Technology Choice, Financial Sector and Economic Integration under the Presence of Efficiency Wages

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Abstract

Impact of economic integration on unemployment is studied in a general equilibrium model in which unemployment is a result of the existence of efficiency wages. Banks provide capital to manufacturing firms and engage in oligopolistic competition. Manufacturing firms choose technologies and also engage in oligopolistic competition. A country with a more efficient financial sector has a lower unemployment rate and a comparative advantage in producing manufactured goods. Trade integration decreases the unemployment rate and increases the wage rate and the equilibrium level of technology. An additional financial integration will decrease the unemployment rate and increase the wage rate and the level of technology further.

Keywords: Unemployment, economic integration, efficiency wages, choice of technology, two-tier oligopoly

JEL Classification Numbers: F12, E24, J64

1. Introduction

With increasing returns in production, economic integration should be beneficial to participating countries. Actually, there is no country in the world that is both rich and closed. While in general economic integration is beneficial to countries, countries still have various concerns about the impact of economic integration, such as its impact on a country's levels of unemployment and technology. First, unemployment is an economically and politically important issue. How will trade liberalization affect a country's unemployment rate (Davidson and Matusz, 2010)? Second, international division of labor may be hierarchical, and countries want to specialize in industries with great technological potentials. How will economic integration affect a country's choice of technologies and productivity? While there is no consensus, many empirical studies have demonstrated that trade openness and financial openness increase productivity (Wu, 2000; Alcala and Ciccone, 2004; Bekaert, Harvey, and Lundblad, 2011). Empirical research such as Bekaert, Harvey, and Lundblad (2011) also reveals the importance of the quality of financial institutions in affecting a country's gain from openness.

In this paper, we study the impact of trade and financial integration on unemployment in a general equilibrium model. Capital and labor are the two factors of production. There are two sectors: agriculture and manufacturing. Unemployment is the result of the existence of efficiency wages (Shapiro and Stiglitz, 1984). Banks provide capital to manufacturing firms. As a two-tier oligopoly model, banks engage in oligopolistic competition (Williamson, 1986; Jungblut, 2004), manufacturing firms also engage in oligopolistic competition (Neary, 2003, 2016; Zhang, 2007; Andrzej and Ryan, 2012) and choose production technologies to maximize profits.

We show that a country with a more efficient financial sector chooses a more advanced technology, has a lower unemployment rate and a comparative advantage in producing manufactured goods. Trade integration leads to equalization of unemployment rate in the two countries even though they may differ in the level of efficiency in the financial sector and factor endowments. Trade integration increases social welfare in both countries because it decreases the unemployment rate and increases the wage rate. After trade integration, an additional financial integration between the two countries will increase the wage rate and reduce unemployment rate in both countries further.

For studies on financial integration, Lane (2013) discusses the relationship between financial globalization and financial crisis. In Beck (2002), financial friction is captured by an iceberg type search cost and a country with a higher search cost will export food. Ju and Wei (2011) study a model that there are agency costs of using external finance. With low agency costs, factor endowments determine a country's comparative advantage. With high agency costs, agency costs in the financial sector determine a country's comparative advantage. One significant difference between this paper and Beck (2002) and Ju and Wei (2011) is that unemployment is not studied in those papers.

Depending how unemployment is incorporated, models studying the impact of opening of international trade on unemployment can be classified as follows. First, for models with search generated unemployment, Davidson, Martin, and Matusz (1999) establish a model in which firms engage in perfect competition. They show that labor market efficiency is an independent source of a country's comparative advantage. Davidson, Matusz, and Shevchenko (2008) study a model with firm heterogeneity. They show that exporting firms are bigger and pay higher wages than other firms. Helpman and Itskhoki (2010) show that a decrease in labor market friction in a country may harm its trading partner. Helpman, Itskhoki, and Redding (2010) show that opening of trade increases wage inequality and has an ambiguous impact on unemployment. Second, Matusz (1996) demonstrates that the opening of international trade increases the wage rate. This wage change affects the non-shirking constraint in the Shapiro-Stiglitz model and thus the unemployment rate.

Hoon (2001) examines a Ricardian model in which countries differ in technologies. Brecher and Chen (2010) address how international trade, migration, and outsourcing affect unemployment. Davis and Harrigan (2011) introduce firm heterogeneity into an efficiency wage model in which firms differ in their monitoring intensities of workers who may shirk. Third, Egger and Kreickemeier (2012) explore the impact of international trade on unemployment and income inequality in which unemployment results from the existence of fair wages. Fourth, Arnold and Trepl (2015) incorporate unemployment through union wage bargaining. Finally, Brecher, Chen, and Yu (2013) study the interaction between offshoring and unemployment under the presence of wage floor. While this paper focuses on the interaction between the financial sector, the choice of technology, and unemployment, the financial sector and the choice of technology are not addressed in the above models.

Models above (especially the search type models) provide a detailed microfoundation for studying unemployment. To have a tractable model on a firm's choice from a continuum of technologies, here we choose to adopt efficiency wage approach because unemployment can be incorporated in a simple way through the non-shirking condition (equation (7) below). Equation (7) establishes a negative relationship between the wage rate and the unemployment rate: the higher the wage rate, the lower the unemployment rate. If this negative relationship is also present in other types of models, then results here will be robust to alternative setups.

For models in which manufacturing firms engage in oligopolistic competition, Zhou (2010) addresses impact of trade integration with firm heterogeneity, Wen and Zhou (2012) examine financial and trade integration, and Gong and Zhou (2014) study a model of international trade in which manufacturing firms choose production technologies. One important difference between this paper and the above three papers is that unemployment is not addressed in those papers. Zhou (2015) visits financial and trade integration for developing countries. The wage rate is exogenous given in Zhou (2015) while it is endogenously determined in this paper. Zhou (2018) addresses the impact of international trade on unemployment in which unemployment is a result of the existence of efficiency wages. This paper differs from Zhou (2018) in two aspects. In this paper, capital is a factor of production and banks engage in oligopolistic competition. In Zhou (2018), there is neither capital nor financial sector.

The plan of the paper is as follows. Section 2 sets up the model and establishes the equilibrium conditions in which countries are in autarky. Section 3 studies the impact of the opening of international trade on the wage rate, the level of technology, and unemployment. Section 4 examines the impact of financial and trade integration between the two countries. Section 5 discusses some generalizations and extensions of the model and concludes.

2. Countries in autarky

There are two countries: home and foreign. In this section, we study the equilibrium for a country in autarky. Without loss of generality, we focus on the home country. First, we study a consumer's utility maximization. Second, we study profit maximization of firms. Third, we establish market clearing conditions, such as the clearance of the market for manufactured goods. Finally, we conduct comparative statics to explore properties the steady state.

There are two types of goods: the agricultural good and a continuum of manufactured goods. The agricultural good is produced by labor with constant returns to scale. The number of employed individuals in the agricultural sector is L_a. Without loss of generality, we assume that each employed individual in the agricultural sector produces one unit of the agricultural good. There is a continuum of manufactured goods indexed by a number $\varpi \in [0,1]$.[1] All manufactured goods have the same costs of production and enter a consumer's utility function in the same way. Both capital and labor are used in producing each manufactured good. The amount of exogenously given capital is K. Capital is assumed to be owned equally by all individuals.[2] Banks attract deposits from individuals and supply capital to firms. Variables associated with the banking sector usually carry a subscript b.

2.1. Individual behavior

The size of the population is L. An individual's level of consumption of the agricultural good is c_a and that of manufactured good ϖ is $c(\varpi)$. Each individual is endowed with one unit of labor. The cost of effort for a worker without shirking is ϕ. The subjective discount rate of a consumer is ρ. For $\alpha \in (0,1)$, a consumer's utility function is specified as

[1] The motivation of introducing a continuum of manufactured goods instead of one manufactured good is to eliminate a firm's market power in the labor market (Neary, 2003, 2016). Even though a manufacturing firm has market power in product market, it does not have market power in the labor market because there is an infinite number of manufacturing firms demanding labor.

[2] With homothetic preferences assumed in this paper, the distribution of ownership of capital will not affect aggregate demand of final goods.

$$\int_0^\infty U(t)e^{-\rho}\ dt,$$

$$U(t) = c_a^\alpha \int_0^1 c(\varpi)^{1-\alpha} d\varpi - s\phi. \tag{1}$$

In the above specification, $s \in \{0, 1\}$. If a worker shirks, then $s = 0$; if a worker does not shirk, then $s = 1$. The price of the agricultural good is p_a and that of manufactured good ϖ is $p(\varpi)$. An individual's expenditure is I, which is spent on the agricultural good and manufactured goods: $p_a c_a + \int_0^1 p(\varpi)c(\varpi)d\varpi = I$. For an individual, the per capita income from ownership of capital is η. The wage rate in the manufacturing sector is w and the unemployment rate in the economy is u. If an individual is unemployed, $I = \eta$; If an individual is employed, $I = w + \eta$.

With the specification of the utility function, utility maximization leads to α per cent of income spent on the agricultural good and $1 - \alpha$ per cent of income spent on manufactured goods. The indirect utility function can be written as

$$V(I, p_a, p, e) = \frac{\alpha^\alpha (1-\alpha)^{1-\alpha}}{p_a^\alpha p^{1-\alpha}} I - s\phi.$$

The exogenous job separation rate is b. If a worker shirks, the probability that shirking is detected is q. A worker found shirking will be fired. The expected lifetime utility of an employed shirker is V_E^S, that of an unemployed individual is V_u, and that of an employed nonshirker is V_E^N. For a shirker, the instant utility is $U(w + \eta)$. At each moment, there is a probability of $b + q$ of becoming unemployed and thus asset value change $V_u - V_E^S$. Thus, the asset equation for a shirker is

$$\rho V_E^S = U(w + \eta) + (b + q)(V_u - V_E^S). \tag{2}$$

For a non-shirker, the exogenous job separation rate at each moment is b. For this kind of worker, the instant utility is $U(w + \eta) - \phi$. At each moment, there is a probability of b of becoming unemployed and thus asset value change $V_u - V_E^N$. Thus, the asset equation for a non-shirker is

$$\rho V_E^N = U(w + \eta) - \phi + b(V_u - V_E^N). \tag{3}$$

A worker will not shirk if the expected lifetime utility for a shirker is smaller than that for a non-shirker: $V_E^N \geq V_E^S$. From equations (2) and (3), for a worker not to shirk, the following condition needs to be satisfied:

$$U(w + \eta) \geq \rho V_u + \frac{(\rho + b + q)\phi}{q}. \tag{4}$$

The instant rate for an unemployed individual to find employment is a. For an unemployed individual, the instant utility is $U(\eta)$. At each moment, there is a probability of a of finding a job and thus a change of asset value of $\max(V_E^S, V_E^N) - V_u$. The asset equation for an unemployed individual is

$$\rho V_u = U(\eta) + a[\max(V_E^S, V_E^N) - V_u]. \tag{5}$$

In equilibrium, $\max(V_E^S, V_E^N) = V_E^N$. From equations (3) and (5), we have

$$\rho V_u = \frac{a[U(w+\eta)-\phi]+(\rho+b)U(\eta)}{a+b+\rho}. \tag{6}$$

Suppose total employment is N. With a job separation rate of b, the flow into the unemployment pool is bN. With a job acquisition rate a, the flow out is $a(L-N)$. Since time is continuous, the change in unemployment rate is

$$\dot{u} = \frac{1}{L}[bN - a(L-N)].$$

In a steady state, there is no change in unemployment rate: $\dot{u} = 0$. Thus, $a = b\frac{N}{L-N}$, or $a = b\frac{1-u}{u}$. In equilibrium the non-shirking condition is held with equality. Combining equations (4) and (6) with $a = b\frac{1-u}{u}$ yields

$$\frac{\alpha^\alpha(1-\alpha)^{1-\alpha}}{p_a^\alpha p^{1-\alpha}}w - \phi - \frac{\phi}{q}\left(\frac{b}{u} + \rho\right) = 0. \tag{7}$$

2.2. Firm behavior

Firms producing the same manufactured good engage in Cournot competition. The number of firms producing manufactured good ϖ is $m(\varpi)$. To produce a manufactured good, there is a continuum of technologies indexed by a positive number n. A higher value of n indicates a more advanced technology. For technology n, a firm's fixed cost is $f(n)$ units of capital and its marginal cost is $\beta(n)$ units of labor. It is assumed that fixed costs increase while marginal cost decreases with the level of technology: $f'(n) > 0$ and $\beta'(n) < 0$.[3] The level of output of a manufacturing firm is x. A bank charges an interest rate of R for each unit of capital provided to a manufacturing firm. Thus, a firm's profit is $px - f(n)R - \beta(n)xw$. To make sure that the elasticity of demand

[3] One illustration of this tradeoff between fixed and marginal costs in the choice of technology is as follows. The adoption of containers is an important innovation in the transportation sector in the twentieth century. Before the introduction of containers, the loading and unloading of cargos were handled by longshoremen and were labor intensive. Compared with loading and unloading by longshoremen, containerization is a technology with a higher fixed cost but a lower marginal cost of production.

for capital for a manufacturing firm is constant (see footnote 6 for the derivation of this elasticity), capital and labor requirements are specified as[4]

$$f(n) = \psi n^{\theta}, \tag{8a}$$

$$\beta(n) = g n^{-h}. \tag{8b}$$

A manufacturing firm takes the wage rate, the cost of capital, and other manufacturing firms' output as given and chooses its technology and output to maximize its profit. The first order condition for a manufacturing firm's optimal choice of technology is

$$-f'(n)R - \beta'(n)xw = 0. \tag{9}$$

The first order condition for a manufacturing firm's optimal choice of output is $p + x\frac{\partial p}{\partial x} = \beta(n)w$. In a Cournot competition, a firm takes other firms' output as given when choosing its output. As a result, $\frac{\partial x}{\partial p} = L\frac{\partial c}{\partial p} = \frac{Lc}{p}\frac{\partial c}{\partial p}\frac{p}{c}$. Since the absolute value of a consumer's elasticity of demand for a manufactured good is one, $\frac{x}{p}\frac{\partial p}{\partial x} = -\frac{1}{m}$. Thus, a manufacturing firm's optimal choice of output yields

$$p\left(1 - \frac{1}{m}\right) = \beta w. \tag{10}$$

The number of manufacturing firms is determined by the zero-profit condition.[5] Zero profit for a manufacturing firm requires that

$$px - fR - \beta x w = 0. \tag{11}$$

The number of banks serving manufacturing firms producing manufactured good ϖ is $m_b(\varpi)$. The interest rate a bank pays to a depositor is r. The fixed cost of operating a bank is f_b units of capital.[6] With the amount of deposits x_b, a bank's profit is $Rx_b - f_b r - r x_b$. Banks engage in Cournot competition. A bank takes the interest rate paid to depositors as given and

[4] The specifications in equations (8a) and (8b) to ensure a constant elasticity of demand for capital for a manufacturing firm plays a role similar to the specification of the utility function in equation (1) which ensures a constant elasticity of demand for manufactured goods. Thus, for this two-tier oligopoly, both stages exhibit constant elasticity of demand.
[5] See Sections 3.7 and 4.5 of Brander (1995), Zhang (2007), and Liu and Wang (2010) for examples of Cournot competition with free entry.
[6] Without increasing returns in the intermediation of financial services, financial intermediation is not needed, and a manufacturing firm may contact individuals directly for capital. There are various sources leading to increasing returns in the financial sector. First, banks engage in monitoring, which is a fixed cost. Second, banks rely on computer systems extensively (Pilloff, 2005, p. 145). Third, advertising is another source of increasing returns.

chooses its amount of deposits to maximize its profit. A bank's optimal choice of the amount of deposits yields[7]

$$R\left(1-\frac{\theta+h}{\theta m_b}\right)=r. \tag{12}$$

There is free entry and exit in the banking sector. Zero profit for a bank requires that

$$Rx_b-f_b r-rx_b=0. \tag{13}$$

2.3 Market clearing conditions

We now establish various market-clearing conditions. For manufactured good ϖ, the amount of capital supplied by banks $m_b x_b$ should be equal to the amount of capital used by manufacturing firms mf:

$$m_b x_b=mf. \tag{14}$$

For the market for capital, demand is the sum of demand from the banking sector $\int_0^1 m_b(\varpi)f_b(\varpi)d\varpi$ and manufacturing sector $\int_0^1 m(\varpi)f(\varpi)d\varpi$. Thus, total demand is $\int_0^1 m_b(\varpi)f_b(\varpi)d\varpi+\int_0^1 m(\varpi)f(\varpi)d\varpi$. Total supply of capital is K. The clearance of the market for capital requires

$$\int_0^1 m_b(\varpi)f_b(\varpi)d\varpi+\int_0^1 m(\varpi)f(\varpi)d\varpi=K. \tag{15}$$

For manufactured good ϖ, each firm demands βx units of labor and demand for labor from m firms is $m(\varpi)\beta(\varpi)x(\varpi)$. Integrating over all manufactured goods, with unemployment rate $u(\varpi)$, total amount of labor in the manufacturing sector is $\int_0^1 \frac{m(\varpi)\beta(\varpi)x(\varpi)}{1-u(\varpi)}d\varpi$. Unemployment rate in the agricultural sector is the same as that in the manufacturing sector and total amount of labor in the agricultural sector is $L_a/(1-u)$. The total supply of labor is L. Equilibrium in the labor market requires that

$$\int_0^1 \frac{m(\varpi)\beta(\varpi)x(\varpi)}{1-u(\varpi)}d\varpi+\frac{L_a}{1-u}=L. \tag{16}$$

Total income of the home country is $(1-u)wL+uzL+\eta L$ and α per cent of total income is spent on the agricultural good, thus demand for the agricultural good is $\alpha[(1-u)wL+uzL+$

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[7] For the derivation of equation (12), plugging equations (8a) and (8b) into equation (9) leads to $n=\left(\frac{ghxw}{\theta\psi R}\right)^{\frac{\theta}{\theta+h}}$. Thus, $\frac{df}{dR}\frac{R}{f}=f'\frac{dn}{dR}\frac{R}{f}=-\frac{\theta}{\theta+h}$.

$\eta L]$. Value of supply of the agricultural good is $p_a L_a$. The clearance of the market for the agricultural good requires

$$\alpha[(1-u)wL + uzL + \eta L] = p_a L_a. \tag{17}$$

Since $1-\alpha$ per cent of total income is spent on manufactured goods, demand for manufactured goods is $(1-\alpha)[(1-u)wL + uzL + \eta L]$. The value of supply of manufactured goods is $\int_0^1 p(\varpi)m(\varpi)x(\varpi)d\varpi$. The clearance of the market for manufactured goods requires

$$(1-\alpha)[(1-u)wL + uzL + \eta L] = \int_0^1 p(\varpi)m(\varpi)x(\varpi)d\varpi. \tag{18}$$

The return for an individual in the manufacturing sector is w. Since each individual produces one unit of the agricultural good, the return for an individual employed in the agricultural sector is p_a. Individuals in the two sectors face the same unemployment rate. For an individual to be indifferent between the agricultural sector and the manufacturing sector, the returns in the two sectors should be equal:

$$w = p_a. \tag{19}$$

In equilibrium, the total amount of revenue received by individuals as owners of capital ηL should be equal to the sum of capital income rK:

$$\eta L = rK. \tag{20}$$

In a closed economy, equations (7) and (9)-(20) form a system of thirteen equations defining thirteen variables L_a, w, u, η , p_a, r, m, m_b, p, R, x, n, and x_b as functions of exogenous parameters. We focus on a symmetric equilibrium in which the number of producing firms, output of a firm, the price, and consumption are the same for all manufactured goods. Since the measure of manufactured goods is one, for simplicity we drop the integration operator in a symmetric equilibrium. A symmetric equilibrium in a closed economy is a tuple ($L_a, w, u,\ \eta$, p_a, r, m, m_b, p, R, x, n, x_b) satisfying equations (7) and (9)-(20). For the rest of the paper, a representative manufactured good is used as the numeraire: $p \equiv 1$.

2.4. Comparative statics

To explore properties of the equilibrium, we conduct some manipulations. Plugging the value of mf from equation (14) into equation (15), using equation (12) to eliminate m_b and equation (13) to eliminate x_b from the resulting equation yields the following relationship between the interest rate paid to depositors and the interest rate charged by banks:

$$r = R\left(1 - \sqrt{\frac{(\theta+h)f_b}{\theta K}}\right). \tag{21}$$

Plugging (21) into (12) and (13), we get $m_b = \sqrt{\frac{(\theta+h)K}{\theta f_b}}$ and $x_b = \sqrt{\frac{\theta K f_b}{\theta+h}} - f_b$. Plugging those results into equation (14), the number of manufacturing firms is

$$m = \frac{K - \sqrt{\frac{\theta+h}{\theta} K f_b}}{f}. \tag{22}$$

The system of equations (7) and (10)-(20) defining the equilibrium in a closed economy is reduced to the following system of three equations defining three variables w, u, and n as functions of exogenous parameters:[8]

$$\Gamma_1 \equiv \alpha^{\alpha}(1-\alpha)^{1-\alpha}w^{1-\alpha} - \phi - \frac{\phi}{q}\left(\frac{b}{u} + \rho\right) = 0, \tag{23a}$$

$$\Gamma_2 \equiv \left(1 - \sqrt{\frac{(\theta+h)f_b}{\theta K}}\right)K - \frac{f}{1-\beta w} = 0, \tag{23b}$$

$$\Gamma_3 \equiv -f'(1-\beta w) - \beta' f w = 0. \tag{23c}$$

Partial differentiation of equations (23a)-(23c) with respect to w, u, n, K, b, and f_b yields

$$\begin{pmatrix} \frac{\partial \Gamma_1}{\partial w} & \frac{\partial \Gamma_1}{\partial u} & 0 \\ \frac{\partial \Gamma_2}{\partial w} & 0 & 0 \\ \frac{\partial \Gamma_3}{\partial w} & 0 & \frac{\partial \Gamma_3}{\partial n} \end{pmatrix} \begin{pmatrix} dw \\ du \\ dn \end{pmatrix} = -\begin{pmatrix} 0 \\ \frac{\partial \Gamma_2}{\partial K} \\ 0 \end{pmatrix} dK - \begin{pmatrix} \frac{\partial \Gamma_1}{\partial b} \\ 0 \\ 0 \end{pmatrix} db - \begin{pmatrix} 0 \\ \frac{\partial \Gamma_2}{\partial f_b} \\ 0 \end{pmatrix} df_b. \tag{24}$$

Partial differentiation of equations (23a) and (23b) reveals that $\frac{\partial \Gamma_1}{\partial u} > 0$, $\frac{\partial \Gamma_2}{\partial w} < 0$ and $\frac{\partial \Gamma_3}{\partial n} < 0$. Thus, the determinant of the matrix of the coefficients of endogenous variables of (24) is negative: $\Delta \equiv -\frac{\partial \Gamma_1}{\partial u}\frac{\partial \Gamma_2}{\partial w}\frac{\partial \Gamma_3}{\partial n} < 0$. With Δ nonsingular, a unique equilibrium exists.

The following proposition studies the impact of an increase in the amount of capital on the unemployment rate and the wage rate.

Proposition 1: An increase in the amount of capital causes the unemployment rate to decrease, the equilibrium wage rate to increase, and the level of technology to increase.

Proof: Applying Cramer's rule on (24) yields $\frac{dw}{dK} > 0$, $\frac{du}{dK} < 0$, and $\frac{dn}{dK} > 0$. ■

[8] Equations (23a)-(23c) are derived as follows. First, equation (23a) results from plugging the value of p_a from equation (19) into equation (7). Second, equation (23b) comes from plugging the value of m from equation (22) into equation (10). Third, equation (23c) is derived by plugging the value of x from equation (11) into equation (9).

The intuition behind Proposition 1 is as follows. When the amount of capital increases, both the number of banks and the level of output of a bank increase. To absorb an increased supply of capital to the manufacturing sector, either the number of manufacturing firms or the level of technology or both will increase. First, if the number of manufacturing firms increases, this increased degree of competition among firms trying to hire workers will cause the wage rate to increase. A higher wage rate increases a manufacturing firm's incentive to adopt more advanced technologies because the marginal benefit from adopting a more advanced technology increases with the wage rate. Second, if the number of firms does not change and firms adopt more advanced technologies, a more advanced technology will reduce the marginal cost of production. Through equation (10), marginal revenue would not change if the number of manufacturing firms does not change. To make sure that marginal revenue equals marginal cost, the wage rate needs to increase. Thus, both the wage rate and the level of technology will always increase with the amount of capital. Through the non-shirking condition, a higher wage rate is associated with a lower unemployment rate.

One parameter measuring the degree of efficiency in the labor market is the exogenous job separation rate. A higher job separation rate may be interpreted as a less efficient labor market. The following proposition studies the impact of a change in the exogenous job separation rate.[9]

Proposition 2: An increase in the exogenous job separation rate increases the unemployment rate and changes neither the wage rate nor the level of technology.

Proof: Applying Cramer's rule on (24) yields $\frac{du}{db} > 0$, $\frac{dw}{db} = 0$, and $\frac{dn}{db} = 0$. ■

To understand Proposition 2, equations (23b) and (23c) form a system of two equations defining the level of technology and the wage rate as functions of exogenous parameters. Since the exogenous job separation rate does not show up in those equations, wage rate and technology are not affected by the exogenous job separation rate. When the exogenous job separation rate increases, from equation (23a), the unemployment rate increases so that the non-shirking constraint is maintained.

[9] Impact of an increase in the cost of exerting effort is similar to that of an increase in the exogenous job separation rate.

A higher fixed cost in the financial sector indicates a less efficient financial sector. The following propositions studies the impact of a change in the level of efficiency in the financial sector.

Proposition 3: A country with a more efficient financial sector has a higher wage rate, a lower unemployment rate, and a more advanced technology.

Proof: Applying Cramer's rule on (24) yields $\frac{dw}{df_b} < 0$, $\frac{du}{df_b} > 0$, and $\frac{dn}{df_b} < 0$. ■

The intuition behind Proposition 3 is as follows. A more efficient financial sector uses less capital, and the released capital can be used by manufacturing firms. A higher number of manufacturing firms leads to a higher wage rate and a lower unemployment rate. A higher wage rate increases the marginal benefit of adopting a more advanced technology and equilibrium level of technology increases. Poor institutions such as the existence of red tapes can increase the level of fixed costs in the financial sector significantly. Thus Proposition 3 is consistent with empirical studies such as Bekaert, Harvey, and Lundblad (2011) that quality of institutions affects a country's gain from openness.

A country's comparative advantage in producing manufactured goods is measured by the relative price of manufactured goods to the agricultural good. With the price of manufactured goods normalized to one in this model, a country's comparative advantage can be measured by the price of the agricultural good: the higher the price of the agricultural good, the higher a country's comparative advantage in producing manufactured goods. Since the price of the agricultural good is equal to the wage rate, from Propositions 1 and 3, a country with a higher amount of capital or a more efficient financial sector has a comparative advantage in producing manufactured goods. Interestingly, from the system of equations (23a)-(23c), a country's comparative advantage is not affected by population size or the level of efficiency in the labor market.

3. Trade integration

In this section, we study the impact of trade integration. With the opening of international trade, markets for manufactured goods in the two countries are integrated while the banking sectors are not. Consumers in the foreign country are assumed to have the same preference as domestic consumers. The foreign country is assumed to have the same level of efficiency in the labor market and the same technology in the agricultural and manufacturing sectors. However, the foreign country may have different capital and labor endowments. The two countries may also differ in their level of efficiency in the financial sector. Variables associated with the foreign country carry an asterisk mark.

With trade integration, a manufacturing firm competes with both domestic and foreign firms producing the same good. Like the derivation of equation (10), a domestic manufacturing firm's optimal choice of output yields

$$p\left(1-\frac{x}{mx+m*x*}\right)=\beta w. \tag{25}$$

Similarly, a foreign firm's optimal choice of output yields

$$p\left(1-\frac{x*}{mx+m*x*}\right)=\beta w^*. \tag{25*}$$

Like the equilibrium conditions for the home country, the following conditions hold for the foreign country:

$$\frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}{p_a^{\alpha}}w^*-\phi-\frac{\phi}{q}\left(\frac{b}{u*}+\rho\right)=0, \tag{7*}$$

$$-f'(n^*)R^*-\beta'(n^*)x^*w^*=0. \tag{9*}$$

$$px^*-fR^*-\beta x^*w^*=0, \tag{11*}$$

$$R^*\left(1-\frac{\theta+h}{\theta m_b^*}\right)=r^*, \tag{12*}$$

$$R^*x_b^*-f_b^*r^*-r^*x_b^*=0, \tag{13*}$$

$$m_b^*x_b^*=m^*f, \tag{14*}$$

$$\int_0^1 m_b^*(\varpi)f_b^*(\varpi)d\varpi+\int_0^1 m^*(\varpi)\,f(\varpi)d\varpi=K^*, \tag{15*}$$

$$\int_0^1\frac{m^*(\varpi)\beta(\varpi)x^*(\varpi)+L_a^*}{1-u^*(\varpi)}d\varpi=L^*. \tag{16*}$$

$$w^*=p_a, \tag{19*}$$

$$\eta^*L^*=r^*K^*. \tag{20*}$$

Like equation (17), the clearance of the world market for the agricultural good under trade integration requires

$$\alpha[(1-u)(wL+w^*L^*)+z(uL+u^*L^*)+\eta L+\eta^*L^*]=p_a(L_a+L_a*). \tag{26}$$

Like equation (18), the clearance of the world market for manufactured goods under trade integration requires

$$(1-\alpha)[(1-u)(wL+w^*L^*)+z(uL+u^*L^*)+\eta L+\eta^*L^*]$$

$$= \int_0^1 p(\varpi)[m(\varpi)x(\varpi) + m^*(\varpi)x^*(\varpi)]d\varpi. \quad (27)$$

With trade integration, equations (7), (7*), (9), (9*), (11)-(16), (11*)-(16*), (19)-(20), (19*)-(20*), (25), (25*), and (26)-(27) form a system of 24 equations defining 24 endogenous variables w, w^*, u, u^*, η , η^*, p_a, r, r^*, m, m^*, m_b, m_b^*, p, R, R^*, x, x^*, L_a, L_a^*, n, n^*, x_b and x_b^* as functions of exogenous parameters. From (19) and (19*), since there is no transportation cost for the agricultural good and the two countries have the same production technology in the agricultural sector, wage rate in the two countries will be equal: $w = w^*$. From (19), (19*), (25), and (25*), domestic and foreign firms in the manufacturing sector will have the same level of output with a trade integration: $x = x^*$. From (7), (7*), (19), and (19*), the two countries will have the same unemployment rate with a trade integration: $u = u^*$.

With trade integration, it can be shown that the two countries pay different interest rates to depositors even though banks charge the same interest rate to manufacturing firms. From equation (21), interest rate paid to depositors increases with the level of efficiency in the financial sector. Thus, the country with a more efficient financial sector pays a higher interest rate to depositors.

Like the derivation of equations (23a)-(23c), the system of equations defining the equilibrium with trade integration can be reduced to the following system of three equations defining three variables w, u, and n as functions of exogenous parameters:

$$\Phi_1 \equiv \alpha^\alpha(1-\alpha)^{1-\alpha}w^{1-\alpha} - \phi - \frac{\phi}{q}\left(\frac{b}{u} + \rho\right) = 0, \quad (28a)$$

$$\Phi_2 \equiv \left(1 - \sqrt{\frac{f_b}{K}}\right)K + \left(1 - \sqrt{\frac{f_{b^*}}{K^*}}\right)K^* - \frac{f}{1-\beta w} = 0, \quad (28b)$$

$$\Phi_3 \equiv -f'(1-\beta w) - \beta' f w = 0. \quad (28c)$$

Partial differentiation of equations (28a)-(28c) with respect to w, u, n, and K^* yields

$$\begin{pmatrix} \frac{\partial \Phi_1}{\partial w} & \frac{\partial \Phi_1}{\partial u} & 0 \\ \frac{\partial \Phi_2}{\partial w} & 0 & 0 \\ \frac{\partial \Phi_3}{\partial w} & 0 & \frac{\partial \Phi_3}{\partial n} \end{pmatrix}\begin{pmatrix} dw \\ du \\ dn \end{pmatrix} = \begin{pmatrix} 0 \\ -\frac{\partial \Phi_2}{\partial K^*} \\ 0 \end{pmatrix} dK^* . \quad (29)$$

The determinant of the coefficient matrix of endogenous variables of (29) is negative: $\Delta_\Phi \equiv -\frac{\partial \Phi_1}{\partial u}\frac{\partial \Phi_2}{\partial w}\frac{\partial \Phi_3}{\partial n} < 0$. With Δ_Φ nonsingular, a unique equilibrium exists.

The following proposition studies the impact of trade integration on the unemployment rate, wage rate, and level of technology.

Proposition 4: Trade integration decreases the unemployment rate, increases the wage rate and the level of technology.

Proof: A comparison of (23a)-(23c) with (28a)-(28c) reveals that the impact of trade integration can be captured by a change of K^* from zero to a positive number. Applying Cramer's rule on (29) yields $\frac{du}{dK^*} < 0$, $\frac{dw}{dK^*} > 0$, and $\frac{dn}{dK^*} > 0$. ■

The intuition behind Proposition 4 is as follows. Trade integration increases the degree of competition in the manufacturing sector. Since the price of a manufactured good as a markup over marginal cost decreases, manufacturing firms produce more. This increase in the demand for workers causes the wage rate to increase and the unemployment rate to decrease. Proposition 4 is consistent with empirical evidence such as Alcala and Ciccone (2004) showing that trade openness increase productivity.

Since firms earn zero profits, social welfare can be measured by consumer welfare. With the wage rate increases at the same magnitude as the price of the agricultural good and the price of manufactured goods does not change, consumer welfare increases. Consumer welfare also increases because a lower unemployment rate means expected length of unemployment is lower. Overall, with trade integration, social welfare in both countries increases.

From (29), a more efficient financial sector in any of the two countries will increase wage rate and reduce unemployment rate in both countries. Thus, an increase in the level of efficiency in the financial sector in one country will benefit both countries.

4. Financial and trade integration

In this section, in addition to trade integration, countries also have financial integration. With financial integration, the two countries have the same level of interest rate paid to depositors and the same interest rate charged by banks. When countries have both trade and financial integration, we call it a joint integration. In this section, we assume countries have the same level of efficiency in the financial sector. The two countries may still have different endowments of labor and capital.

With financial integration, the following equations are valid:

$$R\left(1-\frac{(\theta+h)x_b}{\theta(m_b x_b+m_b^* x_b^*)}\right)=r, \tag{30}$$

$$R\left(1-\frac{x_b^*}{\theta(m_b x_b+m_b^* x_b^*)}\right)=r, \tag{30*}$$

$$m_b x_b+m_b^* x_b^*=mf+m^* f, \tag{31}$$

$$\int_0^1 m_b f_b d\varpi+\int_0^1 mf d\varpi+\int_0^1 m_b^* f_b^* d\varpi+\int_0^1 m^* f d\varpi=K+K^*. \tag{32}$$

Explanations of equations (30), (30*), (31), and (32) are as follows. First, equation (30) comes from a domestic bank's optimal choice of the amount of deposits. Second, equation (30*) comes from a foreign bank's optimal choice of the amount of deposits. Third, equation (31) states that the total amount of deposits in the banks for the world as a whole $m_b x_b+m_b^* x_b^*$ is equal to the total amount of capital in the manufacturing sector $mf+m^* f$. Finally, equation (32) states that world demand for capital $\int_0^1 m_b f_b d\varpi+\int_0^1 mf d\varpi+\int_0^1 m_b^* f_b^* d\varpi+\int_0^1 m^* f d\varpi$ equals world supply of capital $K+K^*$.

Equations (7), (7*), (9), (9*), (11), (11*), (13), (13*), (16), (16*), (19), (19*), (20), (20*), (25), (25*), (26), (27), (30), (30*), (31), and (32) form a system of 22 equations defining 22 endogenous variables w, w^*, u, u^*, η , η^*, p_a, r, m, m^*, m_b, m_b^*, p, R, x, x^*, L_a, L_a^*, n, n^*, x_b, and x_b^* as functions of exogenous parameters.

Like the derivation of (21) and (22), under joint integration we have

$$r=R\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta(K+K^*)}}\right), \tag{33}$$

$$m+m^*=\frac{K+K^*-\sqrt{\frac{\theta+h}{\theta}(K+K^*)f_b}}{f}. \tag{34}$$

With a joint integration, the two countries will have the same unemployment rate. Like the derivation of equations (23a)-(23c), the system of equations defining the equilibrium with joint integration can be reduced to the following system of three equations defining three variables w, u, and n as functions of exogenous parameters:

$$\Omega_1 \equiv \alpha^\alpha(1-\alpha)^{1-\alpha}w^{1-\alpha}-\phi-\frac{\phi}{q}\left(\frac{b}{u}+\rho\right)=0, \tag{35a}$$

$$\Omega_2=\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta(K+K^*)}}\right)(K+K^*)-\frac{f}{1-\beta w}=0, \tag{35b}$$

$$\Omega_3 \equiv -f'(1-\beta w)-\beta' f w=0. \tag{35c}$$

Partial differentiation of equations (35a)-(35c) with respect to w, u, n, and K^* yields

$$\begin{pmatrix} \frac{\partial \Omega_1}{\partial w} & \frac{\partial \Omega_1}{\partial u} & 0 \\ \frac{\partial \Omega_2}{\partial w} & 0 & 0 \\ \frac{\partial \Omega_3}{\partial w} & 0 & \frac{\partial \Omega_3}{\partial n} \end{pmatrix} \begin{pmatrix} dw \\ du \\ dn \end{pmatrix} = - \begin{pmatrix} 0 \\ \frac{\partial \Omega_2}{\partial K^*} \\ 0 \end{pmatrix} dK^* . \tag{36}$$

The determinant of the coefficient matrix of endogenous variables of (36) is negative: $\Delta_\Omega \equiv \frac{\partial \Omega_1}{\partial u} \frac{\partial \Omega_2}{\partial w} \frac{\partial \Omega_3}{\partial n} > 0$. With Δ_Ω nonsingular, a unique equilibrium exists.

The following proposition compares the equilibrium with a joint integration with the autarky equilibrium.

Proposition 5: Compared with autarky, a joint integration increases the wage rate and the level of technology and reduces the unemployment rate.

Proof: A comparison of (23a)-(23b) with (35a)-(35b) reveals that a joint financial and trade integration can be captured by a change of K^* from zero to a positive number. Applying Cramer's rule on (36) yields $\frac{du}{dK^*} < 0, \frac{dn}{dK^*} > 0$, and $\frac{dw}{dK^*} > 0$. ∎

To understand Proposition 5, financial integration increases the degree of competition in the financial sector. While the total number of banks in the world will not be smaller than the number of banks in either country before financial integration, some banks in each country will exit after financial integration. This exit releases capital for the manufacturing sector. Trade integration increases the degree of competition in the manufacturing sector. Both kinds of integration cause the wage rate to increase and the unemployment rate to decrease.

The following proposition studies the impact of a financial integration after a trade integration.

Proposition 6: Starting from a trade integration, a further financial integration increases the wage rate and decreases the unemployment rate.

Proof: When the two countries have the same level of efficiency in the financial sector, equation (28b) becomes

$$\left(1 - \sqrt{\frac{(\theta+h)f_b}{\theta K}}\right) K + \left(1 - \sqrt{\frac{(\theta+h)f_b}{\theta K^*}}\right) K^* = \frac{f}{1-\beta w}. \tag{37}$$

Equation (35b) can be rearranged as

$$\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta(K+K^*)}}\right)K+\left(1-\sqrt{\frac{(\theta+h)f_b}{\theta(K+K^*)}}\right)K^*=\frac{f}{1-\beta w}. \tag{38}$$

For equations (37) and (38), the wage rate increases when the left-hand side increases. A comparison of equation (37) with (38) reveals that the wage rate defined in (38) is higher than that defined in (37). Thus, the unemployment rate defined by equation (35a) is lower than that defined by equation (28a). ■

To understand Proposition 6, with financial integration, in each country some banks will exit. The released capital can be used by manufacturing firms in each country. This causes the wage rate to increase and unemployment rate to fall. Proposition 6 is consistent with empirical research such as Bekaert, Harvey, and Lundblad (2011) showing that financial openness increase productivity.

5. Conclusion

The level of unemployment could be affected by firms' choice of technologies, and technology choices in a country could be affected by the level of efficiency in the financial sector. With the opening of international trade, will a country with a less efficient financial sector have a higher unemployment rate than a country with a more efficient financial sector? With oligopoly as an important type of market structure in a modern society, it will be interesting to address those questions in a model in which firms engage in Cournot competition. In this paper, we have studied the impact of economic integration on unemployment in a general equilibrium model in which banks and manufacturing firms engage in oligopolistic competition and unemployment is the result of the existence of efficiency wages. In a closed economy, we have shown that an increase in the amount of capital causes the unemployment rate to decrease and the level of technology to increase. An increase in the exogenous job separation rate increases the unemployment rate and changes neither the wage rate nor the level of technology. A country with a higher amount of capital or a more efficient financial sector has a comparative advantage in producing manufactured goods. Trade or financial integration can cause the unemployment rate to decrease and the wage rate to increase in both countries.

There are some interesting generalizations and extensions of the model. First, for simplicity, we have assumed land is not a factor of production in the agricultural sector and unemployment rate in this sector is the same as that in the manufacturing sector. It will be interesting to study a model relaxing those assumptions. Second, various countries experienced financial crises during previous decades and the benefit of financial integration has been debated. It will be interesting to incorporate the possibility of financial crises into the current model. Third, impact of economic integration on a country's welfare is frequently affected by a country's technological capacity. A country will be more likely to benefit from economic integration if it has strong technological capacity. In this model, new technologies are always available. It will be valuable to incorporate endogenous development of technologies into the model. Finally, in this model there is no unemployment benefit. The model can be generalized to the case that the government imposes a lump-sum tax to finance unemployment income. This generalization will be useful to address issues such as the sectorial optimal taxation or labor versus capital taxation.

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