Impact of International Trade on Unemployment under Oligopoly

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Abstract

By studying a two-sector general equilibrium model in which firms engage in oligopolistic competition and unemployment is a result of the existence of efficiency wages, we derive the following results analytically. A country's comparative advantage in producing manufactured goods increases with the level of efficiencies in the labor market. The opening of international trade leads to the equalization of wage rates even though countries differ in their factor endowments and labor market efficiencies. If countries have the same level of labor market efficiencies but differ in their endowments of labor and land, the opening to international trade leads to an increase in the wage rate in both countries.

Keywords: Unemployment, international trade, oligopoly, efficiency wages, increasing returns

JEL Classification Numbers: F12, E24, J64

1. Introduction

For a modern society, oligopoly became an important type of market structure after the Second Industrial Revolution (Chandler, 1990). Oligopoly is a prevalent form of market structure and industries including automobiles, steel, aluminum, petrochemicals, electrical equipment, and computers are all oligopolistic (Pindyck and Rubinfeld, 2005, p. 441). Since firms engaging in international trade on average are larger than firms that do not engage in trade, the relevance of oligopolistic competition to international trade is greater than that to a closed economy (Bleaney and Wakelin, 2002). Firms engaging in international trade frequently have market power and engage in oligopolistic competition.

The impact of opening of international trade on the labor market has been studied extensively by scholars (Acemoglu and Autor, 2011; Brecher, Chen, and Yu, 2013; Caliendo, Dvorkin, and Parro, 2015). This paper contributes to the literature by studying how the level of unemployment in a country is affected by the opening of international trade in a general equilibrium model in which firms in the manufacturing sector engage in oligopolistic competition. In this model, the agricultural sector exhibits constant returns to scale. With the existence of fixed costs, the manufacturing sector has increasing returns in production. A worker chooses to exert effort if the expected payoff from working is not smaller than that from shirking. To provide workers with incentives to exert efforts, in equilibrium there is unemployment in the manufacturing sector (Shapiro and Stiglitz, 1984).

Like a Heckscher-Ohlin model, we show that opening to international trade leads to the equalization of the wage rate between countries even though countries differ in labor market efficiencies. If countries have the same level of labor market efficiencies but differ in their endowments of labor and land, then the opening to international trade leads to an increase in the wage rate in all countries. In a model without unemployment, the real wage rate increases with the opening to international trade if there are increasing returns in production (Venables, 1985; Zhou, 2007). In this model, we show that this beneficial effect of international trade remains valid with the existence of unemployment.

In this model, the opening to international trade has an ambiguous effect on a country's unemployment rate. This ambiguity is illustrated in empirical studies. While Autor, Dorn, and Hanson (2013, 2016) and Acemoglu et al. (2016) have argued the existence of negative effects of trade on employment in the United States,[1] Felbermayr, Prat and Schmerer (2011) find positive effects of trade on employment in OECD and developing countries. Moreover, Currie and Harrison (1997) and Harrison and Hanson (1999) find no significant effects of trade on employment in Morocco and Mexico.

In this model, a higher wage rate decreases a worker's incentive to shirk. However, whether a worker shirks or not is not necessary for the efficiency wage theory to be valid. The efficiency wage theory provides other kinds of justification on the positive relationship between the wage rate and productivities. For example, a higher wage rate can increase the nutrition level of workers and thus increases productivities. While we adopt the efficiency wage approach to model unemployment, our results are robust to alternative assumptions. The reasoning is as follows. The key equation we derive from the efficiency wage approach is equation (7) below, which shows a negative relationship between the real wage and the unemployment rate. This negative relationship can remain valid under alternative assumptions of unemployment.

Unemployment may be the result of various factors, such as labor market search or the existence of efficiency wages. First, Davidson, Martin, and Matusz (1999) study a model in which unemployment is of the search type. In their model, firms engage in perfect competition.

[1] Caliendo, Dvorkin, and Parro (2015) find that trade reduces employment, but increases social welfare for the United States.

They show that labor market efficiency is an independent source of a country's comparative advantage. Helpman and Itskhoki (2010) and Helpman, Itskhoki, and Redding (2013) demonstrate that a decrease in labor market friction in a country may harm its trading partner. One significant difference between the above papers and this one is the following. While their models incorporate unemployment through labor market search, this model incorporates unemployment through the efficiency wage setting. Second, there are models incorporating unemployment through efficiency wages or fair wages. Matusz (1996) shows that the opening of international trade increases the wage rate. This wage change affects the nonshirking 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 by allowing differences in monitoring intensities of firms. 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. There are some significant differences between those papers and this one. In the above papers, firms engage in monopolistic competition. With the opening to international trade, adjustment is achieved through the expansion of more efficient firms and the exit of less efficient firms. In this paper, firms engage in oligopolistic competition. With the opening to international trade, the degree of competition in the market for manufactured goods increases. Third, for models of unemployment under oligopoly, Zhou (2015a) examines the choice of technology in an efficiency wage setup. However, Zhou (2015a) is a one-sector model and does not address a country's comparative advantage and the impact of international trade on unemployment. Zhou (2015b) studies the impact of financial and trade integration among developing countries on the level of unemployment. One key difference between Zhou (2015b) and this paper is that the wage rate is exogenously given in Zhou (2015b) while it is endogenously determined in this paper.

The plan of the paper is as follows. Section 2 develops conditions characterizing the equilibrium in a closed economy. Section 3 conducts comparative statics to explore properties of the steady state and addresses factors determining a country's comparative advantage. Section 4 studies the impact of the opening to international trade on the wage rate and the unemployment rate. Section 5 concludes the paper. The Appendix contains proofs of all propositions.

2. Equilibrium in a closed economy

Time is continuous. The endogenous variables are functions of time, but the time notation will be suppressed for convenience. Individuals live forever. The size of the population is L and does not change over time.

There are two types of goods: one agricultural good and a continuum of manufactured goods (Neary, 2003, 2016). The production of the agricultural good uses land only.[2] The amount of land in the economy is T, which is a positive constant. Land is equally owned by all individuals.[3] The production of the agricultural good exhibits constant returns to scale. Without loss of generality, we assume that one unit of land produces one unit of the agricultural good. Thus, the level of output in the agricultural sector is T. Manufactured goods are indexed by a number $\varpi \in [0,1]$, and all manufactured goods have the same production technologies and enter a consumer's utility function in a symmetric way.[4]

2.1. Utility maximization

Individuals are risk neutral. An individual is endowed with one unit of labor. The wage rate is w. An individual's level of consumption of the agricultural good is c_a and that of manufactured good ϖ is $c_m(\varpi)$. The cost of effort for a worker without shirking is e. The subjective discount rate is ρ. For the constant $\alpha \in (0,1)$, a consumer's utility function is specified as

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

$$U(t) = c_a{}^\alpha \int_0^1 c_m(\varpi)^{1-\alpha} d\varpi - se. \tag{1}$$

[2] This specification that the agricultural good is produced by a factor specific to the agricultural sector is similar to the setup in Krugman (1991).

[3] With homothetic preferences assumed in this paper, the distribution of ownership of land will not affect aggregate demand of the agricultural good and manufactured goods.

[4] One difficulty of incorporating oligopolistic competition into a general equilibrium framework is that a firm may have market power not only in the product market, but also market power in the labor market. The purpose of having a continuum of manufactured goods rather than one manufactured good is to eliminate a manufacturing firm's market power in the labor market (Neary, 2003, 2016). With a continuum of manufactured goods, since each good is produced by a small number of firms, a firm has market power in the product market. Since there is an infinite number of firms demanding labor, a firm does not have market power in the labor market.

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 $p_m(\varpi)$. An individual's expenditure is I, which is spent on the agricultural good and manufactured goods: $p_a c_a + \int_0^1 p_m(\varpi) c_m(\varpi) d\varpi = I$.

The unemployment rate is u. If an individual is unemployed, income for this individual is z, and $z \geq 0$. This return can be interpreted as leisure income. Alternatively, it can be interpreted as return from being employed in the informal sector in a developing country. For an individual, the level of income from ownership of land is η. Thus, the level of income is $w + \eta$ if employed, and $z + \eta$ if unemployed.

With the specification of the utility function in (1), utility maximization requires that a consumer spends α percent of income on the agricultural good and $1-\alpha$ percent of income on manufactured goods. Also, a consumer will consume equal amount of all manufactured goods. Thus, the indirect utility function of a consumer can be written as

$$V(I, p_a, p_m, e) = \frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}{p_a^{\alpha} p_m^{1-\alpha}} I - se.$$

If a worker shirks, the probability that shirking is detected is q. The exogenous job separation rate is b. The expected lifetime utility of an employed shirker is V_E^S, and that of an unemployed individual is V_u. Like Shapiro and Stiglitz (1984), the asset equation for a shirker is $\rho V_E^S = U(w+\eta) + (b+q)(V_u - V_E^S)$. This equation shows that a shirker enjoys instant utility of $U(w+\eta)$, the possibility of job separation at each moment is $b+q$, and a change of asset value of $V_u - V_E^S$. Rearrangement of this equation yields

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

The expected lifetime utility of an employed nonshirker is V_E^N. For a nonshirker, the exogenous job separation rate at each moment is b. The asset equation for a nonshirker is $\rho V_E^N = U(w+\eta) - e + b(V_u - V_E^N)$. Rearrangement of this equation yields

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

A worker will choose not to shirk if the value from nonshirking is not smaller than that from shirking: $V_E^N \geq V_E^S$. From equations (2) and (3), the nonshirking condition is

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

When an individual is unemployed, this individual still gets income from owning land. The instant rate for an unemployed individual to find employment is a. The asset equation for an unemployed individual is

$$\rho V_u = U(\eta+z) + a(V_E - V_u). \tag{5}$$

From equations (3) and (5), we get

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

Plugging equation (6) into (4), for a worker not to shirk, the wage rate needs to satisfy the following condition:

$$U(w+\eta) \geq \frac{a[U(w+\eta)-e]+(\rho+b)U(\eta)}{a+b+\rho} + \frac{(\rho+b+q)e}{q}.$$

In equilibrium, the above relationship will hold with equality. Combining the indirect utility function and the above expression, the nonshirking condition becomes

$$\frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}{p_a{}^{\alpha}\, p_m{}^{1-\alpha}}(w-z) = e + \frac{e}{q}\left(\frac{b}{u}+\rho\right). \tag{7}$$

2.2. Profit maximization

Manufactured good ϖ is produced by $m(\varpi)$ identical firms. Firms producing the same manufactured good engage in Cournot competition. For a firm, the level of fixed cost is f units of labor and the level of marginal cost is β units of labor. For a firm with output level x, its revenue is $p_m x$, and its profit is $p_m x - f\,w - \beta\, x\, w$. A firm takes the wage rate as given and chooses its output to maximize its profit. Its optimal choice of output yields $p_m\left(1+\frac{x}{p_m}\frac{\partial p_m}{\partial x}\right) = \beta\, w$. From a consumer's utility maximization, the absolute value of a consumer's elasticity of demand for a manufactured good is one. Combining this result with the condition for a firm's optimal choice of output yields

$$p_m\left(1-\frac{1}{m}\right)=\beta w. \tag{8}$$

2.3. Market clearing conditions

We now establish market clearing conditions, such as clearance of the labor market, and markets for manufactured goods and the agricultural good.

For the labor market, each individual supplies one unit of labor and total supply of labor is L. For manufactured good ϖ, each firm demands $f+\beta x$ units of labor and demand for labor from m firms is $m(\varpi)[f(\varpi)+\beta(\varpi)x(\varpi)]$. Integrating over all manufactured goods, with unemployment rate $u(\varpi)$, the amount of labor is $\int_0^1 \frac{m(\varpi)[f(\varpi)+\beta(\varpi)x(\varpi)]}{1-u(\varpi)}d\varpi$. Equilibrium in the labor market requires

$$\int_0^1 \frac{m(\varpi)[f(\varpi)+\beta(\varpi)x(\varpi)]}{1-u(\varpi)}d\varpi = L. \tag{9}$$

For the market for manufactured goods, since $1-\alpha$ per cent of total income of this economy is spent on manufactured goods and total income is $(1-u)wL+uzL+\eta L$, total demand for manufactured goods is $(1-\alpha)[(1-u)wL+uzL+\eta L]$. The value of total supply of manufactured goods from all firms is $\int_0^1 p_m(\varpi)m(\varpi)x(\varpi)d\varpi$. The clearance of the market for manufactured goods requires

$$(1-\alpha)[(1-u)wL+uzL+\eta L]=\int_0^1 p_m(\varpi)m(\varpi)x(\varpi)d\varpi. \tag{10}$$

For the market for the agricultural good, since α per cent of total income of this economy is spent on the agricultural good and total income is $(1-u)wL+uzL+\eta L$, total demand for the agricultural good is $\alpha[(1-u)wL+uzL+\eta L]$. The value of total supply of the agricultural good is $p_a T$. The clearance of the market for the agricultural good requires

$$\alpha[(1-u)wL+uzL+\eta L]=p_a T. \tag{11}$$

Firms will enter the manufacturing sector until the profit is zero.[5] This condition determines the equilibrium number of firms in the manufacturing sector. Zero profit for a firm requires

$$p_m x - f\, w - \beta\, x\, w = 0\,. \tag{12}$$

In equilibrium, the total amount of revenue received by individuals as owners of land ηL should be equal to total land revenue $p_a T$:

$$\eta L = p_a T\,. \tag{13}$$

In a steady state, all manufactured goods have the same levels of output and price. Since the total measure of manufactured goods is one and all manufactured goods are symmetric, we drop the integration operator for manufactured goods and do not index manufactured goods in a steady state. In a steady state, equations (7)-(13) form a system of seven equations defining a set of seven variables p_a, p_m, x, m, w, η, and u as functions of exogenous parameters. A steady state is a tuple (p_a, p_m, x, m, w, η, u) satisfying equations (7)-(13).[6] For the rest of the paper, a representative manufactured good is used as the numeraire.[7] That is,

$$p_m \equiv 1\,. \tag{14}$$

By using equations (9) and (14), equation (7) becomes

$$\frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}{p_a{}^{\alpha}}(w-z) = e + \frac{e}{q}\left(\frac{b}{u}+\rho\right). \tag{15}$$

3. Comparative statics

In this section, we study properties of the steady state. To achieve this goal, we simplify the system of equations (7)-(13) defining the steady state into a smaller and thus manageable set of equations.

First, equation (8) yields

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[5] For examples of firms engaging in Cournot competition and earning zero profits, see Dasgupta and Stiglitz (1980) and Brander (1995).

[6] When equations (7)-(10) and (12)-(13) are satisfied, equation (11) is always satisfied. That is, one equation is redundant. With Walras's law in mind, this redundancy is not surprising.

[7] The choice of the numeraire will not change the equilibrium values of real variables. The reason that manufactured goods are chosen as numeraire in this paper is for convenience. With this choice, the wage rate is the ratio of the wage rate to the price of manufactured goods. With increasing returns in the manufacturing sector, an increase in the wage rate means an increase in the ratio of the wage rate to the price of manufactured goods. If the agricultural good was used as the numeraire, the wage rate would be the ratio of the wage rate to the price of the agricultural good, and results would be more difficult to interpret.

$$m = \frac{1}{1-\beta w}. \tag{16}$$

Second, equation (12) yields

$$x = \frac{fw}{1-\beta w}. \tag{17}$$

With the above manipulation, the system of equations (7)-(13) is reduced to the following system of three equations defining three endogenous variables u, p_a, and n as functions of exogenous parameters:[8]

$$\Omega_1 \equiv \frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}(w-z)}{p_a{}^{\alpha}} - \frac{e}{q}\left(\frac{b}{u}+\rho\right) = 0, \tag{18a}$$

$$\Omega_2 \equiv L - \frac{f}{(1-u)(1-\beta w)^2} = 0, \tag{18b}$$

$$\Omega_3 = p_a T(1-\alpha)(1-\beta w)^2 - \alpha f w = 0. \tag{18c}$$

Equation (18a) is the condition for a worker to exert effort. This equation is inherited from the Shapiro-Stiglitz model. Equation (18b) is the labor market equilibrium condition. Equation (18c) comes from the goods market clearing conditions. Partial differentiation of equations (18a)-(18c) with respect to u, p_a, n, T, ρ, b, e, L, and q yields

$$\begin{pmatrix} \frac{\partial\Omega_1}{\partial p_a} & \frac{\partial\Omega_1}{\partial u} & \frac{\partial\Omega_1}{\partial w} \\ 0 & \frac{\partial\Omega_2}{\partial u} & \frac{\partial\Omega_2}{\partial w} \\ \frac{\partial\Omega_3}{\partial p_a} & 0 & \frac{\partial\Omega_3}{\partial w} \end{pmatrix} \begin{pmatrix} dp_a \\ du \\ dw \end{pmatrix} = -\begin{pmatrix} 0 \\ \frac{\partial\Omega_2}{\partial L} \\ 0 \end{pmatrix} dL - \begin{pmatrix} 0 \\ 0 \\ \frac{\partial\Omega_3}{\partial T} \end{pmatrix} dT$$

$$-\begin{pmatrix} \frac{\partial\Omega_1}{\partial\rho} \\ 0 \\ 0 \end{pmatrix} d\rho - \begin{pmatrix} \frac{\partial\Omega_1}{\partial b} \\ 0 \\ 0 \end{pmatrix} db - \begin{pmatrix} \frac{\partial\Omega_1}{\partial e} \\ 0 \\ 0 \end{pmatrix} de - \begin{pmatrix} \frac{\partial\Omega_1}{\partial q} \\ 0 \\ 0 \end{pmatrix} dq. \tag{19}$$

[8] Equations (18a)-(18c) is derived as follows. First, equation (18a) is derived from equation (15). Second, equation (18b) is derived by plugging the value of m from equation (16) and the value of x from equation (17) into equation (9). Third, dividing equation (10) by equation (11), then plugging the value of m from equation (16) and the value of x from equation (17) into the resulting equation yields equation (18c).

Let Δ denote the determinant of the coefficient matrix of endogenous variables of the system (19). Stability requires $\Delta < 0$.[9]

The following proposition studies the impact of an increase in population.

Proposition 1: An increase in population leads to a higher wage rate and a higher price of the agricultural good. Also, the number of firms and the size of a firm increase. Impact of population growth on unemployment rate is ambiguous. However, if the percentage of income spent on the agricultural good is sufficiently low, unemployment rate decreases with population size.

The intuition behind Proposition 1 is as follows. First, an increase in population leads to a higher level of demand for manufactured goods. To satisfy this higher level of demand, the number of manufacturing firms increases. This leads to a lower level of markup of price over marginal cost and each firm produces more to break even. With the existence of fixed costs, there are increasing returns in the manufacturing sector. A higher level of output leads to a lower average cost. Since firms earn profits of zero, a lower average cost is shown as an increase in the real wage rate. Second, an increase in population increases the supply of the manufactured good but does not change the supply of the agricultural good, thus the price of the agricultural good increases.

Third, when the size of the population increases, there are two effects on the unemployment rate. On the one hand, since there are more firms producing a higher level of output, demand for labor also increases and this tends to reduce the unemployment rate. This reflects increasing returns in the manufacturing sector. On the other hand, an increase in population does not change the level of agricultural output because the agricultural good is produced by land. This reflects the "bottleneck" nature of the agricultural sector. Population growth causes the price of the agricultural good to increase. When the price of the agricultural good increases, other things equal, the benefit of exerting effort decreases. To make sure that the non-shirking condition (15) remain valid, unemployment rate tends to increase. In general, without imposing additional structure, it is not clear which effect dominates and thus the impact of population growth on the unemployment rate is ambiguous. In the special case that the

[9] Samuelson (1983, chap. 9) provides a justification of this kind of assumption.

percentage of income spent on the agricultural good is zero, the second effect disappears and the unemployment rate decreases with population. When the percentage of income spent on the agricultural good is sufficiently low, the first effect still dominates and unemployment rate decreases with population size. When the percentage of income spent on the agricultural good is sufficiently high, the second effect may dominate and unemployment rate increases with population size.

The following proposition studies the impact of an increase in land endowment.

Proposition 2: An increase in land endowment leads to an increase in the wage rate and a decrease in the unemployment rate. Also, the number of firms and the size of a firm increase.

The intuition behind Proposition 2 is as follows. With an increase in the amount of land, the value of output in the agricultural sector increases. With a homothetic demand, the ratio between the total value of the agricultural good and that of manufactured goods is a constant. When the total value of agricultural output increases, the total value of output in the manufacturing sector also increases. Since the price of manufactured goods is normalized to one, a higher value of manufactured goods indicates a higher level of output. To produce a higher level of output, there is a decrease in the unemployment rate in the manufacturing sector.

Like the proof of Proposition 2, it can be shown that the impact of an increase in land endowment on the price of the agricultural good is ambiguous. The reasoning is as follows. While an increase in the amount of land increases the supply of the agricultural good, from Proposition 2, the level of output in the manufacturing sector increases and the demand for the agricultural good increases. Overall, the impact on the price of the agricultural good is ambiguous.

An increase in the probability that shirking is detected indicates an increase in the level of efficiencies in the labor market. The following proposition studies the impact of a change in labor market efficiencies through an increase in q.

Proposition 3: An increase in the probability that shirking is detected decreases the unemployment rate, and increases the price of the agricultural good and the wage rate.

The intuition behind Proposition 3 is as follows. When there is an increase in the probability that shirking is detected, the punishment for shirking increases.[10] The unemployment rate declines to decrease the punishment for shirking, so that the condition for workers to exert effort continues to hold. A decline in the unemployment rate is associated with an increase in the number of employed workers. With increasing returns in the manufacturing sector, the wage rate increases. An increase in the number of employed workers is associated with an increase in the value of manufactured goods. Since the ratio of the total value of manufactured goods and that of the agricultural good is fixed, with a fixed amount of land, the price of the agricultural good increases.

Like the proof of Proposition 3, it can be shown that the impact of a change in the exogenous job separation rate b, the cost of exerting effort e, and the discount rate ρ is the opposite of that of a change in q. The intuition behind the impact of an increase in b, e, and ρ can also be understood through the non-shirking condition.

A country's comparative advantage in producing manufactured goods is measured by the price ratio between manufactured goods and the agricultural good. Since in this model the price of manufactured goods is normalized to one, a country's comparative advantage is measured by the price of the agricultural good. The higher the price of the agricultural good, then the higher a country's comparative advantage in producing manufactured goods. From Propositions 1 and 3, a country's comparative advantage in producing manufactured goods increases with the size of the population and the probability that shirking is detected. First, with increasing returns in the manufacturing sector, it is understandable that an increase in population increases a country's comparative advantage in the producing manufactured goods. Second, suppose the probability that shirking is detected increases. From equation (18a), it causes a country's comparative advantage to change shown by an increase in the price of the agricultural good through the following mechanism. When the probability that shirking is detected increases, through the nonshirking condition, less utility is needed to ensure that a worker exerts effort. This is consistent with an increase in the price of the agricultural good: when the price of the agricultural

[10] In this model, workers employed in the manufacturing sector always choose to exert effort in equilibrium. Also, the level of effort of a worker is fixed. Thus, an increase in the probability that shirking is detected does not mean an increase in worker productivity or firm productivity. When there is an increase in the probability that shirking is detected, a worker's incentive to exert effort is maintained by an increase in the unemployment rate through the non-shirking condition, even though the wage rate does not change.

good increases, for the same level of income, the utility from working is lower. Thus, an increase in the probability that shirking is detected increases a country's comparative advantage in producing manufactured goods. The impact of a change in the exogenous job separation rate, the cost of exerting effort, and the discount rate on a country's comparative advantage can also be understood through the nonshirking condition.

4. Impact of international trade

In this section, we study impact of the opening to international trade on the wage rate and unemployment. Variables associated with the foreign country carry an asterisk mark. The foreign country has the same fixed and marginal costs in producing manufactured goods and the same technology in producing the agricultural good. However, endowments of labor and land and parameters measuring labor market efficiencies in the foreign country may be different from those in the home country. Markets for manufactured goods in the two countries are integrated. We assume that there is no transportation cost for goods among countries.[11] Thus, the opening of international trade will lead to equal prices of goods between countries.[12]

With the opening to international trade, equations (9), (12), (13), and (15) remain valid. In addition, the following conditions need to hold. First, labor market equilibrium in the foreign country requires

$$\int_0^1 \frac{m^*(\varpi)[f(\varpi)+\beta(\varpi)\,x^*(\varpi)]}{1-u^*(\varpi)}\,d\varpi = L^*. \tag{9*}$$

Second, zero profit for a foreign firm requires

$$p_m x^* - f\,w^* - \beta\,x^*\,w^* = 0. \tag{12*}$$

Third, in the foreign country, the total amount of revenue received by individuals as owners of land ηL^* should be equal to land revenue $p_a T^*$:

$$\eta L^* = p_a T^*. \tag{13*}$$

Fourth, nonshirking condition in the foreign country requires

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[11] Transport costs are important when markets for manufactured goods in different countries are segmented after the opening of international trade such as Horstmann and Markusen (1992). In this model, markets in different countries are integrated. Like a typical Heckscher-Ohlin model, we assume there is no transport cost.

[12] The result in Proposition 4 depends on the equalization of prices of manufactured goods. With strictly positive trade costs, like the Heckscher-Ohlin model, the opening of international trade will reduce the difference of factor returns between countries rather than leads to an equalization of factor returns.

$$\frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}{p_a{}^{\alpha}}(w^*-z^*)=e^*+\frac{e^*}{q^*}\left(\frac{b^*}{u^*}+\rho^*\right). \tag{15*}$$

Fifth, with the opening to international trade, instead of equation (8), a domestic manufacturing firm's optimal choice of output yields

$$1-\frac{x}{mx+m^*x^*}=\beta w. \tag{20}$$

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

$$1-\frac{x^*}{mx+m^*x^*}=\beta w^*. \tag{20*}$$

Finally, with a homothetic utility function, the ratio between spending on manufactured goods and the agricultural good is $(1-\alpha)/\alpha$. The clearance of the markets for manufactured goods and the agricultural good for the world requires

$$\frac{\alpha}{1-\alpha}=\frac{p_a(T+T^*)}{mx+m^*x^*}. \tag{21}$$

Equations (9), (9*), (12), (12*), (13), (13*), (15), (15*), (20), (20*), and (21) form a system of 11 equations defining a system of 11 variables p_a, x, x^*, m, m^*, w, w^*, η, η^*, u, and u^* as functions of exogenous parameters. An equilibrium with international trade is a tuple (p_a, x, x^*, m, m^*, w, w^*, η, η^*, u, u^*) satisfying this set of equations.

With the opening of international trade, the following proposition establishes the equalization of the wage rate between the two countries even though countries differ in factor endowments and labor market efficiencies.

Proposition 4: The opening to international trade leads to the equalization of the wage rate between the two countries. The two countries will also have equal firm size in the manufacturing sector.

The equalization of the wage rate in Proposition 4 is like the equalization of factor returns in a standard Heckscher-Ohlin model. In a Heckscher-Ohlin model, there is a one-to-one relationship between relative factor return and relative price of final goods if countries have the same production technologies. Thus, equalization of the relative price of final goods from the opening to international trade leads to an equalization of relative factor return. In this model, countries also have the same production technologies. To understand Proposition 4, from equations (20) and (20*), the wage rate is affected by the level of output of a manufacturing firm and the price of manufactured goods. From equations (12) and (12*), the level of output of a manufacturing firm is a function of the wage rate. Thus, the wage rate is a function of the price of manufactured goods. Since the opening of international trade leads to an equalization of the price of manufactured goods in the two countries, the wage rates in the two countries will also equal.

From equations (15) and (15*), though the opening of international trade leads to equal wage rate, the unemployment rate in the two countries will be different if they differ in labor market efficiencies. The country with a less efficient labor market has a higher unemployment rate.

The impact of the opening to international trade on unemployment rate is ambiguous even though countries differ only in labor and land endowments. The reasoning is as follows. In a closed economy, the impact of an increase in population on unemployment rate is ambiguous. The opening to international trade includes but is not limited to the effect of an increase in population. Thus, the opening to international trade has an ambiguous effect on each country's unemployment rate. If countries differ only in labor and land endowments and the percentage of income spent on the agricultural good is sufficiently low, the opening to international trade will lead to a decrease in the unemployment rate in both countries.

We now study properties of the equilibrium with international trade. Plugging the value of m from equation (9), the value of $m*$ from equation (9*), the value of x from equation (12), and the value of $x*$ from equation (12*) into equation (21) yields

$$\frac{1-\alpha}{\alpha}=\frac{Lw(1-u)+L*w*(1-u*)}{p_a(T+T*)}. \tag{22}$$

From the system of equations defining the equilibrium with international trade, we can derive the following system of two equations defining two variables w and p_a as functions of exogenous parameters:[13]

[13] Equations (23a) and (23b) are derived as follows. First, plugging the value of u from equation (15) and the value of $u*$ from equation (15*) into equation (22) yields equation (23a). Second, plugging the value of m from equation (9), the value of $m*$ from equation (9*), the value of x from equation (12), the value of $x*$ from equation (12*), and the value of $Lw(1-u)+L*W*(1-u*)$ from equation (22) into equation (20) yields equation (23b).

$$\Phi_1 \equiv p_a(1-\alpha)(T+T^*)-\alpha w(L+L^*)$$

$$+\frac{\alpha wbL}{\dfrac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}(w-z)q}{e(p_a)^{\alpha}}-q-\rho}+\frac{\alpha wb^*L^*}{\dfrac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}(w-z)q^*}{e^*(p_a)^{\alpha}}-q^*-\rho^*}=0\,, \qquad (23a)$$

$$\Phi_2 \equiv \alpha fw - p_a(1-\alpha)(1-\beta w)^2(T+T^*)=0\,. \qquad (23b)$$

The following proposition studies the impact of international trade on the wage rate if countries have the same level of labor market efficiencies.

Proposition 5: If countries have the same level of labor market efficiencies but differ in their endowments of labor and land, then the opening to international trade leads to an increase in the wage rate in both countries.

The result in Proposition 5 that the real wage rate increases with the opening to international trade is like that in Venables (1985) in which firms also engage in Cournot competition. In his model, markets for manufactured goods in different countries are segmented and there is no unemployment. In this model, we show that this beneficial effect of international trade remains valid with the existence of unemployment. With the opening of international trade, an increase in the number of firms reduces a firm's price as a markup over marginal cost. To break even, a firm produces more to cover fixed costs of production. With a higher level of output, average cost decreases. Since firms earn profits of zero, average cost is equal to price. With the price of a manufactured good normalized to one, a reduction in price is shown as an increase in the wage rate. Thus, the real wage rate is higher with the opening of international trade.

An inspection of (23a) and (23b) reveals that parameters related to the home country and those related to the foreign country affect the wage rate in a similar way. Like the proofs of Propositions 1 and 2, it can be shown that the wage rate and the price of the agricultural good increase with foreign population and the probability that shirking is detected, and decreases with the job separation rate in the foreign country.

5. Conclusion

In this paper, we have studied how the opening of international trade affects unemployment in a general equilibrium model in which manufacturing firms engage in oligopolistic competition. Increases in labor market efficiencies increase a country's comparative advantage in producing manufactured goods. The opening of international trade leads to the equalization of wage rates even though countries differ in factor endowments and labor market efficiencies. The opening to international trade leads to an increase in the wage rate in both countries if countries differ only in their endowments of labor and land.

There are various generalizations and extensions of the model. First, with the existence of unemployment and market power of firms, one interesting extension of the model is to study the impact of different government policies on social welfare. Second, while the analysis could become much more complicated, it will be interesting to introduce labor as a factor of production in the agricultural sector.

Appendix

Proof of Proposition 1:

An application of Cramer's rule to the system (19) yields

$$\frac{dw}{dL} = -\frac{\partial \Omega_1}{\partial u}\frac{\partial \Omega_2}{\partial L}\frac{\partial \Omega_3}{\partial p_a} / \Delta > 0 ,$$

$$\frac{dp_a}{dL} = \frac{\partial \Omega_1}{\partial u}\frac{\partial \Omega_2}{\partial L}\frac{\partial \Omega_3}{\partial w} / \Delta > 0 ,$$

$$\frac{du}{dL} = \frac{\partial \Omega_2}{\partial L}\left(\frac{\partial \Omega_1}{\partial w}\frac{\partial \Omega_3}{\partial p_a} - \frac{\partial \Omega_1}{\partial p_a}\frac{\partial \Omega_3}{\partial w}\right) / \Delta .$$

From equation (16), since the wage rate increases, the number of firms increases. From equation (17), the size of a firm increases.

Partial differentiation of equations (18a) and (18c) yields

$$\frac{\partial \Omega_1}{\partial w}\frac{\partial \Omega_3}{\partial p_a} - \frac{\partial \Omega_1}{\partial p_a}\frac{\partial \Omega_3}{\partial w} = \frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}{(p_a)^{\alpha}}\left\{T(1-\alpha)(1-\beta w)[1-\beta w - 2\alpha\beta(w-z)] - \frac{\alpha^2 f(w-z)}{p_a}\right\}.$$

In general, the sign of $\frac{\partial \Omega_1}{\partial w}\frac{\partial \Omega_3}{\partial p_a} - \frac{\partial \Omega_1}{\partial p_a}\frac{\partial \Omega_3}{\partial w}$ is ambiguous. However, if α is sufficiently small, $\frac{\partial \Omega_1}{\partial w}\frac{\partial \Omega_3}{\partial p_a} - \frac{\partial \Omega_1}{\partial p_a}\frac{\partial \Omega_3}{\partial w} > 0$. In this case, $\frac{du}{dL} < 0$. In the extreme case that $\alpha = 0$, from equations (18a) and (18b), the following equations are valid in the steady state without international trade:

$$w - z - \frac{e}{q}\left(\frac{b}{u} + \rho\right) = 0, \tag{A1}$$

$$L - \frac{f}{(1-u)(1-\beta w)^2} = 0. \tag{A2}$$

Equations (A1) and (A2) form a system of two equations defining w and u as functions of exogenous parameters. Like the proof of Proposition 1, partial differentiation of the two equations and an application of Cramer's rule yields $\frac{du}{dL} < 0$. ■

Proof of Proposition 2:

An application of Cramer's rule to the system (19) yields

$$\frac{dw}{dT} = -\frac{\partial \Omega_1}{\partial p_a}\frac{\partial \Omega_2}{\partial u}\frac{\partial \Omega_3}{\partial T} / \Delta > 0,$$

$$\frac{du}{dT} = \frac{\partial \Omega_1}{\partial p_a}\frac{\partial \Omega_2}{\partial w}\frac{\partial \Omega_3}{\partial T} / \Delta < 0.$$

From equation (16), since the wage rate increases, the number of firms increases. From equation (17), the size of a firm increases. ■

Proof of Proposition 3:

An application of Cramer's rule to the system (19) yields

$$\frac{du}{dq} = -\frac{\partial \Omega_1}{\partial e}\frac{\partial \Omega_2}{\partial w}\frac{\partial \Omega_3}{\partial p_a} / \Delta < 0,$$

$$\frac{dp_a}{dq} = -\frac{\partial \Omega_1}{\partial q}\frac{\partial \Omega_2}{\partial u}\frac{\partial \Omega_3}{\partial w} / \Delta > 0,$$

$$\frac{dw}{dq} = \frac{\partial \Omega_1}{\partial q}\frac{\partial \Omega_2}{\partial u}\frac{\partial \Omega_3}{\partial p_a} / \Delta > 0. \text{ ■}$$

Proof of Proposition 4:

Plugging the value of x from (12) and the value of x^* from (12*) into equations (20) and (20*) yields $\frac{(1-\beta w)^2}{(1-\beta w^*)^2} - \frac{w}{w^*} = 0$. There are two solutions to this equation. One solution is $ww^* = \frac{1}{\beta^2}$. From (20) and (20*), since $\frac{x}{mx + m^* x^*} > 0$ and $\frac{x^*}{mx + m^* x^*} > 0$, we have $1 > \left(1 - \frac{x}{mx + m^* x^*}\right)\left(1 - \frac{x^*}{mx + m^* x^*}\right) = \beta^2 ww^*$. If $ww^* = \frac{1}{\beta^2}$, then $1 > \beta^2 ww^* = 1$. Thus, this solution leads to a contradiction and is discarded. The other solution $w = w^*$ is kept.

From equations (20) and (20*), if $w = w^*$, then $x = x^*$. ■

Proof of Proposition 5:

For a closed economy, the system of equations (18a)-(18c) can be reduced to the following system of two equations:

$$p_a T(1-\alpha) - \alpha wL + \frac{\alpha wbL}{\frac{\alpha^\alpha (1-\alpha)^{1-\alpha}(w-z)q}{e(p_a)^\alpha} - q - \rho} = 0, \tag{A3}$$

$$\alpha fw - p_a T(1-\alpha)(1-\beta w)^2 = 0. \tag{A4}$$

A comparison of equations (23a)-(23b) and equations (A3) and (A4) reveals that the opening to international trade can be captured by an increase in labor and land if countries have the same level of labor market efficiencies. From Propositions 1 and 2, since either an increase in labor or land will increase the wage rate, the opening to international trade leads to an increase in the wage rate in both countries. ■

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