Global Production and Currency Devaluation

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Abstract

This simple paper models the production allocation choices of a multinational enterprise (MNE) in a three-country framework -- a northern country and two southern countries. The products made in the southern countries are of lower quality, and have higher substitutability than those between the south and the north. We investigate how exchange rates affect production, employment, profits and welfare, and find that currency devaluation from different countries gives rise to contrasting and unconventional results. In particular, a currency appreciation in the southern country (X) producing the lowest-quality good with the lowest cost may reduce production (employment) in the north, while an appreciation in the other southern currency (Y) always raises production in the north. A northern depreciation against both southern currencies may increase production in country X, but always reduces that in country Y. These arise because the MNE shifts production to minimize costs. Northern welfare always falls following currency appreciation in southern countries.

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1. Introduction

It has been argued that the devaluation of the Chinese yuan since the late 1980s played a significant role in fostering China's two-digit export growth in the last two decades. However, the indirect impact of yuan devaluation, which has been realized through the influx of export oriented foreign direct investment (FDI), has been far more important in increasing exports, than the direct effect which is on the exports of Chinese domestic firms.

For instance, from 1992 to 2001, China's exports more than tripled from $US84.94 billion to $US266.15 billion (China Statistics Yearbook, various years). But such dramatic increase is mainly the contribution of foreign multinationals, i.e., Chinese subsidiaries of global MNEs. Over the same period, exports of foreign invested firms increased by more than 75 times, from $US1.74 billion to $US 133.24 billion. In 2001, the exports of the latter firms exceeded 50 percent of China's total exports. Even though the Chinese currency devalued substantially in the early 1990s, it seems Chinese domestic firms surprisingly failed to benefit from it. As the above figures indicate, the exports of domestic firms grew more slowly than the GDP in the same period. That is, the performance of these firms had been worse than the whole economy.

In fact, multinationals' global outsourcing activities have made major economies dependent on China as a source of cheap labor. Largely due to the contributions of foreign MNEs, China has become the largest destination country for FDI in the developing world.[1] Multinationals flock to China for its cheap labor, land and other inputs (which Krugman (1998) calls "fire-sale FDI"), to conduct export-processing operations.[2] The reality check

[1] In fact, it may soon become the overall number one destination, overtaking the US.

[2] Over the years 1997-1999, processing exports accounted for 53.7% of China's total exports (Feenstra and Hanson, 2003). And Japanese subsidiaries in China exported more than 65 percent of outputs in 2001.

reveals that, (1). China's rapid exports growth is mainly driven by export-oriented FDI, especially as a result of global outsourcing activities of foreign multinationals; (2). The yuan's devaluation strengthened China's competitiveness in attracting global FDI and redirecting outsourcing activities to China.[3]

The phenomenon above motivates us to analyze the role of exchange rates in global outsourcing and its implications on commercial policy. We investigate how exchange rates affect global outsourcing activities, and the welfare impacts of coordinated as well as unilateral devaluation in the currencies of outsourcing destination countries. We consider a MNE with production facilities in three different countries -- a northern country (Z) and two southern countries (X and Y). The products made in the southern countries are of lower quality, and have higher substitutability than those between the south and the north. Production costs and product quality in the three countries are all different. We examine the effects of exchange rate changes on production, employment, profits and welfare, and find that currency devaluation from different countries gives rise to contrasting and unconventional results.

Specifically, a currency appreciation in the southern country X (e.g., China) producing the lowest-quality good with the lowest cost may reduce production (employment) in the north, while an appreciation in the other southern currency (Y) always raises production in the north. A northern depreciation against both southern currencies may increase production in country X, but always reduces that in country Y. These arise because

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[3] For instance, the ASEAN-4 (Indonesia, Malaysia, Thailand, and the Philippines) had been the prime destination for Japanese FDI in manufacturing in Asia. In 1990, Japanese manufacturing FDI in China accounted merely 5 percent of its total in Asia. However, as the yuan devalued sharply after 1990, China became a relatively cheaper production base. Japanese manufacturing FDI in China surged significantly to 47 percent of its total in Asia in 1995.

the MNE shifts production to minimize costs. Under such global outsourcing, northern welfare, surprisingly, always falls following currency appreciation in southern countries.

Despite the simplicity of the model, it sheds light on the current China debate. China's role in manufacturing is still only a provider of cheap labor, with "an unlimited supply". And the majority of Chinese exports are low-price, low quality goods such as textiles, shoes, toys, plastic products, electronic appliances, etc, which are usually sold at deep discount stores such as Wal-Mart. Limited appreciation of the yuan simply reduces China's comparative advantage relative to other developing countries, and redirects export-oriented FDI to these areas. As a consequence, products from these countries may replace those "Made in China" in the global market. Industrialized countries, on the other hand, may not benefit from the yuan's appreciation. Cries of "hollowing out" and "de-industrialization" will continue, except for the destination.[4]

While the classical literature believes exchange rate movements do not affect FDI flows, recent theoretical works find a close relationship between exchange rates and FDI, see for instance, Kohlhagen (1977), Cushman (1985), and Froot and Stein (1991). Several empirical studies, such as Klein (1994), and Goldberg and Klein (1997), find support for the theoretical analysis. Blonigen (1997) argues that Japanese FDI into the U.S. during 1985-1990 were motivated by the desire to acquire the knowledge assets of U.S. firms. Recently, Ekholm, Forslid and Markusen (2003) analyze the MNE's location choices in three-country models, but focusing on trade and transportation costs and production technology. Chen, Ishikawa and Yu (2002) study outsourcing activities that are not related to exchange rates.

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[4] For example, as the US presidential election campaign began, politicians and pressure groups are drawing the candidates' attention, by alleging that the Chinese currency has made lots of American workers jobless. Japanese Finance Minister Masajuro Shiokawa repeatedly accused China of "exporting deflation" to Japan.

Regarding FDI in China, Branstetter and Feenstra (1999) show that FDI inflows reflect political openness and state ownership there; Cheng and Kwan (2000) find that large regional market, good infrastructure, and preferential policy are important determinants of FDI in China; Feenstra and Hanson (2003) examine the organization of export processing operations of foreign MNEs in China and test the property rights model.

The rest of the paper is organized as follows. Section 2 sets up the basic model, section 3 derives the equilibrium and its properties, and analyzes how exchange rate changes affect the production shifting of the MNE, section 4 investigates the impacts on profits and welfare, and section 5 provides concluding remarks.

2. Basic Model Setup

2.1 Consumer Demand

Consider two southern countries X, Y, and a northern country Z. We focus on the market in the northern country, say either the US, Europe or Japan. A typical northern consumer consumes a numeraire good *m*, and three differentiated goods: *x*, *y*, and *z*, all produced by a single MNE whose home country is Z. Goods *x*, y, and *z* are produced respectively in countries X, Y and Z, i.e., goods *x* and *y* are the result of FDI by the MNE from country Z in countries X and Y respectively. Countries X and Y do not own any firm. All goods are sold in country Z only. Thus, country Z's total imports are $x + y$.

The products made in the north have the highest recognition in both brand name and quality. In contrast, the goods made in the southern countries have low acceptance by northern consumers, due to problems of brand recognition. They are usually considered as low quality goods as well, compared with those made in the north.

Given the above, the typical northern consumer can be assumed to maximize the following utility function:

$$V(m,x,y,z) = m + U(x,y,z)\,, \tag{1}$$

where

$$U(x,y,z) = ax + by + cz - \frac{1}{2}(x^2 + y^2 + z^2) - (\gamma_{xz}xz + \gamma_{xy}xy + \gamma_{yz}yz)\,. \tag{2}$$

The parameter γ_{ij} indicates the substitutability between goods *i* and *j*, for all $i, j = x, y, z,\ \ i \neq j$. We assume that $0 < a < b < c$, and $0<\gamma_{xz}<\gamma_{yz}<\gamma_{xy}<1$, which hopefully capture the preferences of the northern consumers roughly. They imply: (i) the three goods $x,\ y,\ z$ are imperfect substitutes; (ii) goods *x* and *z* are most differentiated, followed by goods *y* and *z*, and FDI goods *x* and *y* are least differentiated. In addition, If $\gamma_{ij} = 0$, there is zero substitutability; and if $\gamma_{ij} = 1$, there is perfect substitutability. We assume that these two special cases do not arise in the present model.

We wish to use this setup to illustrate the scenario of a northern MNE outsourcing in two developing countries, say China (country X) and ASEAN (country Y) as examples. The northern made good has the highest quality, the ASEAN made one has the middle quality, and the Chinese made one has the lowest quality. However, the quality difference between the ASEAN made and the Chinese made is very small.

Maximization of the consumer's problem in (1) subject to the standard budget constraint yields the inverse demand functions for goods *x*, *y*, and *z* in units of good *m*.

$$p_x = a - x - (\gamma_{xy}y + \gamma_{xz}z)\,, \tag{3a}$$

$$p_y = b - y - (\gamma_{xy} x + \gamma_{yz} z), \tag{3b}$$

$$p_z = c - z - (\gamma_{xz} x + \gamma_{yz} y). \tag{3c}$$

2.2 Production

On the production side, we assume the MNE uses identical technology in all countries. Let the constant marginal cost of production in each country be w_i, $i = X, Y, Z$. The profit function of the MNE consists of three parts: the sum of those from each country.

$$\pi = (p_z - w_Z)z + (p_x - \alpha e_X w_X)x + (p_y - \alpha e_Y w_Y)y - 2F. \tag{4}$$

The parameter e_j, $j = X, Y$, denotes the exchange rate, i.e., the price of country j's currency in terms of country *Z*'s currency. The exchange rate enters because the MNE's cost is paid in country j's currency when undertaking FDI there, while profits are accrued in country *Z*'s currency. We assume $e_X w_X \le e_Y w_Y < w_Z$, i.e., the ranking of average cost follows that of product quality introduced earlier. We also assume that the exchange rate does not affect demand of the goods directly, but indirectly through price adjustments following changes in the production costs. The parameter $\alpha > 0$ will be used to conduct analysis on northern currency policy against both southern countries simultaneously, in contrast to northern policy against only one southern currency, which is represented by changes in e_j. Finally, *F* is a fixed cost for each FDI plant.[5] In contrast, fixed cost is not incurred when producing at home.

[5] See also the literature on the new FDI theory (e.g., Ethier, 1986; Helpman, 1985; Markusen, 1984, Janeba, 1998), in which FDI does not need to involve physical capital movement abroad. Incorporating explicit capital investment in the model complicates the algebra without adding essential insights.

In addition, transportation cost is assumed to be zero.[6] For analysis stressing fixed and transportation costs of FDI, see Dei (1990), Markusen and Venables (1998), McLaren (2000), Yeaple (2002) and Ekholm, Forslid and Markusen (2003).

3. The Equilibrium and Its Properties

The MNE chooses x, y, and z to maximize (4). Using (3a-c), the FOCs are

$$a - 2x - 2(\gamma_{xy} y + \gamma_{xz} z) - \alpha e_X w_X = 0, \tag{5a}$$

$$b - 2y - 2(\gamma_{xy} x + \gamma_{yz} z) - \alpha e_Y w_Y = 0, \tag{5b}$$

$$c - 2z - 2(\gamma_{xz} x + \gamma_{yz} y) - w_Z = 0. \tag{5c}$$

Given the exchange rates, marginal costs, and substitutability parameters, conditions (5a-5c) jointly determine a unique solution (x, y, z), which is the optimal production allocation over the three countries.[7]

Total differentiation of conditions (5a-5c) yields the following matrix.

$$-2\begin{pmatrix} 1 & \gamma_{xy} & \gamma_{xz} \\ \gamma_{xy} & 1 & \gamma_{yz} \\ \gamma_{xz} & \gamma_{yz} & 1 \end{pmatrix}\begin{pmatrix} dx \\ dy \\ dz \end{pmatrix} = \alpha w_X \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} de_X + \alpha w_Y \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} de_Y + \begin{pmatrix} w_X e_X \\ w_Y e_Y \\ 0 \end{pmatrix} d\alpha \tag{6}$$

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[6] Adding transportation cost for imports changes the level of profits and welfare, but not the qualitative results of the model.

[7] Closed form solutions of the endogenous variables can be obtained, but in messy algebraic forms.

Given the assumption $0<\gamma_{xz}<\gamma_{yz}<\gamma_{xy}<1$, the determinant of the Hessian matrix is negative,

$$\Delta = 2(\gamma_{xy}^2 + \gamma_{yz}^2 + \gamma_{xz}^2 - 1 - 2\gamma_{xy}\gamma_{yz}\gamma_{xz}) < 0 . \quad (7)$$

Now, we turn to the comparative static analysis. We focus on how changes of the exchange rates affect the production allocation decisions of the MNE in the three countries. If the currency of country X appreciates against that of country Z, e_X will rise. From equation (6), we derive

$$dx / de_X = 4\alpha w_X (1-\gamma_{yz}^2) / \Delta < 0 , \quad (8a)$$

$$dy / de_X = -4\alpha w_X (\gamma_{xy} - \gamma_{xz}\gamma_{yz}) / \Delta > 0 , \quad (8b)$$

$$dz / de_X = 4\alpha w_X (\gamma_{xy}\gamma_{yz} - \gamma_{xz}) / \Delta . \quad (8c)$$

Conditions (8a) and (8b) indicate that, an appreciation in country X's currency leads to a production decrease in country X, but an increase in country Y. These arise because the cost of production in country X increases measured in country Z's currency, causing the MNE to shift production to country Y.

The sign of (8c) is ambiguous. That is, it is uncertain whether production in country Z, the home country of the MNE, will increase or not. Normally, one would expect the sign of (8c) to be positive, i.e., an appreciation of country X's currency to raise production in country Z, due to production substitution. Careful examination of (8c) reveals that it is positively signed if $\gamma_{xy} < \gamma_{xz} / \gamma_{yz}$. It implies that sufficiently high substitutability between goods *x* and *z* is the necessary and sufficient condition for output to increase in country Z.

However, if the substitutability between goods *x* and *y* is high and that between *x* and *z* is low such that $\gamma_{xy} > \gamma_{xz} / \gamma_{yz}$ holds, then condition (8c) becomes negative. In other words, currency appreciation in country X will raise the new equilibrium price p_x, resulting in substitution for both goods *y* and *z* by the representative consumer. Simultaneously, to avoid the rising cost in country X, the MNE will shift its production to country Y. And if consumers in country Z can easily substitute good *y* for good *x*, then the MNE will shift production by so much that production in its home country Z is also substituted out.

To see this more clearly, let us examine an extreme case in which goods *x* and *y* are identical, i.e., both $\gamma_{xy} = 1$ and $\gamma_{xz} = \gamma_{yz}$ hold. Using (8a-8c) we find that $dx / de_x = -dy / de_x < 0$ and $dz / de_x = 0$. That is, currency appreciation in country X does not increase production and employment in country Z at all. The MNE simply shifts production to country Y from country X. Of course, if there is near perfect substitutability such that $\gamma_{xy} \approx 1 > \gamma_{xz} / \gamma_{yz}$, then condition (8c) is always negatively signed.

Thus, as long as there exists multiple destination countries for outsourcing activities, it is unlikely that currency appreciation in the country producing the lowest quality will force the northern MNE to move back production to its home country. Relocating production to another outsourcing destination country will be the first choice to avoid the rising costs induced by the appreciation. This is true especially when the substitutability between the products made in the two destination countries is high.

The above can be restated in the following proposition.

Proposition 1: *Under outsourcing FDI in two southern countries, a currency appreciation in the southern country producing the lowest quality product against the northern currency,*

(i). raises production in the other southern country (i.e., producing the middle quality product); (ii). reduces (raises) production in the northern country if the substitutability between the products made in the two southern countries is high (low) enough; (iii) has no effect on production in the northern country if the two southern goods are identical.

Analogously, an appreciation of country Y's currency leads to:

$$dx / de_Y = -4\alpha w_y (\gamma_{xy} - \gamma_{yz}\gamma_{xz}) / \Delta > 0 , \qquad (9a)$$

$$dy / de_Y = 4\alpha w_Y (1 - \gamma_{xz}^2) / \Delta < 0 , \qquad (9b)$$

$$dz / de_Y = 4\alpha w_Y (\gamma_{xy}\gamma_{xz} - \gamma_{yz}) / \Delta > 0 . \qquad (9c)$$

The interpretations of (9a) and (9b) are similar to (8a) and (8b). The important difference arises between conditions (8c) and (9c). While the former can be positive, zero, or negative, the latter is always positively signed, i.e.,

Proposition 2: *An appreciation in the country producing the middle-quality good always raises production in the country producing the highest-quality good.*

Proof: We need to prove the sign of (9c). Because $\Delta < 0$, we need $\gamma_{xy}\gamma_{xz} - \gamma_{yz} < 0$, i.e., $\gamma_{xy} < \gamma_{yz} / \gamma_{xz}$. But the assumption $0<\gamma_{xz}<\gamma_{yz}<\gamma_{xy}<1$ guarantees that $\gamma_{xy} < 1 < \gamma_{yz} / \gamma_{xz}$ always holds. QED

Note that currency appreciation in the present model brings two effects: one on production cost, the other on demand (through price changes). On production cost, the MNE always chooses the optimal level of output in each country (i.e., shifting production among the three countries) to maximize total global profits. The interpretation for proposition 2 lies in the demand side, which can be summarized as follows.

The assumption $0<\gamma_{xz}<\gamma_{yz}<\gamma_{xy}<1$ implies that the qualities and consumer preference for the three goods can be ranked as $x \prec y \prec z$. That is, good *y* lies in the middle. Similar to the previous case, p_y increases following currency appreciation in country Y. The subsequent adjustment of optimal consumption leads to substitution for goods *x* and *z*. The critical difference here lies in that *y* is the middle good. It not only has high substitutability with the least quality good *x*, but also relatively high substitutability with the highest quality good *z*. The closer substitutability between *y* and *z* (than between *x* and *z*) as well as the improved quality from *y* to *z* guarantees that the substitution effect is also positive for good *z*. Thus, the MNE increases production of both goods.

In contrast, if appreciation occurs in country X, because good *x* is the lowest quality good and has higher substitutability with *y* than *z*, the consumer will substitute most of the reduced consumption on *x* by y, resulting in relatively small substitution effects for z. Coupled with the rising production cost due to the appreciation in country X, the MNE will cut its production in country Z.

Propositions 1 and 2 give rise to contrasting changes to the production in country Z. The important implications are: (i). Good *y* is the middle-quality good. An appreciation of Y's currency increases the production of both the lower quality good *x* and the higher quality

good *z*; (ii). A currency appreciation in the country producing the lowest quality good may not necessarily lead to output and employment increases in the country producing the highest quality good—the northern country, because consumers may substitute the middle quality good for the lowest quality one by a large scale, which forces the MNE to cut production in its home country.

The above theoretical results have important implications for commercial policies in the industrialized countries, where many are blaming "the undervalued yuan" for a host of manufacturing ills. While products bearing the "Made in China" label are gaining popularity, they are mainly labor-intensive goods, which can be easily substituted by similar goods from other developing countries with similar resource endowments as in China. Appreciation of the Chinese yuan will drive consumers to substitute goods made in other southern countries, rather than in the USA or Japan, unless "Made in USA" and "Made in Japan" have relatively high substitutability with "Made in China". A strong yuan will force the MNEs to cut production in China and subsequently relocate to other southern countries. It is highly unlikely that MNEs will shift production facilities back to the northern country, such as the USA or Japan, simply because there are many other southern countries the MNEs could use as the destination of outsourcing activities.

Of course, the above implications are derived based on the assumption that China at present is country X. If after some years, product quality and production costs increase, and China becomes country Y, then the predictions of country Y apply, compared with some other country X, such as Cambodia or Vietnam.

Next, we investigate the case that country Z devalues its currency against both southern currencies by the same proportion simultaneously, which can also be viewed as a

coordinated appreciation of both southern currencies. The coordinated appreciation can be represented by an increase in parameter α. From equation (6), we derive

$$dx/d\alpha = 4\{w_X e_X (1-\gamma_{yz}^2) - w_Y e_Y (\gamma_{xy} - \gamma_{yz}\gamma_{xz})\}/\Delta, \quad (10a)$$

$$dy/d\alpha = 4\{w_Y e_Y (1-\gamma_{xz}^2) - w_X e_X (\gamma_{xy} - \gamma_{xz}\gamma_{yz})\}/\Delta, \quad (10b)$$

$$dz/d\alpha = 4\{w_X e_X (\gamma_{xy}\gamma_{yz} - \gamma_{xz}) - w_Y e_Y (\gamma_{yz} - \gamma_{xz}\gamma_{xy})\}/\Delta. \quad (10c)$$

Given the assumptions $w_X e_X \le w_Y e_Y < w_Z$ and $0<\gamma_{xz}<\gamma_{yz}<\gamma_{xy}<1$, we obtain unambiguously,

$$dy/d\alpha < 0, \quad (10b')$$

$$dz/da > 0. \quad (10c')$$

Proof: (i). We first prove (10b'). The assumption $0<\gamma_{xz}<\gamma_{yz}<\gamma_{xy}<1$ gives rise to $0<\gamma_{xy}<1$ and $0 < \gamma_{xz}^2 < \gamma_{xz}\gamma_{yz}$. Thus, $(1-\gamma_{xz}^2) > (\gamma_{xy} - \gamma_{xy}\gamma_{yz})$. And given $w_Y e_Y \ge w_X e_X > 0$, we have $w_Y e_Y (1-\gamma_{xz}^2) < w_X e_X (\gamma_{xy} - \gamma_{xy}\gamma_{yz})$. Since $\Delta < 0$, we obtain

$$dy/d\alpha = 4\{w_Y e_Y (1-\gamma_{xz}^2) - w_X e_X (\gamma_{xy} - \gamma_{xy}\gamma_{yz})\}/\Delta < 0.$$

(ii). Now we prove (10c'). The assumption $0<\gamma_{xz}<\gamma_{yz}<\gamma_{xy}<1$ also implies $\gamma_{yz} > \gamma_{yz}\gamma_{xy}$ and $\gamma_{xz} > \gamma_{xz}\gamma_{xy}$. Thus, $(\gamma_{xy}\gamma_{yz} - \gamma_{xz}) < (\gamma_{yz} - \gamma_{xz}\gamma_{xy})$. Multiplying $w_X e_X$ to the left side and $w_Y e_Y$

to the right side of the inequality, and invoking $w_Y e_Y \geq w_X e_X > 0$ yields

$w_X e_X(\gamma_{xy}\gamma_{yz} - \gamma_{xz}) < w_Y e_Y(\gamma_{yz} - \gamma_{xz}\gamma_{xy})$, which in turn gives rise to:

$$dz/d\alpha = 4\{w_X e_X(\gamma_{xy}\gamma_{yz} - \gamma_{xz}) - w_Y e_Y(\gamma_{yz} - \gamma_{xz}\gamma_{xy})\}/\Delta > 0.$$

QED.

As the currency of the home country depreciates against those of both FDI hosting countries in the same proportion, the MNE will increase its output at home and reduce its production in the outsourcing destination country where the average cost is relatively higher. In other words, the less competitive destination country will be worse off under the scenario of simultaneous currency appreciation (or coordinated currency appreciation). Conversely, an appreciation of the northern currency against both southern currencies will make the less competitive country better off.

The sign of (10a) is ambiguous. That is, it is uncertain whether production in the country with the lowest cost would increase or decrease. Given $w_Y e_Y \geq w_X e_X > 0$, we find that if $\gamma_{xy} > 1 - \gamma_{yz}(\gamma_{yz} - \gamma_{xz})$, then $dx/d\alpha > 0$. In other words, if the substitutability between the two southern goods is high enough, then northern depreciation will make the MNE raise production in country X, which produces the lowest-quality good with the lowest cost. The intuition is as follows. Northern depreciation will reduce production in countries X and Y directly. However, because good *y* is the middle quality good, the reduced production in country Y will be shifted to two directions—to countries Z as well as X. It turns out that the shift to country X outweighs the direct reduction if the substitutability between goods *x* and *y* is high enough, resulting in a net increase of output *x*.

Here again we look into the extreme case in which goods *x* and *y* are identical, and find that $dx/d\alpha = -dy/\alpha > 0$ and $dz/d\alpha = 0$. That is, currency depreciation in country Z does not increase production and employment in country Z at all. The MNE simply shifts production to country X from country Y.

We are now in a position to summarize the results above as follows.

Proposition 3: *If both southern currencies appreciate by the same proportion simultaneously against the northern currency, (i). production in the northern country will increase; (ii). production in the middle-ranked country (in terms of cost and product quality) will decrease; (iii). production in the lowest-ranked country will increase if the substitutability between the two low-quality goods is sufficiently high; (iv). production in the north does not change if the two southern goods are identical.*

Finally, we look into how changes in the exchange rates affect the MNE's total world output (employment). To save on notation, let $q = x + y + z$, then we obtain

$$dq/de_X = 4\alpha w_X\{(1-\gamma_{yz}^2)-(\gamma_{xy}-\gamma_{xz}\gamma_{yz})+(\gamma_{xy}\gamma_{yz}-\gamma_{xz})\}/\Delta, \qquad (11a)$$

$$dq/de_Y = 4\alpha w_Y\{(1-\gamma_{xz}^2)-(\gamma_{xy}-\gamma_{xz}\gamma_{yz})+(\gamma_{xy}\gamma_{xz}-\gamma_{yz})\}/\Delta, \qquad (11b)$$

$$\begin{aligned} dq/d\alpha = (4/\Delta)\{&w_X e_X[(1-\gamma_{yz}^2)-(\gamma_{xy}-\gamma_{xz}\gamma_{yz})+(\gamma_{xy}\gamma_{yz}-\gamma_{xz})] \\ &+ w_Y e_Y[(1-\gamma_{xz}^2)-(\gamma_{xy}-\gamma_{xz}\gamma_{yz})+(\gamma_{xy}\gamma_{xz}-\gamma_{yz})]\} \end{aligned} . \qquad (11c)$$

Rearranging (11a) to yield

$$dq/de_X = 4\alpha w_X(1-\gamma_{yz})(1+\gamma_{yz}-\gamma_{xy}-\gamma_{xz})/\Delta < 0\,. \qquad (11a')$$

That is, currency appreciation of the country with the lowest cost will reduce global production. Even though outputs in countries Y and Z may rise, it cannot offset the reduction in country X due to the appreciation-induced increase in production cost.

Similarly, condition (11b) can be rewritten as

$$dq/de_Y = 4\alpha w_Y(1-\gamma_{xz})(1+\gamma_{xz}-\gamma_{xy}-\gamma_{yz})/\Delta\,, \qquad (11b')$$

whose sign is ambiguous. If $\gamma_{xy} < 1+\gamma_{xz}-\gamma_{yz}$, then (11b') is negatively signed. That is, if the substitutability between *x* and *y* is sufficiently low (high), global employment (output) falls (rises) as a result of currency appreciation in country Y.

Equation (11c) measures the marginal change of global output as the currencies of countries X and Y appreciate against that of country Z by the same proportion. It is in fact the sum of eqs. (11a) and (11b). Using eqs. (11a') and (11b'), it is straightforward to conclude that global production will decrease if $\gamma_{xy} < 1+\gamma_{xz}-\gamma_{yz}$. However, global output can increase, if and only if $1+\gamma_{xz}-\gamma_{yz} < \gamma_{xy}$ and $\frac{w_X e_X}{w_Y e_Y} < -\frac{(1-\gamma_{xz})(1-\gamma_{xy}+\gamma_{xz}-\gamma_{yz})}{(1-\gamma_{yz})(1-\gamma_{xy}+\gamma_{yz}-\gamma_{xz})}$ hold.

The above findings can be summarized as

Proposition 4: *(i) Global production decreases following a unilateral currency appreciation of the outsourcing destination country with the lowest cost; (ii) Global production also*

decreases if $\gamma_{xy} < 1 + \gamma_{xz} - \gamma_{yz}$, *following unilateral appreciation in the other destination country, or coordinated appreciation of both destination countries.*

4. Profit and Welfare Analysis

The welfare of the home country of the MNE consists of two parts: the profit of the MNE and the consumer surplus. First, we investigate how currency revaluation affects the MNE's profits. Differentiating (4) with respect to e_X, e_Y, and α respectively yields

$$d\pi / de_X = -\alpha w_X x < 0, \tag{12a}$$

$$d\pi / de_Y = -\alpha w_Y y < 0, \tag{12b}$$

$$d\pi / d\alpha = -(w_X e_X x + w_Y e_Y y) < 0. \tag{12c}$$

Clearly, currency appreciation either in one southern country, or both, will undermine the profits of the MNE. From (12a-12c), we obtain

Proposition 5. *Under global outsourcing, (i). An appreciation in the currency of either outsourcing destination countries will reduce the profits of the northern MNE; (ii). An appreciation of the northern currency will raise the profits of the MNE.*

Part (i) comes from conditions (12a) and (12b), and part (ii) comes from condition (12c). Conventionally, foreign currency appreciation would raise the profits of home firms, and home currency appreciation would do just the opposite. However, proposition 5 states

that in the present model, exactly the opposite arises. This is so because we incorporate FDI outsourcing, under which the MNE allocates production to maximize global profits. When costs are lower in foreign countries than at home, foreign appreciation drives the MNE to shift production back home, increasing production costs, and in turn lowering profits. Similarly, home currency appreciation pushes the MNE to shift more production abroad, where cost is lower, leading to higher profits.

Now, we turn to the overall welfare of country Z, which consists of two parts: the north MNE profits and consumer surplus, i.e.

$$\Phi = \pi + U(x, y, z) - xp_x - yp_y - zp_z . \tag{13}$$

Differentiating with respect to e_X, e_y and α, and substituting relevant expressions yields respectively

$$\frac{d\Phi}{de_X} = \alpha w_X x(3 + 2\gamma_{xz}\gamma_{xy}\gamma_{yz} - \gamma_{xz}^2 - \gamma_{yz}^2 - \gamma_{xy}^2)/\Delta < 0, \tag{14a}$$

$$\frac{d\Phi}{de_Y} = \alpha w_Y y(3 + 2\gamma_{xz}\gamma_{xy}\gamma_{yz} - \gamma_{xz}^2 - \gamma_{yz}^2 - \gamma_{xy}^2)/\Delta < 0, \tag{14b}$$

$$\frac{d\Phi}{d\alpha} = \frac{1}{\alpha}(e_X \frac{d\Phi}{de_X} + e_Y \frac{d\Phi}{de_Y}) < 0 . \tag{14c}$$

These results can be restated as follows.

Proposition 6: *Welfare in the northern country falls if either southern currency appreciates, or if both southern currencies appreciate by the same proportion.*

Proposition 6 follows from proposition 5. When global outsourcing is possible, currency appreciation in either or both southern countries will cause the MNE to shift production to a country with higher costs before appreciation, leading to overall higher costs and lower profits for the MNE. The MNE thus reduces global output, which in turn lowers consumer surplus. The total effects on welfare in country Z are negative. Thus, the northern country will be worse off if its currency depreciates against those of its outsourcing destinations, which is in stark contrast with the case in the absence of global outsourcing.

5. Concluding Remarks

Using a three-country model, we have analyzed how exchange rate changes affect the MNE's global outsourcing decisions, which cause important consequences on production, employment, profits and welfare. Several contrasting and unconventional findings emerge. A currency appreciation in the southern country (X) producing the lowest-quality good with the lowest cost may reduce production (employment) in the north, while an appreciation in the other southern currency (Y) always raises production in the north. A northern depreciation against both southern currencies may increase production in country X, but always reduces that in country Y. Under the MNE's global outsourcing, northern welfare always falls following currency appreciation in southern countries.

We believe this simple model and its predictions can shed light on the current China debate. While products bearing the "Made in China" label are gaining popularity, they are mainly low-quality, low-price manufacturing goods. As multiple countries are involved in MNEs' global outsourcing activities, and substitutable goods from various countries compete

in the global market, appreciation of the Chinese Yuan will drive consumers to substitute goods made in other southern countries, leading the MNEs to increase production there and subsequently cut production in China. Thus, production and employment in China decrease. In addition, those in the home countries of the MNEs also decrease. As a result, commercial policies targeting the currency appreciation of a single trading partner will most likely not improve domestic employment, neither strengthen the global competitiveness of domestic firms, but on the contrary undermine the national welfare as well as the profits of home MNEs. This is especially true when the targeted country produces the lowest quality product with the lowest cost.

These implications are based on the assumption that China produces the lowest quality with the least cost, which is largely true at present. If over some years wages and other costs increase along with product quality in China, then China becomes the middle quality country and the predictions of country Y apply.

One might argue that even though northern welfare falls with home currency depreciation, northern employment may rise because the MNE shifts production back home. It is worth noting that even if unemployment assistance is incorporated in the paper, the mechanism generating our results does not evaporate. That is, exchange rate movements affect FDI and global outsourcing, through which the MNE's home country may gain in welfare. But the gain may be smaller taking consideration of unemployment assistance and training.

To simplify the analysis, countries X and Y are assumed to not own any firms. In a related paper, we incorporate firm ownership by a FDI host country to analyze reverse imports. The MNE in the present model chooses output to maximize global profits. It could also choose prices. It is well known that prices are lower and outputs higher when choosing

prices than choosing quantity (see for instance, Cheng, 1985). Other than these, all of our qualitative results remain valid.

While our model has a horizontal structure, it can be readily applied vertically. For instance, if we assume $\gamma_{xy} \approx 1$, and $\gamma_{xz} = \gamma_{yz} \approx 0$, and allow some fixed relationship between *x*, *y*, and *z*, then the model becomes one in which the MNE produces inputs in foreign countries and final output at home, which probably is closer to the outsourcing realities of many MNEs. We conjecture that the main results in the model remain robust.

We have investigated the impact of exchange rate changes. The mechanism is the same if wages or other production costs increase in the outsourcing destination countries. Further, commercial policy such as tariffs can be incorporated in the model. Suppose final output is only consumed in country Z, increases in import tariffs cause identical effects as currency appreciations in the southern countries.

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