# Financial Development, the Choice of Technology, and Comparative Advantage

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Abstract

In this general equilibrium model, banks and manufacturing firms engage in oligopolistic competition. A more advanced manufacturing technology has a higher fixed cost but a lower marginal cost of production. We show that manufacturing firms located in a country with a more efficient financial sector choose more advanced technologies and this country has a comparative advantage in the production of manufactured goods. Even though the foreign country has a less developed financial sector than the home country, the opening up of trade with the foreign country leads domestic manufacturing firms to adopt more advanced technologies. An increase in the level of efficiency in the financial sector of one country causes manufacturing firms in both countries to adopt more advanced technologies.

**Keywords:** Financial development, the choice of technology, comparative advantage, oligopolistic competition, increasing returns

**JEL Classification Numbers:** O16, F12, D43

## 1. Introduction

A country's financial sector could affect a country's comparative advantage through various channels. For example, in Saint-Paul (1992), a well developed financial system allows the diversification of risk. This leads to a finer division of labor, higher productivity, and thus comparative advantage in manufacturing for a country. Alternatively, it may function through the following channel: A better developed financial system provides a higher level of supply of capital to the manufacturing sector, so that the manufacturing firms are able to choose more advanced technologies, which leads to lower marginal costs of production and thus comparative advantage in the manufacturing sector. While the logic is quite intuitive, surprisingly, to our best knowledge, there has been no formal model demonstrating this mechanism in a general equilibrium model.

In this paper, we study how the level of efficiency in the financial sector affects manufacturing firms' optimal choice of technologies and thus a country's comparative advantage in a general equilibrium model. There are two countries. A consumer in a country derives utility from the consumption of an agricultural good and a continuum of manufactured goods. Consistent with the Heckscher-Ohlin model of international trade, such as Antras and Caballero (2009) and

Ju and Wei (2011), there are two factors of production: labor and capital. The production of the agricultural good uses labor only, while both labor and capital are needed in the production of manufacture goods. Banks attract deposits from capital owners and then provide capital to manufacturing firms. There exist fixed costs to start up a bank. Since a higher start-up cost does not bring any additional benefit to the bank, the level of efficiency in the financial sector decreases when the level of start-up costs increases. Similar to Williamson (1986) and Jungblut (2004), we assume that banks engage in Cournot competition.

For a manufacturing firm, capital is the fixed cost and wages paid for labor are the marginal cost of production. With the existence of fixed costs, market structure in the manufacturing sector is oligopoly. Other than choosing quantities in a Cournot competition, manufacturing firms also choose their technologies optimally to maximize profits. Similar to Zhou (2007, 2011), a manufacturing firm chooses from a continuum of technologies and a more advanced technology has a higher fixed cost but a lower marginal cost of production.[1]

Even banks and manufacturing firms engaging in oligopolistic competition in a general equilibrium model, we are still able to derive results analytically. First, we study a country in autarky. We show that manufacturing firms in a country with a more efficient financial sector choose more advanced technologies and this country has a comparative advantage in manufacturing. The reason is as follows. When the level of efficiency in the financial sector rises, even though the equilibrium number of banks increases, the overall effect is that the financial sector absorbs a smaller amount of capital as start-up costs. Thus the amount of capital left for the manufacturing sector increases. Because the equilibrium number of manufacturing firms does not change with the level of efficiency in the financial sector, in equilibrium each manufacturing firm employs a higher amount of capital and chooses a more advanced technology, which leads to a lower marginal cost. As a result, a country with a more efficient financial sector has a comparative advantage in manufacturing.

Our result that a country's comparative advantage in the manufacturing sector is affected by the level of efficiency of the financial sector is consistent with the experience of East Asian economic development. For countries such as South Korea, the link between strong export performance of the manufacturing sector and cheaper sources of finance has often been

[1] As discussed in Gerschenkron (1962), one advantage of late development is the existence of many technologies to be adopted.

emphasized (Amsden, 1989, Wade, 2004, Cimoli et al., 2009). After President Park Chung Hee came to power in South Korea, he nationalized the banks. Large conglomerate firms (chaebols) in strategic industries received favored loans from state-owned banks with low interest rates. As a result, they adopted technologies suitable for large-scale production. With advanced technologies, the South Korean firms were very competitive in international markets in manufacturing sectors such as shipbuilding, steel, and consumer electronic products.

Here we argue that a country's comparative advantage is affected by the level of efficiency in the financial sector. The level of efficiency in the financial sector is different from the size of the financial sector. In this model, if the size of the financial sector is correlated with the level of fixed costs in the financial sector, then a larger financial sector absorbs more resources from the economy and reduces social welfare. This result is consistent with the observation from recent financial crises that a too large financial sector might not be efficiency enhancing.

Second, we study the impact of the opening up of international trade. Even if the foreign country has a less developed financial sector than the home country, we show that the opening up of trade with the foreign country leads domestic manufacturing firms to adopt more advanced technologies. This result is consistent with the practice of the South Korea government. One condition for firms in South Korea to receive favored loans was that those firms were required by the South Korea government to export in the international market. Our result shows that this type of policy of requesting domestic firms to participate in international trade was indeed beneficial to the South Korean economy.

Third, for developing countries, one question is whether to have financial liberalization. While financial liberalization can increase capital inflow, financial liberalization can also increase the risk of financial crises. We show that an increase in the level of efficiency of the financial sector in the foreign country leads domestic manufacturing firms to adopt more advanced technologies. The reason is as follows. For the foreign country, if the level of efficiency in the financial sector increases, the equilibrium number of manufacturing firms in the foreign country increases. Through product market competition, an increase in the number of foreign manufacturing firms leads to a decrease in the number of domestic manufacturing firms. Each remaining domestic manufacturing firm employs a higher amount of capital and chooses a more advanced technology. Thus, even without financial liberalization, an improvement in the quality of the financial system in a country should be beneficial to all countries.

In the literature, how a country's comparative advantage could be affected by the financial sector has been addressed by many studies, such as Kletzer and Bardhan (1987), Beck (2002), Matsuyama (2005), Wynne (2005), Antras and Caballero (2009), and Ju and Wei (2011). In a pioneering paper, Kletzer and Bardhan (1987) have argued that differences in the financial sector among countries are independent sources of comparative advantage. They show that a country with a smaller default risk, or better enforcement of contracts, will have a comparative advantage in sectors requiring more credit. In Beck (2002), financial friction is captured by an iceberg type search cost. He has shown that a country with a higher search cost will export food. Matsuyama (2005) has shown that a country with rich entrepreneurs and better corporate governance may have comparative advantage in sectors in which external finance is relatively more important. Wynne (2005) has shown that wealth distribution can also affect the pattern of trade among countries. When the direction of trade based on wealth distribution is the opposite of the direction of trade based on factor endowment, the direction and volume of trade could be different from those predicted by the Heckscher-Ohlin model. In Antras and Caballero (2009), there is financial friction in one of the two sectors of production. They have shown that a country that is less constrained in external finance has a comparative advantage in the production of the sector with financial friction. In Ju and Wei (2011), there are agency costs of external finance. They have shown that when the agency costs are sufficiently low, a country's resource allocation and comparative advantage will be determined by factor endowment. However, if agency costs are sufficiently high, a country's resource allocation and comparative advantage will be determined by agency costs in the financial sector. In the above papers, financial intermediaries are run by entrepreneurs. In the sense that banks are intermediaries between owners of capital and manufacturing that need the capital for investments, this model is related to the literature on entrepreneurs. This paper differs from the literature on entrepreneurs and venture capital in the aspect that technology is endogenously determined in this model.

The choice of technologies in the manufacturing sector has been studied in Saint-Paul (1992) and Wen and Zhou (2012). The modeling of the financial sector in Saint-Paul (1992) is significantly different from that in this paper. In Saint-Paul (1992), a more developed financial sector is captured by a better possibility for the diversification of risk. In this model, a more developed financial sector uses a smaller amount of capital to provide the same level of service. Thus the channel through which the financial sector influences the manufacturing sector in Saint-

Paul (1992) is different from that in this paper. Wen and Zhou (2012) have compared the impact of financial integration and product market integration. There are several significant differences between this paper and Wen and Zhou (2012). First, in this model, capital is employed in both the financial sector and the manufacturing sector, whereas in Wen and Zhou (2012), capital is only employed in the manufacturing sector. Second, in this paper, a two-sector model is studied, while there is only one sector in Wen and Zhou (2012). Third, in this paper, countries have different levels of efficiencies in the financial sector. In Wen and Zhou (2012), the two countries are identical in all aspects. How a country's comparative advantage is affected by the financial sector is not addressed in Wen and Zhou (2012).

The plan of the paper is as follows. Section 2 studies the equilibrium in the home country when the two countries are in autarky. Section 3 studies the impact of the opening up of international trade. Section 4 discusses some possible extensions and generalizations of the model and concludes. The Appendix contains the proof of all propositions.

## 2. Financial development and the choice of technology for a country in autarky

There are two countries: home and foreign. In this section, there is no trade between the two countries. Without loss of generality, we focus on the study of the home country. The size of the population in the home country is $L$. Each individual supplies one unit of labor inelastically. The total amount of capital in the home country is $K$.[2] There are two types of goods: an agricultural good and a continuum of manufactured goods indexed by a number $\varpi \in [0,\ 1]$ with a total measure of one.[3] The price of the agricultural goods is $p_a$ and the price of the manufactured good is $p$.

There are three sectors: the agricultural sector, the manufacturing sector, and the financial sector. For the agricultural sector, the number of individuals employed in this sector is $L_a$. The agricultural good is produced by using labor only with constant returns to scale. Without loss of generality, each individual in the agricultural sector is assumed to be able to produce one unit of

[2] With homothetic preferences assumed in this model, the distribution of the ownership of capital does not affect the total demand for the agricultural good and manufactured goods.

[3] As argued in Neary (2002), the main purpose of having a continuum of manufactured goods instead of one manufactured good is to eliminate a manufacturing firm's market power in the labor market. With a continuum of manufactured goods, even though each manufactured good is produced by a small number of firms, there is an infinite number of manufacturing firms in the home country demanding labor. Thus, a manufacturing firm does not have market power in the labor market.

the agricultural good. Firms in the financial sector are called banks. Variables associated with a bank are usually denoted with a subscript $b$. Banks attract deposits from owners of capital and provide capital to manufacturing firms. A bank pays an interest of $r$ for each unit of capital attracted from depositors and charges manufacturing firms an interest rate of $R$. Banks are assumed to engage in Cournot competition. For manufactured good $\varpi$, there are $m(\varpi)$ identical firms producing it. Firms producing the same manufactured good are assumed to engage in Cournot competition.[4]

**2.1. Equilibrium conditions in a closed economy**

In the following, first, we study a consumer's utility maximization. Second, we establish equilibrium conditions in production, including equilibrium conditions in the agricultural sector, the manufacturing sector, and the financial sector. Finally, we establish markets clearing conditions, including markets for capital, labor, the agricultural good, and manufactured goods.

First, we study a consumer's utility maximization. If a representative consumer's consumption of the agricultural good is $c_a$ and her consumption of the manufactured good $\varpi$ is $c(\varpi)$, for $\alpha \in (0,1)$, her utility function is specified as $\alpha \ln c_a + (1-\alpha)\int_0^1 \ln c(\varpi) d\varpi$. With this homothetic utility function, a consumer's utility maximization leads to $\alpha$ percent of the income spent on the agricultural good and $1-\alpha$ percent of the income spent on manufactured goods.

Second, we establish equilibrium conditions in production. For the agricultural sector, since each worker produces one unit of the agricultural good, the value marginal product of labor is equal to the price of the agricultural good. With perfect competition in the agricultural sector, in equilibrium, the wage rate $w$ will be equal to the value marginal product of labor in the agricultural sector:

$$w = p_a. \tag{1}$$

For the manufacturing sector, to produce a manufactured good, we assume that there is a continuum of technologies indexed by a positive number $n$. A higher value of $n$ indicates a more advanced technology. To capture the substitution between fixed costs and marginal costs of

[4] Similar to Salinger (1988), when there are two stages of production, a bank takes the interest rate paid to depositors as given and a manufacturing firm takes the interest rate charged by a bank as given. That is, banks and manufacturing firms do not view they have market power in their input markets.

production, we assume that fixed costs increase with the level of technology while marginal costs decrease with the level of technology: $f'(n) > 0$ and $\beta'(n) < 0$.[5] For $\theta$ and $h$ denoting positive constants, the cost functions in the manufacturing sector are specified as

$$f(n) = n^{\theta}, \tag{2a}$$

$$\beta(n) = n^{-h}. \tag{2b}$$

The specifications in (2a) and (2b) play a role in the profit maximization of a manufacturing firm similar to the role played by the homothetic utility function in a consumer's utility maximization. With a homothetic utility function, a consumer's utility maximization requires that this consumer spends a fixed percentage of income on each type of goods. For the specifications in (2a) and (2b), a manufacturing firm's profit maximization requires that this firm spends a fixed percentage of revenue on capital and the remaining percentage of revenue on labor.

For a manufacturing firm with the level of output $x$, its total revenue is $px$, its costs of capital is $f(n)R$, and its costs of labor is $\beta(n)xw$. Thus the profit of this firm is $px - f(n)R - \beta(n)xw$. A manufacturing firm takes the wage rate and the interest rate charged by a bank as given and chooses its levels of output and technology optimally to maximize its profit. A manufacturing firm's optimal choice of output leads to $p + x\frac{\partial p}{\partial x} - \beta\, w = 0$. Remember that manufactured good $\varpi$ is produced by $m(\varpi)$ firms. Combining equation $p + x\frac{\partial p}{\partial x} - \beta\, w = 0$ with the result that the absolute value of the elasticity of demand for a manufactured good is one leads to the following familiar relationship showing that a manufacturing firm's price is a markup over its marginal cost of production:

$$p(\varpi)\left(1 - \frac{1}{m(\varpi)}\right) = \beta(\varpi)\, w. \tag{3}$$

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[5] The tradeoff between marginal cost and fixed cost can be motivated by the following two studies. First, Prendergast (1990) has examined the relationship between the scale of production and the optimal choices of technologies in three industries: nuts and bolts, iron founding, and machine tools. In all the three industries he examined, the average cost decreases when the level of output increases. This process is associated with the switch of technologies and the spread of fixed costs over a high level of output. Second, the adoption of containers in the transportation sector provides another example demonstrating the substitution between marginal costs and fixed costs. Before the adoption of containers, the loading and unloading of cargos were conducted by longshoremen. With high wage rates, marginal costs were high. The adoption of containers required high levels of fixed costs because specially designed cranes, containerships, and container ports had to be built. However, marginal costs of loading and unloading decreased sharply after the adoption of containers (Levinson, 2006).

The first order condition for a manufacturing firm's optimal choice of technology requires that

$$f'(n)R + \beta'(n)x\,w = 0\,. \tag{4}$$

In equation (4), when a firm chooses its technology, it takes the output of competitors as given. This assumption that manufacturing firms do not internalize the strategic effect on rivals is consistent with the "open loop" approach in the R&D literature with oligopoly such as Vives (2008). Vives studies the impact of the degree of competition on R&D spending under both the open loop and the closed loop (in which the strategic interaction effect is taken into account) approaches. He shows that the incorporation of the strategic interaction has an ambiguous impact on comparative statics under free entry. In this model, we are mainly interested in the impact of the financial sector on a country's comparative advantage. Since a manufacturing firm's strategic choice of technology is not our focus, for simplicity, we adopt the open loop approach.

Free entry and exit in the production of manufactured goods leads to a profit of zero for a manufacturing firm:[6]

$$p\,x - f\,R - \beta\,x\,w = 0\,. \tag{5}$$

For each bank, entering the market requires $f_b$ units of capital. This parameter is used to measure a country's level of efficiency in the financial sector and it plays an important role in this model. De Soto (2002) has argued that because an entrepreneur needs to go through many steps of approval, the start-up costs of establishing a new business in a developing country such as Peru could be very high. Other things equal, if it is more costly to establish a bank, then the less efficient is the financial sector. Thus in this model, the higher the value of $f_b$, the less efficient the financial sector is.

The existence of fixed costs in the financial sector captures increasing returns in the bank sector. First, one source of increasing returns is technology (Pilloff, 2005, p. 145). Banks rely on computer systems heavily and fixed costs of computer systems are significant. Second, advertising in the bank sector also leads to increasing returns. Large banks operate over wide geographic regions and advertise through various media, such as radio and television. Third, banks engage in

[6] See Chao and Yu (1997) and Chen and Shieh (2011) for some recent examples of Cournot competition with free entry.

monitoring of firms and monitoring costs are fixed costs. The existence of significant monitoring costs is another source of increasing returns in the financial sector (Williamson, 1986).

Since a bank pays $f_b r$ for its start-up costs and earns $(R-r)x_b$ from lending $x_b$ units of capital to manufacturing firms, its profit is $R x_b - f_b r - r x_b$. A bank takes the interest rate paid to depositors as given and chooses its level of output to maximize profit. The first order condition for a bank's optimal choice of output requires that $R + x_b \partial R / \partial x_b - r = 0$.

For manufactured good $\varpi$, the supply of capital from banks to manufacturing firms is $m_b(\varpi)x_b(\varpi)$. The demand for capital from manufacturing firms is $m(\varpi)f(\varpi)$. In equilibrium, the quantity demanded and the quantity supplied of capital for manufacturing good $\varpi$ should be equal:

$$m_b x_b = m f \,. \tag{6}$$

Plugging equations (2a) and (2b) into equation (4) leads to $f = \left(\frac{hxw}{\theta}\right)^{\frac{\theta}{\theta+h}} R^{-\frac{\theta}{\theta+h}}$. Partial differentiation of $f$ with respect to $R$ leads to $\frac{\partial f}{\partial R}\frac{R}{f} = -\frac{\theta}{\theta+h}$. Let $x_{-b}$ denote the sum of output of other banks. Since banks engage in Cournot competition, when a bank chooses its level of output $x_b$, it treats the output of other banks $x_{-b}$ as given. With this in mind, partial differentiation of $x_b + x_{-b} = mf$ with respect to $R$ and using $\frac{\partial f}{\partial R}\frac{R}{f} = -\frac{\theta}{\theta+h}$ yields

$$\begin{aligned}\frac{\partial x_b}{\partial R}\frac{R}{x_b} &= \frac{R}{x_b} m \frac{\partial f}{\partial R} \\ &= \frac{R}{x_b} m \left(\frac{\partial f}{\partial R}\frac{R}{f}\right)\frac{f}{R} = -\frac{\theta m_b}{\theta+h}\,.\end{aligned}$$

Plugging $\frac{\partial x_b}{\partial R}\frac{R}{x_b} = -\frac{\theta m_b}{\theta+h}$ into a bank's optimal choice of output $R + x_b \partial R / \partial x_b - r = 0$, the relationship between a bank's interest rate it pays to depositors and the interest rate it charges is given by

$$R\left(1 - \frac{\theta+h}{\theta m_b}\right) = r \,. \tag{7}$$

Free entry and exit in the banking sector leads to a profit of zero for a bank:

$$R x_b - f_b r - r x_b = 0. \tag{8}$$

Finally, we establish market clearing conditions. For the market for capital, the total demand for capital is the sum of the demand from the financial sector $\int_0^1 m_b x_b d\varpi$ and the demand from the manufacturing sector $\int_0^1 m f d\varpi$. Thus total demand for capital in this country is $\int_0^1 m_b f_b d\varpi + \int_0^1 m f d\varpi$. The total supply of capital in this country is $K$. The clearance of the market for capital requires that

$$\int_0^1 m_b f_b d\varpi + \int_0^1 m f d\varpi = K. \tag{9}$$

For the market for labor, demand for labor is the sum of the demand from the agricultural sector $L_a$ and the demand from the manufacturing sector $\int_0^1 m \beta x d\varpi$. Thus total demand for labor in this country is $L_a + \int_0^1 m \beta x d\varpi$. Total supply of labor in this country is $L$. The clearance of the market for labor requires that

$$L_a + \int_0^1 m \beta x d\varpi = L. \tag{10}$$

For the market for the agricultural good, the supply of the agricultural good is $p_a L_a$. Because banks and manufacturing firms earn profits of zero, total income in this closed economy is the sum of factor income paid to labor and capital: $wL + rK$. Since $\alpha$ percent of the total income is spent on the agricultural good, total demand for the agricultural good is $\alpha(wL + rK)$. The clearance of the market of the agricultural goods requires that

$$p_a L_a = \alpha(wL + rK). \tag{11}$$

For the market for the manufactured goods, total supply of manufactured goods is $\int_0^1 m p x d\varpi$. Since $1-\alpha$ percent of the total income is spent on manufactured goods, total demand for manufactured goods is $(1-\alpha)(wL + rK)$. The clearance of the market for the manufactured goods requires that

$$\int_0^1 m p x d\varpi = (1-\alpha)(wL + rK). \tag{12}$$

We focus on a symmetric equilibrium in which $m$ , $m_b$, $p$ , $n$ , $R$ , $x$ , and $x_b$ are the same for all manufactured goods. Thus manufactured goods are not indexed by $\varpi$ . Because the total measure of manufacturing goods is one and all manufactured goods are symmetric, we drop the integration operation in the manufacturing sector. In a symmetric equilibrium, equations (1) and (3)-(12) form a system of 11 equations defining 11 endogenous variables $L_a$, $p_a$, $w$ , $r$ , $m$ , $m_b$, $p$ , $n$ , $R$ , $x$ , and $x_b$ as functions of exogenous parameters. An equilibrium in a closed economy is a tuple ( $L_a$, $p_a$, $w$ , $r$ , $m$ , $m_b$, $p$ , $n$ , $R$ , $x$ , $x_b$ ) satisfying equations (1) and (3)-(12). For the rest of the paper, manufactured goods are used as the numeraire: $p \equiv 1$ .

A country's comparative advantage in the production of manufactured goods is defined as the ratio between the price of manufactured goods and the price of the agricultural good. Since the price of manufactured goods is normalized to one, the price of the agricultural good measures a country's comparative advantage in the production of manufactured goods. In this model, from equation (1), the price of the agricultural good is equal to the wage rate, thus the wage rate in a country measures this country's comparative advantage in the production of manufactured goods. The higher the wage rate, the more competitive is a country in the production of manufactured goods.

### 2.2. Comparative statics

To conduct comparative statics, we need to condense the system of 11 equations characterizing the autarky equilibrium into a smaller and thus manageable number of equations.

First, plugging the value of $x$ from equation (5) into equation (4) leads to

$$f'(1-\beta w)+\beta' f w=0 . \qquad (13)$$

Second, plugging the value of $m f$ from equation (6) into equation (9) and the value of $x_b$ from equation (8) into the resulting equation, the number of banks can be expressed as $m_b = K(R-r)/(f_b R)$ . Plugging this value of $m_b$ into equation (7) and solving the resulting quadratic equation, the relationship between the interest rate paid to depositors and the interest rate charged to manufacturing firms is given by $r = R\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right)$ . Plugging this value of $r$ into the equation $m_b = K(R-r)/(f_b R)$, the number of banks can be expressed as a function of exogenous parameters:

$$m_b = \sqrt{\frac{(\theta+h)K}{\theta f_b}}\,. \tag{14}$$

Partial differentiation of equation (14) leads to $dm_b / df_b < 0$. That is, a less efficient financial sector has a lower degree of competition. Ju and Wei (2011, p. 180) have argued that a higher value of rent to the financial institutions can be interpreted as representing a less competitive financial intermediation market. Here we have provided a justification of their statement in a general equilibrium model by demonstrating that a less efficient financial sector leads to a less competitive financial intermediation market.

Third, dividing equation (11) by equation (12) leads to

$$\frac{w(L-m\beta x)}{mx} = \frac{\alpha}{1-\alpha}\,. \tag{15}$$

The system of 11 equations is now condensed into the following system of 3 equations defining 3 endogenous variables $w$, $n$, and $r$ as functions of exogenous parameters:[7]

$$V_1 \equiv K(1-\beta w)\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right) - f = 0\,, \tag{16a}$$

$$V_2 \equiv f'(1-\beta w) + \beta' f w = 0\,, \tag{16b}$$

$$V_3 \equiv f\,r\big(\alpha + (1-\alpha)\beta w\big) - (1-\alpha)wL\big(1-\beta w\big)^2\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right) = 0\,. \tag{16c}$$

Partial differentiation of equations (16a)-(16c) with respect to $w$, $n$, $r$, $L$, $K$, and $f_b$ leads to[8]

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[7] Equations (16a)-(16c) are derived as follows. First, plugging the value of $m$ from equation (3), the value of $x_b$ from equation (8), and the value of $m_b$ from $m_b = K(R-r)/f_b R$ into equation (6) and using $r = R\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right)$ to simplify the resulting equation lead to equation (16a). Second, equation (16b) is the same as equation (13). Third, plugging the value of $m$ from equation (3) and the value of $x$ from equation (5) into equation (15) leads to equation (16c).

[8] By using equation (16b), it can be shown that $\partial V_1 / \partial n = 0$.

$$
\begin{pmatrix} \frac{\partial V_1}{\partial w} & 0 & 0 \\ \frac{\partial V_2}{\partial w} & \frac{\partial V_2}{\partial n} & 0 \\ \frac{\partial V_3}{\partial w} & \frac{\partial V_3}{\partial n} & \frac{\partial V_3}{\partial r} \end{pmatrix} \begin{pmatrix} dw \\ dn \\ dr \end{pmatrix} = -\begin{pmatrix} 0 \\ 0 \\ \frac{\partial V_3}{\partial L} \end{pmatrix} dL - \begin{pmatrix} \frac{\partial V_1}{\partial K} \\ 0 \\ \frac{\partial V_3}{\partial K} \end{pmatrix} dK - \begin{pmatrix} \frac{\partial V_1}{\partial f_b} \\ 0 \\ \frac{\partial V_3}{\partial f_b} \end{pmatrix} df_b . \tag{17}
$$

Let $\Delta$ denote the determinant of the coefficient matrix of the system (17): $\Delta = \frac{\partial V_1}{\partial w}\frac{\partial V_2}{\partial n}\frac{\partial V_3}{\partial r}$. Partial differentiation of equations (16a)-(16c) leads to $\frac{\partial V_1}{\partial w} < 0$, $\frac{\partial V_2}{\partial n} > 0$, and $\frac{\partial V_3}{\partial r} > 0$. Thus $\Delta < 0$. With $\Delta$ nonsingular, there exists a unique equilibrium for the system (17).

An application of the Cramer's rule on the system (17) leads to $dn/dL = 0$ and $dw/dL = 0$ . That is, the level of technology in the manufacturing sector and the wage rate are not affected by the size of the population. The reason is as follows. In this general equilibrium model, a manufacturing firm's level of technology is determined by equation (4) characterizing a firm's optimal choice of technology and equation (9) characterizing the clearance of the market for capital. More specifically, a manufacturing firm's level of technology is pinned down by equation (9). Once a firm's level of technology is determined, equation (13), which is a modified version of equation (4), determines the level of wage rate correspondingly. Since the size of the population shows up in neither equation, a firm's level of technology is not affected by the size of the population. Since the size of the population does not affect the level of technology, the wage rate does not change with the size of the population.

Also, from the system (17), it can be shown that $\frac{dr}{dL} = -\frac{\partial V_1}{\partial w}\frac{\partial V_2}{\partial n}\frac{\partial V_3}{\partial L} / \Delta > 0$. That is, an increase in the size of the population increases the interest rate paid to depositors. The reason is as follows. For a manufacturing firm, with the specification of fixed cost and marginal cost in equations (2a) and (2b), a manufacturing firm spends fixed percentages of revenue on capital and labor. When the size of the population $L$ increases, other things equal, $wL$ increases. Correspondingly, the amount of income going to capital $RK$ also increases. With the amount of capital fixed, $R$ increases. Since the amount of capital and the degree of competition in the financial sector do not change, through equation (7), the interest rate paid to the depositors increases.

The following proposition studies the impact of a change in the endowment of capital on a country's comparative advantage.

**Proposition 1.** An increase in the endowment of capital leads manufacturing firms to choose more advanced technologies. A country with a higher endowment of capital has a comparative advantage in the production of manufactured goods.[9]

To understand Proposition 1, the increased amount of capital is allocated either to the financial sector or to the manufacturing sector. From equation (14), the number of banks increases if the amount of capital increases, but at a rate smaller than that of the increase of capital. That is, the financial sector does not absorb all the increased amount of capital. As a result, the amount of capital available for the manufacturing sector increases. With the specification of fixed cost and marginal cost for a manufacturing firm in equations (2a) and (2b), a manufacturing firm spends a fixed percentage of revenue on labor cost. Since in equilibrium $\beta w x$ is a fixed percentage of $p x$, $\beta w$ will be a fixed percentage of the price of the manufactured goods, $p$. From equation (3), since the price of manufactured goods is normalized to one and $\beta w$ is a fixed percentage of the price of the manufactured good, the number of manufacturing firms does not change. Since the amount of capital allocated to the manufacturing sector increases, in equilibrium each manufacturing firm receives a higher amount of capital and chooses a more advanced technology. Since the wage rate increases with the level of technology in the manufacturing sector, an increase in the amount of capital also increases the wage rate. Since the wage rate measures a country's comparative advantage, a country with a higher endowment of capital has a comparative advantage in the manufacturing sector.

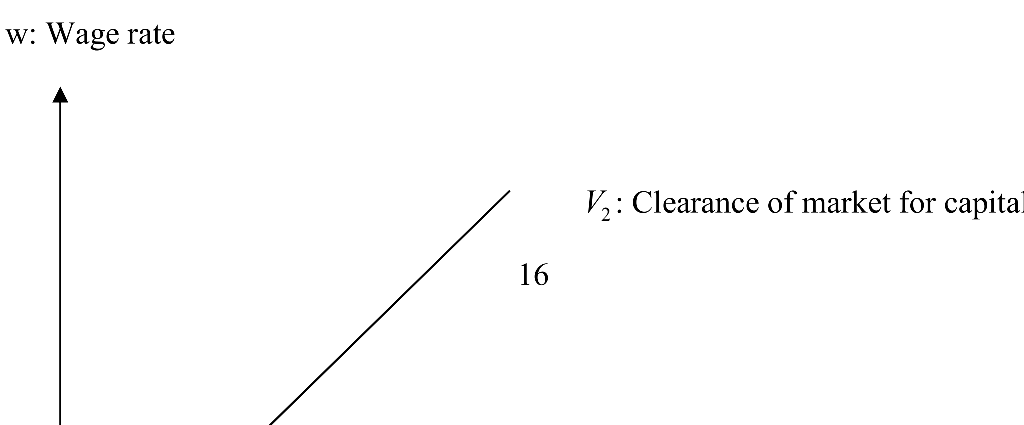
[9] The impact of an increase in the endowment of capital on the interest rate paid to depositors is ambiguous. The reason is as follows. There are two effects on the interest rate paid to depositors when the endowment of capital increases. First, since a manufacturing firm spends a fixed percentage of income on capital, an increase in the amount of capital decreases the return to capital. Second, since the price of manufactured goods is normalized to one, the interest rate is the ratio between the interest rate and the price of manufactured goods. An increase in the endowment of capital leads manufacturing firms to choose more advanced technologies and thus the price of manufactured goods decreases. This increases the ratio between the interest rate paid to depositors and the price of manufactured goods. Because the two effects work in opposite directions, the impact of an increase in the endowment of capital on the interest rate paid to depositors is ambiguous.

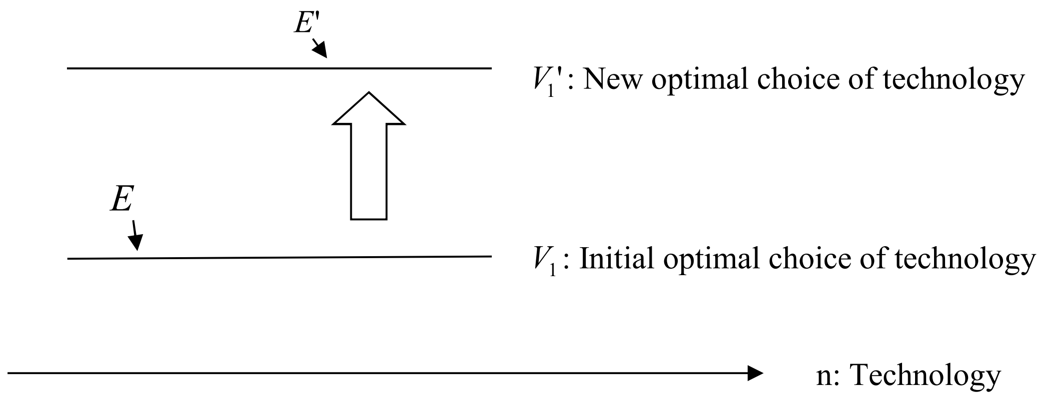
There is an alternative way to understand Proposition 1. For the system of equations (16a)-(16c), equations (16a) and (16b) determine $w$ and $n$. Then for the equilibrium pair of $w$ and $n$, the equilibrium $r$ is determined by equation (16c). That is, we may use a figure showing equations (16a) and (16b) to demonstrate the determination of $w$ and $n$, without bothering equation (16c). First, we may rewrite equation (16a) as $\left(\sqrt{\frac{(\theta+h)K}{\theta f_b}}\right)\left(f_b\left[\sqrt{\frac{\theta K}{(\theta+h)f_b}}-1\right]\right)-\frac{1}{1-\beta w}f=0$. Because in equilibrium $\sqrt{\frac{(\theta+h)K}{\theta f_b}}=m_b$, $f_b\left[\sqrt{\frac{\theta K}{(\theta+h)f_b}}-1\right]=x_b$, and $\frac{1}{1-\beta w}=m$, equations (16a) is equivalent to $m_b x_b = mf$, which is equation (6), the condition for the equalization of supply and demand for capital in the manufacturing sector. In this equation, $\left(\sqrt{\frac{(\theta+h)K}{\theta f_b}}\right)\left(f_b\left[\sqrt{\frac{\theta K}{(\theta+h)f_b}}-1\right]\right)$ is the supply of capital to the manufacturing sector and $\frac{1}{1-\beta w}f$ is demand for capital from the manufacturing sector. Thus we may call the curve defined by equation (16a) as the curve for the clearance of the market for capital in the manufacturing sector. In equation (16a), since $\frac{\partial V_1}{\partial w}<0$ and $\frac{\partial V_1}{\partial n}=0$, the curve for the clearance of the market for capital is a horizontal line between $w$ and $n$. The interpretation of $\frac{\partial V_1}{\partial w}<0$ is that an increase in the wage rate leads to supply smaller than demand in the manufacturing sector because an increase in the wage rate increases the demand for capital while supply does not change. The intuition for $\frac{\partial V_1}{\partial n}=0$ is that when the level of technology changes, in the margin the impact on the demand for capital is zero because the level of technology is chosen optimally in equilibrium. Second, equation (16b) comes from equation (4), the condition for a manufacturing firm's optimal choice of technology. Thus, we may call the curve defined by equation (16b) as the curve for the optimal choice of technology. In equation (16b), since $\frac{\partial V_2}{\partial w}<0$ and $\frac{\partial V_1}{\partial n}>0$, the curve for the optimal choice of technology defines a positive relationship between $w$ and $n$.

The intuition for this positive relationship between $w$ and $n$ is that an increase in the wage rate increases a manufacturing firm's incentive to adopt a more advanced technology.

With the above discussion in mind, we can use the following Figure 1 to illustrate Proposition 1. In Figure 1, the horizontal axis is the level of technology and the vertical axis is the wage rate. The intersection of the two curves determines the equilibrium *E*. Since $\frac{\partial V_1}{\partial w} < 0$ and $\frac{\partial V_1}{\partial K} > 0$, an increase in the amount of capital increases the wage rate. That is, an increase in the amount of capital moves the line $V_1$ upward to $V_1'$. The intuition behind this is that an increase in the amount of capital increases supply of capital to the manufacturing sector. Since the amount of capital does not appear in equation (16b), an increase in the amount of capital does not affect the position of $V_2$, and the new equilibrium $E'$ is determined by the intersection of $V_1'$ and $V_2$. In the new equilibrium, both the level of technology and the wage rate are higher.

Figure 1: Impact of an increase in the amount of capital






It is frequently argued that the high performance of East Asian economies relied on a strong exporting sector (Wade, 2004). The performance of the manufacturing sector may be affected by other sectors, such as the financial sector. As argued in Amsden (2001), late industrialization is associated with large-scale production. Cheaper financial sources are important for funding large-scale production technologies. The following proposition studies how a country's comparative advantage is affected by the level of efficiency in the financial sector.

**Proposition 2.** A more efficient financial sector leads manufacturing firms to choose more advanced technologies. A country with a more efficient financial sector has a comparative advantage in the production of manufactured goods.[10]

To understand Proposition 2, when the level of start-up costs decreases, from equation (14), the equilibrium number of banks increases, but at a rate smaller than the decrease in the level of start-up costs in the financial sector. The overall effect of a decrease in the level of start-up costs is that the financial sector absorbs a smaller amount of capital. Since capital is employed either in the financial sector or the manufacturing sector, a more efficient financial sector increases the amount of capital supplied to the manufacturing sector. With the specification of fixed and

[10] The impact of a more efficient financial sector on the interest rate paid to depositors is ambiguous. With a more efficient financial sector, there are two channels affecting the interest rate paid to depositors. First, from equation (14), the equilibrium number of banks increases. A higher degree of competition in the financial sector tends to increase the interest rate paid to depositors. Second, a more efficient financial sector leads to an impact similar to that of an increase in the supply of capital. From footnote 9, the impact of an increase in the supply of capital on the level of interest rate paid to depositors is ambiguous. Thus the total effect of a more efficient financial sector on the level of interest rate paid to depositors is ambiguous.

marginal costs in the manufacturing sector, a manufacturing firm spends a fixed percentage of revenue on labor. Similar to the argument in the paragraph after Proposition 1, the number of manufacturing firms does not change with the amount of capital. This leads to an increase in the amount of capital used by each manufacturing firm. As a result, firms in the manufacturing sector choose more advanced technologies and the price of manufactured goods is lower.

There are empirical studies addressing the impact of financial development on countries' comparative advantages. Svaleryd and Vlachos (2005) have studied the pattern of comparative advantages for OECD countries. They find that financial development explains the patterns of comparative advantages better than human capital does. Bao and Yang (2009) have studied factors determining comparative advantages of Chinese firms. They find that both size and efficiency of the financial sector affect comparative advantages in significant ways. Bao and Yang's finding is consistent with our results that both the amount of capital and the level of efficiency in the financial sector affect a country's comparative advantages.

## 3. Impact of the opening up of international trade

In this section, we study the impact of the opening up of international trade between the two countries. Variables associated with the foreign country carry an asterisk. Consumers in the foreign country are assumed to have the same preferences as consumers in the home country. An individual in the foreign country employed in the agricultural sector is able to produce one unit of the agricultural good. Foreign manufacturing firms have access to the same set of technologies as domestic manufacturing firms. Without loss of generality, we assume that the home country is at least as efficient as the foreign country in the financial sector. That is, $f_b^* \geq f_b$. There is neither labor mobility nor capital mobility between the two countries. Like a Heckscher-Ohlin type model, we focus on the scenario that both countries produce both types of goods after the opening up of international trade. We assume that there is no transportation costs for trade of goods between the two countries. With the opening up of international trade, prices of the agricultural good and manufactured goods will be the same in the two countries.

### 3.1. Equilibrium conditions with international trade

Similar to the equilibrium conditions in the home country, for the foreign country, the following equations are valid when the two countries engage in international trade:

$$w^* = p_a\,, \tag{1*}$$

$$f^{*\prime} R^* + \beta^{*\prime} x^* w^* = 0\,, \tag{4*}$$

$$p\,x^* - f^* R^* - \beta^* x^* w^* = 0\,, \tag{5*}$$

$$m_b^* x_b^* = m^* f^*, \tag{6*}$$

$$R^*\left(1 - \frac{\theta + h}{\theta m_b^*}\right) = r^*, \tag{7*}$$

$$R^* x_b^* - f_b^* r^* - r^* x_b^* = 0\,, \tag{8*}$$

$$\int_0^1 m_b^* f_b^* + \int_0^1 m^* f^* d\varpi = K^*, \tag{9*}$$

$$L_a^* + \int_0^1 m^* \beta^* x^* d\varpi = L^*. \tag{10*}$$

We assume that markets for manufactured goods in the two countries are integrated. That is, a manufacturing firm will not be able to charge different prices in the two countries. With the opening up of international trade, for a manufactured good, the world supply is the sum of supply from the two countries. As a result, similar to the derivation of equation (3), a domestic manufacturing firm's optimal choice of output leads to

$$p\left(1 - \frac{x}{mx + m^* x^*}\right) = \beta w. \tag{18}$$

With the opening up of international trade, a foreign manufacturing firm's optimal choice of output leads to

$$p\left(1 - \frac{x^*}{mx + m^* x^*}\right) = \beta^* w^*. \tag{18*}$$

For the market for the agricultural good, total supply of the agricultural good in the world is $p_a(L_a + L_a^*)$. Total world income is $wL + rK + w^* L^* + r^* K^*$ and $\alpha$ percent of the total income is spent on the agricultural good. Thus total world demand for the agricultural good is $\alpha(wL + rK + w^* L^* + r^* K^*)$. The clearance of the market for the agricultural good requires that

$$p_a(L_a + L_a^*) = \alpha(wL + rK + w^* L^* + r^* K^*). \tag{19}$$

For the market for the manufactured goods, total world supply of manufactured goods is $\int_0^1 (m\,p\,x + m^*\,px^*) d\varpi$ and total world demand for the manufactured goods is

$(1-\alpha)(wL+rK+w^*L^*+r^*K^*)$. The clearance of the market for manufactured goods requires that

$$\int_0^1 (m\,p\,x+m^*\,px^*)d\varpi=(1-\alpha)(wL+rK+w^*L^*+r^*K^*)\,. \tag{20}$$

Equations (1) and (4)-(10) are still valid with the opening up of international trade. Those equations and equations (1*), (4*)-(10*), (18), (18*), (19), and (20) form a system of 20 equations defining 20 endogenous variables $L_a$, $L_a^*$, $p_a$, $w$, $w^*$, $r$, $r^*$, $m$, $m^*$, $m_b$, $m_b^*$, $p$, $n$, $n^*$, $R$, $R^*$, $x$, $x^*$, $x_b$, and $x_b^*$ as functions of exogenous parameters. An equilibrium with international trade is a tuple ($L_a$, $L_a^*$, $p_a$, $w$, $w^*$, $r$, $r^*$, $m$, $m^*$, $m_b$, $m_b^*$, $p$, $n$, $n^*$, $R$, $R^*$, $x$, $x^*$, $x_b$, $x_b^*$ ) satisfying this set of 20 equations.

**3.2. Properties of the equilibrium with international trade**

From equations (1) and (1*), the wage rates in the two countries will be equal after the opening up of international trade. The reason is that the opening up of international trade leads to the equalization of the prices of the agricultural good in the two countries if there is no transportation cost for the agricultural good. Since in each country the wage rate is equal to the price of the agricultural good, the opening up of international trade leads to the equalization of the wage rates in the two countries.

For the foreign country, plugging the value of $x^*$ from equation (5*) into equations (4*) leads to

$$f^{*\prime}(1-\beta^*w)+\beta^{*\prime}f^*w=0\,. \tag{13*}$$

Since the wage rates in the two countries are the same and there is a monotonic relationship between the wage rate and the level of technology in a country, from equations (13) and (13*), the levels of technologies in the two countries will also be the same: $n=n^*$. When the two countries have the same level of technology, from equations (18) and (18*), manufacturing firms in the two countries will produce the same level of output: $x=x^*$. Thus the opening up of international trade leads to the adoption of the same level of technology and manufacturing firms produce the same level of output in the two countries.

The following proposition compares the interest rates paid to depositors in the two countries after the opening up of international trade.

**Proposition 3.** Banks in the two countries charge the same interest rate to manufacturing firms. The country with a less efficient financial sector pays a lower interest rate to depositors.

With manufacturing firms in the two countries producing the same level of output, equations (18) and (18*) reduce to

$$p\left(1-\frac{1}{m+m^*}\right)=\beta w. \tag{21}$$

Dividing equation (19) by equation (20) and plugging the value of $L_a$ from equation (10) and the value of $L_a^*$ from equation (10*) into the resulting equation lead to

$$\frac{w(L-m\beta x+L^*-m^*\beta x)}{(m+m^*)x}=\frac{\alpha}{1-\alpha}. \tag{22}$$

Now the system of 20 equations characterizing the equilibrium with international trade is condensed into the following set of 3 equations defining 3 endogenous variables $w$, $n$, and $r$ as functions of exogenous parameters:[11]

$$(1-\beta w)\left(K\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right)+K^*\left(1-\sqrt{\frac{(\theta+h)f_b^*}{\theta K^*}}\right)\right)-f=0, \tag{23a}$$

$$f'(1-\beta w)+\beta' f w=0, \tag{23b}$$

$$fr(\alpha+(1-\alpha)\beta w)-(1-\alpha)w(L+L^*)(1-\beta w)^2\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right)=0. \tag{23c}$$

To facilitate comparative static studies, equations (23a)-(23c) are rewritten as

[11] Equations (23a)-(23c) are derived as follows. First, plugging the value of $m$ derived from equations $m_b=K(R-r)/f_bR$ and $R=r/\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right)$ and the value of $m^*$ derived from equations $m_b^*=K^*(R^*-r^*)/(f_b^*R^*)$ and $R^*=r^*/\left(1-\sqrt{\frac{(\theta+h)f_b^*}{\theta K^*}}\right)$ into equation (21) leads to equation (23a). Second, equation (23b) is the same as equation (13). Third, plugging the value of $m+m^*$ from equation (21) and the value of $x$ from equation (5) into equation (22) and using $R=r/\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right)$ to replace $R$ lead to equation (23c).

$$\Omega_1 \equiv (1-\beta w)\left( K\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right) + sK^*\left(1-\sqrt{\frac{(\theta+h)f_b^*}{\theta K^*}}\right)\right) - f = 0, \tag{24a}$$

$$\Omega_2 \equiv f'(1-\beta w) + \beta' f w = 0, \tag{24b}$$

$$\Omega_3 \equiv f\, r\big(\alpha + (1-\alpha)\beta w\big) - (1-\alpha)w(L+sL^*)(1-\beta w)^2\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta K}}\right) = 0. \tag{24c}$$

For the system of equations (24a)-(24c), the parameter $s$ measures the degree of integration between the home country and the foreign country. When it takes the value of zero, equations (24a)-(24c) reduce to equations (16a)-(16c) and the two countries are in autarky. When it takes the value of one, equations (24a)-(24c) are the same as (23a)-(23c) and the two countries have free trade of goods. The opening up of international trade is thus captured by an increase in the value of $s$.

Partial differentiation of equations (24a)-(24c) with respect to $w$, $n$, $r$, $s$, and $f_b^*$ leads to[12]

$$\begin{pmatrix} \frac{\partial\Omega_1}{\partial w} & 0 & 0 \\ \frac{\partial\Omega_2}{\partial w} & \frac{\partial\Omega_2}{\partial n} & 0 \\ \frac{\partial\Omega_3}{\partial w} & \frac{\partial\Omega_3}{\partial n} & \frac{\partial\Omega_3}{\partial r} \end{pmatrix}\begin{pmatrix} dw \\ dn \\ dr \end{pmatrix} = -\begin{pmatrix} \frac{\partial\Omega_1}{\partial s} \\ 0 \\ \frac{\partial\Omega_3}{\partial s} \end{pmatrix} ds - \begin{pmatrix} \frac{\partial\Omega_1}{\partial f_b^*} \\ 0 \\ 0 \end{pmatrix} df_b^*. \tag{25}$$

Let $\Delta_\Omega$ denote the determinant of the coefficient matrix of the system (25): $\Delta_\Omega = \frac{\partial\Omega_1}{\partial w}\frac{\partial\Omega_2}{\partial n}\frac{\partial\Omega_3}{\partial r}$. Partial differentiations of equations (24a)-(24c) leads to $\frac{\partial\Omega_1}{\partial w} < 0$, $\frac{\partial\Omega_2}{\partial n} > 0$, and $\frac{\partial\Omega_3}{\partial r} > 0$. Thus $\Delta_\Omega < 0$. With $\Delta_\Omega$ nonsingular, there exists a unique equilibrium for the system (25).

The following proposition studies the impact of the opening up of international trade on the wage rate and the choice of technology in the manufacturing sector.

[12] By using equation (24b), it can be shown that $\partial\Omega_1 / \partial n = 0$.

**Proposition 4.** The opening up of international trade leads to the adoption of more advanced technologies in the manufacturing sector and the wage rate increases.[13]

Proposition 4 shows that manufacturing firms adopt more advanced technologies and the wage rate increases even though a country opens trade with the other country with a less developed financial sector. To understand Proposition 4, since equation (14) is still valid with the opening up of international trade, the number of banks in a country does not change with the opening up of international trade. A comparison of equations (3) and (21) demonstrates that the sum of the numbers of manufacturing firms in the two countries after the opening up of international trade is the same as the number of manufacturing firms in each country before the opening up of international trade. That is, in each country, the opening up of international trade leads to the exit of some manufacturing firms. Since the number of banks in a country does not change while the number of manufacturing firms is smaller, each of the remaining manufacturing firm in a country employs more capital and chooses a more advanced technology. Since the wage rate increases with the level of technology, the wage rate is higher after the opening up of international trade. With a more advanced technology, the level of fixed costs of production is higher. To break even, manufacturing firms in each country produces a higher level of output after the opening up of international trade.

Industrial policies in East Asia have received a lot of attention (Cimoli et al., 2009). While large manufacturing firms in strategic industries received favored loans from the governments, governments such as the South Korean government had encouraged firms to compete in the international market. Proposition 4 shows that international product market competition will induce domestic firms to choose more advanced technologies and is indeed beneficial to the domestic economy.

The following proposition shows that an increase in the level of efficiency of the financial sector in a country leads to the adoption of more advanced technologies in both countries.

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[13] For wage earners, the wage rate relative to the price of manufactured goods increases and the wage rate relative to the price of the agricultural good does not change. Thus wage earners always benefit from the opening up of international trade. With the opening up of international trade, whether the interest rate paid to depositors in the home country will increase or decrease is not clear. Thus it is not clear whether capital owners always benefit from the opening up of international trade. If capital owners also benefit from the opening up of international trade, then everyone benefits from the opening up of international trade.

**Proposition 5.** An increase in the level of efficiency of the financial sector in a country leads manufacturing firms in both countries to adopt more advanced technologies and the wage rate increases.

Proposition 5 shows that an increase in the level of efficiency of the financial sector in the foreign country has repercussions on domestic manufacturing firms' choices of technologies. To understand Proposition 5, when the level of efficiency in the foreign country is higher, some capital will be released to the manufacturing sector in the foreign country. As a result, the number of manufacturing firms increases and the level of technology in the foreign country also increases. Since the total number of manufacturing firms in the two countries is fixed and the number of manufacturing firms in the foreign country increases, there will be a decrease in the number of domestic manufacturing firms. When some manufacturing firms in the home country exit, the amount of capital they used is released. This released amount of capital allows remaining manufacturing firms in the home country to choose more advanced technologies.

For developing countries, one question is whether to introduce financial liberalization or not. While financial liberalization can lead to short-run capital inflow, it can also increase the risk of financial crises (Chang, 2006). Proposition 5 shows that even without financial liberalization, an improvement in the quality of the financial system in a country should be beneficial to all countries. Thus compared with financial liberalization, improving the quality of financial system should have a priority for a developing country.

## 4. Conclusion

In this paper, we have studied how the level of efficiency in the financial sector affects manufacturing firms' optimal choices of technologies and thus a country's comparative advantage in the production of manufactured goods in a general equilibrium model. Banks incur start-up costs and a higher level of start-up costs means a less efficient financial sector. Banks and manufacturing firms engage in oligopolistic competition. We have derived the following results analytically. For a closed economy, we have demonstrated that firms in a country with a more efficient financial sector choose more advanced technologies and this country has a comparative advantage in the production of manufactured goods. With the opening up of international trade, even though the home country trades with the foreign country with a less developed financial sector, domestic manufacturing firms will adopt more advanced technologies. An increase in the level of efficiency of the financial sector in a country leads to manufacturing firms in both countries to adopt more advanced technologies and the wage rate increases.

There are some interesting generalizations and extensions of the model. First, in this paper we have focused on the scenario that only trade flow between the two countries is allowed. Suppose the two countries have both trade and financial flow. Under this scenario, since the interest rate paid to depositors in a country with a less efficient financial sector is lower, depositors in this country will try to move their capital out of the country to get a higher return. Banks in the country with a more efficient financial sector will supply capital to manufacturing firms in the country with a less efficient financial sector. This will generate a pattern similar to the bypass effect studied in Ju and Wei (2010). Second, in this paper, we have made the unrealistic assumption that there transportation costs are zero between countries. When there are no transportation costs, market integration for manufactured goods leads firms in different countries to choose the same technologies. With the existence of transportation costs between countries, prices of manufactured goods in different countries could be different and firms in different countries may not adopt the same level of technologies. However, the result that the opening up of international trade encourages the adoption of more advanced technologies will still apply. The reason is that even with the existence of transportation costs the opening up of international trade will still increase the degree of competition in the market for manufactured goods. Since the price of a manufactured good as a markup over marginal costs is lower with a higher degree of competition, a manufacturing firm will produce a higher level of output to break even with the opening up of international trade. A higher level of output makes the adoption of more advanced technologies more likely. Thus, with the existence of transportation costs, the opening up of international trade will still encourage manufacturing firms in different countries to adopt more advanced, though possibly not identical technologies.

**Appendix**

Proof of Proposition 1:

An application of the Cramer's rule on (17) leads to

$$\frac{dn}{dK} = \frac{\partial V_1}{\partial K}\frac{\partial V_2}{\partial w}\frac{\partial V_3}{\partial r} / \Delta > 0,$$

$$\frac{dw}{dK} = -\frac{\partial V_1}{\partial K}\frac{\partial V_2}{\partial n}\frac{\partial V_3}{\partial r} / \Delta > 0 .$$

Proof of Proposition 2:

An application of the Cramer's rule on (17) leads to

$$\frac{dn}{df_b} = \frac{\partial V_1}{\partial f_b}\frac{\partial V_2}{\partial w}\frac{\partial V_3}{\partial r} / \Delta < 0 ,$$

$$\frac{dw}{df_b} = -\frac{\partial V_1}{\partial f_b}\frac{\partial V_2}{\partial n}\frac{\partial V_3}{\partial r} / \Delta < 0 .$$

Proof of Proposition 3:

From equations (5) and (5*), since manufacturing firms in the two countries produce the same level of output and pay the same wage rate, we have $R = R^*$. Plugging the value of $m^* f^*$ from equation (6*) into equation (9*) and the value of $x_b^*$ from equation (8*) into the resulting equation, the number of banks in the foreign country can be expressed as $m_b^* = \frac{K^*(R^* - r^*)}{f_b^* R^*}$. Plugging this value of $m_b{}^*$ into equation (7*) leads to $R^* = r^* / \left(1 - \sqrt{\frac{(\theta + h) f_b^*}{\theta K^*}}\right)$. From $R = r / \left(1 - \sqrt{\frac{(\theta + h) f_b}{\theta K}}\right)$ and $R^* = r^* / \left(1 - \sqrt{\frac{(\theta + h) f_b^*}{\theta K^*}}\right)$, if $f_b^* > f_b$, then $r^* < r$.

Proof of Proposition 4:

An application of Cramer's rule on (25) leads to

$$\frac{dn}{ds} = \frac{\partial \Omega_1}{\partial s}\frac{\partial \Omega_2}{\partial w}\frac{\partial \Omega_3}{\partial r} / \Delta_\Omega > 0 ,$$

$$\frac{dw}{ds} = -\frac{\partial \Omega_1}{\partial s}\frac{\partial \Omega_2}{\partial n}\frac{\partial \Omega_3}{\partial r} / \Delta_\Omega > 0 .$$

Proof of Proposition 5:

An application of Cramer's rule on (25) leads to

$$\frac{dn}{d f_b^*} = \frac{\partial \Omega_1}{\partial f_b^*} \frac{\partial \Omega_2}{\partial n} \frac{\partial \Omega_3}{\partial r} / \Delta_\Omega < 0 ,$$

$$\frac{dw}{d f_b^*} = - \frac{\partial \Omega_1}{\partial f_b^*} \frac{\partial \Omega_2}{\partial n} \frac{\partial \Omega_3}{\partial r} / \Delta_\Omega < 0 .$$

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