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ENTREPRENEURIAL SELECTION, FINANCIAL MARKETS, AND PATTERNS OF INTERNATIONAL TRADE

BIN XU*

University of Florida

This paper introduces entrepreneurial selection and imperfect financial markets to the 2x2x2 model of international trade. Entrepreneurs are heterogeneous in ability and borrow from banks who do not observe their ability. The pattern of international trade depends on (1) factor abundance, (2) endogenously determined productivity, and (3) endogenously determined financial market imperfections. We show that entrepreneurial selection results in a diminished Rybczynski effect and financial market imperfections further reduce the effect; hence differences in capital abundance imply a smaller trade volume than predicted by the Heckscher-Ohlin theorem. The results help to resolve a conflict between the Heckscher-Ohlin model and data. [F11]

1. INTRODUCTION

The conflict between data and the Heckscher-Ohlin prediction of trade patterns has been well known since Leontief (1953). Recent studies by Trefler (1993, 1995) find that the computed factor content of net exports is much smaller than what is predicted by factor abundance, a so-called "missing trade" phenomenon. Trefler shows that a great proportion of this "missing trade" can be explained by productivity differences.[1] Other recent studies find similar results.[2]

The empirical findings present a theoretical challenge. In particular, they call for a modification of the HO model to account for productivity differences. There are various sources of productivity differences, however. In this paper we endogenize productivity differences by introducing entrepreneurial selection and imperfect financial markets to the 2x2x2 model of international trade.

The HO model assumes identical productivity and perfect financial markets. In this paper, we consider individuals with different entrepreneurial ability who

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[1]Trefler's other explanation is a home bias in demand.

[2]See Helpman (1999) for a survey of other recent studies.

choose between being entrepreneurs and being workers. Moreover, we assume that entrepreneurs must borrow from banks to produce the capital-intensive good, but banks do not observe their ability; this informational asymmetry leads to an adverse selection problem in financial intermediation. Thus, our model adds two dimensions to the HO model. First, the productivity of the capital-intensive sector is endogenously determined as a result of entrepreneurial selection; the higher the ability threshold for entrepreneurial entry, the higher the average productivity of entrepreneurs producing the capital-intensive good. Second, factor prices and factor intensities are affected by financial market imperfections whose degree is inversely related to the self-finance capacity of entrepreneurs; the lower the amount of capital invested by entrepreneurs themselves, the higher the incentive of adverse selection, and the larger the effects of financial market imperfections on factor prices and factor intensities.

Our extension of the HO model is related to two strands of literature. In the literature on entrepreneurial selection and international trade, Bond (1986) modified the HO model by introducing entrepreneurial ability as an additional production factor. He found that with heterogeneous entrepreneurs several modifications are necessary in the traditional results of the HO model. In the literature on imperfect financial markets and international trade, Kletzer and Bardhan (1987) showed asymmetric information in financial markets as a determinant of international trade patterns, and Gertler and Rogoff (1990) analyzed asymmetric information in financial markets as a determinant of international investment patterns. In this paper, we follow Bond (1986) to consider the role of entrepreneurial selection and follow Kletzer and Bardhan (1987) and Gertler and Rogoff (1990) to consider the role of imperfect financial markets in determining the patterns of international trade and investment. It is worth noting that our analysis abstracts from the risk-sharing function of financial markets. Helpman and Razin (1978: Ch. 7), Anderson (1981), and Grinols (1987: Ch. 4), among others, have explicitly modeled risk-sharing and trade in risk and reinterpreted the basic results of the HO model.

To preview our main results, we find that differences in capital abundance imply a smaller trade volume than what is predicted by the HO theorem. In our model, comparative advantage has three sources: (1) differences in factor abundance, (2) differences in the productivity of the capital-intensive sector caused by entrepreneurial selection, and (3) differences in financial market imperfections. Furthermore, the second and third sources depend endogenously on the first source. We show that if a country is capital-abundant, then the ability threshold for entrepreneurial entry is lower, and consequently the average productivity of the capital-intensive sector is lower; this endogenous productivity effect offsets the comparative advantage based on factor endowments. We further show that if a country is capital-abundant, then entrepreneurs have higher self-finance capacity, and consequently the adverse selection incentive is smaller; this endogenous financial market imperfection effect also offsets (and may even reverse) the comparative advantage based on factor endowments. These endogenous effects of capital abundance on productivity and financial market imperfections, which are not present in the HO model, help explain the "missing trade" phenomenon.

We also investigate the relationship between commodity and factor prices. In our model, factor prices depend not only on commodity prices, but also on the domestic supply of capital. Factor price equalization is a key property of the HO model. Leamer and Levinsohn (1995) argue that a more accurate interpretation of this property is the factor price insensitivity theorem, which states that factor prices are insensitive to factor supplies at fixed commodity prices. They indicate that the approach Trefler (1993, 1995) uses to introduce technology differences to the HO model rejects the factor price equalization theorem but not the factor price insensitivity theorem. There is strong evidence, however, that factor prices depend significantly on factor supplies at constant commodity prices. Our model yields implications consistent with this empirical evidence.

We also use the model to examine international capital movements. In the HO model, international commodity trade and international capital movements are perfect "substitutes" (Mundell, 1957). In the present model, however, international commodity trade does not substitute for international capital movements because factor prices are not equalized. We find that when financial market imperfections respond inelastically to the self-finance capacity of entrepreneurs, the rate of return to capital is lower in the capital-abundant country than in the labor-abundant country; consequently, capital flows from the former to the latter. However, when financial market imperfections respond elastically to the self-finance capacity of entrepreneurs, capital may flow from the labor-abundant country to the capital-abundant country, a phenomenon studied by Lucas (1990).[3] We find that international capital movements do not eliminate the incentive for international commodity trade. While perfect international capital mobility equalizes rates of return to capital, it does not equalize self-finance capacity of entrepreneurs across countries.

The remainder of the paper is organized as follows. Section 2 introduces entrepreneurial selection and imperfect financial markets to the 2x2x2 model of international trade. Section 3 derives the international trade equilibrium, examines the properties of the equilibrium, and links model implications with empirical observations. Section 4 concludes.

[3]Lucas (1990) provides four possible explanations for this pattern of international capital movements, one of which is financial market imperfections. Gertler and Rogoff (1990) develop a model in which patterns of international capital movements depend on endogenously determined financial market imperfections driven by moral hazard, where capital flowing from poor to rich countries is a possible pattern.

2. THE MODEL

A. Production

Consider a country with a continuum of individuals indexed by $i \in [0,1]$. For simplicity, we assume that factor endowments are distributed evenly in the population; each individual is endowed with one unit of labor and k units of capital. Labor (L) and capital (K) are used to produce two goods, X and Y. The two goods differ in capital intensity; good X is assumed to be more capital-intensive than good Y at any relative factor price ratio. Let good Y be the numéraire. Denote p as the price of good X.

In the capital-intensive X sector, each entrepreneur undertakes one project to which the outcome is uncertain. Entrepreneurial ability (denoted by q) is distributed in the population according to the distribution function $F(.)$ over the interval [0,1]. To undertake a project, entrepreneur i uses one unit of labor and k_x^i units of capital. If the project is successful, the outcome is $x(k_x^i)$; if the project fails, the outcome is zero. We assume that the probability of success equals the entrepreneur's ability index $q^i \in [0,1]$. The expected output of entrepreneur i is given by

$$x^i = q^i x(k_x^i), \quad x' > 0, \; x'' < 0. \tag{1}$$

For simplicity, we assume that project risks are idiosyncratic. Thus, when a large number of projects are undertaken, the aggregate output of good X is deterministic.

We assume no uncertainty in the production of the labor-intensive good Y.[4] A producer in this sector can use one unit of labor and k_y units of capital to obtain y units of good Y. The output of good Y per unit of labor is given by

$$y = y(k_y), \qquad y' > 0, \quad y'' < 0. \tag{2}$$

Let r and w be the market rates of return to capital and labor, respectively. Profit maximization in the Y sector implies

$$y'(k_y) = r, \tag{3}$$

[4]This assumption is not essential because projects in sector Y are entirely self-financed (see below). Even if Y production were risky, there would be no need for financial intermediation and no adverse selection problem in the Y sector.

$$y(k_y) - y'(k_y)\, k_y = w. \tag{4}$$

B. Financial Markets and Entrepreneurial Selection

An entrepreneur must borrow from financial markets if her capital endowments are not enough for undertaking a project. It can be verified that $k_y < k$ (see below); hence entrepreneurs in the labor-intensive sector do not need external funds. For entrepreneur i in the capital-intensive sector, if $k_x^i > k$, then she must borrow $b^i = k_x^i - k$ in order to undertake her project. We assume that capital is intermediated by banks, which receive deposits of capital endowments and make loans. Given that the market rate of return to capital is r, banks offer r as the deposit rate. Denote R as the gross loan repayment rate. When the project of entrepreneur i is successful, she repays b^iR; when the project fails, limited liability allows her to default on the loan.

An informational asymmetry exists between banks and borrowers. We assume that borrowers know their own success probability q^i but banks do not.[5] We further assume that banks observe k (capital endowments) and require a borrower to commit all k in her project as collateral; this restriction eliminates the possibility that banks screen borrowers by altering the amount of collateral across contracts.[6] As a result, loan terms are set according to $\bar{q}$, the average success probability of the entrepreneur pool. Banks, which are risk neutral, maximize the expected return per unit of loan, $\bar{q}R$, net of the cost of funds, r. Competition among banks implies a zero-profit condition,

$$\bar{q}R = r. \tag{5}$$

Equation (5) implies that individuals with different success probabilities face the same loan repayment rate R in the asymmetric-information equilibrium.

Banks also choose the loan size k_x^i. Since banks can obtain $y'(k_y)$ as the marginal rate of return from investment in the Y sector, they expect the same marginal rate of return from investment in any project in the X sector. Therefore, we have

$$p\,\bar{q}x'(k_x^i) = y'(k_y). \tag{6}$$

[5]We assume that it is too costly for banks to verify individual q^i.

[6]If banks allow the self-finance amount of a borrower to differ from her capital endowments, then there will be a menu of possible contracts. We do not pursue this generalization because it would significantly complicate the model without adding new insights.

Equation (6) implies that $k_x^i = k_x$ for all i; hence $b^i = b$ for all i.[7] Since each entrepreneur uses one unit of labor and k_x units of capital, the capital intensity of the X sector is k_x.

Given the loan terms, individuals decide between being entrepreneurs in the X sector and being workers in the Y sector. All individuals are risk-neutral. Individual i chooses to be an entrepreneur if the expected return from her project, $p^i = q^i\{px(k_x) - bR\}$, exceeds the opportunity costs of the labor and capital she commits in the project, $w + rk$. If both goods are produced in equilibrium as we assume, there exists a marginal entrepreneur with $\hat{q} \in [0, 1]$ who is indifferent between being an entrepreneur and being a worker,

$$\hat{q}\left\{px(k_x) - (k_x - k)R\right\} = w + rk. \tag{7}$$

The value $\hat{q}$ defines an entry threshold for entrepreneurial selection; individuals with $q \geq \hat{q}$ choose to be entrepreneurs.[8] The average success probability of the entrepreneur pool is given by

$$\bar{q} = \frac{\int_{\hat{q}}^{1} q dF(q)}{1 - F(\hat{q})}. \tag{8}$$

Equation (8) implies that $d\bar{q}/d\hat{q} > 0$, i.e., the higher the success probability of the marginal entrepreneur, the higher the average success probability of the entrepreneur pool.[9]

To see the nature of entrepreneurial selection and financial market imperfections in the asymmetric-information equilibrium, it is useful to establish the following partial equilibrium result (see Appendix for proof):

LEMMA 1. *$d\hat{q}/dk > 0, dR/dk < 0$, and $dk_x/dk > 0$ at given p, r, and w.*

Lemma 1 shows that entrepreneurial selection and loan terms depend on k, the self-finance capacity of entrepreneurs. This is a distinctive feature of imperfect financial markets with asymmetric information. If financial markets were perfect, then the selection of entrepreneurs would depend only on their ability and would

[7] Given the assumptions of the model, b would be the loan amount chosen by borrowers if they could borrow as much as they want at the repayment rate R.

[8] The expected return from being an entrepreneur rises with q provided that p is sufficiently high.

[9] $d\bar{q}/d\hat{q} = [\,F'(\hat{q}) \int_{\hat{q}}^{1} (q - \hat{q})dF(q)]\,/(1 - F(\hat{q}))^2 > 0.$

be independent of their self-finance capacity. When banks do not observe entrepreneurial ability, however, they have to set loan terms according to the average ability of entrepreneurs, which implies that low-ability entrepreneurs can obtain loan rates below what they would pay under perfect information. As a result, some low-ability entrepreneurs are adversely selected to receive loans in the asymmetric-information equilibrium. However, the incentive of adverse selection is smaller when entrepreneurs self-finance a larger amount. Therefore, when k is larger, entrepreneurial selection is characterized by a higher entry threshold $\hat{q}$. Since a higher $\hat{q}$ implies a higher success probability of the entrepreneur pool, banks offer a lower loan rate R and a larger loan amount k_x.

C. General Equilibrium in a Small Country

The partial equilibrium analysis of entrepreneurial selection neglects the general equilibrium effects induced by changes in p, r, and w. In this subsection, we proceed with a general equilibrium analysis of a small country that opens to international trade but not to international factor movements. Thus, p is determined in the world market, while r and w are determined in domestic markets. We assume full employment so that $L_x + L_y = L$ and $K_x + K_y = K$. These two conditions imply

$$(1 - l)\, k_x + l\, k_y = k, \tag{9}$$

where l L_y/L. Since a fraction $F(\hat{q})$ of the population becomes workers,

$$l = F(\hat{q}). \tag{10}$$

It is useful to point out that equation (9) implies $k_y < k < k_x$. We can rewrite equation (9) as $(1 - l)(k_x - k) + l(k_y - k) = 0$, which shows equilibrium in the loanable fund market, i.e., total savings by workers equal total loans to entrepreneurs.

Equations (1)-(10) characterize the general equilibrium in a small country. The 10 equations determine 10 endogenous variables: x^i, y, k_x, k_y, w, r, R, $\bar{q}, \hat{q}$, and l.

To solve the model, we substitute (3), (5), and (6) into (7) to obtain

$$p\hat{q}\{x(k_x) - x'(k_x)\, k_x - (\bar{q}/\hat{q} - 1)x'(k_x)\, k\} = w. \tag{11}$$

Equation (11) shows that the expected marginal return to the labor employed in the marginal project, $p\hat{q}\{x(k_x) - x'(k_x)k_x\}$, is higher than the wage rate. The reason is that the investment size k_x is smaller than the efficient level due to asymmetric information. Using (11) together with (3), (4), and (6), we obtain

$$q \equiv \frac{r}{w} = \frac{(\overline{q}/\hat{q})x'(k_x)}{x(k_x) - x'(k_x)k_x - (\overline{q}/\hat{q} - 1)x'(k_x)k} = \frac{y'(k_x)}{y(k_y) - y'(k_y)k_y}. \tag{12}$$

Totally differentiating (12), using $d(\overline{q}/\hat{q})\ /d\hat{q} < 0$,[10] we obtain

$$k_x = k_x(q, \hat{q}, k), \qquad \partial k_x/\partial q < 0,\ \ \partial k_x/\partial \hat{q} < 0,\ \ \partial k_x/\partial k > 0, \tag{13}$$

$$k_y = k_y(q), \quad k_y'(q) < 0. \tag{14}$$

Equations (13) and (14) show that capital intensities of both sectors depend inversely on the relative price of capital, reflecting the usual factor substitution effect. Equation (13) shows, however, that the capital intensity of the X sector depends also on $\hat{q}$ and k. The dependence of k_x on $\hat{q}$ reflects entrepreneurial selection. As the selection threshold $\hat{q}$ rises, both the marginal return to labor and the marginal return to capital in sector X rise, but the former rises faster than the latter (an implication of $d(\overline{q}/\hat{q})\ / d\hat{q} < 0$), causing q to fall; to keep q constant, k_x must decrease; this explains $\partial k_x/\partial \hat{q} < 0$. The dependence of k_x on k reflects financial market imperfections. As Lemma 1 indicates, higher self-finance capacity k implies a higher loan amount k_x.

Applying (13) and (14) to (6), we have

$$p\overline{q} = \frac{y'\left[k_y(q)\right]}{x'\left[k_x(q, \hat{q}, k)\right]}. \tag{15}$$

Totally differentiating (15), using $d\overline{q}/d\hat{q} > 0$, we have

[10] $d(\overline{q}/\hat{q})\ / d\hat{q} = \{\int_{\hat{q}}^{1}[(1 - F(q))\ \hat{q}\ \ F'(\hat{q}) - (1 - F(\hat{q}))qF'(q)]dq\}\ / [\hat{q}(1 - F(\hat{q}))]^2 < 0.$

$$q = q(p, \hat{q}, k), \qquad \partial q / \partial p > 0,\ \partial q / \partial \hat{q} > 0,\ \partial q / \partial k < 0. \tag{16}$$

Equation (16) shows that relative factor prices depend not only on relative commodity prices as in the HO model, but also on $\hat{q}$ and k. The new effects are due to entrepreneurial selection and financial market imperfections. An increase in $\hat{q}$ implies an increase in the productivity of the capital-intensive X sector, whose effect on q is equivalent to an increase in p. Thus, the relative price of capital rises with $\hat{q}$. A higher self-finance amount k implies a smaller incentive of adverse selection and thereby a larger loan amount; for relative factor returns to be equalized across sectors, the relative price of capital must fall.

Substituting (16) into (13) and (14) we obtain

$$k_x = k_x(p, \hat{q}, k), \qquad \partial k_x / \partial p < 0,\ \partial k_x / \partial \hat{q} < 0,\ \partial k_x / \partial k > 0, \tag{17}$$

$$k_y = k_y(p, \hat{q}, k), \qquad \partial k_y / \partial p < 0,\ \partial k_y / \partial \hat{q} < 0,\ \partial k_y / \partial k > 0. \tag{18}$$

Equations (17) and (18) show a key difference between the HO model and the present model. In the HO model, capital intensities depend only on commodity prices. In the present model, however, capital intensities also depend on $\hat{q}$ and k because of the endogenous determination of productivity level and financial market imperfections.

Finally, we substitute (17) and (18) into (9) and (10) to obtain

$$(1 - F(\hat{q}))\ k_x(p, \hat{q}, k) + F(\hat{q})\ k_y(p, \hat{q}, k) = k. \tag{19}$$

Equation (19) solves $\hat{q}$ as a function of exogenous parameters,

$$\hat{q} = \hat{q}(p, k). \tag{20}$$

The other endogenous variables can be solved by substituting the solution to $\hat{q}$ into the corresponding equations.

3. INTERNATIONAL TRADE

A. Capital Abundance and Relative Commodity Supply

In this section, we examine the two-country trading equilibrium by endogenizing p. As in the HO model, the two countries differ only in capital abundance k.[11] We assume identical and homothetic preferences so that the consumption of good X relative to good Y is the same in the two countries. Thus, to see the pattern of international trade, we need to show the relationship between capital abundance and the supply of good X relative to good Y at a given p.

In the HO model, the Rybczynski theorem states that an increase in k at a fixed p gives rise to a more than proportional increase in the output of the capital-intensive good X and a reduction in the output of the labor-intensive good Y. The Rybczynski theorem can be derived from the resource constraint $(1 - l)k_x + l k_y = k$. In the HO model, capital intensities k_x and k_y are constant at a fixed p, while l changes according to[12]

$$\frac{d\,l}{dk} = -\frac{1}{(k_x - k_y)} < 0 \quad \text{(The HO model).} \tag{21}$$

Equation (21) implies that an increase in k lowers the share of labor allocated to the Y sector. Since k_y is fixed, a decrease in l implies that both K_y and L_y decrease. It follows that the output of good Y falls and the output of good X rises.

In the present model, we can totally differentiate (19) and use $l = F(\hat{q})$ to obtain

$$\frac{d\,l}{dk} = -\frac{1 - A}{(k_x - k_y) + B}, \tag{22}$$

where

$$A \equiv (1 - F(\hat{q}))(\partial k_x/\partial k) + F(\hat{q})(\partial k_y/\partial k) > 0, \tag{23}$$

[11]We assume that the population is fixed so that an increase in k refers to an increase in the quantity of capital.

[12]This is obtained by totally differentiating $(1 - l)\, k_x + l k_y = k$. See Findlay (1995: 12).

$$B \equiv ((1 - F(\hat{q}))\ /\ F(\hat{q}))\ (-\partial k_x/\partial \hat{q})\ + (F(\hat{q})\ /\ F(\hat{q}))\ (-\partial k_y/\partial \hat{q}) > 0. \tag{24}$$

Equation (22) adds two terms, *A* and *B*, to the HO equation (21).[13] Clearly the HO equation (21) is a special case of equation (22) when both *A* and *B* are zero.

The term *B* shows an endogenous productivity effect due to entrepreneurial selection. As the selection threshold $\hat{q}$ rises, the *X* sector experiences an increase in its average productivity, which causes a rise in the return to capital relative to the return to labor. The rise in *r* relative to w induces substitution of labor for capital in both sectors, and consequently both k_x and k_y fall, implying a positive *B*.

The term *A* shows a financial market imperfection effect. As discussed earlier, an increase in the self-finance amount *k* reduces the incentive of adverse selection, and consequently the threshold $\hat{q}$ is higher and the loan size k_x is larger. In equilibrium, the relative price of capital must fall so that relative factor returns are equalized across sectors. The fall in *r* relative to w induces substitution of capital for labor in both sectors, and consequently both k_x and k_y rise, implying a positive *A*.

Equation (22) shows that the sign of dl/dk depends on the value of *A*. Inspecting equation (23), we see that *A* is a weighted sum of the effects of the self-finance capacity of entrepreneurs, *k*, on the capital intensities of the two sectors, k_x and k_y. The value of *A* is thus determined by the responsiveness of k_x and k_y to *k*. If the increases in k_x and k_y are smaller than the increase in *k*, then $A < 1$, and *vice versa*. We have

LEMMA 2. *At a fixed p, if* $A < 1$, *then* $dl/dk < 0$; *if* $A > 1$, *then* $dl/dk > 0$.

Lemma 2 shows how *k* affects the allocation of labor between the two production sectors. In the HO model, this labor allocation effect determines the relative commodity supply at fixed commodity prices; in the present model, *k* also affects the relative commodity supply by changing factor intensities and productivity. To see how *k* affects k_x, k_y, and $\hat{q}$, we establish (see Appendix for proof):

LEMMA 3. *At a fixed p, if* $A < 1$, *then* $d\hat{q}/dk < 0$, $dk_x/dk > 0$, *and* $dk_y/dk > 0$; *if* $A > 1$, *then* $d\hat{q}/dk > 0$ *and the signs for* dk_x/dk *and* dk_y/dk *are ambiguous.*

Equipped with Lemmas 2 and 3, we derive the relationship between capital abundance and relative commodity supply. The supplies of the two goods are given by[14]

[13]The signs of *A* and *B* are determined by using (17) and (18).

[14]Note that $L = 1$ since the economy has a continuum of individuals of unit mass and each individual is endowed with one unit of labor.

$$X = X(\hat{q}, K_x, L_x) = \int_{\hat{q}}^{1} q x(k_x) dF(q), \tag{25}$$

$$Y = Y(K_y, L_y) = F(\hat{q}) y(k_y). \tag{26}$$

Notice that the supply of good X depends not only on factor inputs, but also on the endogenously determined productivity term $\hat{q}$. We establish:

PROPOSITION 1. (Modified Rybczynski Theorem). *In the two-good, two-factor model with heterogenous producers and imperfect financial markets, holding commodity prices fixed, an increase in a country's quantity of capital raises the supply of the capital-intensive good and lowers the supply of the labor-intensive good provided that capital intensities respond inelastically to the self-finance capacity of entrepreneurs* ($A < 1$). *However, the relative commodity supply changes by a smaller magnitude than what is predicted by the Rybczynski theorem of the HO model.*

PROOF: Differentiating (25) we obtain $dX/dk = (\partial X/\partial \hat{q})\ (d\hat{q}/dk) + (\partial X/\partial k_x)\ (dk_x/dk)$. It is clear from (25) that $\partial X/\partial \hat{q} < 0$ and $\partial X/\partial k_x > 0$. According to Lemma 3, if A < 1, then $d\hat{q}/dk < 0$ and $dk_x/dk > 0$. Therefore, $dX/dk > 0$ if $A < 1$. Since both k_x and L_x rise with k, we must have K_x rising with k. Therefore, both L_y and K_y fall as k rises; hence $dY/dk < 0$ in the case of $A < 1$. By comparing (21) and (22), we know that an increase in k causes l to fall by a smaller amount than in the HO model. Moreover, an increase in k causes k_y to rise in the present model, compared with a constant k_y in the HO model. Therefore, an increase in k causes $Y = l y(k_y)$ not to fall as much as in the HO model. Since capital and labor do not fall as much in the Y sector, they do not rise as much in the X sector. It follows that capital abundance affects the relative commodity supply by a smaller magnitude in the present model than in the HO model.

Two points are worth noting. First, Proposition 1 shows that the prediction of the Rybczynski theorem remains qualitatively true in the case of $A < 1$. The value of A indicates the role played by financial market imperfections. If financial markets were perfect, then capital intensities would be independent of the self-finance capacity of entrepreneurs and hence $A = 0$. The condition $A < 1$ means that financial market imperfections play a relatively small role in determining capital intensities. If financial market imperfections play a relatively big role ($A > 1$), then the prediction of the Rybczynski theorem may be reversed.[15]

[15]The condition $A > 1$ is not sufficient for the reversal, however, which depends also on how k_x and k_y change with k (recall Lemma 3).

Second, Proposition 1 states that the Rybczynski effect is quantitatively smaller in the presence of entrepreneurial selection and financial market imperfections. It should be pointed out that the presence of entrepreneurial selection alone would imply a diminished Rybczynski effect even if financial markets are perfect.[16] With the presence of financial market imperfections, however, the magnitude of the Rybczynski effect is further reduced.

B. Factor Prices and Commodity Prices

The Stolper-Samuelson theorem summarizes the relationship between factor prices and commodity prices in the HO model. It states that an increase in the relative price of a good yields an increase in the real return to the factor used intensively in that good and a decrease in the real return to the other factor. To see the determination of factor prices in the present model, we substitute (18) into (3) and (4) to obtain

$$r = r(p,\hat{q},k), \qquad \partial r/\partial p > 0,\ \partial r/\partial \hat{q} > 0,\ \partial r/\partial k < 0, \tag{27}$$

$$w = w(p,\hat{q},k), \qquad \partial w/\partial p < 0,\ \partial w/\partial \hat{q} < 0,\ \partial w/\partial k > 0. \tag{28}$$

Equations (27) and (28) show that p affects r and w directly and indirectly through $\hat{q}$. The direct effect of an increase in p raises r and lowers w, as in the Stolper-Samuelson theorem. To see the indirect effect, we establish (see Appendix for proof):

LEMMA 4. $d\hat{q}/dp < 0$.

Lemma 4 implies that an increase in p causes a reduction in the selection threshold $\hat{q}$, lowering the average productivity of the X sector. The reason is that a higher p raises the expected return from being entrepreneurs, inducing individuals with relatively low q to become entrepreneurs. Equations (27)-(28) imply that the indirect effect of an increase in p through $\hat{q}$ is to lower r and raise w, which works in the opposite direction of the Stolper-Samuelson theorem. Thus, whether or not an increase in p raises r depends on the relative strength of the direct effect and the indirect effect. This leads to:

[16] If we assume perfect information between banks and borrowers in the present model, we would obtain $dl/dk = -1/[(k_x - k_y) + B^*]$, where B^* is the same as B except that the threshold is q^* rather than $\hat{q}$. The value of q^* satisfies $q^*px = w + rk_x$.

PROPOSITION 2. (Modified Stolper-Samuelson Theorem). *In the two-good, two-factor model with heterogenous producers and imperfect financial markets, an increase in the relative price of the capital-intensive good has a direct effect of raising the real return to capital and lowering the real return to labor, but an indirect effect of lowering the real return to capital and raising the real return to labor due to an endogenous reduction in the productivity of the capital-intensive sector. The Stolper-Samuelson prediction on the relationship between factor prices and commodity prices holds only when the direct effect dominates the indirect effect.*

It is worth noting that the modification of the Stolper-Samuelson theorem is due to the heterogeneity of producers rather than financial market imperfections. When changes in commodity prices induce endogenous changes in productivity, they will affect factor prices both directly and indirectly, whether financial markets are imperfect or not.

C. Patterns of International Trade

The pattern of international trade is obtained by comparing the relative supply and relative demand of the two goods. To derive a relative supply curve, we need to examine how supplies change with the relative price p. Totally differentiating (25) yields

$$\frac{dX}{dp} = \frac{\partial X}{\partial \hat{q}} \frac{d\hat{q}}{dp} + \frac{\partial X}{\partial k_x} \frac{dk_x}{dp}. \tag{29}$$

Since $\partial X / \partial \hat{q} < 0$, $\partial X / \partial k_x > 0$, and $d\hat{q}/dp < 0$ (Lemma 4), we have $dX/dp < 0$ as long as dk_x/dp is either positive or negative but sufficiently small, which we assume.[17] Similarly, we totally differentiate (26) to obtain

$$\frac{dY}{dp} = \frac{\partial Y}{\partial \hat{q}} \frac{d\hat{q}}{dp} + \frac{\partial Y}{\partial k_y} \frac{dk_y}{dp}. \tag{30}$$

[17]Note that $dk_x/dp = \partial k_x / \partial p + (\partial k_x / \partial \hat{q})\ (d\hat{q}/dp)$, where the first term on the right-hand side is negative but the second term is positive. The same applies to $dk_y/dp = \partial k_y / \partial p + (\partial k_y / \partial \hat{q})\ (d\hat{q}/dp)$.

Since $\partial Y / \partial \hat{q} > 0$, $\partial Y / \partial k_y > 0$, and $d\hat{q}/dp < 0$ (Lemma 4), we have $dY/dp < 0$ as long as dk_y/dp is either negative or positive but sufficiently small, which we assume.

Figure 1 illustrates a two-country free trade equilibrium. The curve labeled RS_0 is the relative supply curve of the capital-scarce country and the curve labeled RS_1 is the relative supply curve of the capital-abundant country. Given that $dX/dp > 0$ and $dY/dp < 0$, we have $d(X/Y)/dp > 0$; hence the relative supply curves are positively sloped. According to the modified Rybczynski theorem, when $A < 1$, the supply of good X relative to good Y is higher in the capital-abundant country than in the capital-scarce country at any given p; hence RS_1 is to the right of RS_0. The curve labeled RD is the relative demand curve. Given identical and homothetic preferences, the demand for good X relative to good Y is identical across countries and is a negative function of p. The free trade equilibrium is achieved at point B where $AB = BC$.

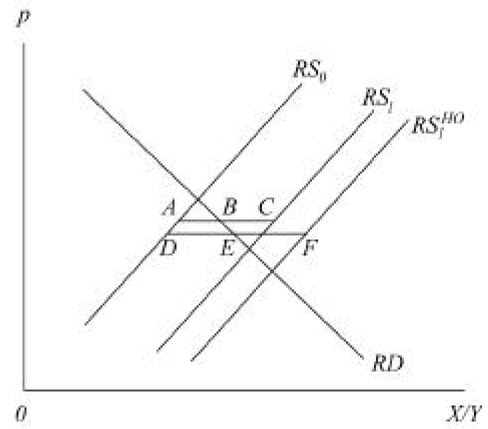

Figure 1. Patterns of International Trade

The modified Rybczynski theorem also states that in the presence of heterogenous producers and imperfect financial markets, a change in the quantity of capital leads to a change in the relative commodity supply of a smaller magnitude than that in the HO model. Figure 1 also illustrates the free trade equilibrium in the HO model. In that model, if the relative supply curve for the capital-scarce country is RS_0, then the relative supply curve for the capital-abundant country (labeled RS_1^{HO}) must lie to the right of RS_1. The HO equilibrium is achieved at point E where $DE = EF$. Since $AB < DE$, we conclude that the magnitude of the trade volume is smaller in the present model than in the HO model. This establishes:

PROPOSITION 3. (Modified Heckscher-Ohlin Theorem). *In the free trade equilibrium of the two-good, two-factor model with heterogenous producers and imperfect financial markets, the capital-abundant country exports the capital-intensive good and the labor-abundant country exports the labor-intensive good provided that capital intensities respond inelastically to the self-finance capacity of entrepreneurs* ($A < 1$). *However, the trade volume is smaller than what is predicted by the HO theorem.*

Proposition 3 implies that the HO theorem overstates the comparative advantage derived from capital abundance. The reason is that in the present model, capital abundance also impacts the comparative advantage of a country by inducing changes in productivity and financial market imperfections. First, an increase in the quantity of capital reduces the entry threshold of entrepreneurs, causing a reduction in the average productivity of production. This endogenous productivity effect offsets the comparative advantage derived directly from capital abundance. Second, an increase in the quantity of capital raises the self-finance capacity of entrepreneurs, causing an increase in both the loan amount and the entry threshold of entrepreneurs. As a result, the capital-intensive sector has fewer entrepreneurs, each with more capital. This endogenous financial market imperfection effect also offsets the comparative advantage derived directly from capital abundance; it may even reverse the endowments-based comparative advantage if the fall in the number of entrepreneurs exceeds the rise in the capital intensity.

Proposition 3 may help to resolve a conflict between the HO theorem and data. Empirical studies by Trefler (1993, 1995) show that the computed comparative advantage based on factor content of trade flows leaves a large proportion of international trade unexplained. His studies further show that a significant proportion of this “missing trade” can be explained by productivity differences between countries.[18] Our model endogenizes the determination of productivity differences and provides an account for this “missing trade” phenomenon. We show that capital abundance impacts comparative advantage directly as in the HO model, and also affects comparative advantage indirectly by causing endogenous changes in productivity and financial market imperfections. We find that the indirect effects offset the direct effect, leading to a smaller trade volume than what is predicted by the HO theorem.

D. International Differences in Factor Prices

In the HO model, factor prices are equalized by international trade, a result called the factor price equalization (FPE) theorem. Leamer and Levinsohn (1995) argue that a more accurate name for conveying the true meaning of the

[18]See Helpman (1999) for a survey of recent advances in this area of research.

result would be the factor price insensitivity (FPI) theorem in that factor prices are insensitive to changes in factor supplies at fixed commodity prices. They indicate that the way Trefler (1993, 1995) introduces technology differences into the HO model rejects FPE but not FPI. There exists strong evidence, however, that factor prices depend significantly on factor supplies at constant commodity prices.

In the present model, factor prices depend not only on *p* but also on $\hat{q}$ and *k*, as shown in equations (27) and (28). Since $\hat{q}$ depends on *p* and *k* as shown in equation (20), factor prices vary with *k* when *p* is fixed. Therefore, factor prices are not equalized in the free trade equilibrium between two countries with different capital abundance. The result also implies that factor prices are sensitive to domestic capital supply. Thus, neither FPE nor FPI holds in the present model.

From equations (27) and (28), we know that *r* falls with *k* and rises with $\hat{q}$. From Lemma 3, we know that $\hat{q}$ falls as *k* rises in the case of $A < 1$. Therefore, the capital-abundant country will have a lower *r* and a higher *w* than the labor-abundant country provided that $A < 1$. We summarize the results in:

PROPOSITION 4. (Factor Price Sensitivity Theorem). *In the free trade equilibrium of the two-good, two-factor model with heterogenous producers and imperfect financial markets, factor prices are sensitive to the domestic supply of capital. Given that capital intensities respond inelastically to the self-finance capacity of entrepreneurs* ($A < 1$), *the capital-abundant country has a lower rate of return to capital and a higher wage rate than the labor-abundant country.*

E. International Capital Mobility

In the HO model, international commodity trade equalizes factor prices across countries, eliminating the need for international factor movements. On the other hand, Mundell (1957) shows that international capital movements would also eliminate the need for international commodity trade in the HO model. Thus, international trade and international factor movements are considered to be "substitutes."

Does international trade eliminate the incentive for international capital movements in our model? The answer is no because international commodity trade does not lead to factor price equalization. According to Proposition 4, when $A < 1$, the rate of return to capital is lower in the capital-abundant country than in the labor-abundant country; consequently, there is an incentive for capital to flow from the former to the latter.

Does perfect international capital mobility eliminate the incentive for international commodity trade? The answer is also no. To see this, note that international capital movements equalize rates of return to capital but not self-finance capacity of entrepreneurs in different countries. With perfect international capital mobility, r is the same in the two countries. This implies, according to equations (3) and (4), that the two countries have the same w and k_y. However, entrepreneurs in the capital-abundant country have a higher self-finance capacity, which implies a lower loan rate R a larger loan amount k_x and a higher selection threshold $\hat{q}$ (Lemma 1). Applying these results to equation (26), we find that at any given p, the capital-abundant country produces more good Y than the labor-abundant country under international capital movements. On the other hand, we find from equation (25) that the capital-abundant country may produce more or less good X than the labor-abundant country; an increase in $k$may cause so large a reduction in the number of entrepreneurs that the output of good X falls relative to the output of good Y. This proves that there will in general exist international commodity trade when capital moves internationally. We summarize this result in:

PROPOSITION 5. (International Capital Mobility). *In the two-good, two-factor model with heterogenous producers and imperfect financial markets, perfect international capital mobility will not in general eliminate international commodity trade.*

It should be pointed out that the key to Proposition 5 is financial market imperfections, not entrepreneurial selection. If financial markets were perfect, then factor prices would be independent of capital abundance. From equation (27) we would see that perfect international capital mobility equalizes ability threshold $\hat{q}$ across countries at any given p, and hence eliminates international commodity trade completely.

It is interesting to note that if $A > 1$, the labor-abundant country may have a lower r than the capital-abundant country. Recall that $r = r(p, \hat{q}(k), k)$. In this equation, k has two effects on r. First, an increase in k raises the capital intensities of both sectors, implying a lower rate of return to capital. Second, an increase in k affects the occupational choice between entrepreneurs and workers, and consequently the relative size of the two sectors. As discussed earlier, when $A > 1$, an increase in k may reverse the Rybczynski effect, leading to a shrinkage of the capital-intensive sector. In this case, a higher k implies a higher $\hat{q}$, which in turn implies a higher r. If the second effect dominates the first, then $dr/dk > 0$, implying an incentive for capital to flow from the labor-abundant country to the capital-abundant country. Recall that the value of A reflects the significance of financial market imperfections in determining capital intensities, and the condition $A > 1$ means that financial market imperfections play a relatively important role in determining capital intensities. Lucas (1990) raises the question of why capital does not flow from rich to poor countries; he provides four possible reasons, one of which is financial market imperfections. Our model shows that imperfect financial markets can indeed be responsible for this pattern of international capital flows.

4. CONCLUSIONS

In this paper we introduce entrepreneurial selection and imperfect financial markets to the 2x2x2 model of international trade. We consider individuals with different entrepreneurial ability who choose between being entrepreneurs and being workers, and financial markets with asymmetric information regarding entrepreneurial ability. The model adds two dimensions to the HO model. First, the productivity of the capital-intensive sector is endogenously determined as a result of entrepreneurial selection. Second, factor prices and factor intensities are affected by financial market imperfections whose degree is inversely related to the self-finance capacity of entrepreneurs.

By considering entrepreneurial selection and financial intermediation, we find that capital abundance impacts comparative advantage not only directly but also indirectly through productivity and financial market imperfections. We show that entrepreneurial selection results in a diminished Rybczynski effect and financial market imperfections further reduce the effect; hence differences in capital abundance imply a smaller trade volume than predicted by the Heckscher-Ohlin theorem. Thus, the results of our model provide an account for the "missing trade" phenomenon (i.e., the factor content of observed trade flows is smaller than the endowments-based prediction of the HO model).

We also use the model to reexamine the main propositions in the HO model. With the presence of financial market imperfections, we find that factor prices depend on the domestic supply of capital, which is consistent with empirical observations. We show that international commodity trade does not substitute for international capital movements, and *vice versa*. We also show that the pattern of international capital movements depends on the endogenously determined financial market imperfections.

APPENDIX

PROOF OF LEMMA 1.

Substituting (5) into (7) and totally differentiating, we obtain

$$\frac{d\hat{q}}{dk} = \frac{(1 - \hat{q}/\,\overline{q})r}{d\hat{p}/d\hat{q}}.$$

Under the maintained assumption that individuals with higher entrepreneurial ability choose to be entrepreneurs, we have $d\hat{p}\ /\ d\hat{q} > 0$. Since $\overline{q} > \hat{q}$, we have $1 - \hat{q}/\overline{q} > 0$. Therefore, $d\hat{q}/dk > 0$. From (3) and (6) we obtain $x'(k_x) = r/(p\overline{q})$, which implies $dk_x/d\hat{q} > 0.$ From (5) and (8) we obtain $dR/d\hat{q} < 0.$ It follows that $dk_x/dk > 0$ and $dR/dk < 0.$

PROOF OF LEMMA 3.

The relationship between $\hat{q}$ and k follows directly from Lemma 2 since $\lambda = F(\hat{q})$. Totally differentiating (17) we $dk_x/dk = (\partial k_x/\partial\hat{q})\ (d\hat{q}/dk) + \partial k_x/\partial k.$ We know from (17) that $\partial k_x/\partial\hat{q} < 0$ and $\partial k_x/\partial k > 0.$ If $A < 1$, we have $d\hat{q}/dk < 0,$ and therefore $dk_x/dk > 0.$ If $A > 1$, however, we have $d\hat{q}/dk > 0,$ and therefore dk_x/dk has an ambiguous sign. The results on dk_y/dk can be similarly shown using equation (18).

PROOF OF LEMMA 4.

Totally differentiating (19), using (17) and (18), we obtain

$$\frac{d\hat{q}}{dp} = \frac{(1-F)(\partial k_x/\partial p) + F(\partial k_y/\partial p)}{(k_x - k_y)F' + (1-F)(-\partial k_x/\partial\hat{q}) + F(-\partial k_y/\partial\hat{q})} < 0.$$

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Mailing Address: Professor Bin Xu, Department of Economics, University of Florida, Gainesville, FL 32611-7140, U.S.A. Tel: 352-392-0122, Fax: 352-392-7860, E-mail: xub@dale.cba.ufl.edu, Web Site: http://bear.cba.ufl.edu/xu