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Economies of Specialization and Downward Sloping Supply Curves: An Inframarginal Analysis

Xiaokai Yang

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Xiaokai Yang

Monash University, Department of Economics
Clayton, Vic., Australia 3168

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Abstract

This paper explores the implications of a small elasticity of substitution between consumption goods and the framework with consumer-producer, economies of specialization, and transaction costs for the analysis of demand and supply. In this framework, a consumer-producer's decision cannot be solved by the marginal analysis. An inframarginal analysis, which implies total benefit-cost analysis across several corner solutions in addition to the marginal analysis of each corner solution, is necessary for deriving demand and supply functions. The tradeoff between economies of specialization and transaction costs is specified to explore the relationship between transaction efficiency, the elasticity of substitution, and the equilibrium level of division of labor and related productivity and extent of the market network. It is shown that supply curves are downward sloping if the elasticity of substitution between consumption goods is smaller than one. As improvements in transaction efficiency drive division of labor to evolve, demand and supply functions discontinuously jump, generating structural changes in economic organization.

1. Introduction

The purpose of the paper is two fold. An utility function with constant elasticity of substitution (CES) is introduced into Yang and Ng's new classical framework with consumer-producers, economies of specialization, and transaction costs to show that supply curves within this framework are downward sloping if the elasticity of substitution is smaller than one; they are upward sloping if the elasticity is larger than one; and they are independent of prices for a unitary elasticity of substitution. This model is motivated to explain the common business practice that a seller of goods with economies of specialization in production charges a lower price as a buyer purchases more of the goods. Two features of the model are crucial for the results. First, the distinction between economies of scale and economies of specialization is drawn, so that monopoly power does not exist and supply functions are well defined when economies of specialization are individual specific (increasing returns are localized). Second, the specification of consumer-producers implies that the properties of supply functions depend not only on production conditions, but also on consumption conditions, while demand functions depend on the conditions for consumption as well as for production.

Suppose a consumer-producer self-provides and sells good y and buys good x and the price of y decreases, so that p_y/p_x decreases, where the two normal goods are substitutes.[1] There are two conflicting effects of the decrease in p_y. First, the quantity supplied of y must be increased to capture more economies of specialization, so that production cost can be covered when the price of good y is lower. Second, consumption of y will be increased relative to x as a result of substitution of y for x. This will reduce the quantity sold of y.[2] If the elasticity of substitution is smaller than one, the first positive effect dominates the second negative substitution effect on the quantity supplied, so that the quantity supplied of y will increase as the price p_y decreases, generating a downward sloping

[1] We do not consider inferior and Giffen goods which will generate more complicated stories.

[2] The real income effect of the increase in p_y is irrelevant here since the consumer-producer self-provides good y and does not buy it when he sells it.

supply curve. The reasoning for the case of the elasticity of substitution that is greater than one is other way around, yielding the result that the supply curve of y will be upward sloping if the elasticity of substitution is greater than one. According to our model, a downward sloping supply curve is more common than an upward sloping supply curve if we accept that the elasticity of substitution is smaller than one for many goods.[3]

The other purpose of the paper is to explore the implications of the inframarginal analysis for the analysis of supply and demand functions. Here, the concept of inframarginal analysis was first proposed by Buchanan and Stubblebine [1962], meaning total benefit-cost analysis across corner solutions in addition to the marginal analysis for each and every corner solutions.[4] The inframarginal analysis will generate several corner demand and supply functions. Real demand or supply function is one of them. The analysis will generate several corner equilibria. The general equilibrium is one of them.[5] There are two types of comparative statics of demand and general equilibrium. The first type of the comparative statics imply that as parameters reach some critical level, supply and demand functions or general equilibrium will discontinuously jump across corner supply and demand functions or across corner equilibria. It will be shown that as transaction efficiency is improved, the equilibrium level of division of labor, the equilibrium level of productivity, and the equilibrium size of the market network will increase because the higher transaction efficiency generates more scope for trading off economies of specialization against transaction costs. As a result of the increase in division of labor,

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[3] The downward sloping supply curve occurs in a Walrasian regime in our model. In contrast, a discounted (or non-linear) price is charged by the monopolist as buyers buy more in the models of Oi [1971], Spence [1977], and Schmalensee [1982].

[4] The application of inframarginal analysis to a decision problem can be found from Kendrick [1978], Little and Mirrless [1980], Becker [1981], and Rosen [1983]. The application of inframarginal analysis to general equilibrium models can be found from Yang [1990], Yang and Borland [1991], Yang and Shi [1992], Yang and Ng [1993, 1995], and Yang and Rice [1994].

[5] Buchanan and Stubblebine [1962], Coase [1946, 1960], Lievowitz and Margolis [1994] and other economists argue that many so called problems of coordination, multiple equilibria, and network externalities are generated by the assumption that individuals cannot do total benefit-cost analysis across corner solutions and they naively stick to marginal analysis of a globally non-optimum corner solution.

decreases in factor prices of all goods and increases in quantities supplied of the goods take place concurrently. This looks like a downward sloping supply curve.

The second type of the comparative statics, analogous to the conventional comparative statics, imply that supply and demand or equilibrium levels of endogenous variables continuously change in response to those changes in parameters that take place within the ranges defined by their critical values given by the first type of comparative statics. One feature of the second type of the comparative statics is that supply curves are downward sloping if the elasticity of substitution between consumption goods is smaller than one.

Allyn Young [1928] and Goerge Stigler [1951] explored the implications of the endogenization of individuals' level of specialization for the analysis of demand and supply. Becker [1981] and Rosen [1983] use decision models to explore the implications of the inframarginal analysis for the endogenization of individuals' level of specialization. Baumgardner [1988], Locay [1990], Kim [1989], and Becker and Murphy [1992] develop equilibrium models to explore the implications of the endogenization of individuals' level of specialization for the analysis of demand.

Yang [1990], Yang and Borland [1991], and Yang and Ng [1993] develop a new classical microeconomic framework with consumer-producers, economies of specialization, and transaction costs to investigate the general equilibrium implications of the inframarginal analysis and the endogenization of individuals' level of specialization. They show that within the framework, each person's optimum decision is always a corner solution, so that marginal analysis does not work and inframarginal analysis is essential for solving for the demand, supply, and general equilibrium based on corner solutions. Their static and dynamic general equilibrium models are used to explain evolution of division of labor, of productivity, of the extent of the market network, of market integration, and of the degree of endogenous comparative advantage, and the emergence of the institution of the firm, business cycles, money, cities, and a hierarchical structure of transactions. Their inframarginal analysis formalizes Allyn Young's ideas that demand and supply are two sides of the division of labor and the level of division of labor and the extent of the market network are two sides of the same coin. We cannot really understand what are demand and supply if we do not understand the mechanism that determines the equilibrium level of division of labor which is based on individuals' optimal decisions of their levels and patterns of specialization.

But in their models the elasticity of substitution is not allowed to be smaller than one, so that supply curves are either upward sloping or independent of relative prices. This implies that the implication of the framework of consumer-producer, economies of specialization, and transaction costs and related inframarginal marginal analysis for downward sloping supply curves has not been explored by the models. This paper shall fill in the gap.[6]

The paper is organized as follows. Section 2 introduces an utility function with an elasticity of substation that might be smaller, greater than, or equal to one into Yang's model [1994a]. Then, the general equilibrium and its comparative statics are solved. The final section concludes the paper.

2. A Model with Consumer-producers, Economies of Specialization, the CES Utility Function, and Transaction Costs

Consider an economy with M ex ante identical consumer-producers and three consumption goods where M is very large. Each consumer-producer has the following decision problem.

(1) Max $u = [(x+kx^d)^{-\rho}+(y+ky^d)^{-\rho}+(z+kz^d)^{-\rho}]^{-1/\rho} n^\beta$ (utility function)

s.t. $x+x^s = \text{Max}\{0, L_x-\alpha\}$, $y+y^s = \text{Max}\{0, L_y-\alpha\}$, $z+z^s = \text{Max}\{0, L_z-\alpha\}$,

$\alpha \in [0, 1)$ (production function)

$L_x+L_y+L_z = 1$ (endowment constraint)

$p_x x^s + p_y y^s + p_z z^s = p_x x^d + p_y y^d + p_z z^d$, (budget constraint)

$x, x^s, x^d, y, y^s, y^d, z, z^s, z^d, L_i \geq 0$ (non-negative constraint)

[6] In Dixit-Stiglitz' model [1977], Krugman's model [1979], Ethier's model [1982], Judd's model [1985], Romer's model [1986], and Grossman-Helpman's model [1989], elasticity of substitution is not allowed to be smaller than one. Hence, the implications of the elasticity of substitution that is smaller than one for the analysis of demand, supply, and equilibrium cannot be explored in their models.

where p_i is the price of good i, x, y, and z are respective self-provided quantities of the three goods. x^d, y^d, and z^d are respective quantities of the three goods purchased, and x^s, y^s, and z^s are respective quantities of the three goods sold. Fraction 1-k of the quantity purchased disappears in transit because of transaction costs. kx^d, ky^d, or kz^d is thus received if x^d, z^d, or y^d is purchased. Here, it is assumed that $k \in [0,1]$. Hence, $x+kx^d$, $y+ky^d$, or $z+kz^d$ is the quantity of a good received for consumption and $x+x^s$, $y+y^s$, or $z+kz^s$ is a person's output level of a good. The elasticity of substitution between consumption goods is $1/(1+\rho)$, which is greater (or smaller) than one if $\rho \in (-1,0)$ (or if $\rho > 0$). Here, it is assumed that $\rho \in (-1, \infty)$. Note that the utility function tends to be of the Leontief type as ρ approaches ∞, tends to be linear as ρ approaches -1, and tends to be of the Cobb-Douglas type as ρ approaches 0. n is the number of a person's traded goods. β represents the desirability of a variety of traded goods. Later, it will be shown that as a person chooses different number of traded goods, the variety of professions for society will be determined. If individuals prefer the variety of traded goods, then $\beta > 0$. It will be shown that a person's level of specialization increases with n. This implies that β (>0) can be interpreted as a person's degree of addiction to the production of good sold by him since more utility is increased by a person's higher level of specialization if β is larger. If individuals dislike the variety of traded goods, then $\beta < 0$ and n^β can be considered as a person's managing cost of his variety of traded goods in terms of utility loss. The effects of n on utility will generate equilibrium implications by introducing complicated tradeoffs among economies of specialization, economies of consumption variety, the effects of the variety of traded goods, and transaction costs. L_i is a person's allocation of labor to the production of good i, which is defined as his level of specialization in producing good i. Each person is endowed with one unit of labor. x, x^s, x^d, y, y^s, y^d, z, z^s, z^d, and L_i are decision variables. The non-negative constraint on the decision variables implies that the number of traded goods n is a decision variable as well.

There are economies of specialization in producing a good if labor productivity of this good increases with a person's level of specialisation in producing this good. The system of production functions and endowment constraint in problem (1) displays economies of specialization where $\alpha \in [0,$

1) is a fixed learning or training cost in producing each good. The division of labor can avoid duplicated fixed learning cost and thereby improve productivity. Each person's decision is to efficiently trade off one against others among economies of specialization, economies of consumption variety, effects of variety of traded goods, and transaction costs. The economies of specialization generated by the fixed learning cost are individual specific. They do not extend beyond the scale of a person's limited time. Hence, productivity would not increase if labor is pooled within a firm in the absence of an increase in individuals' levels of specialization.[7] Due to the localized increasing returns, a Walrasian regime prevails. As shown by Houthakker [1956], an agent's transformation curve for the production function in this paper is not concave (the production set is not convex) despite the fact that production functions are linear. There is an aggregate transformation curve for a certain level of division of labor that is higher than the one for a lower level of division of labor. The aggregate production possibility frontier will discontinuously jump between the different transformation curves as individuals shift between different levels of specialization. A more detained discussion about the properties of the aggregate transformation curves for the system of production functions with economies of specialization can be found from Yang [1994a, b] or from Yang and Ng [1993].

Due to the non-negative constraint, there are $2^{3x3}=512$ combinations of zero and positive values of the decision variables x, x^s, x^d, y, y^s, y^d z, z^s, and z^d. Each person must consider them before choose one of them as his decision. Proposition 1 in Yang [1990] or Yang and Borland [1991] establishes, on the basis of the Kuhn-Tucker theorem, that for a model with consumer-producers, economies of specialization, and transaction costs, we have

[7] Yang and Ng [1995] use the new classical framework with consumer-producers, economies of specialization, and transaction costs to show that division of labor is necessary but not sufficient for the emergence of the firm. If the transaction efficiency for intermediate goods is lower than that for labor hired to produce the intermediate goods, then the institution of the firm will emerge from evolution in division of labor. According to their theory of indirect pricing, the institution of the firm can get the activity with the lowest transaction efficiency involved in the division of labor, meanwhile avoiding direct pricing and marketing of output and input of that activity.

Lemma 1

An individual sells at most one good and does not simultaneously buy and self-provide or simultaneously buy and sell the same good.[8]

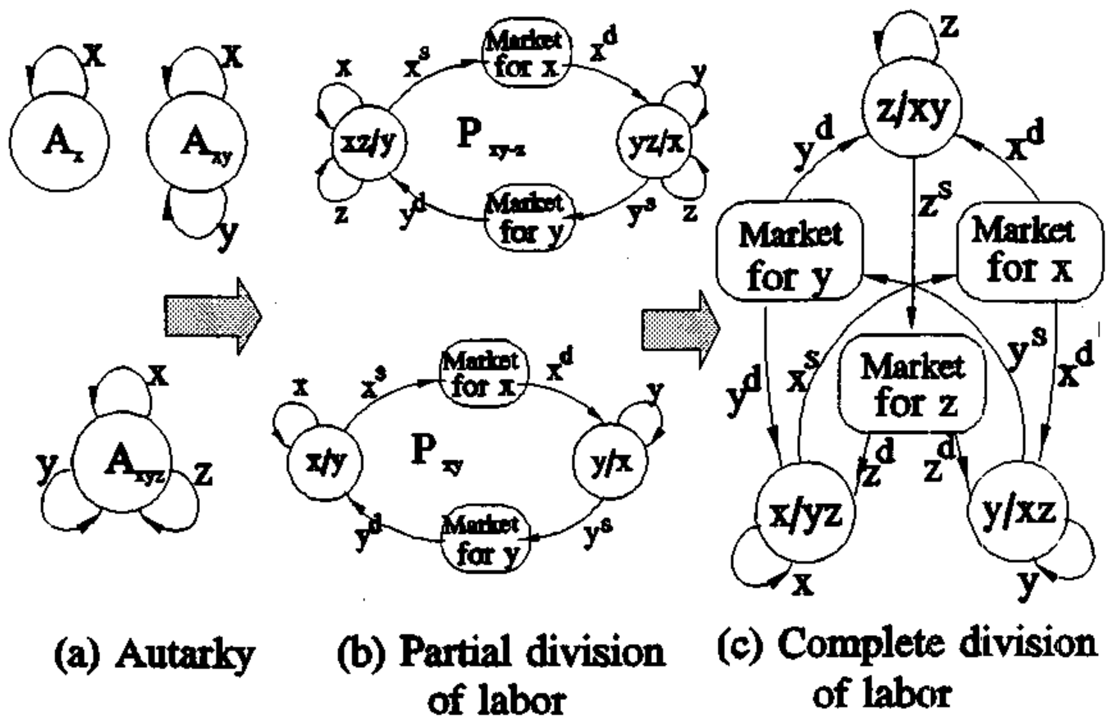
This lemma implies, on the one hand, that the interior solution cannot be optimal and marginal analysis based on interior solution does not work here. It implies, on the other, that we need only consider a few of many corner solutions. Taking lemma 1 into account, there are 22 configurations of zero and positive values of the decision variables that must be considered.

The 22 configurations can be divided into 4 classes. The first class is autarky, denoted by A_i, A_{ij}, and A_{ijr}, respectively. A_x, A_{xy}, and A_{xyz} are shown in Fig 1a where circles represent configurations and lines with arrows represent flows of goods. A_i represents that good i is self-provided by each individual, where i=x, y, z. A_{ij} represents that goods i and j are self-provided by each individual, where i,j=x, y, z. A_{xyz} represents that goods x, y, and z are self-provided by each individual. There are 7 configurations from this class: A_x, A_y, A_z, A_{xy}, A_{xz}, A_{yz}, and A_{xyz}. The configurations from the second class are partial specialization with 3 goods consumed, denoted by *(ir/j)*. An individual choosing *(ir/j)* sells and self-provides good *i*, self-provides good $r \neq i, j$, and buys good *j*. He does not buy good *i* and does not produce good *j*. That is, $i, i^s, j^d, r, l_i, l_r > 0$ and $i^d = j^s = j = r^s = r^d = l_j = 0$. There are six configurations from this class: *(xz/y)*, *(yz/x)*, *(xy/z)*, *(zy/x)*, *(yx/z)*, and *(zx/y)*. Configurations (xz/y) and (yz/x) are shown in Fig 1b. The configurations from the third class are partial specialization with 2 goods consumed, denoted by *(i/j)*. An individual choosing *(i/j)* sells and self-provides good *i* and buys good *j*. He does not buy good *i*, does not produce good *j*, and does not consume and produce good $r \neq i, j$. That is, $i, i^s, j^d, l_i > 0$ and $i^d = j^s = j = r = r^s = r^d = l_r = l_j = 0$. There are six configurations from this class: *(x/y)*, *(y/x)*, *(x/z)*, *(z/x)*, *(y/z)*,

[8] Wen [1994] proves this lemma for a general specification of quasi-concave utility function and separable production functions with economies of specialization, and non-increasing transaction cost coefficient functions. However, the comparative statics of the general equilibrium models based on the inframarginal analysis cannot be sorted out without explicit specification of functional forms.

and (z/y). Configurations (x/y) and (y/x) are shown in Fig 1b. The configurations from the third class are complete specialization, denoted by (*i*/*jr*), shown in Fig 1c. An individual choosing (*i*/*jr*) self-provides and sells good i and buys goods j and r, that is, $i, i^s, j^d, r^d, l_i > 0$ and $i^d = j = j^s = r = r^s = l_j = l_r = 0$. There are three configurations from this class: (x/yz), (y/xz), and (z/xy).

Figure 1: Configurations and Structures



There are two steps for each consumer-producer to solve for his optimum decision when he conducts inframarginal analysis. First, he solves for a corner solution for each configuration and for given relative prices of traded goods, using marginal analysis. Second, he compares utility levels across configurations and chooses the corner solution that generates the highest level of utility. For a configuration, such as (xz/y), the decision problem is

(2a) Max $u = [x^{-\rho}+(ky^d)^{-\rho}+z^{-\rho}]^{-1/\rho}2^\beta$ (utility function)

s.t. $x+x^s = L_x-\alpha, \ z = L_z-\alpha$ (production function)

$L_x+L_z = 1$ (endowment constraint)

$p_x x^s = p_y y^d$, (budget constraint)

$$x,\ z,\ x^s,\ y^d,\ L_z,\ L_x > 0,\ x^d,\ z^d,\ y,\ z^s,\ y^s,\ L_y = 0 \qquad \text{(non-negative constraint)}$$

The solution of the problem is

(2b)
$$L_x = [1-\alpha+(kp_x/p_y)^{\rho/(1+\rho)}]/[1+2(kp_x/p_y)^{\rho/(1+\rho)}] \qquad x^s = (1-2\alpha)/[1+2(kp_x/p_y)^{\rho/(1+\rho)}],$$
$$y^d = p_x x^s/p_y, \qquad x = z = (1-2\alpha)(kp_x/p_y)^{\rho/(1+\rho)}/[1+2(kp_x/p_y)^{\rho/(1+\rho)}],$$
$$u_x = (1-2\alpha)(kp_x/p_y)[1+2(kp_x/p_y)^{\rho/(1+\rho)}]^{-(1+\rho)/\rho}2^{\beta},$$

where x^s is the corner supply function of x for configuration (xz/y), which will be a supply function if the corner solution is an optimum corner solution given by inframarginal analysis, y^d is the corner demand function for (xz/y), and u_x is the corner indirect utility function for configuration (xz/y), which will be an indirect utility function if this corner solution is an optimum one. Note that the number of traded goods in this configuration n=2. Following this procedure, all corner solutions can be solved. 10 of them are summarized in Table 1. Due to the symmetry of the model, the corner solutions for configurations A_y and A_z are symmetric to A_x; A_{xz} and A_{yz} are symmetric to A_{xy}; those for (x/z), (z/x), (y/z), and (z/y) are symmetric to (x/y) and (y/x); and those for (xy/z), (zy/x), (yx/z), and (zx/y) are symmetric to (xz/y) and (yz/x).[9] We omit the 12 corner solutions to save space in Table 1.

[9] Asymmetric new classical models with the Cobb-Douglas utility function are used by Yang [1990] and Yang and Rice [1994] to investigate the implications of relative size of the parameters of tastes, production, and transaction costs between goods for the equilibrium pattern of division of labor and urbanization.

Table 1: Corner Solutions for 10 Configurations

Configuration	Demand function	Supply function	Self-provided quantity	(Indirect) utility function
A_x			$x=(1-\alpha)$	$1-\alpha$
A_{xy}			$x=y=(1-2\alpha)/2$	$(1-2\alpha)2^{-(1+\rho)/\rho}$
A_{xyz}			$x=y=z=(1-3\alpha)/3$	$(1-3\alpha)3^{-(1+\rho)/\rho}$
(xz/y)	$y^d=(1-2\alpha)p_x/p_y [1+2(kp_x/p_y)^{\rho/(1+\rho)}]$	$x^s=(1-2\alpha)/[1+2(kp_x/p_y)^{\rho/(1+\rho)}]$	$x=z=(1-2\alpha)(kp_x/p_y)^{\rho/(1+\rho)}/[1+2(kp_x/p_y)^{\rho/(1+\rho)}]$	$(1-2\alpha)(kp_x/p_y)[1+2(kp_x/p_y)^{\rho/(1+\rho)}]^{-(1+\rho)/\rho}2^\beta$
(yz/x)	$x^d=(1-2\alpha)p_y/p_x [1+(kp_y/p_x)^{\rho/(1+\rho)}]$	$y^s=(1-2\alpha)/[1+2(kp_y/p_x)^{\rho/(1+\rho)}]$	$y=z=(1-2\alpha)(kp_y/p_x)^{\rho/(1+\rho)}/[1+2(kp_y/p_x)^{\rho/(1+\rho)}]$	$(1-2\alpha)(kp_y/p_x)[1+2(kp_y/p_x)^{\rho/(1+\rho)}]^{-(1+\rho)/\rho}2^\beta$
(x/y)	$y^d=(1-\alpha)p_x/p_y [1+(kp_x/p_y)^{\rho/(1+\rho)}]$	$x^s=(1-\alpha)/[1+(kp_x/p_y)^{\rho/(1+\rho)}]$	$x=(1-\alpha)(kp_x/p_y)^{\rho/(1+\rho)}/[1+(kp_x/p_y)^{\rho/(1+\rho)}]$	$(1-\alpha)(kp_x/p_y)[1+(kp_x/p_y)^{\rho/(1+\rho)}]^{-(1+\rho)/\rho}2^\beta$
(y/x)	$x^d=(1-\alpha)p_y/p_x [1+(kp_y/p_x)^{\rho/(1+\rho)}]$	$y^s=(1-\alpha)/[1+(kp_y/p_x)^{\rho/(1+\rho)}]$	$y=(1-\alpha)(kp_y/p_x)^{\rho/(1+\rho)}/[1+(kp_y/p_x)^{\rho/(1+\rho)}]$	$(1-\alpha)(kp_y/p_x)[1+(kp_y/p_x)^{\rho/(1+\rho)}]^{-(1+\rho)/\rho}2^\beta$
(x/yz)	$y^d=(1-\alpha)p_x p_y^{-1/(1+\rho)}/B_x$, $z^d=(1-\alpha)p_x p_z^{-1/(1+\rho)}/B_x$	$x^s=(1-\alpha)[p_y^{\rho/(1+\rho)}+p_z^{\rho/(1+\rho)}]/B_x$	$x=(1-\alpha)(kp_x)^{\rho/(1+\rho)}/B_x$	$(1-\alpha)kp_x B_x^{-(1+\rho)/\rho}3^\beta$
(y/xz)	$x^d=(1-\alpha)p_y p_x^{-1/(1+\rho)}/B_y$, $z^d=(1-\alpha)p_y p_z^{-1/(1+\rho)}/B_y$	$y^s=(1-\alpha)[p_x^{\rho/(1+\rho)}+p_z^{\rho/(1+\rho)}]/B_y$	$y=(1-\alpha)(kp_y)^{\rho/(1+\rho)}/B_y$	$(1-\alpha)kp_y B_y^{-(1+\rho)/\rho}3^\beta$
(z/xy)	$x^d=(1-\alpha)p_z p_x^{-1/(1+\rho)}/B_z$, $y^d=(1-\alpha)p_z p_y^{-1/(1+\rho)}/B_z$	$z^s=(1-\alpha)[p_x^{\rho/(1+\rho)}+p_y^{\rho/(1+\rho)}]/B_z$	$z=(1-\alpha)(kp_z)^{\rho/(1+\rho)}/B_z$	$(1-\alpha)kp_z B_z^{-(1+\rho)/\rho}3^\beta$

In Table 1, $B_x \equiv [(kp_x)^{\rho/(1+\rho)}+p_y^{\rho/(1+\rho)}+p_z^{\rho/(1+\rho)}]$, $B_y \equiv [(kp_y)^{\rho/(1+\rho)}+p_x^{\rho/(1+\rho)}+p_z^{\rho/(1+\rho)}]$, and $B_z \equiv [(kp_z)^{\rho/(1+\rho)}+p_x^{\rho/(1+\rho)}+p_y^{\rho/(1+\rho)}]$. It can be shown that the second order condition for utility maximization problems in each and every configurations is satisfied if $\rho \in (-1, \infty)$.

The results in Table 1 formalize Young's [1928] idea that demand and supply are two sides of the division of labor and Stigler's [1951] idea that as individuals change their decisions of level of specialization, demand and supply function will discontinuously jump. As indicated in (2b) and in Table 1, demand for y (or for x) is the reciprocal of supply of x (or y). They are zero if individuals choose autarky, are positive if individuals choose the partial specialization, and jump to a higher level as individuals shift from the partial specialization to the complete specialization. Later it will be shown that demand and supply functions will jump from zero or from a low level to a higher level as transaction efficiency increases to a critical value. We cannot find a neoclassical counterpart of this type of comparative statics of demand and supply functions. For a given configuration with trade, comparative statics of demand and supply functions in our model are similar to that in neoclassical microeconomics based on marginal analysis.

For instance, for a given configuration (x/y) or (y/x), the own price derivative of the quantity supplied of a good is negative if $\rho > 0$ or if the elasticity of substitution is smaller than one; it is positive if $\rho \in (-1,0)$ or if the elasticity of substitution is greater than one; and it is zero if $\rho = 0$ or if the elasticity is unitary. The supply functions for configuration (ir/j) or (i/jr) where i, j, r = x, y, z, have the same properties. This implies that the supply curve is downward sloping if goods are not very close substitutes and it is upward sloping if goods are very close substitutes.

The intuition of the surprising results goes as follows. Suppose a consumer-producer self-provides and sells good y and buys good x and the price of y decreases, so that p_y/p_x decreases, where the two normal goods are substitutes. There are two conflicting effects of the decrease in p_y. First, the quantity supplied y^s must increase to capture more economies of specialization, so that production cost can be covered when the price of outputs is lower. Second, consumption of y will be increased relative to x as a result of substitution of y for x. This will reduce the quantity sold y^s. If the elasticity of substitution is smaller than one, the first positive effect dominates the second negative substitution effect on the quantity supplied, so that the quantity supplied y^s will increase as the price p_y decreases, generating a downward sloping supply curve. The reasoning for the case of the elasticity of substitution that is greater than one is other way around, yielding the result that the supply curve will be upward sloping if the elasticity of substitution is greater than one.

It is not difficult to show that the demand law and other neoclassical properties for the system of the Marshallian demand functions, such as homogeneity of degree zero in all prices and income and symmetry between cross price derivatives of demand, hold for all corner demand functions in

Table 1 if $\rho \in (-1, \infty)$ or if the normal goods are substitutes.

A combination of configurations that is compatible with the market clearing conditions is called a market structure or simply a structure. There are at least 18 structures derived from feasible combinations of the 22 configurations. Each autarkical configuration itself is a structure. Three market structures are referred to as the partial division of labor with 2 consumption goods *i* and *j*, and denoted by P_{ij}. P_{ij} consists of configurations (*i/j*) and (*j/i*). P_{xy} is shown in Fig 1b. There are 7 structures for the partial division of labor with 3 consumption goods. Structure P(xzy) consists of (x/y), (y/z), and (z/x) and P(yzx) consists of (y/x), (z/y), and (x/z). Structure $P_{xy\text{-}z}$ consists of (xz/y) and (yz/x), structure $P_{xz\text{-}y}$ consists of (xy/z) and (zy/x), structure $P_{yz\text{-}x}$ consists of (yx/z) and (zx/y), structure P_{xzy} consists of (xz/y), (yx/z), and (zy/x), and structure P_{yzx} consists of (yz/x), (zx/y), and (xy/z). Structure C, the complete division of labor shown in Fig 1c, consists of configurations (*x/yz*), (*y/xz*), and (*z/xy*). The 18 structures are referred to as symmetric structures. A structure that does not involve more than one configuration selling the same good is referred to by Yang and Ng [1993] as a basic structure. All the symmetric structures are basic structures. In each of other asymmetric basic structures, such as a combination of configurations (z/xy), (x/y), and (y/z), some individuals trade three goods and others trade two goods.

A corner equilibrium for a certain structure is defined by a set of relative prices of traded goods and a set of relative numbers of individuals choosing different configurations that equilibrate total corner-demand to total corner-supply of each traded goods and equalize all individuals' utility levels. Plugging the corner equilibrium relative price back into utility function yields percapita real income in each structure. Other than the basic structures, there are many non-basic structures. In each of them at least two configurations sell the same goods. It has been shown by Yang and Ng [1993, chapter 6] that no Walrasian corner equilibrium exists for such a structure because the system of utility equalization conditions has no consistent solutions of relative prices.

A corner solution for an autarkical structure is a corner equilibrium. Each of other corner equilibria can be solved from the market clearing and utility equalization conditions. It can be shown that the asymmetric basic structures cannot be general equilibrium for the symmetric model where all parameters of tastes, production, and transactions are the same across goods. Also, structures P_{ij}, P(xzy), and P(yzx) generate the same utility for each person and structures $P_{ij\text{-}r}$, P_{xzy}, and P_{yzx} generate the same utility for any i,j=x,y,z.[10] Hence, we can focus on P_{xy} and $P_{xy\text{-}z}$ without loss of generality. The corner equilibrium in structure $P_{xy\text{-}z}$ can be solved from the following market clearing and utility equalization conditions, and the population equation:

$$(3) \qquad M_x x^s = M_y x^d, \quad u_x = u_y, \; M_x + M_y = M$$

where M_i is the number individuals selling good i, x^s is the corner supply function of configuration (xz/y), x^d is the corner demand function of configuration (yz/x), u_x is the corner indirect utility function of configuration (xz/y) and u_y is the corner indirect utility function of (yz/x) which are given in Table 1. Note that the market clearing condition for good y is independent of (3) due to Walras' rule. Equations in (3) yield the corner equilibrium in structure $P_{xy\text{-}z}$.

$$(4) \qquad p_x/p_y = 1, \qquad M_x = M_y = M/2, \qquad u(P_{xy\text{-}z}) = (1-2\alpha)(2 + k^{-\rho/(1+\rho)})^{-(1+\rho)/\rho} 2^{\beta}$$

where $u(P_{xy\text{-}z})$ is the percapita real income in structure $P_{xy\text{-}z}$. Following the procedure, the corner equilibria in the 6 structures can be solved and summarized in Table 2.

[10] The proof of the propositions can be found from Yang and Ng [1993, chapter 6].

Table 2: Corner Equilibria in the 6 Structures

Structure	Corner equilibrium relative prices	Numbers of individuals selling different goods	Percapita real income u
A_x			$(1-\alpha)$
A_{xy}			$(1-2\alpha)2^{-\rho/(1+\rho)}$
A_{xyz}			$(1-3\alpha)3^{-\rho/(1+\rho)}$
P_{xy}	$p_x/p_y=1$	$M_x=M_y=M/2$	$(1-\alpha)(1+k^{-\rho/(1+\rho)})^{-(1+\rho)/\rho}2^{\beta}$
$P_{xy\text{-}z}$	$p_x/p_y=1$	$M_x=M_y=M/2$	$(1-2\alpha)(2+k^{-\rho/(1+\rho)})^{-(1+\rho)/\rho}2^{\beta}$
C	$p_x/p_y=p_x/p_z=1$	$M_x=M_y=M_z=M/3$	$(1-\alpha)(1+2k^{-\rho/(1+\rho)})^{-(1+\rho)/\rho}3^{\beta}$

where M_i is the number of individuals selling good i. The corner equilibrium for A_y or A_z is symmetric to that for A_x; the corner equilibrium for A_{yz} or A_{xz} is symmetric to that for A_{xy}; the corner equilibrium for P_{yz} or P_{xz} is symmetric to that for P_{xy}; and the corner equilibrium for $P_{yz\text{-}x}$ or $P_{xz\text{-}y}$ is symmetric to that for $P_{xy\text{-}z}$.

General equilibrium is defined as a fixed point that satisfies the following conditions. (i) Each individual uses inframarginal analysis to maximize his utility with respect to configurations and quantities of each good produced, consumed, and traded for a given set of relative prices of traded goods and a given set of the numbers of individuals selling different goods; (ii) The set of relative prices of traded goods and the set of numbers of individuals selling different goods clear the markets for traded goods and equalize utility for all individuals selling different goods. According to this definition, the general equilibrium in this model is the corner equilibrium that yields the highest percapita real income because it satisfies the two conditions for the definition of general equilibrium and other corner equilibria do not satisfy condition (i). It is proven in Yang and Ng [1993, chapter 6] that individuals have incentives to deviate from those corner equilibria that do not generate the highest percapita real income. Therefore, comparisons in real incomes between the three corner equilibria yield the general equilibrium and its comparative statics of the non-continuous type as summarized in Table 3.

Table 3: General Equilibrium and its Comparative Statics

Subtable 3.1

ρ	>0					
β	<0	$\in(0, \beta_0)$			$>\beta_0$	
k		$<k_0$	$\in(k_0, k_1)$	$>k_1$	$<k_2$	$>k_2$
Equilibrium structure	A_x	A_x	P_{xy}	C	A_x	C

Subtable 3.2

ρ	$\in(-1, 0)$				
$\beta>0$	$\in(0, \beta_1)$			$>\beta_1$	
k	$<k_3$	$\in(k_3, k_4)$	$>k_4$	$<k_5$	$>k_5$
Equilibrium structure	A_{xyz}	$P_{xy\text{-}z}$	C	A_{xyz}	C

Subtable 3.3

ρ	$\in(\rho_0, 0)$									
α	$\in(0, 1/3)$					$\in(1/3, \alpha_1)$				
$\beta<0$	$\in(-1, \beta_1)$			$\in(\beta_1, 0)$		$\in(-1, \beta_2)$			$\in(\beta_2, 0)$	
k	$<k_3$	$\in(k_3, k_4)$	$>k_4$	$<k_5$	$>k_5$	$<k_6$	$\in(k_6, k_4)$	$>k_4$	$<k_7$	$>k_7$
Equilibrium structure	A_{xyz}	$P_{xy\text{-}z}$	C	A_{xyz}	C	A_{xy}	$P_{xy\text{-}z}$	C	A_{xy}	C

Subtable 3.4

ρ	$\in(\rho_1, 0)$									
α	$\in(\alpha_1, \alpha_0)$					$\in(\alpha_0, 1)$				
$\beta<0$	$\in(-1, \beta_3)$			$\in(\beta_3, 0)$		$\in(-1, \beta_0)$			$\in(\beta_0, 0)$	
k	$<k_3$	$\in(k_3, k_1)$	$>k_1$	$<k_7$	$>k_7$	$<k_0$	$\in(k_0, k_1)$	$>k_1$	$<k_2$	$>k_2$
Equilibrium structure	A_{xy}	P_{xy}	C	A_{xy}	C	A_x	P_{xy}	C	A_x	C

Subtable 3.5

ρ	$\in(-1, \rho_1)$	
α	$\in(0, \alpha_2)$	$\in(\alpha_2, \alpha_1)$

$\beta<0$	$\in(-1, \beta_1)$			$\in(\beta_1, 0)$		$\in(-1, \beta_2)$			$\in(\beta_2, 0)$	
k	$<k_3$	$\in(k_3, k_4)$	$>k_4$	$<k_5$	$>k_5$	$<k_6$	$\in(k_6, k_4)$	$>k_4$	$<k_7$	$>k_7$
Equilibrium structure	A_{xyz}	P_{xy-z}	C	A_{xyz}	C	A_{xy}	P_{xy-z}	C	A_{xy}	C

Subtable 3.6

ρ	$\in(-1, \rho_1)$									
α	$\in(\alpha_1, \alpha_0)$					$\in(\alpha_0, 1)$				
$\beta<0$	$\in(-1, \beta_3)$			$\in(\beta_3, 0)$		$\in(-1, \beta_0)$			$\in(\beta_0, 0)$	
k	$<k_8$	$\in(k_8, k_1)$	$>k_1$	$<k_7$	$>k_7$	$<k_0$	$\in(k_0, k_1)$	$>k_1$	$<k_2$	$>k_2$
Equilibrium structure	A_{xy}	P_{xy}	C	A_{xy}	C	A_x	P_{xy}	C	A_x	C

In the entries of the first row different value ranges of ρ are listed, in the second row of subtables 3.1 and 3.2 or the third row of subtables 3.3-3.6 different value ranges of β are listed, in the second row of subtables 3.3-3.6 different value ranges of α are listed, in the third row of subtables 3.1 and 3.2 or the fourth row of subtables 3.3-3.6 different value ranges of k are listed, and in the bottom row equilibrium structures are listed for different values of parameters. For instance, the third, fourth, and fifth columns of subtable 3.1 indicate that for $\beta\in(0, \beta_0)$ and $\rho>0$, the equilibrium structure is autarky with one good produced if $k<k_0$, is the partial division of labor with 2 consumption goods if $k\in(k_0,k_1)$, and is the complete division of labor with three goods consumed and produced if $k>k_1$. Note that $\alpha\in[0,1)$, $k\in[0,1]$, and $\rho\in(-1,\infty)$ are assumed. The critical values of the parameters are given as follows. $k_0\equiv[2^{\beta/P}-1]^{-P}$, where $P\equiv(1+\rho)/\rho$, $k_1\equiv\{[2(2/3)^{\beta/P}-1]/[1-(2/3)^{\beta/P}]\}^P$, $k_2\equiv[2/(3^{\beta/P}-1)]^P$, $k_3\equiv\{3[(1-3\alpha)/(1-2\alpha)2^\beta]^{-1/P}-2\}^{-P}$, $k_4\equiv\{(2[(1-2\alpha)(2/3)^\beta/(1-\alpha)]^{-1/P}-1)/[2-(1-2\alpha)(2/3)^\beta/(1-\alpha)]\}^{-P}$, $k_5\equiv\{1.5[(1-3\alpha)/(1-\alpha)3^\beta]^{-1/P}-0.5\}^{-P}$, $k_6\equiv[2(2^{\beta/P}-1)]^{-P}$, $k_7\equiv\{.5[(1-2\alpha)2^{-P}3^{-\beta}/(1-\alpha)]^{-1/P}-.5\}^{-P}$, $k_8\equiv\{[(1-2\alpha)/(1-\alpha)]^{-1/P}2^{1+(\beta/P)}-1\}^{-P}$, $\beta_0(\rho)$ is given by $k_0(\beta,\rho)=k_1(\beta,\rho)$, $\beta_1(\alpha,\rho)$ is given by $k_3(\alpha,\beta,\rho)=k_4(\beta, \rho)$, $\beta_2(\alpha,\rho)$ is given by $k_4(\alpha,\beta,\rho)=k_6(\beta, \rho)$, $\beta_3(\alpha,\rho)$ is given by $k_8(\alpha,\beta,\rho)=k_1(\beta, \rho)$, $\alpha_0(\rho)$ is given by $u(A_x)=u(A_{xy})$, $\alpha_1(k,\rho)$ is given by $u(P_{xy})=u(P_{xy-z})$, $\alpha_2(\rho)$ is given by $u(A_{xy})=u(A_{xyz})$, and $\rho_0(k)$ is given by $\alpha_1(k,\rho)=1/3$. It can be shown that $.5>\alpha_0>1/3>\alpha_1>\alpha_2>0$ if $\rho<\rho_0$ and that $.5>\alpha_0>\alpha_1>1/3>\alpha_2>0$ if $\rho>\rho_0$.

The critical values of the parameters are identified by comparisons of percapita real incomes in different structures and a careful examination of the compatibility of the inequalities generated by the comparisons. The proof of Table 3 is in Appendix. Tables 1- 3 yield the following proposition.

Proposition 1

(I) Suppose that the elasticity of substitution is smaller than one, or $\rho>0$.

(1) If individuals dislike the variety of trade ($\beta<0$), the general equilibrium is always autarky with one good produced and consumed.

(2) If the variety of trade generates significant positive utility ($\beta>\beta_0$), then the general equilibrium starts from autarky with one good produced and consumed and then jumps to the complete division of labor with three goods produced and consumed as transaction efficiency is improved.

(3) If positive utility generated by the variety of trade is neither very significant nor very insignificant, then the general equilibrium gradually evolves from autarky with one good produced and consumed, followed by the partial division of labor with two goods produced and consumed, finally to the complete division of labor with three goods as transaction efficiency is improved.

(4) Supply curves are downward sloping. As transaction efficiency is improved, new goods emerge from the evolution in the number of consumption goods and new demand and supply functions emerge from the evolution in division of labor, demand and supply of each traded good discontinuously jump up, and labor price of each traded good decreases.

(II) Suppose that the variety of trade generates positive utility and that the elasticity of substitution is greater than one, or $\rho\in(-1,0)$.

(1) No evolution in the number of consumption goods will be generated by improvements in transaction efficiency.

(2) If the variety of trade yields significant positive utility ($\beta > \beta_1$), then the general equilibrium starts from autarky with three goods produced and consumed and then jumps to the complete division of labor as transaction efficiency is improved.

(3) If the variety of trade yields insignificant positive utility ($\beta < \beta_1$), then the general equilibrium gradually evolves from autarky with three goods produced and consumed, followed by the partial division of labor with three goods produced and consumed, finally to the complete division of labor as transaction efficiency is improved.

(4) Supply curves are upward sloping. As transaction efficiency is improved, new demand and supply functions emerge from the evolution in division of labor, demand and supply of each traded good discontinuously jump up, and labor price of each traded good decreases

(III) Suppose that the variety of trade generates negative utility and that the elasticity of substitution is greater than one, or $\rho \in (-1,0)$.

(1) Evolution in the number of consumption goods is more likely to take place as transaction efficiency is improved if the fixed learning cost α is greater.

(2) Improvements in transaction efficiency yield non-gradual jump of the level of division of labor if the variety of trade generates insignificant negative utility or if $\beta \in (\beta_1, 0)$.

(3) The evolution in division of labor is gradual if the variety of trade generates significant negative utility or if $\beta \in (-1, \beta_1)$.

(4) Supply curves are upward sloping. As transaction efficiency is improved, new goods emerge from the evolution in the number of goods, new demand and supply functions emerge from the evolution in division of labor, demand and supply of each traded good discontinuously jump up, and labor price of each traded good decreases.

The intuition behind the proposition is straightforward. If the elasticity of substitution is small, individuals will concentrate their limited lime to produce one consumption good to capture more economies of specialization if a low transaction efficiency generates a small scope for trading off economies of specialization against transaction cost such that autarky is chosen. Provided individuals prefer a diversity of trade, a higher transaction efficiency generates more scope for trading off economies of specialization against transaction costs, so that the equilibrium levels of division of labor, productivity, and trade dependence, and equilibrium number of goods and size of the market network increase.[11] Due to economies of specialization, for those goods that have no very close substitutes, producers are willing to take a lower price as they sell more, yielding a downward sloping supply curve. For those goods that have close substitutes, substitution effects dominate effects of economies of specialization, yielding an upward sloping supply curve. According to our model, a downward sloping supply curve is more common than an upward sloping supply curve if we accept that the elasticity of substitution is smaller than one for many goods.

For a large elasticity of substitution, a preference for a variety of trade ($\beta > 0$) ensures that evolution in division of labor occurs, but the evolution in the number of goods does not occur as transaction efficiency is improved. If the variety of trade generates negative utility which can be interpreted as a person's managing cost of the variety of trade, the tradeoff between the managing cost and economies of specialization in addition to the tradeoff between economies of specialization and transaction cost will yield various patterns of evolution in division of labor and/or in the number of goods. Since $\alpha_i(\rho)$ increases with ρ, a larger value of α implies a larger value of ρ, which means a greater degree of economies of complementarity between goods in raising utility due to inverse relationships between ρ and the elasticity of substitution and between the elasticity and the degree of

11 Adam Smith proposed the conjecture that the extent of the market is determined by transportation efficiency [1976, pp. 31-32] in addition to the proposition that the division of labor is limited by the extent of the market [1976, chapter 3 of book I]. Houthakker [1956] indicates that the tradeoff between economies of specialization and transaction costs can be used to formalize the positive relationship between transaction efficiency and the level of division of labor.

complementarity. Hence, subtables 3.3-3.6 imply that the evolution in the number of goods is more likely to take place if the degree of economies of complementarity is greater.

The condition for gradual evolution in division of labor is not that intuitive. The condition implies the evolution in division of labor is gradual if individuals' preferences for the diversity of trade is not that great. This means that benefit of division of labor is not very great compared to its cost. This condition is analogous to the second order condition for a neoclassical profit maximization problem that marginal cost is greater than marginal revenue in equilibrium.

Figure 1 illustrates proposition 1. Panel (a) illustrates three autarkical structures. In fact there are more individuals than shown in Figure 1. Circles represent configurations. The lines represent flows of goods self-provided. In autarky there is no market demand and supply. Productivity is low (or the factor price of goods is high) because of a low level of specialization. However, transaction costs do not exist because people have no business with each other. There are two structures with the partial division of labor in Panel (b). The lines represent the flows of goods. For structure P_{xy} or $P_{xy\text{-}z}$, there is a local business community comprised of two persons. There are two markets, one for x and the other for y. There are two distinctive professional sectors. The percapita output of each good is higher and the factor price of each good is lower than in autarky because of a higher level of specialization for each person. But transaction cost is greater than in autarky because each person has to undertake two transactions to obtain the necessary consumption. In structure C, depicted in Fig 1c, the number of markets, aggregate demand and supply, the size of the market network, productivity, and the difference in productivity between the buyer and the seller of a traded good is greater than in structure P. It is interesting to note that as improvements in transaction efficiency drive division of labor to evolve, labor prices of all goods decrease and quantities of goods produced increase. The two concurrent phenomena look like a downward sloping supply curve.

Multiple equilibria occur for three reasons. First, for the trivial case with $k=1$ and $\alpha=\beta=0$, any of the corner equilibria in the basic structures can be a general equilibrium since they generate the same percapita real income. If the conditions for the partial division of labor to be equilibrium are satisfied, any of structures P_{ij} for i, j =x,y,z, P(xzy), and P(yzx) or any of structures $P_{ij\text{-}r}$ for i, j, r =x,y,z, P_{xzy}, and P_{yzx} can be a general equilibrium. An infinitesimal difference in any one of the parameters across goods will rule out the indeterminacy and ensure that P(xzy), P(yzx), P_{xzy}, and P_{yzx} cannot be equilibrium. Also, who is specialized in producing which good is indeterminate in an equilibrium. Hence, there exist multiple equilibria with the same percapita real income if we distinguish between the equilibria that assign a person to different configurations. If exogenous (ex ante) differences between individuals are specified, then the indeterminacy will be ruled out.

We cannot find a neoclassical counterpart of the comparative statics of the general equilibrium based on the inframarginal analysis, summarized in Table 3. For a given structure, the comparative statics of the corner equilibrium are analogous to neoclassical comparative statics of general equilibrium based on marginal analysis. The comparative statics of the second type can be obtained by plugging the corner equilibrium values of prices that are given in Table 2 into variables given in Table 1 and by differentiating the resulting variables with respect to parameters.

Following the approach devised in Yang [1990, 1994], it can be shown that a sufficient improvement in transaction efficiency generates the following concurrent phenomena: progress in labor productivity (or decreases in labor prices of goods), the increases in individuals' level of specialization, in the diversity of professional sectors, in the degrees of production concentration and integration of the economy, in the extent of the market, in the degree of endogenous comparative advantages, and in the degree of commercialization, and the decrease in self-sufficiency of each person.

It is interesting to see that marginal cost pricing rule no longer holds in the equilibrium involving specialization. From the production functions and endowment constraint in (1), it is clear that the transformation function is $X+Y+Z=1-3\alpha$ if $X,Y,Z>0$; $X+Y=1-2\alpha$ if $X,Y>0$ and $Z=0$; $Y=1-\alpha$ if $X,Z=0$; and $X=1-\alpha$ if $Y,Z=0$, where X,Y,Z are the respective output levels of the three goods. This implies that the marginal opportunity cost of good x in terms of good y is ∞ for a specialist producer of x (no more of X can be produced by him because of his endowment constraint of individual specific labor) and is α for a specialist producer of y, but the equilibrium price of good x in terms of good y is 1 in the general equilibrium with the complete division of labor. This is a formal substantiation of Coase's argument [1946] against marginal cost pricing rule. He argues that total benefit-cost analysis is necessary and marginal analysis is inappropriate to the pricing of those goods with increasing returns in production.

3. Concluding Remarks

There are several features of equilibrium that distinguish our framework from the neoclassical microeconomic framework. The first is that aggregate demand and supply can be endogenized in this framework even though Say's law holds. Say's law holds in our model. That is, demand is the reciprocal of supply, and demand always equals supply. For the division of labor, demand equals supply in the market place. From expression (2b), we can see that demand is the reciprocal of supply. In autarky, self-demand always equals self-supply because they are two sides of self-provided quantity of goods. However, there is no market demand and supply in autarky and such demand and supply exist only if the division of labor emerges. In Young's words [1928], demand and supply are two sides of the division of labor and the level of division of labor and the extent of the market are two sides of the same coin. If we cannot understand the mechanism that determines individuals' level of specialization and the level of division of labor for society as a whole, we cannot really understand what are demand and supply.

Young's the view of demand and supply is substantially different from Alfred Marshall's [1890] marginal analysis of demand and supply, which separates the analysis of demand and supply from individuals' decisions of their levels and patterns of specialization. In Marshall's framework, each consumer cannot choose his level of specialization or its reciprocal: degree of self-sufficiency. Each consumer has to buy all goods from the market place. Marshall's neoclassical microeconomics formulates a tradeoff between quantities of different goods in raising utility level and a tradeoff between quantities of factors allocated to produce different goods in producing a certain level of output. The tradeoffs are used to explain relative prices and relative quantities of goods and factors by relative tastes, relative technology, and relative endowments for give scarcity and level of division of labor. This is referred to as the problem of resource allocation. For our framework, the economic story consists of two parts. One is the problem of resource allocation for a given pattern of economic organization which is solved by a corner equilibrium. The other is the problem of economic organization which is solved by the general equilibrium. The general equilibrium endogenizes aggregate demand and aggregate supply when it endogenizes the level of division of labor and productivity which is the reciprocal of scarcity. For our new classical framework, marginal analysis does not work and inframarginal analysis is essential. The general equilibrium, demand and supply functions, and other variables will discontinuously jump between several corner equilibria, yielding shifts in the pattern of organization and related market network.

The second feature of our framework is a possible disparity between the production possibility frontier (PPF) and the Pareto optimum. The PPF in our model is associated with the complete division of labor because of economies of specialization. However, the Pareto optimum productivity and the utility frontier may be associated with autarky if transaction costs outweigh economies of division of labor. As transaction efficiency is improved, equilibrium as well as the Pareto optimum will become closer to the PPF due to the tradeoff between economies of division of labor and transaction costs. In contrast, the Pareto optimum always coincides with the PPF in neoclassical microeconomics. This feature generates productivity implications of transaction efficiency. Such implications become extremely important in the view of the effects of institutional arrangements, urbanization, and government policies on transaction efficiency. Also, our model substantiates Coase's argument [1946] that marginal cost pricing rule no longer holds for those goods with economies of specialization in production.

Related to the second feature, our model formalizes the concept of endogenous comparative advantages. If transaction efficiency is extremely low, autarky is equilibrium. Labor productivity for three goods is the same for all individuals. No comparative advantages exist. If transaction efficiency is sufficiently large, then equilibrium is the division of labor where the labor productivity of the seller of a good is greater than the buyer of the good because the level of specialization of the former in producing the good is greater than the latter. That is, ex post comparative advantages between ex ante identical individuals endogenously emerge from the division of labor and specialization.

Finally, our model can be used to predict a downward sloping supply curve as a result of economies of specialization and small elasticity of substitution. This prediction is consistent with the common business practice that a seller charges a lower price as a buyer purchases more.

Other implications of our model for business practice are interesting, but not so straightforward. The founding of the McDonald Restaurant network can be considered as a decision to choose a pattern of high level of division of labor between the headquarters' specialized production of management and planning and the franchisees' specialized production of direct services and between specialized production of food and specialized production of other goods. Since all variables and demand and supply functions are discontinuous from the old corner equilibrium prior to the establishment of the franchise to the new corner equilibrium, the marginal analysis based on interior solutions cannot provide the founder of this franchise with the information for right decision. Our model based on corner solutions may provide a better analysis. For instance, an improvement in pricing efficiency of planning services, a sort of intangible intellectual property, provided by the headquarters may be achieved by using the franchise network which enforces rights to headquarters' intangible property via fixed and monthly franchise fees, so that this new pattern of division of labor will be a success in equilibrium. Also, the development of automobile manufacturing at the time when the founder of McDonald Restaurant was about to try the new way of doing business generated a higher transaction efficiency k such that a discontinuous jump of the price of restaurant services from a high level to a substantially lower one may generate a viably higher level of division of labor, which is associated with a larger extent of the market, a greater productivity in all more specialized sectors, a discontinuous jump of demand and supply functions, and a higher percapita real income. But a marginal analysis of demand and supply would indicate that any marginal increase in output and marginal decrease in the price of food from their existing market clearing levels will reduce profit and therefore is not viable commercially. The marginal analysis would not provide the founder of McDonald franchise with right information.

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Appendix: Proof of the Results in Table 3

We prove subtable 3.1 first. Consider the case of $\rho > 0$ and $\beta < 0$. Comparisons between $u(A_x)$, $u(P_{xy})$, and $u(C)$ indicate that $u(A_x) > u(P_{xy}) > u(C)$. A comparison between $u(A_x)$, $u(A_{xy})$ and $u(A_{xyz})$ indicates that $u(A_x) > u(A_{xy}) > u(A_{xyz})$. A comparison between $u(A_{xy})$ and $u(P_{xy\text{-}z})$ indicates that $u(A_{xy}) > u(P_{xy\text{-}z})$. Hence, A_x generates the highest percapita real income if $\rho > 0$ and $\beta < 0$.

Second, we consider the case of $\rho > 0$ and $\beta > 0$. The comparisons among utilities in A_x, A_{xy}, A_{xyz}, P_{xy}, $P_{xy\text{-}z}$, and C yield that $u(P_{xy}) > u(P_{xy\text{-}z})$ and $u(A_x) > u(A_{xy}) > u(A_{xyz})$. Hence, only A_x, P_{xy}, and C are the candidates for the equilibrium. Comparisons between $u(A_x)$, $u(P_{xy})$, and $u(C)$ yield that $u(A_x) > u(P_{xy})$ iff $k < k_0$ and that $u(P_{xy}) > u(C)$ iff $k < k_1$, where $k_1 > k_0$ iff $\beta < \beta_0$. Hence, for $\beta > \beta_0$, we have $k_0 > k_1$ which implies that $u(A_x) > u(P_{xy})$ if $k < k_1$ and that $u(P_{xy}) < u(C)$ if $k > k_1$. In other words, P_{xy} cannot be equilibrium. Therefore, for $\beta > \beta_0$, k_0 and k_1 are irrelevant. A comparison between $u(A_x)$ and $u(C)$ yields that $u(A_x) < u(C)$ iff $k < k_2$. The deduction yields the results for $\rho > 0$ and $\beta > 0$ in subtable 3.1.

Next, we consider the case of $\rho \in (-1,0)$ and $\beta > 0$ in subtable 3.2. The comparisons among utilities in A_x, A_{xy}, A_{xyz}, P_{xy}, $P_{xy\text{-}z}$, and C yield that $u(P_{xy}) < u(P_{xy\text{-}z})$ and $u(A_x) < u(A_{xy}) < u(A_{xyz})$. Hence, only A_{xyz}, $P_{xy\text{-}z}$, and C are the candidates for the equilibrium. Comparisons between $u(A_{xyz})$, $u(P_{xy\text{-}z})$, and $u(C)$ yield that $u(A_{xyz}) > u(P_{xy\text{-}z})$ iff $k < k_3$ and that $u(P_{xy\text{-}z}) > u(C)$ iff $k < k_4$, where $k_4 > k_3$ iff $\beta < \beta_1$. Hence, for $\beta > \beta_1$, we have $k_3 > k_4$ which implies that $u(A_{xyz}) > u(P_{xy\text{-}z})$ if $k < k_4$ and that $u(P_{xy\text{-}z}) < u(C)$ if $k > k_4$. In other words, $P_{xy\text{-}z}$ cannot be equilibrium. Therefore, for $\beta > \beta_1$, k_3 and k_4 are irrelevant. A comparison between $u(A_{xyz})$ and $u(C)$ yields that $u(A_{xyz}) > u(C)$ iff $k < k_5$. The deduction yields the results for $\rho \in (-1,0)$ and $\beta > 0$ in subtable 3.2.

Finally, we consider the case of $\rho \in (-1,0)$ and $\beta < 0$. The comparisons among utilities in A_x, A_{xy}, A_{xyz}, P_{xy}, $P_{xy\text{-}z}$, and C yield that $u(P_{xy}) < u(P_{xy\text{-}z})$ iff $\alpha > \alpha_1$, that $u(A_x) > u(A_{xy})$ iff $\alpha > \alpha_0$ and that $u(A_{xy}) > u(A_{xyz})$ iff $\alpha > \alpha_2$. Comparisons between α_i yields that $.5 > \alpha_0 > 1/3 > \alpha_1 > \alpha_2$ if $\rho \in (-1,\rho_0)$ and that $.5 > \alpha_0 > \alpha_1 > 1/3 > \alpha_2$ if $\rho \in (\rho_0, 0)$. The analsysis implies that for $\rho \in (-1, \rho_0)$, only A_{xyz}, $P_{xy\text{-}z}$, and C are the candidates for the equilibrium if $\alpha \in (0, \alpha_2)$; only A_{xy}, $P_{xy\text{-}z}$, and C are the candidates for the equilibrium if $\alpha \in (\alpha_2, \alpha_1)$; only A_{xy}, P_{xy}, and C are the candidates for the equilibrium if $\alpha \in (\alpha_1, \alpha_0)$; and only A_x, P_{xy}, and C are the candidates for the equilibrium if $\alpha \in (\alpha_0, 1)$. Comparisons between $u(A_x)$, $u(A_{xy})$, $u(A_{xyz})$, $u(P_{xy})$, $u(P_{xy\text{-}z})$, and u(C) yield the critical values of k and β in subtables 3.5 and 3.6. The procedure for deriving the results for $\rho \in (\rho_0, 0)$ in subtables 3.3 and 3.4 is similar to this.

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