marginal utility theory, assuming that other factors could be put to one side. In terms of Figure 1, changes in demand and supply with the respective price and quantity outcomes could be represented and explained by shifts in the utility functions. The difficulty was, however, in explaining how an equilibrium could be attained.

In the Principles, Jevons argued that the laws "are in no sense ultimate, natural, or invariable laws, but only expressions of the general course of phenomena exhibited in commerce when there are many buyers and sellers". The market characteristics necessary for the laws were the same as those for perfect competition in TPE [Jevons 1905, pp.56,57]. Consistent with TPE, the summary of the laws in the lectures indicated that any change in demand or supply would change the price, producing an equilibrium: "The whole problem of value is supposed to be summed up in this equation, that the value will be adjusted to the point at which the quantity demanded is equal to the quantity offered" [Black 1973-81, vi, pp.81-2; see also Jevons 1878a, pp.99-100]. The record of the lectures acknowledged that it was difficult to explain how the 'equation' of demand and supply occurred, "except the higgling of the market achieves it" [Black 1973-81, vi, p.82]. While the primer also referred to higgling as 'settling' the price at a "Butter Cross" in a "market town", Jevons claimed there that all transactions took place at equilibrium:

> The [market] price must be such that the quantity demanded at any time is equal to the quantity supplied.
> The market price will be such that the demand at that price will equal the supply at that price. The quantity of butter or any other commodity that is sold must equal what is bought, because it is not sold until it is bought; but the price will settle itself accordingly [Jevons 1878a, p.100].

This was a peculiar claim - all transactions took place at equilibrium because, by definition, what was bought must equal what was sold. Here, Jevons was repeating an argument made by John Stuart Mill in 1869 when he rejected part of William Thornton's critique of the role of the laws of supply and demand in explaining price formation. In his On Labour (1869), Thornton had argued that, on a market day, most trading took place at disequilibrium positions. Disequilibrium was indicated by unsold inventories that provided a signal for sellers to adjust prices in a series of steps. Reviewing Thornton's text, Mill claimed that inventories should not be regarded as part of the market supply; the effect of this claim was to make demand and supply equal for all trades. As J.E. Cairnes explained to Mill, that `explanation' for equilibrium was a tautology (a `truism'), a point Mill conceded.[11]

Jevons also appeared to refer to Mill's tautology in TPE when claiming that "it is not difficult to find practical illustrations which will show how [the marginalist theory of exchange] is verified in the actual working of a great market. The ordinary laws of supply and demand, when properly stated, are the practical manifestation of the theory" [Jevons 1970, p.148]. Referring to Thornton's critique and to Mill's review, Jevons claimed (quite misleadingly) that he not only `accepted' Thornton's "view" but would "carry it further":

> The [marginalist] theory consists in carrying out this view to the point of asserting that it is only comparatively insignificant quantities of supply and demand which are at any moment operative on the ratio of exchange. This is practically verified by what takes place in any very large market -- say that of the Consolidated Three Per Cent Annuities ... Now the theory [asserts] ... that the market price of the funds is affected from hour to hour not by the enormous amounts which might be bought or sold at extreme prices, but by the comparatively insignificant amounts which are being bought or sold at the existing prices. A change of price is always occasioned by the overbalancing of the inclinations of those who will or will not sell just about the point at which prices stand. When Consols are at $93^{1/2}$, and business is in a tranquil state, it matters not how many buyers there are at 93, or sellers at 94. They are really off the market [Jevons 1970, pp.149-50].

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[11] See the discussion and references in White 1994b, pp.161-2 and section 5 below. Mill's attraction to a tautological treatment of equilibrium was evident from the 1830s in some notes he made on Nassau Senior's Outline [Mill 1945, p.134].

In the context of the references to Thornton and Mill, this statement had the effect of claiming that stocks could be ignored when explaining an equilibrium between demand and supply. If that was consistent with the definition of equilibrium in his primer,[12] Jevons had also confirmed that `comparatively insignificant' transactions would change the price. However, he then gave the impression that the theory could deal with disequilibrium transactions:

> When the price of funds is very steady and the market quiescent, it means that the stocks are distributed among holders in such a way that the exchange of more or less at the prevailing price is a matter of indifference. In practice, no market ever long fulfils the theoretical conditions of equilibrium, because, from the various accidents of life and business, there are sure to be people every day compelled to sell, or having sudden inducements to buy. There is nearly always, again, the influence of prospective supply or demand, depending on the political intelligence of the moment. Speculation complicates the action of the laws of supply and demand in a high degree, but does not in the least degree arrest their action or alter their nature. We shall never have a science of economics unless we learn to discern the operation of law even among the most perplexing complications and apparent interruptions [Jevons 1970, p.150].

It might be suggested that the ambiguous statements regarding price-taking and the possibility of accounting for disequilibrium transactions simply reflected confusion on Jevons' part. There are, however, two reasons for concluding that he was fully aware of the equilibrium attainment problem. The first is that, when he referred to `the cardinal difficulty with the whole theory' in the Preface to the first edition, Jevons wrote that he had `alluded' to the problem in the section of Chapter IV on the "Ratio of Exchange" [Jevons 1871, pp.91-5], which was retitled "The Law of Indifference" in the second edition [Jevons 1970, pp.136-9]. In that section, having discussed the law of indifference and how prices "must be conceived in a state of continual change", Jevons added: "Theoretically speaking, it would not usually be possible to buy two portions of the same commodity successively at the same ratio of exchange, because no sooner would the first portion have been bought than the conditions of utility would have been altered"

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[12] See also Jevons' reference in TPE to Mill's discussion of equilibrium having the appearance of a `truism' [Jevons 1970, p.143].

[Jevons 1970, p.137]. He reiterated the point in the same paragraph: "In theory this effect of exchange upon the ratio of exchange must be conceived to exist in some degree, however small may be the purchases made" [ibid. p.138]. This seems to be a reference to the attainment problem. It remained an `allusion', however, because Jevons did not make clear to the reader that the point entailed that he could not explain how an equilibrium was attained.

The second reason for concluding that Jevons was aware of the attainment problem was the way he proceeded, in the same section, to defend his basic equilibrium exchange condition against the criticism that it was unsatisfactory because it was not possible to derive a total integral of utility from it [Jevons 1871, pp.93-5; 1970, pp.138-9]. Following a restatement of that critique by a reviewer of the first edition, Jevons added a further defence in a new section in the second edition [Jevons 1970, pp.144-7]. That discussion was clear in that the problem (the absence of integration) was identified and a defence provided. It does not appear, therefore, that Jevons was referring to the integration criticism when he wrote of `alluding to the central difficulty' in the 1871 Preface.[13]

The integration criticism was quite distinct from the attainment problem in that the latter was pertinent with or without integration. Jevons' defence of the integration criticism is important to consider here, however, because of its implications for his `difficulty'. His defence turned on using metaphors from mechanics and natural philosophy. That is not surprising, as the discussion in the second edition made clear how the basic equilibrium condition was derived from that for a lever in static equilibrium. The significance of the metaphors was not simply that they provided a defence against the integration criticism but, more importantly, that they also provided a rationale for treating all trades as equilibrium transactions in a market period. It will be convenient to discuss Jevons' comments in the first edition of TPE in section 7.3. The following section will consider the further defence added to the second edition.

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[13] One commentary, which suggests that the `allusion' did refer to integration [Schabas 1990, pp.34,40,42,52] suggests [ibid. p.151, n.31] that Alfred Marshall agreed with the integration criticism. That is not the case (see chapter 8 of this thesis).

7.3 Statics and Dynamics

When Jevons referred to "the cardinal difficulty with the whole theory" in the Preface to the first edition of TPE, he added that, "So able a mathematician as my friend Professor Barker, of Owens College, has had the kindness to examine some of the proof-sheets carefully; but he is not, therefore, to be held responsible for the correctness of any part of the work" [Jevons 1970, p.45]. The reason for the qualification was that Barker, professor of mathematics at the College, objected to Jevons' basic condition for equilibrium in exchange. As Jevons subsequently noted in a letter to George Darwin, Barker insisted that the conditions "are (or at any rate ought to be) differential equations demanding integration, whereas I hold that, though deduced by the use of differentials, they are simply algebraic equations. The problem, as I regard it, is a [statical] one" [Black 1973-81, iv, p.87].[14] Harriet, Jevons' wife, later recalled a sharp disagreement on the matter: "Mr. Jevons showed him several of the proofs and I remember quite well the argument they had over one page, but Mr. Jevons said he could not put it otherwise than he had, nor could he see that it was wrong" [Konekamp 1982, p.398].[15]

In the first edition, Jevons' discussion of his "ratio of exchange" as a "differential coefficient" turned on the difference between `statics' and `dynamics' from mechanics as he outlined his defence in three steps. The first was to acknowledge that his approach was limited in that the mathematics could not depict the `dynamics' or `motion' of the system:

> *The real condition of industry is one of perpetual motion*[16] *and change.* Commodities are being continually manufactured and exchanged and

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[14] In the version of this letter published by Harriet Jevons in the Letters and Correspondence [Jevons 1886, pp.326-7], the word `statistical' appears, rather than `statical'. In reprinting the letter in the Papers and Correspondence, Professor Black [1973-81, IV, pp.86-7] suggests that was a misprint, given Jevons' statements in TPE. The problem may have been Harriet's transcription of the letter. The same point could also be made about the word `differential' after the close of the bracket in the quotation above. This appeared as `different' in the Letters and Correspondence and was silently corrected in the Papers and Correspondence.

[15] Barker's particular objection [Konekamp 1982, p.398] was to the statement of the equilibrium condition as $\Delta y/\Delta x = y/x$ or $\Delta y = y/x \,.\, \Delta x$ [Jevons 1871, p.99; 1970, p.141]. The same criticism was made in an unsigned review of the first edition published in the Saturday Review [Black 1973-81, VII, pp.152-7].

[16] Was this a joke, given Jevons' familiarity with the conservation of energy literature where the dismissal of the notion of a `perpetual motion' machine was a standard rhetorical device?

> consumed. If we wished to have a complete solution of the problem in all its natural complexity, we should have to treat it as a problem of motion – a problem of dynamics [Jevons 1970, p.138].

This was confusing. Chapter IV examined a market period with a parametric commodity stock at the beginning of the period. The reference here to production, exchange and consumption referred to an analysis of a series of market-periods tending toward, or oscillating around, a long-period equilibrium position as in Chapter V. The `complete solution' would presumably entail a mathematical analysis of the adjustment toward the long-period equilibrium. Jevons noted, however, that such an analysis was not "within our power" [Jevons 1970, p.138].

The second step was to acknowledge that the analysis could, therefore, deal only with `statics':

> It is only as a purely statical problem that I can venture to treat the action of exchange. Holders of commodities will be regarded not as continuously passing on these commodities in streams of trade, but as possessing certain fixed amounts which they exchange until they come to equilibrium [ibid. p.138].

With the reference to transactors `possessing certain fixed amounts', this step switched the argument to that for a market period. The static analysis of exchange included the process of adjustment to equilibrium. It appeared, therefore, to allow for the possibility of disequilibrium transactions. The final step, however, indicated that an adjustment process was precluded:

> It is much more easy to determine the point at which a pendulum will come to rest than to calculate the velocity at which it will move when displaced from that point of rest. Just so, it is a far more easy task to lay down the conditions under which trade is completed and interchange ceases, than to attempt to ascertain at what rate trade will go on when equilibrium is not attained [ibid].[17]

It was on this basis that Jevons justified his use of a differential coefficient equilibrium condition. If the analysis depicted dynamics, he would require

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[17] See the further discussion of the pendulum metaphor in section 7.4 below.

"differential equations, which would have to be integrated". That was not necessary, however, "in the statical view of the question" [ibid. p.138]. Given the law of indifference, "the last increments in an act of exchange must be exchanged in the same ratio as the whole quantities exchanged". With infinitely small units of a commodity, all transactions would take place at a (momentary) exchange ratio [ibid. p.139].

It was a confusing discussion. Shifting, without clarification, from a long-period to a market-period analysis, the upshot of the discussion was that the mathematical analysis could not depict transactors 'possessing certain fixed amounts of commodities which they exchange until they come to equilibrium', as Jevons had claimed in the second step of his argument. Instead, the analysis was consistent only with the equilibrium condition where 'trade is completed and interchange ceases'. The reader, however, was given the impression that the analysis could deal with disequilibrium trades, because the next section of the chapter contained Jevons' diagram of crossed and superimposed utility functions for a single transactor with the discussion of how exchange would 'go on' until equilibrium was attained (see above). That was followed with a section on "The Symbolic Statement of the Theory" [Jevons 1970, pp.141-4] where, criticising Mill's analysis of supply and demand, Jevons claimed that "our theory is perfectly consistent with the laws of supply and demand" [ibid. p.143]. Exchange was depicted in terms of an equilibrium condition for two transactors. At one point, however, Jevons acknowledged that each transactor "must ... derive equal utility from the final increments, otherwise it will be for his interest to exchange either more or less, and he will disturb the conditions of exchange" [ibid. p.142]. Once again, he had alluded to the attainment problem but failed to explain its significance for his claim about the analytical compatibility between the utility theory and the laws of supply and demand.

7.4 Virtual Realities

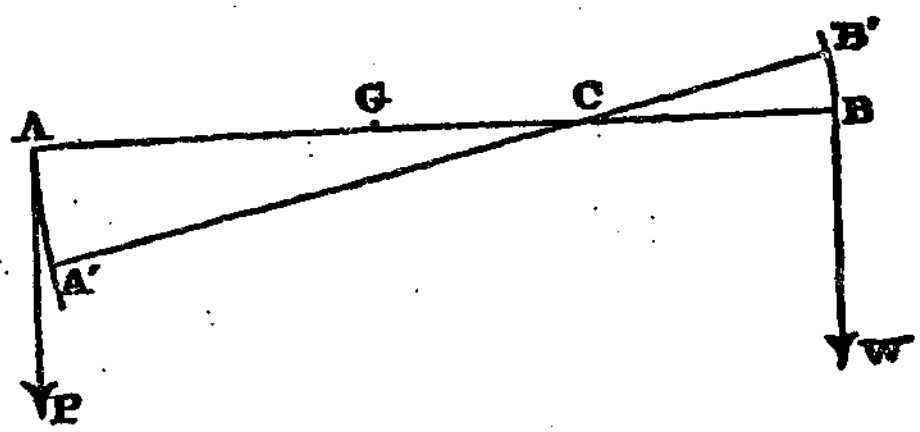
In the Preface to the first edition of TPE, Jevons noted that his

> theory of economy ... presents a close analogy to the science of statical mechanics, and the laws of exchange are found to resemble the laws of equilibrium of a lever as determined by the principle of virtual velocities. The nature of wealth and value is explained by the consideration of indefinitely small amounts of pleasure and pain, just as the theory of

> statics is made to rest upon the equation of indefinitely small amounts of energy [Jevons 1970, p.44].

In the second edition, when defending the basic equilibrium exchange condition against the integration criticism, he explained the analogy in some detail [ibid. pp.144-7], referring to the following diagram from one of the "best modern elementary" treatments of mechanics, Philip Magnus' Lessons in Elementary Mechanics [ibid. p.144; Magnus 1875, p.128].

FIG 2



AB is a lever turning, without friction, about the fulcrum C. P is a force applied at A, while W is the force exerted (or resistance overcome) at B. If the lever turns through the arc ACA', the work done by P = P.AA' and the work done by W = W.BB'. For equilibrium, the work is equivalent, such that P.AC = W.BC, or W/P = AC/BC. Hence, W/P = AA'/BB' = AC/BC. The ratio of the point masses (W/P) is inversely proportional to both the ratio of the arcs of displacement (AA'/BB') and the ratio of point distances from the fulcrum (AC/BC). With an infinitesimally small displacement, the equilibrium condition was "exactly similar in form to ... [that for] the theory of value" [Jevons 1970, p.145], so that

$$W/P = AA'/BB' = AC/BC$$
$$\phi x/\psi y = dy/dx = y/x$$

The final degrees of utility corresponded to the forces, the 'marginal' exchange to the displacement arcs and the exchange ratio to the distance of the point masses from the fulcrum (see Jevons' diagram, ibid. p.146).

Jevons' familiarity with the theory of the lever, used as the basic theoretical explanation for a balance, was the result of his training and work as a chemist and, especially, gold assayer at the Sydney Mint while in Australia (1854-59). Utilising that experience, at the beginning of 1861 he began work on a number of entries for a Dictionary of Chemistry, the first of which, "Balance", provided a detailed examination of the practice of using balances in chemistry, coupled with an explanation of the theory of the balance in terms of a lever [Jevons 1863].[18] The entry opened as follows:

> Chemistry being concerned with the relative masses or quantities of the elements which compose all known substances, and the weight or force of gravitation of a body being the only practicable measure of its mass or quantity of matter, the balance, which shows the equality of two weights, and may hence determine the ratio of all commensurable weights, is the chemist's most important instrument [Jevons 1863, p.481].

It was argued in Chapter 4 of this thesis that Jevons had derived his marginalist theory of behaviour in 1860 from Richard Jennings' representation of behaviour as a mechanics of balancing gravitational forces. The quotation above suggests how he was then able to both adapt and extend Jennings' analysis in formulating the theory of exchange with the lever analogy.[19] The discussion of the balance in TPE was, however, different from that in the chemistry Dictionary in two important respects. The first was Jevons' reference to "indefinitely small amounts of pleasure and pain" as akin to "indefinitely small amounts of energy" [Jevons 1970, p.44]. This was in line with Magnus' discussion [Magnus 1875, p.125] but had only became part of Jevons' language from the mid-1860s (see Chapter 6 of this thesis). The second and more important difference here was the use of the principle of virtual velocities. Jevons argued that, although it was `disguised' in `elementary' texts, the principle was "the real foundation of the science" of mechanics. He summarised it as follows:

> if any number of forces be in equilibrium at one or more points of a rigid body, and if this body receive an infinitely small displacement, the

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[18] See also the discussion in Maas 2001, chapter 7, which considers Jevons' more general use of the balance metaphor in his political economy.

[19] As was indicated in Chapter 1 of this thesis, the lever analogy also underpinned Jevons' depiction of value as an abstract ratio [cf. Jevons 1863, pp.481, 484].

> algebraic sum of the products of each force into its displacement is equal to zero. In the case of a lever of the first order, this amounts to saying that one force multiplied into its displacement will be neutralized by the other force multiplied into its negative displacement [Jevons 1970, p.145].

Without further explanation, it might seem that this was much the same argument as in the chemistry Dictionary, where the condition of static equilibrium for a balance was explained as "the sum of the moments of forces on one side [is] equal to that on the other" [Jevons 1863, p.487]. The only difference might appear to be that the argument in TPE depended on infinitesimally small changes, whereas the Dictionary entry (and, as Jevons noted in TPE, Magnus' account) dealt with `finite' changes. The principle of virtual velocities, however, was a general balancing principle that was supposed to apply to all mechanical systems.

Jevons' initial formulation of the balance metaphor drew on two principal theoretical sources. The first was the treatment of the calculus by Augustus De Morgan, whose classes Jevons had attended at University College, London, when he returned from Australia in 1859 [Black 1973-81, II, p.403].[20] The second was S.D. Poisson's Treatise on Mechanics (1833), an influential exposition of the French tradition of 'variational' mechanics which, in referring to the work of J.L. d'Alembert and J.L. Lagrange, stressed the principle of virtual velocities [Poisson 1842 (1833), I, pp.58-71; Grattan-Guinness 1990b, pp.318,325-7]. Jevons referred to Poisson's text in the chemistry Dictionary and in TPE when discussing the lever [Jevons 1863, p.489; 1970, p.147]. He could also have read a discussion of virtual velocities in the chapter "Application to Mechanics" in De Morgan's Differential and Integral Calculus. Like Poisson, De Morgan discussed the principle by referring to d'Alembert, arguing that it should be treated as an "axiomatic truth" [De Morgan 1842b, p.501; see also De Morgan 1842a, p.478].

The significance of the principle of virtual velocities in the variational mechanics tradition was the (problematic) claim that, with d'Alembert's action-reaction principle, all dynamic problems could be analysed in terms of statics and hence in

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[20] Jevons had also attended De Morgan's classes before he left for Australia. See the discussion of Jevons' mathematics with regard to De Morgan in Grattan-Guinness 2002; Black 1972.

terms of equilibrium.[21] As Poisson noted, the principle "implies ... that there is constantly an equilibrium between the given forces" [Poisson 1842 (1833), II, p.3]. De Morgan made the same point when referring to "D'Alembert's principle": "every problem of motion, of which the circumstances are known, may be reduced ... to one of equilibrium: that is to say, the properties of the actual variations which do take place may be investigated by means of the simple changes of place, without reference to time, which might be made in a system of rest" [De Morgan 1842b, p.510]. Jevons used the principle to argue that, because the lever displacements depicted "imaginary infinitesimal quantities", there was no requirement to integrate his basic equilibrium condition ("there is no effect to be summed up" [Jevons 1970, p.147]). The unstated import of the reference to the principle, however, was that it provided a rationale for treating all transactions as equilibrium outcomes in a market period. This was consistent with the way he referred to Mill's equilibrium tautology in the same chapter. In both cases, Jevons failed to explain the significance of his argument where `marginal' trades in the basic equilibrium condition (dy/dx) were virtual transactions that only existed in an `imaginary' form.

If Jevons did not clearly explain the significance of virtual velocities in the second edition of TPE, he had also buried a reference to the principle in the defence of his basic equilibrium condition in the first edition. As was noted above, he defended that condition by referring to a pendulum:

> It is much more easy to determine the point at which a pendulum will come to rest than to calculate the velocity at which it will move when displaced from that point of rest. Just so, it is a far more easy task to lay down the conditions under which trade is completed and interchange ceases, than to attempt to ascertain at what rate trade will go on when equilibrium is not attained [Jevons 1970, p.138].

Jevons had used the pendulum metaphor in Chapter I when justifying his treatment of behaviour as a balancing machine. He referred to De Morgan's Formal Logic (1847), which argued that the human mind could be represented as "an apparatus or piece of mechanism". A complex mechanism could be understood in different ways. Presented with a watch, for example, "One might

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[21] Smith and Wise 1989, pp.372-77; Wise 1989a, pp.289-91; Grattan-Guinness 1990a, pp.276-83. See also the discussion of the significance of virtual velocities as a general balancing principle in Poisson 1842 (1833), I, pp.531-65.

use the pendulum and the weight, another the springs and the balance: one might discover the combination of toothed wheels, another a more complicated action of lever upon lever" [De Morgan 1926 (1847), p.30]. Similarly, the mind could be represented in different ways because "We have manifestations only, without the smallest power of reference to other similar things, or the least knowledge of structure or process, other than what may be derived from those manifestations. It is the problem of the watch to those who have never seen any mechanism at all" [ibid. pp.29-30]. Jevons used a similar argument in TPE when, citing De Morgan on the use of the balance "to detect equality and inequality" [ibid. p.202; Jevons 1970, p.82],[22] he argued that

> It is from the quantitative effects of the feelings that we must estimate their comparative amounts. We can no more know or measure gravity in its own nature than we can measure a feeling; but, just as we measure gravity by its effects in the motion of a pendulum, so we may estimate the equality or inequality of feelings by the decisions of the human mind. The will is our pendulum, and its oscillations are minutely registered in the price lists of the markets [ibid. pp.83-4].

Having used the pendulum to justify the representation of actions as gravitational forces, Jevons indicated in Chapter IV that the metaphor was problematic. The point had also been acknowledged in the chemistry Dictionary when considering a balance "in the character of a compound pendulum" so as to analyse `motion' and hence its `velocity' or `vibration'. Jevons argued that, "Fully to understand the motions of a beam, it would be necessary to determine its moment of inertia round the axis, which is the sum of the moments of each particle, the moment of inertia being the movements of the particle multiplied by the square of its distance from the axis" [Jevons 1863, p.488]. He went on to note that "The mechanical problem of the balance is not so simple as may at first sight appear, and has not, so far as we are aware, been properly considered dynamically. The problem of the compound pendulum, will be found best treated by Poisson (Traite de Mechanique [sic], t.ii. c.i § 3)" [ibid. p.489]. Again, there was no explanation of the problem. The citation of Poisson's Treatise indicates, however, that Jevons was referring to the problem of

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[22] As published in in Jevons 1970, p.82, the paragraph immediately following the quotation from De Morgan appears to have been written by Jevons. It is actually a further quotation from De Morgan, as was clear in the first edition of TPE [Jevons 1871, p.11]. The mistake initially appeared in the second edition [Jevons 1879, p.10].

friction which, Poisson argued, could be dealt with theoretically by the use of d'Alembert's principle and virtual velocities [Poisson 1842 (1833), II, pp.4-5]. That seems to be the import of Jevons' statement, when discussing the lever in TPE, that the "theory is only true for infinitely small displacements, and no sooner has the lever begun to move through any finite arc AA', than it ceases to be exactly true that the work done by P equals P x arc AA' " [Jevons 1970, p.145]. Justifying his use of virtual velocities, Jevons cited Poisson's statement that "the method of infinitely small quantities" had been "exclusively adopted" in his Treatise [Poisson 1842 (1833), I, p.11; Jevons 1970, p.147].

The problem of accounting for friction was also important for a number of experimental results reported in Poisson's Treatise. Poisson noted that, experimentally, it was only in the case of very small oscillations of a pendulum that the force of resistance was proportional to the square of the velocity. In effect, there was a marked difference between the gravitational constant "assigned by the calculus" and that obtained from the experimental results [Poisson 1842 (1833), I, p.285; II, pp.iv,31-2]. Jevons referred to that matter in an article that appeared in Nature in October 1871, just before the publication of TPE. Criticising a summary of non-Euclidean geometry by Hermann von Helmholtz,[23] he wrote that

> The whole science of mechanics rests upon the motion of a uniform force, but where can we find such a force in operation? Gravity, doubtless, presents the nearest approximation to it; but if we let a body fall through a single foot, we know that the force varies even in that small space, and a strictly correct notion of a uniform force is only got by receding to infinitesimals ... [A] science of mechanics ... is generally only true of infinitesimals [Jevons 1871a, p.481].[24]

Here Jevons was following Poisson and De Morgan, who had defined "Force" as "a name given to that which causes a change in the velocity of a body" and a `uniform force' as one where the velocity "acquired ... in any one interval of time is the same as that acquired in any other interval of equal duration" [De Morgan 1842a, p.29].

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[23] See Richards 1988, ch.2.

In the discussion of statics and dynamics in the first edition of TPE and the explanation of the lever added in the second, Jevons' defence of his basic equilibrium exchange condition was dominated by the question of whether it required integration. The significance of the principle of virtual velocities was presented only in that context. The integration question was, however, something of a side-show. The unstated role of the principle was that it provided a means to sidestep his `cardinal difficulty' in that it provided a justification for treating all transactions as equilibrium outcomes. It was symptomatic of Jevons' references to the attainment problem, however, that the full implications of his reference to virtual velocities were not clearly explained.

7.5 Thornton's Revenge

Jevons' references to his `difficulty' read like an elaborate game with the reader of TPE. On the one hand, he remarked that he had `alluded' to the problem and presented a series of clues to identify it. On the other hand, he did not clearly identify the problem and gave the impression that disequilibrium trades posed no difficulty for his analysis. A possible explanation for that rhetorical strategy is that, convinced he had found the `truth', Jevons simply refused to clearly discuss any substantive difficulties he had identified with the theory. While this point is relevant, it would, if taken alone, reduce the explanation to a particular Jevons character trait. Consideration of the context in which TPE was written, however, provides a broader perspective to explain Jevons' peculiar treatment of the attainment problem.

Although it is not clear when Jevons recognised the problem, the available textual evidence suggests that it occurred between 1862, when the `Brief Account' of his theory was written, and late 1870, when he began working on the text of TPE. In the Brief Account, he referred to the properties of his equilibrium exchange condition with "infinitely small quantities of commodities":

> The ratio of the increments of the commodities ... would be indeterminate but for the existence of a law that all quantities of the same commodity, being uniform in kind, must be exchanged at the same rate. The last

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[24] Jevons added, in a phrase he also used in TPE regarding the utility theory, that "plane geometry [is] only approximately true in fact, and exactly true in theory" [Jevons 1871a, p.481].

> increments, then, must be exchanged, in the ratio of the whole quantities exchanged. To explain in ordinary words how the adjustment takes place under this condition is almost impossible [Jevons 1866b (1862), p.284].

While that statement might be taken as an indicator of the attainment problem, it seems more likely that it simply referred to the difficulty in explaining the adjustment without the diagram used in TPE (Figure 1 above). That reading is supported by Jevons' preceding comment that, "Whether the exchange will take place or not can only be ascertained by estimating the utility of the objects on either side, which is done by integrating the appropriate functions as limits. A balance of utility on both sides will lead to an exchange" [ibid. p.284]. A subsequent remark also indicates that, in 1862, Jevons saw no difficulty in referring to integration.[25] It should also be noted that a number of arguments in TPE clearly required a utility integral. The discussion of the gains from international trade in Chapter IV, for example, was conducted in terms of the total utility of a nation [Jevons 1970, pp.172-4].[26] The diagrams used to illustrate the argument appear to date from the early 1860s.[27] The adjustment-to-equilibrium diagram, which probably dates from the same period [White 1989, p.486], also requires an integral if `finite' quantities were referred to, as in TPE. Taken together, these references suggest that, when he initially formulated the theory, Jevons saw no difficulty in referring to a total integral of utility.

In TPE, however, Jevons claimed that his approach was built on "the fearless consideration of infinitely small quantities" [Jevons 1970, p.78] and that, although

> the mind often hesitates and is perplexed in making a choice of great importance ... [the theory] seldom involves the comparison of quantities differing much in amount. The theory turns upon those critical points where

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[25] "[T]hough the exchanges be regulated by equations, there cannot be equality in the whole utilities gained and lost, which are found by integrating the functions of utility of the respective commodities before and after exchange" [Jevons 1866b (1862), p.285].

[26] See also Figure 7 in Jevons 1970, p.160. That diagram was particularly problematic for Jevons as it referred to an indivisible commodity (see chapter 8 of this thesis).

[27] This is indicated by some notes in the Jevons Archive [John Rylands University Library of Manchester, JA 6/23/68-70] where the two separate aggregate utility diagrams in TPE appear on a single diagram. The handwriting suggests that the notes were written in the early to mid-1860s.

> pleasures are nearly, if not quite, equal. I never attempt to estimate the whole pleasure gained by purchasing a commodity [ibid. pp.84,85].

If that statement reflected Jevons' defence of his basic equilibrium exchange condition and hence the attainment problem, the last sentence was clearly incorrect (see above). While this provided another source of confusion in understanding Jevons' argument, it indicates that he was unable to make all aspects of his previous analysis consistent with the stress on infinitesimals in TPE.[28]

The attainment problem associated with disequilibrium trades had particular relevance in the context in which Jevons came to write TPE. As was noted above, in 1869 William Thornton's On Labour had attacked the relevance of references to `the laws of supply and demand' for explaining price formation. Focussing on trading during a market day (within a market period), Thornton defined an equilibrium as the trading cease-point that occurred when all commodity stocks were sold or a sellers' reservation price was reached. He argued that, if demand and supply were defined as the prices at which the purchasers and sellers were prepared, respectively, to trade different quantities, references to demand and supply could, in themselves, explain little about how the equilibrium position was reached. The process of price adjustment required an explanation of market coordination that depended on the interdependent behaviour of heterogeneous sellers with different access to credit facilities, experience and, therefore, knowledge. The signal for price adjustment during the day was the existence of unsold stocks, which meant that most trades occurred at disequilibrium (`intermediate') positions [Thornton 1869, pp.43-77].[29]

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[28] It has been argued that, following De Morgan, Jevons' use of the calculus was something of a blancmange of references to a theory of limits combined with ratios and differential coefficients ("those queer brutes that are smaller than ordinary quantities but not zero" [Grattan-Guinness 2002, p.693]). Grattan-Guinness suggests that Jevons "used the calculus best" in the Brief Account, as "clarity was reduced" in the second edition of TPE with the citation of Poisson on the use of infinitesimals [ibid. p.694]. If clarity was reduced, I suggest it was driven by the attainment problem.

[29] See White 1994b, pp.151-7. That account is, however, marred by the suggestions that Thornton was using a "path-dependent adjustment process" to equilibrium and that he regarded the equilibrium position as "virtually irrelevant" [ibid. pp.154,157].

If Thornton had introduced the question of how an equilibrium position was to be explained by coordination in a market, his focus on disequilibrium trading created a substantive difficulty for those who then attempted to restore `the laws of supply and demand' to the principal explanatory role in a market period. While dismissing Thornton's critique, in the first set of (quantity-form) supply and demand diagrams published in English, the engineer H.C. Fleeming Jenkin was confronted with an equilibrium attainment problem. Although the precise rationale for the shapes of his diagrams was unclear, Jenkin acknowledged that the demand curve for trading on a market day required a given set of expectations as a parameter. Disequilibrium trades would change the expectations and shift the function [Jenkin 1870, pp.153,154,155]. Jenkin then resorted to asserting that, with a uniform price set at any `moment' by market specialists, all trades during the day took place at equilibrium ("at each moment the ... law of supply and demand holds good" [ibid. p.156]).

Jevons' discussion of market-period trading in Chapter IV of TPE was marked by the effects of the debate over Thornton's critique. This is not simply because of the number of references to Thornton's arguments. As Jevons subsequently acknowledged, he wrote up TPE for publication because Jenkin's article made no mention of Jevons' utility theory that had been discussed in an exchange of letters between them in 1868 [Jevons 1911, p.lvii; Black 1973-81, III, pp.166-78]. Jenkin's article was important for Jevons in other ways. The engineer's discussion of indeterminacy in exchange with an indivisible commodity, for example, appears to have prompted Jevons' reassessment of his own analysis of that topic (see Chapter 8 of this thesis). It is also noteworthy that, in TPE, Jevons adopted Jenkin's tactic of claiming that market specialists (brokers) set a uniform price `at any moment'. In both cases, the tactic was used to sidestep an attainment problem that followed the attempt to depict or explain the laws of supply and demand in a functional form. The manifestation of Jevons' problem was different from Jenkin's because he did not use supply and demand functions. Nevertheless, it had the same basis in disequilibrium trades shifting a parameter. Jevons' initial failure to identify the problem, his inconsistent arguments in TPE regarding references to total utility and his use of market specialists to set a uniform price at any moment, might suggest that Jevons identified his particular indeterminacy problem after reading Jenkin's article. The inconsistencies noted above in TPE regarding references to total utility could thus reflect the way in which Jevons hurriedly wrote up TPE to establish his own contribution to the debate over the laws of supply and demand.

Whether Jevons recognised his attainment problem before or after reading Jenkin's article, it was a serious liability in the wake of Thornton's critique. In TPE, the most positive comment that Jevons felt able to make about On Labour was the following:

> Though Mr Thornton's objections [to explanations of price formation in terms of the laws of supply and demand] are mostly beside the question, his remarks have served to show that the action of the laws of supply and demand was inadequately explained by previous economists. What constitutes the demand and the supply was not carefully enough investigated [Jevons 1970, p.149].

While Jevons attributed a positive, albeit limited, role to On Labour, it was extraordinary to claim that Thornton's analysis was `mostly beside the question'. Thornton had argued that references to the laws of supply and demand could not provide a substantive explanation for the adjustment to equilibrium in a market period, and that was precisely the problem that Jevons could not solve within his own framework. It was that context that seems to explain, in large part, his rhetorical strategy in TPE of alluding to, but refusing to explain, the `cardinal difficulty of the whole theory'.

Conclusions

When Jevons delivered a defence of `the' mathematical theory of political economy to the Manchester Statistical Society in 1874, he drew attention to the fundamental similarity between his basic equilibrium condition of exchange in Chapter IV in TPE and that given in the first volume of Leon Walras' Elements (1874). He argued that

> M. Walras and myself have, in entire independence of each other, by paths of reasoning which are, in the forms of expression, the methods of illustration, and all merely incidental circumstances, as different as they well could be, yet arrived at identical results. This fundamental formula of the science of economy is far from being of an obvious character, so that the coincidence cannot possibly be attributed to chance. The only other explanation which can be entertained is that it arises from the sound and truthful investigation of the subject [Jevons 1875, p.3].

While the `fundamental formula' for equilibrium in a market period was `far from being of an obvious character', it did not necessarily follow that the similarity in results was due to Jevons and Walras having arrived at `the truth'. For there was another possible explanation - they had both used the condition for a lever in static equilibrium to derive their `formula'. If Jevons did not enlighten his audience regarding the metaphor in 1874, he reiterated the claim made in TPE that "the laws of supply and demand, as generally accepted by economists, are easily derived from the theory of exchange, so that the theory is verified by experience and statistical science" [Jevons 1875, p.15]. This was ingenuous. As Jevons realised, `the cardinal difficulty of the whole theory' was that the mechanical metaphor of adjustment to equilibrium with a given exchange ratio was incompatible with the changing exchange ratio (price) required by the laws.

If the problem of the attainment of equilibrium has continued to dog post-classical theory [Fisher 1987], it is odd that the secondary literature on TPE has devoted little attention to identifying Jevons' difficulty and hence to explaining why he only alluded to, rather than clearly explaining, the problem. In part, this is because the problem was simply ignored. Knut Wicksell, for example, while using Jevons' crossed and superimposed utility diagrams to represent the transactions of a representative actor, simply `supposed' that "on the market one price or a proportion of exchange between every two commodities establishes itself within in a short time for each commodity in which afterwards the bulk of transactions are done" [Wicksell 1954 (1893), pp.58-9, pp.70-1].

A second strand in the literature erased the terms and complexity of Jevons' argument by reading his distinction between statics and dynamics as a discussion of, respectively, equilibrium and disequilibrium in exchange. This reading first appeared in the late 1890s and early 1890s in the debate between Leon Walras and F.Y. Edgeworth regarding the validity of Walras' tâtonnement explanation of equilibrium [Bridel and Huck 2002, pp.525-7]. It subsequently reappeared in an account which, after referring to Jevons' defence of differential coefficients, suggested that "[b]ehind this `statical view of the question' there must be a dynamic process of trading. What Jevons had in mind is a piecemeal exchange process" of recontracting and arbitrage [Negishi 1982, pp.222, 226; see also Dome 1994, pp.95-7]. TPE's exchange theory is then represented by an Edgeworth-Bowley box where recontracting explains the "law of indifference ... that plays the role of the equilibrium condition for Jevons ... Demand equals supply trivially, since the quantity of a commodity given by person A is equal to the

quantity received by another person B" [Negishi 1994, p.xx]. Putting to one side that Jevons did not refer to recontracting which is inconsistent with his discussion of market-day trading,[30] this misunderstands his distinction between statics and dynamics. In TPE, dynamics referred to the relation between a long period and a series of market periods. Statics included an explanation of an adjustment to equilibrium (although Jevons was unable to do so). The misunderstanding follows from reading Jevons' reference to `dynamics' within the terms of later general equilibrium theory [see Weintraub 1991, ch.7], so that it is assumed to refer to the convergence to a competitive equilibrium within a `short period'. Any attempt to represent Jevons' analysis in terms of an Edgeworth-Bowley box (see also Creedy 1992a, pp.128-39) thus erases his particular distinction between statics and dynamics as well as his depiction of equilibrium prevailing at any moment in a market period.

The importance of paying close attention to Jevons' language is not simply to locate the reference points for, and hence the meaning of, particular categories. It is also essential for unravelling the ways in which he attempted to deal with his `cardinal difficulty'. Although Jevons explicitly used the tautological definition of equilibrium in his primer (was it a tale for children?), the use of momentary equilibria in TPE seems to have been the result of the attainment problem, rather than a belief that disequilibrium transactions were irrelevant in `actual' markets. In noting Jevons' references to `actual markets', a third strand of commentary has suggested he drew a clear (and apparently unproblematic) distinction between the `theoretical' analysis of equilibrium and a `real world' of disequilibrium trading [Ekelund and Thommesen 1989, pp. 583 - 584; Schabas 1990, p.90; Peart 1998]. Those accounts do not, however, satisfactorily explain why Jevons insisted that `the theoretical conception of a perfect market is more or less completely carried out in practice'. Nor do they clarify the analytical roles of brokers and the principle of virtual velocities in his analysis. The problem here, at least in part, seems to be an implicit assumption when reading TPE that Jevons provided a transparent story of market trading, devoid of rhetorical guile. To this extent, Jevons' rhetorical strategy of only `alluding' to his equilibrium attainment problem, so as to obscure its presence and significance, was successful.

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[30] See, for example, Jevons' discussion of the New York Stock Exchange, cited above.

Chapter 8

INDETERMINACY IN EXCHANGE: DISINTERRING JEVONS' TRADING BODIES[1]

In Chapter IV of his Theory of Political Economy (TPE), which analysed trading or exchange in a market period, Jevons used the concept of a trading body to mean "any body of buyers or sellers" in a market, arguing that the concept could be defined so broadly because "the principles of exchange are the same in nature" regardless of the extent of the market or the size of the trading body [Jevons 1970, p.135]. The argument has often been criticised and Lionel Robbins' verdict, delivered in 1936, that the concept was "clumsy" and unsatisfactory [Robbins 1982 (1936), p.317] would receive general assent today. A number of commentaries and critiques have, however, obscured, if not erased, Jevons' analysis of the topic, which makes it difficult to explain the role of his argument in TPE and why he produced it. As the principal purpose of this paper is to recover the context of Jevons' argument, section 8.1 explains the genealogy of the term trading body. First used by Jevons during the mid-1860s, the term was a metaphorical appropriation from his work and training in aspects of physics (`natural philosophy'). The following section shows that the coherence of Jevons' statement in TPE about the generality of the trading body device depended, in the final instance, on a peculiar claim regarding the applicability of the marginalist exchange equations. The claim was made to minimise the problem of commodity indivisibility which threatened the domain of the exchange theory and equations in TPE. Section 8.3 then explains how that problem was identified in 1870 during, and why it was especially pertinent for Jevons in the wake of, the contemporary debate over `the laws of supply and demand'. Section 8.4 considers the initial reactions to Jevons' argument, which was misunderstood until the publication of F.Y. Edgeworth's Mathematical Psychics in 1881. Edgeworth's clarification and the nature of the argument in TPE were, however, obscured in subsequent commentary (section 8.5).

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8.1 Body Language

Although it has been suggested that the trading body device "may" have been "invented" by Jevons following his correspondence regarding the marginalist theory with H.C. Fleeming Jenkin in 1868,[2] the term had appeared in Jevons' work well before that date. In Chapter XV of the first edition of The Coal Question, "The Problem of the Trading Bodies", Jevons used it to characterise nations and groups of nations engaged in international trade, employing a gravitational metaphor to explain a long-period equilibrium position:

> Taking commerce as the free growth of the instincts of gain, we find it resolved into a case of complex attraction and peturbations, as between several gravitating bodies. Trade between two bodies is a case of simple attraction, each naturally attracting and buying the articles which are made with greater facility and cheapness by the other, paying with its own comparatively cheaper products [Jevons 1865, p.308].

Jevons used similar language and a gravitation metaphor in 1874 when describing the basis for the marginalist theory of exchange in a market period: "just as the gravitating force of a material body depends not alone upon the mass of that body, but upon the masses and relative positions and distances of the surrounding material bodies, so utility is an attraction between a wanting body and what is wanted" [Black 1973-1981, VII, p.80]. This was consistent with his characterisation of TPE as "the mechanics of utility and self-interest" and the derivation of the basic equation for exchange from that for a lever in static equilibrium (the balance) [Jevons 1970, pp.90,144-7]. It also explains the metaphorical basis for the terms `body' or `bodies' as that usage was well established in natural philosophy, designating "phenomenal entities" which were underpinned by a "substratum" of matter [Harman 1982, p.150]. S.D. Poisson, for example, opened his Treatise of Mechanics, to which Jevons referred when explaining the metaphorical basis of his exchange equations, with a such a definition [Poisson 1842, I, p.1]. The term also appeared at an early date in Jevons' published work. An article on cloud formation, written in Australia, explained the "whole mystery" of cloud formation by "simple dynamical causes ... [ie.] by the motions occasioned by gravity among bodies of air differing in specific gravity" [Jevons 1858, p.176]. As with much of Jevons' work in political economy,

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[2] Creedy 1992a, p.120. See also Creedy 1992b, p.56; idem. 1998, p.120; Peart

the term trading body was a metaphorical appropriation from his work and training in a number of areas of natural philosophy. Trade should be depicted as analogous to the attraction of gravitating bodies. Just as gravity was a fundamental 'law' underlying the movement of material bodies, the phenomena or appearance of trade had to be theorised to reveal the underlying causes or principles at work. The principles would be the same, despite the apparent complexity of actual cases and the units or bodies in which transactors could be grouped. In The Coal Question, Jevons used the term trading bodies to refer to nations or groups of nations. Six years later, in TPE, the term was used also to mean an individual or group(s) of individuals. By that time, however, Jevons had realised that his claim about the principles of exchange faced a substantive problem.

8.2 Trading Places

In Chapter IV of TPE, Jevons introduced trading bodies as follows:

> I find it necessary to adopt some expression for any number of people whose aggregate influence in a market, either in the way of supply or demand, we have to consider. By a trading body I mean, in the most general manner, any body either of buyers or sellers. The trading body may be a single individual in one case; it may be the whole inhabitants of a continent in another; it may be the individuals of a trade diffused through a country in a third ... We must use the expression with this wide meaning, because the principles of exchange are the same in nature, however wide or narrow may be the market considered. Every trading body is either an individual or an aggregate of individuals [Jevons 1970, p.135].

The essential point was that the term trading body could represent any transactor, whether an individual or a group of individuals, in a market.[3] It is evident from Jevons' use of the phrase 'principles of exchange' in Chapter IV that this meant the marginalist equations of exchange where, assuming infinite divisibility of commodities and the 'law of indifference', commodities would exchange at equilibrium in inverse proportion to the ratio of their final degrees of utility. More

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1996, p.257; idem. 1998, p.321.

[3] Note that the phrase 'whose aggregate influence ... we have to consider' could refer either to a trading body whose actions changed market outcomes or a small transactor who was unable to do so.

generally, the principles would also explain exchange regardless of the extent of a market, which Jevons had previously defined as "two or more persons dealing in two or more commodities, whose stocks and intentions of exchange are known to all" [ibid. p.13]). Some care needs to be taken with that statement, as Jevons then made clear that `stocks and intentions' could only be `known to all' in a `perfect' market where brokers established a uniform price at any moment. Nevertheless, it was indicated at the outset that the principles of exchange could, somehow, be applied to transactions where those conditions were absent.

While the principles were `the same in nature' regardless of the extent of the market, that did not entail that they would have exactly the same form in every case. The "fundamental" equation [Jevons 1970, p.163] or the `simplest' case involved two representative traders dealing with two commodities where the law of indifference prevailed. Some `variation' or modification would, however, have to be made to explain more complex cases. There would, moreover, be some slippage between actual events and the principles, although Jevons argued that any slippage was not sufficient to vitiate the basic underlying theoretical explanation. The first example of this point followed his definition of a trading body when he noted that, while the observed behaviour of particular individuals might appear to disconfirm the theory, because aggregate behaviour was distributed according to the `law of error', market behaviour would, on average, conform to and thus verify the theory: "our laws of economics will be theoretically true in the case of individuals, and practically true in the case of large aggregates; but the general principles will be the same, whatever the extent of the trading body considered. We shall be justified, then, in using the expression with the utmost generality" [ibid. pp.135-6]. By making allowance for the lack of a perfect match, Jevons argued that the principles of exchange would provide the basis for the explanation of all exchange behaviour. He proceeded to set out the fundamental equation of exchange using the simple case and then considered complications of the fundamental story in various ways.

After considering that "it is not difficult to find practical illustrations which will show how it [ie. the theory of exchange] is verified in the actual workings of a great market" [ibid. p.148], Jevons argued that, in all "cases where the commodities are capable of indefinite subdivision, the principles will be exactly the same, but the particular conditions will be subject to some variation" [ibid. p.150]. The first

instance of variation considered at that point concerned a trading body whose commodity stocks were so small in relation to the market that their actions could not affect the price. The equations were then modified to show this for two examples. One was a person facing a given market price for a commodity, such as salt, which accounted for a small proportion of expenditure from wealth. Here, the final degree of utility of money was constant, which was characteristic of "a large part of our purchases", although not for commodities such as meat. The other example represented trade between "the Channel Islands and the great markets of England". In the latter case, the equation was "never absolutely verified because the smallest purchases do affect the market in some degree" [ibid. pp.151-2]. While there was some `slippage' between the theory and actual markets, it was not, Jevons suggested, sufficient to jeopardise the applicability of the theory.

Jevons then argued that "[e]xactly the same principles hold true, however numerous or complicated may be the conditions" [Jevons 1970, p.152], which he illustrated with a three-transactor and three-commodity case. He claimed that he could also

> lay down the conditions of exchange between more numerous bodies, but the principles would be exactly the same. For every quantity of commodity which is given in exchange something must be received; and if portions of the same kind of commodity be received from several distinct parties, then we may conceive the quantity which is given for that commodity to be broken up into many distinct portions. The exchanges in the most complicated case may thus always be decomposed into simple exchanges, and every exchange will give rise to two equations sufficient to determine the quantities involved. The same can also be done when there are two or more commodities in the possession of each trading body [ibid. p.154].

After considering the case "when two parties compete together in supplying a third party with a commodity" [ibid. pp.154-5], Jevons turned to a problem with the principles of exchange in a section headed "Failure of the Equations of Exchange" [ibid. pp.155-61]. The problem concerned the applicability of the assumption, used in the preceding discussion, that commodities were infinitely divisible. Jevons argued that the assumption "is approximately true of all ordinary trade, especially international trade between great industrial nations". However, "cases constantly

occur" where that was not the case so that the equations of exchange "fail to hold true, or lead to impossible results" [ibid. pp.155, 156]. Divisibility was not the only relevant matter, as a number of cases involved trade between two transactors (who were not representatives of a wider market) dealing with, in a number of instances, unique commodities such as the sale of Alaska by Russia. After considering a number of possible transactions, such as the possibility of exchanging two indivisible commodities where the outcome would depend on the estimation of "the whole utility of the complete article" by each transactor [ibid. p.157], Jevons turned to the "much more difficult problem" of exchange between two transactors of an indivisible commodity for a divisible one, such as money:

> In all such cases our equations must fail to exist, because we cannot contemplate the existence of an increment or decrement to an indivisible article ... A bargain of this kind is exceedingly common; indeed it occurs in the case of every house, mansion, estate, factory, ship, or other complete whole ... The theory seems to give a very unsatisfactory answer, for the problem proves to be, within certain limits, indeterminate [ibid. pp.157,158].

As the result would depend on bargaining, the

> transaction must be settled on other than strictly economic grounds ... [such as the] disposition and force of character of the parties, their comparative persistency, their adroitness and experience in business, or it may be feelings of justice or kindliness ... These are motives more or less extraneous to a theory of economics ... It may be that indeterminate bargains of this kind are best arranged by an arbitrator or third party [ibid. p.159].

Such bargaining between two transactors was not the end of the matter, as the equations would also "fail" in more general retail transactions. In his preceding discussion of a small trading body, such as a person buying salt (see above), Jevons assumed that the body was a price-taker, the marginal utility of money was constant and the commodity purchased was infinitely divisible. Using the same example, he now acknowledged that some commodities were divisible but not "infinitely" so. In such cases, as paper, ink and wine for example, a person's decision to purchase would depend on whether the total utility expected from each successive purchase would exceed the total utility of the money price.

Jevons noted that these cases were "similar" to those in the preceding discussion of indeterminacy,

> when the things exchanged are indivisible, except that the question of exchange or no exchange occurs over and over again with respect to each successive unit, and is decided in respect to each by the excess of the total utility of the unit to be received over the total utility of that to be given [ibid. p.161].

It might be thought that this conclusion would threaten the extent of the commodity domain of the marginalist theory, since the number of commodities where the equations would `fail' was now rather large, and would also threaten any claim that the principles of exchange were the same regardless of the size of the market or the number of trading bodies. Immediately following the quotation above, however, Jevons argued that would not be the case:

> There is indeed perfect harmony between the cases where the equations can and cannot be established; for we only have to imagine the indivisible unit of commodity to be indefinitely lessened in size to enable us to pass gradually down to the case where equilibrium of the increments of utility is ultimately established [ibid].

This was the closing sentence of Jevons' discussion of 'failures of the equations of exchange', although he reiterated his point about modifying the "general character of the argument", meaning the fundamental equation of exchange, in the following section on "Negative and Zero Value" which was added in the second edition [ibid. pp.163,165].

It is now possible to see how Jevons defended his argument that the term `trading body' could have such a wide meaning because the `principles of exchange' were `the same in nature' regardless of the extent of the market or the size of a trading body. The phrases `same in nature' and `exactly the same' did not mean that the equations of exchange were identical in every case, because the fundamental equation would have to be modified to represent more complicated transactions. Having repeated the point through the chapter that the principles would be `exactly the same' when examining the complicated transactions, Jevons turned to the problem of commodity indivisibility, acknowledging that the exchange equations would `fail' in what appeared to be a large number of cases. Although

the theory `seems to give a very unsatisfactory answer', he argued that there was actually `perfect harmony' between the cases where the equations could and could not be `established' by `imagining' that the indivisibility problem did not exist. If this seems bizarre, it was the last link in his argument that it was possible to use the term trading body in such a broad way because the `principles of exchange' were the same in all cases.

8.3 Thornton's Revenge (Revisited)

As Jevons informed one correspondent, he was dissatisfied with the analysis of the failure of the equations of exchange: "The conclusion ... that the ratio of exchange was indeterminate seemed unsatisfactory, because I could find no other answer to give. If you can suggest a better result, it will remove what may be regarded as a difficulty in the way of the theory" [Black 1973-81, IV, p.63]. His peculiar claim of `harmony' between cases where the equations could and could not be established was a forced attempt to minimise the extent of the `difficulty'. An explanation for why he felt that move was necessary can, in part, be traced to the context in which TPE was finally written up for publication. That context was the debate over `the laws of supply and demand' which followed the publication of William Thornton's On Labour in 1869. Jevons' problem of indeterminacy appears to have crystallised after reading Fleeming Jenkin's response to Thornton in 1870. The `harmony' claim followed as Jevons attempted to demonstrate the `truth' of his contribution to the debate in TPE .

Jevons' "Brief Account" of his marginalist theory was first published in 1866, although it had been written and delivered to the British Association for the Advancement of Science in 1862. Having discussed "the theory of exchange" with infinitely divisible commodities, he turned to the question of indivisibility in Sections 15 and 16:

> 15. When the useful object on one side only is infinitely divisible, we shall have only one unknown quantity, namely, that of the divisible commodity given for the indivisible object, and also one equation to determine it by, namely, that on the part of the person holding the divisible commodity, and able to give more or less for it. But this does not apply to unique objects, like a statue, a rare book, or gem, which do not admit of the conception of more or less.

> When both commodities are indivisible ... we have neither unknown quantities nor equations.
>
> 16. The equations in an exchange may prove impossible, or without solutions. This will indicate either that no exchange of commodity will take place at all, or that at least one of the parties to the exchange is not satisfied even with the whole of the commodity formerly belonging to the other [Jevons 1866b (1862), p.285].

Section 16 and the last sentence of section 15 are consistent with some aspects of the more detailed discussion of the failure of the equations in TPE. The last sentence of section 15, for example, corresponds to the discussion in TPE of two potential transactors, each with an indivisible object, where Jevons argued that the possibility of exchange depended on the respective estimations of the "whole utility of the complete article" by each of the transactors [Jevons 1970, pp.156-80].[4] There was, however, a difference between the two texts with regard to the first two sentences (or paragraph) of section 15. It appears that, in 1862, the analysis of exchange, where one commodity was indivisible, was restricted to cases of unique commodities, such as rare books, and that such cases posed no substantive difficulty for the theory.[5] That was not the case by 1871, a point Jevons confirmed in 1874 when he declared that the discussion in Section 15 was "erroneous" [Black 1973-81, IV, p.61]. The introduction of the terminology of 'indeterminacy' and its terms of reference in TPE suggest that Jevons' reassessment of indivisibility depended to a significant extent on Jenkin's 1870 article, which had attempted to recast 'the laws of supply and demand' following Thornton's critique.

In a series of articles which first appeared in 1866 and were then collected and published as On Labour [Thornton 1869], Thornton argued that references to the

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[4] See also Jevons 1905, pp.55-6.

[5] Ricardo argued that such irreproducible commodities would have a market-period value explained by the 'proportion' between demand and supply. There could, however, be no systematic (long-period) explanation for their value and such commodities could be ignored in a general explanation of value [Ricardo 1951a (1817), p.12]. Nassau Senior and Alfred Marshall reached the same conclusion [White 1999]. It is evident that, in 1862, Jevons thought he could include such commodities in his equations of exchange. Like Ricardo, he regarded unique commodities as different from most others. It is symptomatic of the theoretical distance between them, however, that, for Ricardo, that difference depended on irreproducibility, while for Jevons it was principally a matter of indivisibility.

laws of supply and demand could not provide a satisfactory explanation for price formation. Although On Labour received a significant number of reviews, most commentators were unable to grasp the significance of Thornton's general analysis of price formation. They focused instead on his reference to Dutch and English auctions, where price outcomes could differ, and on his discussion of counter-examples, which contradicted the laws.[6] That focus is illustrated by Jenkin's 1870 article which recast the laws of supply and demand by quantity-form diagrams. Jenkin first considered a market-period, using an "open market" where, although there was competition between buyers and sellers, the price was set by market specialists. With the price continually changing, an equilibrium prevailed at each moment of trading on a market day [Jenkin 1870, pp.156,158]. Jenkin then turned to Thornton's discussion of auctions and his `anomalous' cases. So far as the auctions were concerned, "with the supply constant at all prices" and prices dependent on "the competition of buyers alone" [ibid. pp.158-9], Jenkin argued that there would be under- and/or over-shooting of the equilibrium price[7] and that it was "only by experience of former markets, and a considerable number of tentative transactions, that the theoretical [equilibrium] price is approached". Thornton's discussion of Dutch and English auctions was then represented by a perfectly inelastic segment of a demand curve so that "the market price is indeterminate". But this was dismissed as unimportant: that "case is not peculiar to any form of bargain, but represents an unusual state of mind" [ibid. p.160]. There was, however, at least one instance where indeterminacy, or the absence of a unique market price, prevailed. Referring to Thornton's counter-example of a horse sale with a small number of buyers offering the same price [Thornton 1869, p.49], Jenkin discussed the case of one buyer, one seller and an indivisible object, concluding that "there can ... be no theoretical [unique] market price". Either no sale would occur or there would be an "indeterminate" range between the highest possible offer of the buyer and the reservation price of the seller. In either case, "neither demand nor supply curve can be drawn" and a similar, though not identical, problem emerged where sealed bids were made for

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[6] See the discussion and references in White 1994b. The exception to the general misunderstanding was J.E. Cairnes who had responded positively when the nub of Thornton's argument was first published. See the two articles by Cairnes headed "The `Law' of Demand and Supply", published in The Economist 1866, October 20, pp.1221-2; November 3, pp.1279-81. My attention was drawn to these by the fine archival work in an Appendix to Donoghue 1998.

[7] There seems to be both over- and under-shooting in a Dutch auction, with over-shooting in an English auction [Jenkin 1870, p.160].

a given object or applications for shares before they were issued in a market [Jenkin 1870, pp.161-3]. Although the impression was given that, in general, Thornton's argument was inaccurate, Jenkin restricted the laws of supply and demand to particular types of transactions, conceding that there could be instances of indeterminate prices where the laws did not apply.

As was noted in Chapter 7 above, Jevons hurriedly wrote up TPE for publication in part because of Jenkin's article [Black 1973-81, III, p.166]. The marginalist theory had been the subject of an exchange of letters between the two in 1868 [ibid. pp.167-78]. This was triggered by Jenkin sending Jevons a copy of his paper on trade unions in which he represented the laws of supply and demand and their equilibrium algebraically [Jenkin 1868, pp.13n-14n]. But when Jenkin's 1870 article appeared there was no mention of the marginalist theory.[8] Given the correspondence of two years before, that was particularly galling because, while the empirical laws of supply and demand were an "unquestionable truth", Jevons regarded his work as providing, for the first time, a satisfactory theoretical explanation for the laws [Jevons 1970, pp.43,148]. In that context, it is not surprising that Jevons' discussion of market-period prices in Chapter IV of TPE bears the marks of the Thornton debate in general and Jenkin's 1870 article in particular.[9]

Jevons adopted Jenkin's argument that the market price was set by specialists (brokers in TPE) in wholesale commodity markets which provided the exemplar for a `perfectly competitive' market. He also followed Jenkin, when referring to Thornton, in focussing on the Dutch and English auctions and the counter-examples, to which he referred as "other particular modes of traffic" [Jevons 1970, p.149]. Here, Jevons acknowledged that, without "continuity of variation",

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[8] Jenkin made clear subsequently that he rejected both the marginal utility theory and the possibility of expressing supply and demand in terms of equations [Jenkin 1871, pp.618,620].

[9] As was mentioned above, it has been suggested that Jevons formulated the trading body concept following his correspondence with Fleeming Jenkin in 1868. Apart from the point that Jevons used the term in The Coal Question, Jevons' problem of indeterminacy was not relevant in the correspondence with Jenkin. Although we have only Jenkin's letters to Jevons, it is evident from them that a misunderstanding arose because Jenkin did not realise that Jevons was assuming the law of indifference so that the traders in his equations were representative transactors [Black 1973-81, III, 167-78]. There was no mention of indivisibility and hence, in that context, no Jevonian problem of indeterminacy.

the laws of supply and demand were "inapplicable ... Economists can never be free from difficulties unless they will distinguish between a theory and the application of a theory" [ibid. pp.148-9]. His subsequent comment that the laws would become "substantially true" once allowance was made for merchants taking "prospective supply and demand ... into account" [ibid. p.149], seems to mean that, in subsequent trading days with changes in supply and/or demand, the problems Thornton discussed would disappear. Nevertheless, as with Jenkin, there was a clear acknowledgement that the laws of supply and demand would not apply in all cases. As Jevons noted in the unfinished Principles of Economics when referring to Thornton, the laws "are only expressions of the general course of phenomena exhibited in commerce when there are many buyers and many sellers" [Jevons 1905, p.57].

Jevons' delphic reference in TPE to `the application of the theory' where the laws were inapplicable was clarified in the subsequent section on the failure of the exchange equations. Discussing the exchange of an indivisible commodity for a divisible one, Jevons wrote that Thornton "exactly expresses the problem" of how the price could range between the highest bid of the purchaser and the reservation price of the seller [Jevons 1970, pp.158-9; Thornton 1869, pp.58-9]. The context of the references to Thornton, the introduction of indeterminacy and the acknowledgement that the laws of supply and demand could not apply in particular cases, suggest that it was the discussion in Jenkin's article which prompted Jevons to reassess his argument. Jenkin had shown, contra to the Brief Account, that indeterminacy would result with two traders and one indivisible commodity. The problem for Jevons, however, was more general because, in using the calculus, his focus was on commodity indivisibility, rather than the number of traders per se. Sales of indivisible commodities were not restricted to horses and indeterminacy could occur in markets where there were large numbers of transactors and price-taking.

Both Jenkin and Jevons argued that Thornton's argument was restricted to anomalous cases. But while Jenkin had restricted the indeterminacy outcome to a limited number of transactions, that problem was far more significant for Jevons. He wrote TPE in part to demonstrate the superiority of his utility theory for explaining the phenomena of supply and demand which had been formalised by Jenkin. But the domain of the theory was shrinking. In an attempt to minimise that problem, Jevons resorted to arguing that there was actually `harmony' between the cases where the equations could and could not be established. Odd as the

argument was, the reason why Jevons produced it can be understood in the context of his attempt to defend the validity of his approach in the contemporary debate concerning the laws of supply and demand.

8.4 Help from Hampstead

Although Jevons' analysis of the failure of the exchange equations pivoted on the problem of commodity indivisibility, the discussion was somewhat confusing in that it conflated the analytically separable questions of indivisibility of commodities, numbers of transactors and unique, or at least heterogeneous, commodities. Yet, after making due allowance for that point, it is notable that much of the subsequent commentary on TPE was apparently unable to grasp the way Jevons had posed the problem and ignored his peculiar claim about the 'harmony' of cases where the equations could and could not be established.

That pattern was evident in one of the first reviews of TPE published by the Saturday Review in November 1871 [Black 1973-81, VII, pp.152-7]. The anonymous reviewer made two basic points in an acerbic attack on Jevons' mathematics.[10] The first was to mock the fundamental equation of exchange for the incoherent results which followed attempting to obtain a total integral of utility. The second was to claim that Jevons' discussion of the indeterminacy of a house price was due to the "the assumed absence of competition" which would disappear with "any number" of houses and, presumably, transactors [ibid. pp.155-7]. If this missed the point of the discussion of indeterminacy in TPE by reducing it to a question of the number of commodities and transactors in a market, the review clearly worried Jevons. Dissatisfied with his discussion of the failure of the equations, he was able, by 1874, to ask sympathetic correspondents for help in dealing with the problems raised in the Saturday Review. So far as the

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[10] It has been suggested [Black 1973-81, VII, p.152n] that the reviewer was G.W. Hemming, fellow of St. John's College, Cambridge, and author of an Elementary Treatise on the Differential and Integral Calculus (1846). If that was the case, it might be noted that Cambridge mathematicians had some reason to be irritated with Jevons. In the course of a signed review of A. Whitworth's Choice And Chance, published in Nature the previous year, Jevons had noted that, while the "doctrines of combinations and probabilities lie at the basis of all mathematical and physical science ... [i]t is strange how little attention has been paid at Cambridge to the theory of probabilities" [Jevons 1870a, pp.4-5]. At that time, Whitworth and Hemming held Fellowships in mathematics at St. John's, as did Alfred Marshall who also reviewed TPE [Black 1973-81, VII, pp.141-6].

indivisibility question was concerned, however, he drew a blank.[11] J. d'Aulnis de Bourouill, who completed a thesis at the University of Leiden based on the value theory in TPE, also interpreted the problem as principally one of `isolated exchange' which he regarded as an uninteresting question [Black 1973-81, IV, pp.58-9,62-3,82,90].[12] A US correspondent, although not so dismissive, read the problem in much the same way [ibid. pp.153-4]. The result was that, despite Jevons' dissatisfaction with his discussion of indeterminacy in the first edition, the text was basically unchanged when the second edition appeared in 1879.[13]

The only substantive clarification came from F.Y. Edgeworth's Mathematical Psychics in 1881. Jevons and Edgeworth had first met in 1879, were neighbours at Hampstead and often walked together on the Heath [Howey 1960, pp.99-101]. In a number of comments through his text and especially in Appendix V, where he gave the Saturday Review(er) a stinging mathematics lesson, Edgeworth focused on the polar cases of perfect competition and indeterminacy in TPE [Edgeworth 1881, pp.19,29-31,33,104-16]. While noting that Jevons' fundamental equations, assuming the law of indifference, "apply not to bare individuals, an isolated couple, but (as he himself sufficiently indicates ...) to individuals clothed with the properties of a market, a typical couple" [ibid. p.31n], Edgeworth offered no help on the indivisibility of commodities, as his own discussion assumed the "indefinite divisibility of each article of contract". So far as commodity indivisibility was concerned, that "species of imperfection will not be explicitly treated here; partly because it is perhaps of secondary practical importance; and partly because it has been sufficiently treated by Professor Jevons" [ibid. p.19,19n]. Edgeworth noted that indefinite commodity divisibility did not necessarily entail that competition was "perfect in other respects", a point he returned to in Appendix V.

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[11] Jevons also asked George Darwin for help with the integration criticism, noting that the point had been raised, before TPE was published, by his colleague, Thomas Barker, professor of mathematics at Owens College (see Chapter 7 of this thesis). While Marshall's review of TPE was critical of Jevons' mathematics, Marshall was clear that the integration claim in the Saturday Review was based on a "misapprehension" [Black 1973-81, VII, p.145]. The point was crystallised in an annotation to his review copy of TPE, now held in the Marshall Library at Cambridge University. At page 95 of Jevons (1871) [Jevons 1970, p.139], referring to Jevons' equation dy/dx = y/x, Marshall noted "Of course he does not mean us to integrate. He is expressly speaking of Statics".

[12] Jevons' expression of the problem in correspondence may have facilitated this [Black 1973-81, IV, p.82].

[13] Some additional comments were made on bargaining [Jevons 1970, p.159].

Here he argued that Jevons' discussion of indeterminacy required "greater precision" by stating clearly that exchange "is indeterminate, if either (1) one of the trading bodies (qua individual or qua union) or (2) the commodity supplied by one of the dealers, be indivisible or not perfectly divisible" [ibid. p.109]. It is noteworthy that Edgeworth did not criticise the trading body concept (since he used it when referring to indeterminacy), offered the mild admonition that Jevons' discussion of indeterminacy required more clarity, and (tactfully?) ignored the peculiar claim Jevons had made regarding the `harmony' between cases where the equations could and could not be `established'.[14]

Jevons acknowledged Edgeworth's clarification when discussing the role of conciliation in labour disputes in The State in Relation to Labour (1882). Referring to the analysis of indeterminacy in TPE, Jevons noted it showed that, in cases of "bargains about a single object", the "laws of supply and demand do not apply" [Jevons 1882, p.157]. Edgeworth's "remarkable work" had shown that "the existence of combinations in trades disputes usually reduce them to a single contract bargain of the same indeterminate kind", so that "there may be absolutely no economic principle on which to decide the question. Mathematically speaking, the problem is an indeterminate one, and must be decided by importing new [`non-economic'] conditions" [ibid. pp.158,159]. With Mathematical Psychics read as both confirming and clarifying his argument, Jevons also returned to the Thornton debate and the analysis of unique commodities in his unfinished Principles of Economics, where he noted that the laws of supply and demand only applied when there were "many buyers and many sellers" and the law of indifference prevailed. The problem of indivisibility was referred to by examples, rather than by an explicit discussion of the relevance of the divisibility assumption. It was simply acknowledged that there were "articles of uncertain value", such as horses (shades of Jenkin), "original paintings, unique vases or other works of art, copies of rare books in better or worse condition, houses and estates of varying beauty and convenience" [Jevons 1905, pp.57,59,60]. The same point was

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[14] Cf. the suggestion that Edgeworth "pointed out" that the concept of a trading body was "completely unsatisfactory" [Blaug 1997, p.296; see also Creedy 1992a, p.120; Mosselmans 1998, p.93]. It has also been suggested that Edgeworth "described the [trading body] concept more clearly as `a sort of typical couple, clothed with the properties of indifference', thereby restricting its applicability to the case of perfect competition" [Creedy 1992b, p.56; see also Creedy 1998, p.19; Peart 1996, p.257]. As the quotation in the text above from Mathematical Psychics shows, however, Edgeworth used `trading body' when referring to indeterminacy. Nor did he define the concept by citing, and thereby restrict its use to, Jevons' `typical couple' [Edgeworth 1881, pp.31n,109].

relevant for rare gems, such as the Koor-i-noor diamond which had appeared in TPE [Jevons 1970, p.156]. Such commodities "being practically unique and incomparable with one another, cannot be said have any ascertainable values". With no "approach to rule or congruity ... no consideration of cost of production or utility can apply; the arbitrary fancy some monarch or wealthy person is the only rule" [Jevons 1905, pp.149-50]. There was no mention in that context of the claim in TPE about the `harmony' of the principles of exchange.

In TPE, Jevons criticised a labour theory of value by citing Ricardo on irreproducible commodities with the following comment: "The mere fact that there are many things, such as rare ancient books, coins, antiquities, etc., which have high values, and which are absolutely incapable of production now, disperses the notion that value depends on labour" [Jevons 1970, p.186]. If this argument misrepresented Ricardo, it also inadvertently drew attention to a notable lacuna in Jevons' alternative theory. While Ricardo excluded irreproducible commodities from a systematic account of value, Jevons was unable to represent a determinate equilibrium not just for irreproducibles, but also for any other commodity where indivisibility was relevant. Jevons' claim that he could use the term trading body with such a `wide meaning' because the `principles of exchange are the same in nature, however wide or narrow may be the market considered', was incoherent within the terms of his own theory.

8.5 Aftermath

Published attacks on the concept of a trading body appeared after Jevons' death, with one line of criticism originating in Alfred Marshall's Principles. Although he could hardly be regarded as indifferent to the analysis of bilateral monopoly, Marshall ignored Jevons' discussion of indeterminacy[15] and criticised the trading body concept on the quite different ground that it ignored problems with the marginal utility of money within an aggregate trading body [Marshall 1961, I, p.818]. This reflected a long-standing Marshallian criticism that some aspects of Jevons' political economy were both analytically incorrect and politically dangerous because they erased questions of equity. What was at stake here was not the question of the `determinacy' of Jevons' equations, but rather an

[15] This is consistent with his reading of the first edition of TPE. Marshall's review copy (see above) has quite extensive pencil markings and comments which help explain the remarks in his published review. There are, however, no marks on the pages dealing with `the failure of the equations of exchange'.

attempt to distance economics from what Marshall regarded as the crude utilitarian brush with which Jevons had tarred the subject.[16] Later commentators followed in the same vein, concluding that, because of the marginal utility of money problem, the trading body concept is incoherent [Peach 1987, pp.1015-6] as is Jevons' claim that `perfect freedom of exchange must be to the advantage of all' [Blaug 1997, p.296].[17]

It should be noted, however, that while the Marshallian critiques are relevant for assessing a number of Jevons' claims in TPE, they do not consider the particular argument Jevons made concerning the generality of the trading body concept. Such critiques cannot, therefore, be part of an historical explanation for how and why Jevons argued in the way he did.[18] A second strand of commentary is more pertinent because it relates Jevons' remarks on trading bodies to his discussion of indeterminacy, usually incorporating some reference to the comments on TPE in Edgeworth's Mathematical Psychics.[19] Unfortunately, this strand resurrects the perspective of the Saturday Review(er) in that TPE is read as if Jevons was concerned principally or only with the number of transactors in a market, rather than with the general problem of indivisibility. No attention is paid to Jevons' discussion of how the indivisibility problem was not confined to two-transactor cases and no mention is made of his statement that there was `perfect harmony' between the cases where the equations could and could not be established.[20]

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[16] For discussion of, and the context for, Marshall's criticism, see White 1996.

[17] For the `perfect freedom' quotation, see Jevons 1970, p.171. That statement was Marshall's target (White 1996). See also Young 1912, pp.584-5, who used Jevons' treatment of money to make a series of (sometimes odd) criticisms of the trading body device.

[18] Peach 1987, pp.1015-6, does, however, carefully separate the Marshallian critique from the question of indeterminacy in exchange.

[19] This strand began, to my knowledge, with the editorial comments by R.D.C. Black [in Jevons 1970, pp.22,267], directed, in part, against the charge that Jevons had ignored indeterminacy in exchange between two transactors [see Hutchison 1953, pp.42-3; translator's note in Walras 1954, p.498; Blaug 1997, p.295].

[20] Creedy 1992a, p.120; idem. 1992b, p.56; idem. 1998, p.120; Peart 1996, p.257; idem. 1998, p.321. Both authors claim that Jevons restricted the domain of trading bodies to cases where the law of indifference prevailed, thereby precluding its use in the discussion of `indeterminacy'. No clear textual evidence is offered in support of the claim. It should be noted that Jevons did not restrict the use of the term `body' to Chapter IV. In his discussion of rent, he referred to "a certain labourer, or what comes to exactly the same thing, a body of labourers" [Jevons 1970, p.220].

Without an appropriate context for Jevons' argument, however, the particularity of his claim about trading bodies cannot be registered.

Recovering the context of Jevons' statement about trading bodies and the principles of exchange reveals why his argument was so tenuous. Within that context, an explanation of the significance of his argument needs to be switched from presenting it as an error or awkward device, which could be rectified by later (more sophisticated) analyses, to consideration of the ways in which Jevons presented his arguments in TPE. The style of argument in the trading body case was not an isolated instance. Ian Steedman has argued that Jevons presented his formula for the rate of interest as if it had "general applicability", although he knew that its derivation depended on, and was restricted to, a special case.[21] Assuming that "what was true in a special case must also be true in the general case", Jevons attempted to justify the assumption with a number of "unfounded" arguments. Noting that this procedure can be observed elsewhere in his work, Steedman suggested viewing Jevons as an example of "a pioneer who thinks that he has grasped the key factor in a problem ... and is thus satisfied that no detailed elaboration will disturb the soundness of his essential insight" [Steedman 1972, pp.43-4]. Much the same conclusion could be drawn about Jevons' treatment of trading bodies and the principles of exchange although, in that case, it is possible to be more specific about the context in which the behavioural tendency suggested by Steedman became manifest. Jevons wrote up TPE for publication in part because Jenkin's exposition of supply and demand diagrams in 1870 had made no mention of his marginalist project. The problem, however, was that, given the way Jenkin had posed the issue of `determinacy', Jevons realised that the commodity domain of his explanation was in jeopardy. Faced with this and yet having "over and over again, questioned the truth of my own notions ... without ever finding any reason to doubt their substantial correctness" [Jevons 1970, p.78], Jevons resorted to the argument that the equations of exchange could explain the basis for all transactions, provided that the conditions in the cases which contradicted that explanation were imagined to be nonexistent.

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[21] The same point could be made about the analysis of labour in Chapter V of TPE, although the extent to which Jevons was aware of this is unclear (see Chapter 5 of this thesis).

EPILOGUE

It was argued in the Introduction to this thesis that Jevons' analysis of value and supply and demand was caricatured by Alfred Marshall and that the effects of that reading are evident in much of the subsequent commentary on TPE. Chapter 1 provided an analysis of Jevons' argument explaining the particular meanings he attributed to value and cost of production which explain why his understanding of `the laws of supply and demand' was quite different from that of his post-classical successors. For Jevons, supply and demand were `facts' recording market price and quantity changes. They were, therefore, the result of a number of causal factors. While he argued that the fundamental theoretical underpinning of the laws was provided by the marginal utility theory, demand was also affected by factors such as the actions of speculators and the distribution of income and wealth, while supply was also affected by speculation and transaction costs. Since the laws were well known, there was little theoretical information imparted by, for example, Jenkin's supply and demand diagrams. The point was to explain the theoretical basis of market exchanges. To argue that Jevons "did not learn as much from [Jenkin] as he might have" because he "never drew a genuine demand curve" [Blaug 1997, p.293] simply fails to explore the possibility that Jevons had a reason for not doing so. It thus erases any consideration of how references to supply and demand were understood and represented in different ways during the nineteenth-century, so that TPE is read in Marshallian terms.

It was noted in the Introduction that Marshall made two main criticisms of TPE. The first was that Jevons had `exaggerated' the importance of demand by arguing that `value depends entirely on utility'. The second was that, when Jevons considered the role of supply, he had effectively argued that value was determined by cost of production. This was a reference to the notorious `catena' introduced in the second edition of TPE (see below). Given the replication of the Marshallian reading, it is appropriate to close the thesis by showing how it depended in large part on reading TPE through a Marshallian cross diagram. The reading was not, however, an `innocent' one, for it was also the result of Marshallian guile, playing off a series of ambiguous statements made by Jevons.

At one level, Jevons' claim that `value depends on utility' is readily understandable. It depended on his definition of value as an abstract ratio that was governed by the

final degree of utility ratio. That argument was referred to in some detail at a number of points in TPE. In chapter IV, for example, Jevons considered the prices of commodities which were "more or less" perfect substitutes in consumption. Using the examples of mutton and beef, he argued that their "ratio of exchange cannot vary much, for it will clearly be defined by the ratio of their utilities", so that the "conditions of supply will have no effect upon the ratio of exchange" [Jevons 1970, pp.166,167]. For such commodities, changes in the amount produced would have no effect on the exchange ratio and hence on value.[1] A variant of the argument appeared in chapter V, where Jevons discussed the possible results of doubling the "producing power" of labour in all "branches of production" of the economy. This would not produce any "direct effect ... upon the terms of its commerce" because, while the quantities produced had increased, the ratios of productiveness would remain unchanged. However, there would be an "indirect effect" via the ratios of the final degree of utility. Since it was unlikely that the "increased amount" of commodities would be "equally desired in every branch of consumption", the exchange ratios would change so that production would ultimately increase in some branches more than others: "We might find in such instances new proofs that value depends not upon labour but upon the degree of utility" [ibid. p.206]. The argument was restated in a slightly different way in the following section on joint production, which was added to the second edition. Here, Jevons argued that joint production was "the general rule" which showed "all the more impressively that it is not cost of production which rules values, but the demand and supply of products" [ibid. p.209].[2]

The key to those arguments was Jevons' definition of value as an abstract ratio. If that has been persistently misunderstood in the secondary literature, Jevons' discussion of the relation between value and utility was relatively straightforward when compared with his attempt, at the close of Chapter IV, to explain why labour

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[1] The (wholesale) price ratio for mutton and beef was taken from statistics in A Serious Fall in the Value of Gold [Jevons 1884, pp.42,44]. After the discussion of mutton and beef in TPE, Jevons referred to the exchange ratio of gold and silver, also discussed in Serious Fall, arguing that the "extraordinary permanence" of the ratio until the late 1870s was due principally to the legislated French "double standard" [Jevons 1970, pp.167-8; 1884, pp.59-63,74-6].

[2] White 2002 has a detailed discussion of Jevons' discussion of joint production and why it was introduced in the second edition of TPE.

could not be "the cause of value" [Jevons 1970, p.185]. The nub of his argument was expressed as follows:

> though labour is never the cause of value, it is in a large proportion of cases the determining circumstance, and in the following way: Value depends solely on the final degree of utility. How can we vary this degree of utility? - By having more or less of the commodity to consume. And how shall we get more or less of it? - By spending more or less labour in obtaining a supply. According to this view, then, there are two steps between labour and value. Labour affects supply, and supply affects the degree of utility, which governs value or the ratio of exchange [Jevons 1970, pp.186-7].

Jevons had made much the same argument at the beginning of chapter I. That statement can be quoted here because it helps clarify the wording of the statement in chapter IV. After noting that the context of the statement was the debates concerning whether labour or utility was "the cause of value", Jevons continued:

> value depends entirely upon utility ... [and] we have only to trace out carefully the natural laws of the variation of utility ... in order to arrive at a satisfactory theory of exchange, of which the ordinary laws of supply and demand are a necessary consequence. This theory is in harmony with facts, and, whenever there is any apparent reason for the belief that labour is the cause of value, we obtain an explanation of the reason. Labour is found often to determine value, but only in an indirect manner, by varying the degree of utility of the commodity through an increase or limitation of the supply [Jevons 1970, p.77].

The argument in both statements depends on Jevons' definitions of value, his understanding of the laws of supply and demand and his use of the Classical method to distinguish between a market-period analysis (chapter IV) and that for a long-period (chapter V). Value was defined as an abstract ratio that depended on the final degree of utility ratio in an exchange. It was in that sense that `value depends solely on the final degree of utility'. The final degree of utility of utility ratio provided the fundamental explanation for demand and supply which recorded the `facts' of trading. Assuming that other factors affecting demand and supply could be

put to one side, demand was explained by the final degree of utility for the commodity purchased while supply was explained by the final degree of utility for the transactor offering the commodity for sale. The final degree of utility in each case depended on the quantity of each commodity. The total quantity of commodities to be traded was given at the beginning of a market period as in Chapter IV. The difference between a market-period price and the cost of production was then used to explain how production levels would be changed by the expenditure of labour (Chapter V). In a subsequent market period, the quantity available for exchange, and hence the supply, would change.

The difficulty with untangling the argument is twofold. The first is that Jevons failed to clearly explain the meaning of his terminology and his use of the Classical method. The second is the language used to depict causal processes. In particular, the link between labour, supply and value jumbled together `affects', `determining circumstance' and `determined in an indirect manner'. `Determine' carries a quite different notion of causation to that of `affect', `indirect' is different from simply `determine'. This point became crucial when, possibly responding to the critiques of Cairnes and Marshall of his argument that value depends on utility, Jevons added the `catena' to his discussion of the origin of value in chapter IV:

> In order that there may be no possible mistake about this all-important series of relations, I will restate it in a tabular form as follows:
>
> Cost of production determines supply;
> Supply determines final degree of utility;
> Final degree of utility determines value
>
> [Jevons 1970, p.187].

Far from ensuring that there was no possible mistake about the argument, the catena only compounded the problem with its failure to clarify the meaning of determine. Indeed, not to put to fine a point on it, the argument had now became a disaster area. If it is read as meaning a simple chain of causation, it is possible, as Marshall claimed, to omit the "intermediate stages" and to read it as arguing that cost of production determines value [Marshall 1961, I, p.818]. If, however, determine means a necessary condition which might or might not be a sufficient

condition of value, the statement might be regarded as roughly consistent with the preceding argument and the method of analysis in chapters IV and V of TPE. For someone who placed such importance on the `dangerous' use of words, Jevons' failure to clarify the meaning of determine facilitated the levying of the charge that his general argument was nonsense: "We might as reasonably dispute whether it is the upper or the under blade of a pair of scissors that cuts a paper, as whether value is governed by utility or cost of production" [ibid. p.348].[3]

In one sense, however, the catena was of secondary importance for Marshall. His major criticism dated from his review of the first edition of TPE where he made clear that he opposed the "main purpose [of TPE which] is to substitute for Mill's Theory of Value the doctrine that `value depends entirely on utility'" [Black 1973-81, VII, p.141]. When the review is coupled with the notes which Marshall made on his copy of the first edition of TPE, it is evident, however, that he was unable to understand Jevons' argument.[4] On the one hand, the characterisation of the value ratio received an incredulous reaction. Following Jevons' criticism of Mill's remarks on value, Marshall noted: "The value of an ounce of gold assumes a unit given. By his own showing value is not a ratio: but we have a ratio of values. There is no use in his struggling to make no use of a standard ... [?] of value".[5] If Marshall was `struggling' with Jevons' notion of abstract value, he argued also that value could not depend entirely on utility because utility in exchange would encompass the prospective utility of a commodity which meant "we must also enquire how great

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[3] Jevons' restatement, with different wording, of the argument in the primer and the Principles only muddied the waters: "Here we have the whole theory of value and labour. The labour which is required to get more of a commodity governs the supply of it; the supply determines whether people do or do not want more of it eagerly; and this eagerness of want or demand governs value" [Jevons 1878, p.103]; "it is obvious that value, though varying according to the laws of supply and demand, may be governed ultimately by cost of production, which may regulate the possible extent of supply, if not of demand" [Jevons 1905, p.63].

[4] As noted in Chapter 8 of this thesis, Marshall's copy of the first edition of TPE is held at the Marshall Library, University of Cambridge. The pencilled notes were evidently used for the review.

[5] Marshall's note on p.83 of Jevons 1871, which corresponds to Jevons 1970, pp.127-8. The argument also appeared in the review [Black 1973-81, VII, pp.143-4].

difficulty [an actor] expects to have in obtaining it; thus labour is a cause of value".[6] Since the `difficulty of obtaining a commodity' in Marshall's meaning had no counterpart in Jevons' theory of exchange, the criticism indicated that Marshall did not understand Jevons' analysis.

A different critique was evident in the Economics of Industry, where the Marshalls, without naming Jevons, criticised the argument that "utility alone ... [is] the basis of Value", albeit (and confusingly) in the context of discussing a long-period position (`Normal Value'). It was now acknowledged that "the price of every commodity must be the measure of its Final Utility" and that Jevons' argument would hold with a perfectly inelastic supply. However, it was not "true [in general] that final utility determines value" since the latter depended on "the relation between the circumstances of supply and those of demand" [Marshall and Marshall 1879, pp.145,148]. This reading, which provided the core of Marshall's subsequent commentary in the Principles, depended on three moves. The first was to read Jevons' argument in terms of a partial equilibrium supply and demand diagram. This erased Jevons' argument that supply and demand could provide only one part of a long-period explanation of relative prices. The second was to read `value' as meaning `price'. This was precisely the opposite of Jevons' argument. While he argued that value depended on the final degree of utility (ratio), he was referring to the abstract ratio, not the price in TPE. The third move was simply to ignore Jevons' references to ratios and to read value/price as the price of a commodity given in money, as on the ordinate of the supply and demand diagram. It then followed that price was explained by the final degree of utility which was equated with the demand.

With that core of the argument, the publication of the catena in the second edition of TPE provided Marshall with an easy target in the Principles where, despite some praise for Jevons' "excellent service" in clarifying demand, he was compared unfavourably with Ricardo and Mill. The catena was "much more misleading" than the "careless brevity" of the statement that value depended on cost of production, while Ricardo was "more philosophic in principle and clear to the actual facts of life"

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[6] Marshall's note and emphasis in his copy of Jevons 1871, p.1, which corresponds to Jevons 1970, p.77. The argument also appeared in the review [Black 1973-81, VII, p.141]. For Jevons' discussion of prospective utility, see 1871, p.73; 1970, p.122.

[Marshall 1961, I, pp.817,819]. In the same vein, although Ricardo was guilty of `careless brevity' on value, Jevons was more at fault because he could have "avoided" any ambiguity over cost of production and supply with "the aid of that technical apparatus of semi-mathematical phrases, which was at his disposal, but not at Ricardo's". Indeed, Jevons should have "emphasized, as Cournot had done, and as the use of mathematical forms might have been expected him to do, that fundamental symmetry of the general relations in which demand and supply stand to value ..." [ibid. pp.818,820].[7]

If Jevons has subsequently been criticised for his deficient mathematics, that particular criticism was a caricature. Moreover, even when allowance is made for incomprehension on Marshall's part, it is difficult to avoid the impression that the caricature was, at least in part, intentional. To fail to examine the discussion of supply and demand in Chapter IV and not even to mention Jevons had made clear that value was to be understood in terms of a ratio, suggests that Marshall was paying Jevons in kind for his persistent attacks on John Stuart Mill. Marshall's extreme irritation on that score is evident in the marginal notes of his copy of the first edition of TPE. It is perhaps a tribute to Marshall's rhetorical skills in the Principles that the polemical form of his commentary on Jevons has gone unnoticed and that his critique has been so widely replicated.

The result of that reading, when coupled with the hunt for precursors, has, as argued above, obscured both the structure of the argument and the historical significance of TPE. I have tried to show that Jevons' marginalist project was the product of a particular moment in Victorian England. It reflected the widespread attempts in both psychology and physics to produce a theory of human behaviour that could be represented as one component of a general mechanical theory of `nature'. The analysis of how that theory was produced and the difficulties Jevons encountered with it help explain why the theory of behaviour in neoclassical economics is so mechanical and why its representation of economic actions in terms of equilibrium states was, and remains, so problematical.

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[7] Marshall's criticism of the catena was neatly combined with another long-standing complaint that Jevons had ignored differences in the marginal utility of money between transactors, so that he had confused statements regarding "utility and value" with those for "demand price and value" [Marshall 1961, I, p.818]. For discussion, see White 1996.

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