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Abstract

In this study, we predict a pattern of offshoring and reshoring over the course of economic development. We achieve this, by extending Grossman and Rossi-Hansberg's (2008) model of offshoring in a simple way by assuming that offshoring requires both workers and capital in the offshored country. As a consequence, the accumulation of capital in the offshored country has two opposing effects on offshoring. On the one hand, it increases the wage rate of workers rendering offshoring less attractive. On the other hand, it decreases the rental price of capital rendering offshoring more attractive. Putting these two effects together, we analytically generate the inverted-U pattern of offshoring recently observed in China.

JEL classification: F11, F16
Keywords: trade, offshoring, economic development

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"A growing number of American companies are moving their manufacturing back to the United States." The Economist (2013)

1 Introduction

Since the mid 1990's, the amount of offshoring from developed countries to China has been steadily increasing; for example, Xing (2012) finds that the volume of processing trade in China increased from about US$10 billion in 1994 to US$300 billion in 2008. However, this increasing trend of offshoring in China has recently been reversed; for example, according to The Boston Consulting Group (2011), "[t]ransportation goods such as vehicles and auto parts, electrical equipment including household appliances, and furniture are among seven sectors that could create 2 to 3 million jobs as a result of manufacturing returning to the U.S. - an emerging trend that is expected to accelerate starting in the next five years". In a subsequent survey, The Boston Consulting Group (2012a) finds that "[m]ore than a third of U.S.-based manufacturing executives at companies with sales greater than $1 billion are planning to bring back production to the United States from China or are considering it". Porter and Rivkin (2012) also find that the rapidly rising wages abroad represent an important trend that is beginning to make US firms favor locating their production domestically.

In this study, we show how a simple model of offshoring can explain this pattern of offshoring and reshoring. As a result of economic development, physical capital in China has been accumulating at a rapid rate; for example, according to Bai *et al.* (2006), gross fixed capital formation as a share of gross domestic product in China increased from 30% in 1978 to 42% in 2005. Furthermore, the wage rate of workers has also been rising rapidly; for example, The Boston Consulting Group (2012b) finds that the "15 to 20 percent annual increases in Chinese wages [...] were rapidly eroding China's manufacturing cost advantage over the U.S.". At the first glance, these two stylized facts seem to suggest that capital accumulation in China should lead to a gradual reduction in offshoring because of its positive effect on wages, which renders offshoring less attractive. However, if one considers an often neglected fact that offshoring also requires the use of domestic capital in the offshored country (i.e., offshored production requires both workers and equipment in the offshored country), then capital accumulation in China would also have a positive effect on offshoring.

To generate the abovementioned effects, it suffices to consider the seminal model of offshoring in Grossman and Rossi-Hansberg (2008).[1] We extend the Grossman-Rossi-Hansberg model by allowing for the possibility that offshoring of labor-intensive tasks requires the use of both workers and capital (e.g., plants, equipment, information and telecommunication structures[2]) in the offshored country. In this case, an increase in the capital stock in China has two opposing effects on the incentives of offshoring. On the one hand, it increases the wage rate of workers rendering offshoring less attractive. On the other hand, it decreases the

[1] In the literature on offshoring, there is an important alternative strand of studies that focus on the choice of organizational form by firms; see the seminal studies by McLaren (2000), Grossman and Helpman (2002, 2004, 2005), Antras (2003), Antras and Helpman (2004) and Antras *et al.* (2006).

[2] Communication between the offshored country and the offshoring country is essential for the offshoring activity, which requires telephones, faxes, and computers, etc.

rental price of capital rendering offshoring more attractive; for example, according to Bai *et al.* (2006), the rate of return to non-mining capital in China decreases from 30% in the mid 1980's to less than 20% in the early 2000's. Putting these two effects together generates an inverted-U effect of capital accumulation on the equilibrium level of offshoring, which is consistent with the recently observed inverted-U pattern of offshoring in China. However, our prediction does not apply only to the albeit very important Chinese case, but also to the generality of other offshored countries.

2 A simple model of offshoring and reshoring

We consider the Grossman-Rossi-Hansberg model of offshoring. The model consists of two goods $j \in \{x, y\}$, which are produced using labor and capital in the form of two varieties of tasks: L-tasks and K-tasks. The measure of each variety of tasks is normalized to one. Firms in the developed country produce both goods. In addition to employing local workers, they can also offshore some of the L-tasks to workers in the developing country. Here we differ from Grossman and Rossi-Hansberg (2008) by assuming that this offshoring process also requires the use of capital in the developing country in order to capture a simple fact that workers in China require local equipment to complete the offshored tasks. Therefore, both capital and labor in the developing country can either be used for domestic production or for offshoring production. We will refer to the developing country (for example, China) as the home country, which is assumed to be a small open economy for simplicity. In order for the effects of factor supplies to work explicitly, as is well known in international trade theory, we need more factors than produced goods; therefore, we assume that the home country produces only one good, say good y. In this industry, a firm needs a_{fy} units of domestic factor $f \in \{L, K\}$ to perform a typical f-task. Due to substitutability between L-tasks and K-tasks, firms choose a_{Ly} and a_{Ky} to minimize their cost. Following Grossman and Rossi-Hansberg (2008), we assume that there is no substitution within the f-tasks, so that each task must be performed once to produce a unit of good y.

If a foreign firm in industry j performs L-task i using local workers, it requires a^*_{Lj} units of local labor. If the foreign firm performs L-task i through offshoring, it requires $l_j(i) = a^*_{Lj}\beta t(i)$ units of labor and $k_j(i) = \delta l_j(i)$ units of capital in the offshored country. Here $\beta > 0$ is a shift parameter that inversely captures technological improvement in offshoring and $\delta \geq 0$ measures the extent to which each offshoring worker requires local capital (e.g., the equipment that each worker needs to perform the tasks). For convenience, we order the tasks by increasing difficulty of offshoring (i.e., $t'(i) > 0$ for $i \in [0, 1]$). Due to the assumption of the home country being a small open economy, all foreign variables denoted by superscript * are given exogenously.

Naturally, we focus on the equilibrium in which offshoring exists by assuming that $a^*_{Lj}w^* > a^*_{Lj}\beta t(0)(w + \delta r)$ and $a^*_{Lj}w^* < a^*_{Lj}\beta t(1)(w + \delta r)$. Therefore, there must exist a threshold value of i, denoted as I, such that

$$w^* = \beta t(I)(w + \delta r). \tag{1}$$

The left-hand side of (1) is the wage cost for firms in the foreign country whereas the right-hand side is the offshoring costs of task I. In both industries $j \in \{x, y\}$, for $i \leq I$, foreign L-tasks are offshored to the home country. For $i > I$, foreign L-tasks are performed domestically in the foreign country.

In the home country, the unit cost for domestic firms in industry y is $wa_{Ly} + ra_{Ky}$. Perfect competition implies

$$wa_{Ly} + ra_{Ky} = p_y = 1, \tag{2}$$

where we normalize the world price of good y to $p_y = 1$. The factor-market condition for labor in the home country is given by

$$a_{Ly}y + Z^*\beta \int_0^I t(i)di = L, \tag{3a}$$

where $Z^* \equiv a^*_{Lx}x^* + a^*_{Ly}y^*$ captures the production scale in the foreign economy. In other words, labor in the home country is either used for domestic production $a_{Ly}y$ or offshoring production $Z^*\beta \int_0^I t(i)di$ for foreign firms. Similarly, the factor-market condition for capital in the home country is given by

$$a_{Ky}y + Z^*\delta\beta \int_0^I t(i)di = K. \tag{3b}$$

In other words, capital in the home country is either used for domestic production $a_{Ky}y$ or offshoring production $\delta\beta Z^* \int_0^I t(i)di$ for foreign firms.[3]

From cost minimization, we can derive $a_{fy}(w/r)$ as a function of w/r, where w is the wage rate of workers and r is the rental price of capital. Taking $a_{fy}(w/r)$ into account, the equilibrium conditions (1), (2) and (3) determine $\{w, r, y, I\}$. Using (3), we can express capital intensity in the home country as

$$\frac{a_{Ky}}{a_{Ly}} = \frac{K - \delta\beta Z^* \int_0^I t(i)di}{L - \beta Z^* \int_0^I t(i)di}. \tag{4}$$

Given that a_{Ky}/a_{Ly} is naturally an increasing function of w/r,[4] the ratio w/r can be expressed using (4) as

$$\frac{w}{r} \equiv \omega(I; K). \tag{5}$$

By (4), we may note two properties of the function ω: (a) ω is increasing (decreasing) in I if $K > (<)\ \delta L$; and (b) ω is increasing in K. We now solve (2) and (5) for r and w to obtain the expressions of $w\,(\omega(I; K))$[5] and $r(\omega(I; K))$[6], where $w'(\cdot) > 0$ and $r'(\cdot) < 0$.[7]

We substitute $w\,(\omega(I; K))$ and $r(\omega(I; K))$ into (1) to obtain

$$w^* = \beta t(I)[w\,(\omega(I; K)) + \delta r\,(\omega(I; K))], \tag{6}$$

[3] To ensure a positive output of y, we assume $L > \beta Z^* \int_0^I t(i)di$ and $K > \delta\beta Z^* \int_0^I t(i)di$.

[4] We will consider an explicit production function below.

[5] Specifically, $w\,(\omega(I; K)) = \omega(I; K)/[\omega(I; K)a_{Ly}(\omega(I; K)) + a_{Ky}(\omega(I; K))]$.

[6] Specifically, $r(\omega(I; K)) = 1/[\omega(I; K)a_{Ly}(\omega(I; K)) + a_{Ky}(\omega(I; K))]$.

[7] In the appendix, we derive these comparative statics.

which determines the equilibrium level of offshoring I for a given K. The offshoring costs in the right-hand side of (6) may increase or decrease with $\omega(I;K)$, and the following chart summarizes the intuition.

$$K\uparrow\Rightarrow\omega(I;K)\uparrow\Rightarrow\begin{array}{c} r\downarrow\Rightarrow\text{offshoring cost}\downarrow \\ w\uparrow\Rightarrow\text{offshoring cost}\uparrow\end{array}\Rightarrow I\uparrow\downarrow.$$

As K increases, the capital cost r decreases but the wage cost w increases. To understand how these effects affect offshoring, we consider a CES technology with the following unit production function $\left[\theta\left(a_{Ky}\right)^{\frac{\varepsilon-1}{\varepsilon}}+(1-\theta)\left(a_{Ly}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}=1$, where $\varepsilon>0$ is the elasticity of substitution between capital and labor. Cost minimization implies that the factor price ratio in (5) becomes

$$\omega(I;K)=\frac{1-\theta}{\theta}\left(\frac{a_{Ky}}{a_{Ly}}\right)^{\frac{1}{\varepsilon}}=\frac{1-\theta}{\theta}\left(\frac{K-\delta\;\beta Z^{*}\int_0^I t(i)di}{L-\beta Z^{*}\int_0^I t(i)di}\right)^{\frac{1}{\varepsilon}}. \tag{7}$$

Finally, using (7) and the unit production function, we can express (6) as[8]

$$w^{*}=\beta t(I)\left\{\underbrace{\left[\theta^{\varepsilon}\omega\left(I;K\right)^{\varepsilon-1}+(1-\theta)^{\varepsilon}\right]^{\frac{1}{\varepsilon-1}}}_{w(\omega(I;K))}+\delta\underbrace{\left[\theta^{\varepsilon}+(1-\theta)^{\varepsilon}\omega\left(I;K\right)^{-(\varepsilon-1)}\right]^{\frac{1}{\varepsilon-1}}}_{r(\omega(I;K))}\right\}. \tag{8}$$

We first consider the special case of $\delta=0$ as in Grossman and Rossi-Hansberg (2008). In this case, a larger stock of capital increases the wage rate of workers rendering offshoring less attractive; in other words, capital has a monotonically negative effect on offshoring I, which is inconsistent with empirical observation. When $\delta>0$, the negative effect of capital on the rental price r generates an additional positive effect on offshoring. Putting these two effects together generates an inverted-U relationship between offshoring and capital, which is consistent with the recently observed inverted-U pattern of offshoring in China. We summarize all these effects in the following proposition.

Proposition 1 *As capital K increases in the offshored country, the wage rate w increases and the rental price r of capital decreases. As for the equilibrium level of offshoring I, it first increases and then decreases after K exceeds δL. In other words, there is an inverted-U relationship between offshoring I and the capital stock K in the offshored country.*

Proof. Differentiating the right-hand side of (8) with respect to I, we can show that it is monotonically increasing in I, noting (7).[9] Given that the left-hand side of (8) is constant, there uniquely exists an equilibrium level of I that is determined by the intersect of both sides. Differentiating the right-hand side of (8) with respect to K, we can show that it is decreasing (increasing) in K when $K<(>)\delta L$, noting (7).[10] Then, simple graphical analysis would suffice to complete the proof. ■

[8] In the appendix, we provide the derivations.
[9] In the appendix, we provide the derivations.
[10] In the appendix, we provide the derivations.

3 Conclusion

In this study, we first documented a pattern of offshoring and reshoring in China. Then, we developed a simple framework to explain this stylized fact. In summary, we find that economic development in offshored countries initially causes an increase in offshoring activities but eventually leads to a return of offshoring tasks to developed countries. Intuitively, capital accumulation as a result of economic development in offshored countries raises the wage rate of workers and reduces the rental price of capital giving rise to a U-shaped pattern in the cost of offshoring over the course of economic development, and these theoretical implications are consistent with the empirical trends in China.

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Appendix

Comparative statics of $r(\cdot)$ and $w(\cdot)$:

Assume that the unit production function $F(a_{Ky}, a_{Ly})$ satisfies the standard neoclassical properties: for each $i = K,\ L$, $\partial F(a_{Ky}, a_{Ly})/\partial a_{iy} = F_i(a_{Ky}, a_{Ly}) > 0$; $\partial^2 F(a_{Ky}, a_{Ly})/\partial (a_{iy})^2 = F_{ii}(a_{Ky}, a_{Ly}) < 0$; $\lambda F(a_{Ky}, a_{Ly}) = F(\lambda a_{Ky}, \lambda a_{Ly})$ for any $\lambda > 0$. First, given the homogeneity of degree 1 in function $F(a_{Ky}, a_{Ly})$, we can have

$$r = F_1(a_{Ky}, a_{Ly}) \text{ and } w = F_2(a_{Ky}, a_{Ly}), \tag{A1}$$

noting $p_y = 1$. We can easily verify from Euler's homogeneous function theorem that $F_i(a_{Ky}, a_{Ly})$ is homogeneous of degree 0 for each i, implying $F_1(a_{Ky}, a_{Ly}) = F_1(a_{Ky}/a_{Ly}, 1)$ and $F_2(a_{Ky}, a_{Ly}) = F_2(a_{Ky}/a_{Ly}, 1)$. Given these two expressions, with $F_{ii}(a_{Ky}, a_{Ly}) < 0$, $F_1(a_{Ky}, a_{Ly})$ is a decreasing function in a_{Ky}/a_{Ly}. Since $\partial^2 F(a_{Ky}, a_{Ly})/(\partial(a_{Ky})\partial(a_{Ly})) = F_{21}(a_{Ky}, a_{Ly}) > 0$ holds due to the neoclassical properties, $F_2(a_{Ky}, a_{Ly}) = F_2(a_{Ky}/a_{Ly}, 1)$ is an increasing function in a_{Ky}/a_{Ly}. By the cost minimizing condition $F_2(a_{Ky}, a_{Ly})/F_1(a_{Ky}, a_{Ly}) = w/r$, we then verify a positive relationship between a_{Ky}/a_{Ly} and w/r. As a result, $F_1(a_{Ky}, a_{Ly})$ ($F_2(a_{Ky}, a_{Ly})$) is a decreasing (increasing) function in w/r. Equation (A1) ensures that r (w) increases (decreases) with w/r.

Derivations of equation (8):

The cost minimization condition gives rise to

$$\frac{a_{Ky}}{a_{Ly}} = \left(\frac{\theta}{1-\theta}\frac{w}{r}\right)^{\varepsilon}. \tag{A2}$$

By (A1) and (A2),

$$r = \left(\theta^{\varepsilon} + (1-\theta)^{\varepsilon}\left(\frac{w}{r}\right)^{-(\varepsilon-1)}\right)^{\frac{1}{\varepsilon-1}} \text{ and } w = \left(\theta^{\varepsilon}\left(\frac{w}{r}\right)^{\varepsilon-1} + (1-\theta)^{\varepsilon}\right)^{\frac{1}{\varepsilon-1}}$$

are calculated from the CES production function. Together with (6), these expressions would prove (8).

Comparative statics of equation (8):

$$w^* = \beta t(I)\left(\underbrace{\left(\theta^{\varepsilon}\omega(I;K)^{\varepsilon-1} + (1-\theta)^{\varepsilon}\right)^{\frac{1}{\varepsilon-1}} + \ \delta\left(\theta^{\varepsilon} + (1-\theta)^{\varepsilon}\omega(I;K)^{-(\varepsilon-1)}\right)^{\frac{1}{\varepsilon-1}}}_{\equiv\Omega(I;K)}\right).$$

First, with (7), differentiating $\Omega(I;K)$ with respect to I yields

$$\frac{\partial\Omega(I;K)}{\partial I} = \theta^{\varepsilon}\left(\theta^{\varepsilon} + (1-\theta)^{\varepsilon}\omega(I;K)^{-(\varepsilon-1)}\right)^{\frac{2-\varepsilon}{\varepsilon-1}}\ \Psi(I;K)\ \frac{d\omega(I;K)}{dI},$$

where

$$\Psi(I;K) \equiv 1 - \delta\left(\frac{L - \beta Z^* \int_0^I t(i)di}{K - \delta\beta Z^* \int_0^I t(i)di}\right)$$

and

$$\frac{d\omega(I;K)}{dI} = (\omega(I;K))^{1-\varepsilon}\left(\frac{1-\theta}{\theta}\right)^{\varepsilon}\frac{\beta Z^{*}t(I)}{\varepsilon}\frac{K-\delta L}{\left(L-\beta Z^{*}\int_{0}^{I}t(i)di\right)^{2}}.$$

Note that both $\Psi(I;K)$ and $d\omega(I;K)/dI$ are strictly positive if and only if $K > \delta L$. Thus, $\partial\Omega(I;K)/\partial I > 0$ always holds. Given $t'(I) > 0$, the right-hand side of (8) increases with I.

Next, differentiating Ω with respect to K yields

$$\frac{\partial\Omega\left(I;K\right)}{\partial K} = \theta^{\varepsilon}\left(\theta^{\varepsilon}\omega\left(I;K\right)^{\varepsilon-1}+(1-\theta)^{\varepsilon}\right)^{\frac{2-\varepsilon}{\varepsilon-1}}\omega\left(I;K\right)^{\varepsilon-2}\ \Psi\left(I;K\right)\ \frac{d\omega(I;K)}{dK},$$

where, in the same way as above, $\Psi\left(I;K\right) > 0$ if and only if $K > \delta L$. Given that $d\omega(I;K)/dK > 0$ always holds, we have shown that the right-hand side of (8) increases with K if $K > \delta L$ and decreases with K if $K < \delta L$.