Labour Productivity in Australian Manufacturing: The Impact of Import Competition and Market Structure

Mita Bhattacharya

Department of Economics, Monash University, GPO BOX 197, Caulfield, Australia 3145

Harry Bloch

School of Economics and Finance, Curtin University of Technology, GPO BOX U1987, Perth, Australia 6845

and

James Ted McDonald

Department of Economics, University of New Brunswick, Fredriction, Canada

Abstract

Through altering competitive conditions, globalization can have a significant impact on productivity of the domestic economy. We estimate the impact of import competition and domestic market structure on labour productivity growth in Australian manufacturing using a panel data analysis covering a period of nearly three decades. The results show strong evidence that import competition increases labour productivity growth, particularly in industries where domestic production is highly concentrated.

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1. Introduction

Growth in productivity enhances economic development. Productivity growth may occur due to competition from domestic as well as international markets. Domestic competition, foreign competition or the threat of foreign competition increases pressure to reduce costs. Firms with relatively low levels of productivity may even be forced to exit the market.

The empirical literature on total factor productivity (TFP) change has gathered a substantial body of 'stylized facts' about the determinants of productivity growth in various countries (see Nadiri, 1970 and 1972, and Nelson, 1981 for early surveys). The role of trade policies in increasing growth and efficiency has long been a major focus in this literature. Tybout (2000) provides an excellent review of empirical research from developing countries, while MacDonald (1994) provides an application to US manufacturing.

Australian industry provides an excellent setting for examining the link between trade reform and productivity growth. Trade liberalization has been ongoing for three decades in Australia. Substantial reductions in tariffs on manufactured imports have been achieved, starting with a 25 percent reduction across the board in 1973 and continuing through the 1990s. As a result, the average rate of assistance for Australian manufacturing has fallen from 35 percent to 5 percent. Between 1984-85 and 1999-2000, manufacturing sales to overseas markets increased from 16 to 27 percent of total sales, while import penetration increased from 26 to 40 percent. However, the extent of liberalization and growth in trade shares varies substantially across industries. The purpose of this study is to add to the evidence of the impact of trade liberalization by

examining differences in the productivity growth experience in Australian manufacturing at the three-digit industry level between 1973 and 1999.

Australian studies such as those by Dixon and McDonald (1991), Chand (1999) and Bloch and McDonald (2001) generally conclude that the effect of trade reform on productivity gains is positive. This paper makes two significant contributions compared to the earlier studies of Australia. Firstly, by dividing samples into high and low concentration industry, we differentiate the effects of import competition on productivity for each group over a period of two and a half decades. Secondly, we examine the persistence of productivity growth in the long run.

The rest of the paper is set as follows. Section 2 reviews the literature briefly. In Section 3, we discuss changes in Australian manufacturing over the trade liberalization period. Section 4 describes the econometric methodology and the data we use for empirical purposes. In Section 5, we analyse the empirical findings. The final section adds some concluding remarks.

2. Import Competition, Market Structure and Efficiency in Production

What are the major links between trade reform and productivity performance? A popular hypothesis, known as 'Verdoorn's law', is that there is a positive relationship between productivity changes and output growth (Verdoorn, 1949). The trade link with productivity growth is explained by scale economies. The size of market increases through liberalization.

A second argument for trade in improving productivity in domestic market is through improvement in efficiency. Leibenstein (1966) first states explicitly the idea of

'proper motivations' for disciplining firms, forcing them to become more efficient or perish. Since then, both developed and developing countries have adopted significant trade liberalization strategies. The literature on the impact of these strategies is vast. Here, we discuss only a few studies.

Levinsohn (1993) investigates the effects of trade policy on market competition using Turkish firm-level data. He refers to the proposition that openness to import competition increases domestic productivity as the imports-as-market-discipline hypothesis, and finds that this hypothesis is supported for relevant industries. Urata and Yokota (1994) analyse the factors affecting TFP growth for Thai manufacturing industries. Intensive competitive pressure from home and abroad, wider choice of intermediate goods, expansion of output base and R&D expenses are found to be the driving forces of productivity growth during 1980s.

There are also studies that focus on industry-level data for more developed countries. For example, MacDonald (1994) examines the effects of import competition on labor productivity growth both for high and low concentration industries from the U.S. manufacturing sector. The effects of import competition on productivity growth are significant in concentrated industries.

Finally, numerous studies have found that openness to trade is important in explaining productivity growth using cross-country data at the aggregate level (see for example, Dollar, 1992; Barro and Sala-i-Martin, 1995 and Edwards, 1998). However, there have been critics who suggest that the estimates of a positive impact may be spurious. In particular, Rodriguez and Rodrik demonstrate that the positive relation between openness and productivity growth found in Dollar (1992) and Edwards (1998) is

not robust. Even with this cautionary note, there is still a *prima facie* case for expecting some positive impact from trade liberalization on productivity growth in highly protected domestic industries.

3. Tariff Reform and Productivity Growth in Australian Manufacturing

Traditionally, the manufacturing sector in Australia has focused on import replacement, protected by tariffs that have been high by world standards. High tariff barriers protected domestic employment within the manufacturing industries for a long time period. However, the Industries Assistance Commission (IAC) Act in 1973, introduced a continuous tariff review program, which has been followed by successive governments and related bodies.[1] Tariffs have declined from a level of 35 percent across manufacturing sector in the mid 1970s to 5 percent in 2001 (except for the motor vehicle industry along with the textile, clothing and footwear industries).

That the increased openness of the Australian economy has significantly increased is reflected in the upward trends in export propensity and import penetration. Merchandise manufacturing exports as a fraction of sales increased from 15 percent in 1984-85 to 25 percent in 1998-99. The share of merchandise (manufactured) imports in sales increased from 26 percent to 37 percent for the same period.

Along with trade liberalization, have come dramatic changes in manufacturing employment. Gretton and Fisher (1997) report manufacturing employment declined by 27 percent over 1968/69 to 1994/95. Within manufacturing, employment has shifted from import-competing industries, such as motor vehicles, textiles, clothing and footwear, to resource-based industries taking advantage of local raw materials. During this period,

employment in the TCF and transport equipment industries has declined by 60 and 40 percent, respectively. Resource-based industries such as food, beverage and tobacco; petroleum, coal and chemical products; and metal products have expanded, so that together they contributed 50 per cent of manufacturing value added in 1998/99 and forty-two percent of total employment. Rising output with declining employment reflects rising labour productivity, with an annual average annual growth rate of 2.9 percent in Australian manufacturing from 1985/86 up to 1998/99.[2]

4. Econometric Methodology and Data

4.1 Labour Productivity Growth with Imperfect Competition

We follow Hall (1988) in deriving an expression for productivity growth that allows for imperfect competition in the sense that price can exceed marginal cost of production. Suppose the production function for the jth industry in terms of labour and capital inputs is:

$$Q_{jt} = \theta_{jt} f_j(K_{jt}, L_{jt}) \qquad (1)$$

In (1), the amount of output, *Q*, produced by industry j at time t in (1) depends on the amounts of capital, *K*, and labour, *L*, it uses in production as well as on the industry's index of technology, θ.[3]

Hall then notes that the marginal cost associated with a change in industry output, ΔQ, and labour input, ΔL, at a economy-wide wage rate, w, is:

$$x_{jt} = w_t \Delta L_{jt} / \Delta Q_{jt} \qquad (2)$$

The influence of competition is isolated by rearranging (2) to solve for the rate of change of output in terms of the rate of change of labour, the markup of price on marginal cost and the share of labour cost in revenue. The share of labour cost in revenue is given by $\alpha_{jt} = w_t L_{jt} / p_{jt} Q_{jt}$, where *p* is the price of the industry's product, as follows:

$$\Delta Q_{jt} / Q_{jt} = (\mu_{jt} \alpha_{jt}) \Delta L_{jt} / L_{jt} \qquad (3)$$

In the long-run, when there are changes in capital input, ΔK, and technical change, $\Delta\theta$, the expression for marginal cost becomes:

$$x_{jt} = \frac{w_t \Delta L_{jt} + r_t \Delta K_{jt}}{\Delta Q_{jt} - \Delta \theta_{jt} Q_{jt}} \qquad (4)$$

In (4), *r* is the rental price of capital. Using this definition of marginal cost and solving for the expression equivalent to (3) yields:

$$\Delta Q_{jt} / Q_{jt} = \mu_{jt} (\alpha_{jt} \Delta L_{jt} / L_{jt} + \beta_{jt} \Delta K_{jt} / K_{jt}) + \Delta \theta_{jt} \qquad (5)$$

where β_{jt} is the share of capital cost in firm revenue.[4]

If there are constant returns to scale, the cost shares for all inputs sum to one. This means the product of the mark-up and the sum of the revenue-share coefficients on the input changes in (5) sum to one, so we can solve for labour productivity growth as:

$$\Delta Q_{jt}/Q_{jt} - \Delta L_{jt}/L_{jt} = \mu_{jt}(\beta_{jt}(\Delta K_{jt}/K_{jt} - \Delta L_{jt}/L_{jt})) + \Delta\theta_{jt} \qquad (6)$$

Thus, it appears that by lowering the mark-up, competition decreases the impact on labour productivity growth of increases in capital, provided that the shares of inputs in revenue are otherwise unaffected. As capital intensity has been steadily rising in most industries, this means that factors that raise the mark-up, such as reduced domestic or foreign competition, can be expected to have a spurious relation to measured productivity growth.[5]

4.2. Estimating Equation

We estimate the following version of the model incorporating the above factors, with time subscripts and industry subscripts deleted:

$$\begin{aligned} LABPROD = {} & a_0 + a_1*K_P + a_2*L_P + a_3*M_P + a_4*CR_4 + a_5*IMPINT \\ & + a_6*EXPINT + \Sigma b_i*INTER + \Sigma c_i*D_i + a_7*TT \end{aligned} \qquad (7)$$

In (7), LABPROD is the logarithm of the level of labour productivity (with productivity measured as real value added per employee), K_P, L_P and M_P are the price of rental capital, wages and material price.[6] Further, CR_4 is the four-firm concentration index, IMPINT is

the import share, EXPINT is the export share, INTER is a series of interaction terms, D is an industry dummy and variable TT is the time trend.

With the right-hand-side variable of (7) in log form, the coefficients provide values for the impact of each left-hand-side variable on the proportionate change in labour productivity. The coefficient of the time trend thus provides a value of the proportionate change in labour productivity per period of time, in other words one hundred times the coefficient gives the annual percentage change (growth or decline) in labour productivity. The interaction of other variables with the time trend likewise give values for the impact of that variable on the annual proportionate change in labour productivity, or the annual percentage productivity change when multiplied by one hundred.

We estimate the effect on productivity levels of competition in the domestic, export and import markets. CR_4 is considered as an inverse measure of competition in the domestic market, while import share (IMPINT) and export share (EXPINT) include competition from the import and export sectors. Also following Bloch and McDonald (2001), we include the interaction term between CR4 and IMPINT to incorporate the interactive effects between domestic and import competition. We also allow the influence of each competition variable to change over time by including the cross product of each with a time trend (TT).

The empirical analysis is based on panel data from 1973 to 1999 for Australian manufacturing industries at the three-digit level.[7] The data are sourced from Industries Assistance Commission reports and from published and unpublished data supplied by the

Australian Bureau of Statistics. Equation (7) is estimated using OLS and panel estimation techniques.

5. Empirical Findings

Table 1 presents three sets of results for our main specification with the full sample of industries. In the first column, estimation is by OLS and the inclusion of a set of industry dummy variables at the 2-digit level to control for some sources of industry unobserved effects while still allowing identification of coefficients for the time-invariant variables. In the second column, estimation is by a fixed-effects model, where unobserved fixed effects are allowed for each three-digit industry group. Because of the inclusion of these industry effects, no time-invariant terms can be identified. In the third column, we allow for a dynamic relationship between labour productivity and the regressors by incorporating a lagged dependent variable. In order to obtain consistent estimates, we estimate this dynamic panel data model using the Arellano-Bond GMM method.

Coefficients of the terms that include interaction with the time trend indicate impacts on the growth of labour productivity.[8] We emphasise these results as productivity growth has been a central focus in testing the "import-as-market-discipline" hypothesis. First, we note that the coefficient of the time trend in all models is negative, although lacking in statistical significance, indicating negative productivity growth for the hypothetical industry with zero levels of concentration or import penetration. However, no industry in the sample has a predicted negative time trend, given the positive coefficients for the other interactions with time trend and the actual industry levels of concentration and import penetration.

The coefficients of the variables for the interaction of import share and concentration with the time trend show general consistency across the various estimation techniques in both sign and magnitude of the estimated coefficients. In particular, the coefficient on trend interacted with concentration is positive but significant only in panel estimation, while the coefficient on trend interacted with concentration and import share is also positive and highly significant.[9] Thus, labour productivity is increasing over time in the combination of import share and industry concentration. Taken together, the results imply that higher concentration is associated with a higher positive trend in labour productivity, and the positive trend is magnified further when import share is high.[10]

For the OLS results, the coefficients on the time invariant variables can be interpreted as indicating the impact of the variable on the level of the log of labour productivity at the beginning of the sample period. This is when the time trend takes the value zero. In later periods, the interaction term makes inference less obvious given the results on interactions reported above. In the initial period, when concentration is less than 0.8, labour productivity is higher for high import share industries, while when import share is less than 0.29, labour productivity is higher for high concentration industries. Compared to an industry with import share and concentration at the sample average, labour productivity is higher for higher import share industries, and lower for higher concentration industries.[11] This result is consistent with the hypothesis that competition, whether foreign or domestic, contributes to the achievement of higher productivity levels.

In the dynamic panel estimation results shown in the third column of Table 1, lagged labour productivity is positive and significant at the one-percent level. It is worth

noting that the magnitudes of most of the estimated coefficients fall by about one half as compared to the panel fixed effects results in the second column, which suggests an unchanged long-run impact of the variable. The only clear exception is the coefficient of the interaction between the time trend and export intensity, which changes sign but is not significantly different from zero in either set of results. This suggests that the significant results in panel estimation are robust to the choice between dynamic and non-dynamic estimation.

Estimates of the coefficients on the input price variables are generally positive although insignificant. The main exception is that higher materials prices are associated with higher labour productivity once unobserved industry effects are controlled. This indicates that, at least for materials prices, there is some evidence that higher input costs are associated with increased productivity for labour, which is consistent with the hypothesis that cost pressures lead to higher efficiency in the use of labour.

In the OLS results, export intensity is positively related to labour productivity, suggesting that export-oriented industries have higher labour productivity than those industries with little presence in foreign markets. However, the export share has no significant effect on the trend over time on labour productivity in any of the specifications. It should be noted that exports have traditionally been very low in most Australian manufacturing industries, so that the impact on labour productivity largely reflects the experience of a few resource-based industries.

In Table 2, we divide the sample roughly equally into ‘higher’ concentration industries, where concentration is greater than 0.6554, and ‘lower’ concentration industries, where concentration is less than this threshold. Because of the potential

omitted variables problem inherent in OLS estimation of panel data, we focus on the fixed effects results.[12] Dividing the sample by concentration reveals significant differences in the determinants of labour productivity. The results for the high-concentration industries are similar to those reported in Table 1, although the only trend interaction that is statistically significant is that with import share and concentration. Thus, the higher concentration and import share industries exhibit significantly larger increases in labour productivity over time than the other industries in the group. However, when import share is low (less than 0.23, which concentration is at the lower bound for the industry group), the trend in labour productivity is close to zero.

For low-concentration industries, the picture is markedly different for the key variable of interest: the interaction of trend with concentration and import share is negative and significant. Thus, given the magnitudes reported in Table 2, while labour productivity trends higher over time for more highly concentration industries, higher import share is associated with a downward trend in labour productivity.[13] Also notable is the result that labour productivity is trends lower with export share for industries in this subgroup, in contrast to the positive (but not significant) effect in the higher concentration subgroup. These findings are consistent with the view that the discipline of competition with foreign firms in either the domestic or foreign markets is not conducive to raising productivity in industries with low concentration among domestic producers. Indeed, such foreign competition seems harmful to labour productivity when the domestic market is already structurally competitive.[14]

6. Concluding Remarks

The manufacturing sector in Australia has traditionally been heavily protected. It is often argued that manufacturing performed poorly under protective market. Trade reform has been a major focus in the policy arena for the Australian economy over the last three decades. Other than this, micro-economic reform, adoption of new information technologies and a work-place reform program are identified as possible sources of a productivity surge in recent years (see Parnham, 2004 for a discussion of Australia's productivity surge and its possible causes).

We add to the empirical evidence on the sources of productivity improvement by applying an econometric model to panel data from the manufacturing sector, focussing particularly on the role of domestic and foreign competition. Our results clearly show a positive link between industry concentration and productivity growth. This might be interpreted as meaning that either large firm size or a lack of competition is good for productivity growth. However, our finding that high concentration is particularly good for productivity growth when there is high import penetration suggests that it the former interpretation that is valid. Foreign competition appears to discipline industries where there is little domestic competition to pursue productivity growth with even greater vigour. Thus, this is clear evidence that the "imports-as-market discipline" hypothesis works in the context of promoting continual productivity improvement in Australian manufacturing.

Appendix:

Table A1-Variable Means, Standard Deviation and Sources (n=675)

Variable	Mean	Standard Deviation.	Sources
Log (LABPROD)	-1.798	0.503	Bureau of Industry Economics (BIE, 1995), Australian Bureau of Statistics (ABS, cat. no. 8221.0)
K_P	6.286	2.222	Bureau of Industry Economics (BIE, 1986), ABS, (unpublished data)
L_P	0.691	0.391	Bureau of Industry Economics (BIE, 1986), ABS (cat. no. 6302.0).
M_P	0.617	31.096	ABS catalogue no.6427.0
CR_4	0.701	0.136	ABS unpublished data
IMPINT	0.481	0.586	ABS unpublished data
EXPINT	0.318	0.763	ABS unpublished data

Table 1: Econometric Results for Full Sample

Estimation Technique	OLS	Panel Fixed Effects	Dynamic Panel Estimation
Independent Variables			
K_P	-0.014	0.012	0.003
	(-0.76)	(1.17)	(0.36)
L_P	0.285[c]	0.057	0.020
	(1.90)	(0.73)	(0.39)
M_P	0.001	0.002[a]	0.001[b]
	(0.90)	(2.66)	(2.09)
CR_4	4.776[a]	-	-
	(9.01)		
IMPINT	13.256[a]	-	-
	(8.23)		
CR_4*IMPINT	-16.627[a]	-	-
	(-7.98)		
EXPINT	6.133[a]	-	-
	(9.88)		
TT	-0.016	-0.014[c]	-0.008
	(-1.00)	(-1.69)	(-1.13)
TT*CR_4	0.021	0.018[a]	0.015[b]
	(1.48)	(2.46)	(2.30)
TT*IMPINT*CR_4	0.054[a]	0.054[a]	0.026[a]
	(3.66)	(7.13)	(3.77)
TT*EXPINT	0.007	0.007	-0.008
	(0.48)	(0.83)	(-1.11)
Lagged LABPROD		-	0.445[a]
			(11.89)
2 digit industry controls	Yes	No	No
R^2 (adjusted)	0.690	-	-
F-statistic	82.08	212.04	-
Wald χ^2 -statistic	-	-	3374.09
Number of Industries	23	23	23
Number of Observations	621	621	575

Notes: Notes: Figures in parentheses are t-ratios.
a Indicates coefficient is significant at the 0.01 level using a two-tailed t-test.
b Indicates coefficient is significant at the 0.05 level using a two-tailed t-test.
c Indicates coefficient is significant at the 0.10 level using a two-tailed t-test.

Table 2: Econometric Results for subgroups of industries

Estimation Technique	Panel Fixed Effects	Panel Fixed Effects
	CR_4 >0.6554	**CR_4 <0.6554**
Independent Variables		
K_P	0.028[b]	-0.003
	(2.14)	(-0.16)
L_P	0.107	0.142
	(1.01)	(1.11)
M_P	0.001[c]	0.003[c]
	(1.70)	(1.95)
CR_4	-	-
IMPINT	-	-
CR_4*IMPINT	-	-
EXPINT	-	-
TT	-0.019	-0.017
	(-1.58)	(-1.20)
TT*CR_4	0.016	0.105[a]
	(1.34)	(2.90)
TT*IMPINT*CR_4	0.060[a]	-0.106[b]
	(4.62)	(-2.11)
TT*EXPINT	0.029	-0.053[a]
	(1.55)	(-2.69)
Lagged LABPROD	-	-
2-digit industry controls	No	No
R^2 (adjusted)	-	-
F-statistic	146.87	80.76
Number of Industries	12	11
Number of Observations	324	297

Notes: Notes: Figures in parentheses are t-ratios.
a Indicates coefficient is significant at the 0.01 level using a two-tailed t-test.
b Indicates coefficient is significant at the 0.05 level using a two-tailed t-test.
c Indicates coefficient is significant at the 0.10 level using a two-tailed t-test.

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Endnotes

[1] See Freedman and Stonecash (1997) for a survey on the industrial policies in Australian manufacturing sector.

[2] Australian Bureau of Statistics (ABS), Australian National Accounts, ABS catalogue 5206.0 and Labour Force Australia, ABS Catalogue 6203.0.

[3] We follow standard practice in estimating equations explaining industry-level productivity growth that relate industry output solely to the aggregate level of inputs used in the industry. This implicitly assumes that the distribution of inputs across firms does not affect the level of output produced by the industry.The assumption is valid if each firm is operating with constant returns to scale and with equal efficiency, meaning an equal value of the efficiency index. While this is an extreme assumption, unlikely to be fulfilled in practice, we have no data on the distribution of output or efficiency across firms from which to construct an appropriate variable for reflecting the distribution of output across firms.

[4] We follow Hall (1988) in focussing on the value added form of the production relationship, ignoring the role of materials inputs. This reflects our use of value added data for measuring industry output growth in the empirical results reported below.

[5] The relation is spurious in the sense that it reflects the role of the markup in the productivity growth accounting relationship given by (6).

[6] We include the price of inputs to allow for the possibility that rising input prices exert pressure on firms to improve productivity in much the same way as competition may lead to productivity improvements. This means the expected sign for each of the price variables is each positive.

[7] Concentration, export and import shares are time invariant.

[8] The dependent variable in the regression is the log of labour productivity, so the coefficients in the regressions are interpreted as impacts of the corresponding variable on the proportional or percentage change in labour productivity.

[9] The interaction of only the import share with the time trend is excluded from results presented in Table 1. The estimated coefficient for this interaction is not statistically significant in results that are not presented but which are available from the authors.

[10] The possibility of spurious results for competition variables through their impact on the markup in (7) is noted in Section 4. This can help explain the apparent contradiction that domestic competition (low concentration) is bad for productivity growth, but foreign competition (high import share) is good.

[11] The average import share for our sample of 23 industries is 0.38, while the average concentration ratio is 0.68.

[12] Results for OLS and Arellano Bond dynamic panel data estimations are available from the authors on request.

[13] The partial derivative with respect to concentration implies a time trend that is increasing in concentration as long as import share is less than 0.75, which larger than the highest import share for all industries in this subgroup.

[14] The exposure to foreign competition may adversely affect labour productivity by inhibiting investment in labour-saving equipment when profit margins are already low due to domestic competition (see Bhattacharya and Bloch, 1997 for evidence of the impact of concentration on profit margins in Australian manufacturing industries).