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The Real Exchange Rate, Mercantilism and the Learning by Doing Externality

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This paper examines the degree to which the learning by doing externality [LBD] calls for an undervalued exchange rate, a policy suggested by recent empirical studies which concluded that mildly undervalued real exchange rate may enhance growth. We obtain mixed results. For an economy where LBD externality operates in the traded sector, real exchange rate undervaluation may be used in order to internalize this externality, if the LBD calls for subsidizing employment in the traded sector. Yet, we also find that these results are not robust to changes in the nature of the LBD externality. If the LBD externality is embodied in aggregate investment, the optimal policy calls for subsidizing the cost of capital in the traded sector, and there is no room for undervalued exchange rate policy.

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1. Introduction

The remarkable takeoff in the hoarding of international reserves by developing countries has been the focus of growing attention and controversies. A casual inspection of the International reserves/GDP ratio trends depicted in Figure 1, and the pattern of hoarding reserves by China in Figure 2, reveals that the hoarding trend from 2001 has been driven mostly by China. Chinese international reserves were stable in the aftermath of the East Asian 1997-8 crisis, but took off at an accelerated speed after 2001, more than quadrupled in five years [2001-2006], reaching by 2008 about 1800 billion dollars. Within this time frame, Chinese international reserves/GDP ratio more than tripled from a relatively high initial level of 15%. Noting the decline in the growth rate of China in the late 1990s, followed by a substantially higher growth rate in the 2000s, some observers attribute the accelerated hoarding of reserves after 2001 to an export-led growth policy supported by mercantilist hoarding of reserves. According to this view, hoarding reserves encourages exports by mitigating or preventing the real exchange rate appreciation that would have occurred under a fully flexible exchange rate system. Indeed, hoarding international reserves has been advocated by Dooley et al. (2005) as a key ingredient of the export-led growth strategy of China.[1] Yet, Aizenman and Lee (2008) noted that such a policy may also reflect competitive hoarding among emerging markets, attempting to preserve their market share in the US and other OECD countries. Modeling this situation in a version of Johnson's tariff game suggests that a country with the lowest cost of sterilization (arguably China), may be the winner of such a game, resulting in "beggar thy neighbor" outcome. The losers on such a game [arguably Korea, Japan, etc.] would keep hoarding reserves to minimize their losses, and will invest directly in China to mitigate their competitive losses. These results are consistent with Figure 3, indicating the acceleration of FDI from Japan and Korea to China from 2001, coinciding with the takeoff of Chinese hoarding of international reserves.

Econometric support for the negative effects of overvaluation on growth has been found by Dollar (1992), Razin and Collins (1999) and others. More recently, Aguirre and Calderón (2005) found that RER misalignments hinder growth but the effect is non-linear: growth declines are larger, the larger the size of the misalignments. Although large undervaluations hurt growth, small to moderate undervaluations enhance growth. [See also Johnson and others (2007).]

[1] For further discussion on Chinese real exchange rate and international reserves see Cheung, Chinn and Fujii (2007) and Tyers, Bain and Bu (2008).

Overviewing this literature, Prasad et al. (2007) point out that overvaluation is frequently the outcome of real factors, like demographic aspects determining the supply of labor, the domestic supply of capital and the inflow of foreign capital, fiscal policy, etc.

A drawback of the above literature is that it presumed that export-led growth strategy requires a policy of undervalued exchange rate, without explaining the potential market failure that is addressed by undervaluation or the hoarding of international reserves. This issue is of obvious relevance for understanding East Asia – Aizenman and Lee (2008) pointed out that mercantilist hoarding of reserves is a relatively new phenomenon in East Asia, and that, during the fast growth phases, Japan (prior to 1992) and Korea (prior to 1997) refrained from an aggressive hoarding of reserves. Instead, Japan and Korea frequently encouraged export-led growth by subsidizing selectively the cost of capital in outward oriented activities, at a cost of reducing the quality of banks' balance sheet. Consequently, there may be various ways of achieving the objective of export-led growth, and one needs to understand the conditions underpinning the desire to subsidize export led growth in order to better understand the policy choices confronting East Asian countries. While the presumption of Dooley et al. (2005) has been that hoarding international reserves by China is a win-win strategy, our approach is more agnostic, viewing it as the outcome of non-cooperative interaction among countries, where some may be adversely affected.

The purpose of the present paper is to model the circumstances that would lead to the export-led growth drive, and to study the challenges associated with implementing such a policy. We model an economy populated by agents consuming non-traded and traded goods. The non-traded is the "traditional" good, produced only by labor, whereas the traded, dubbed manufacturing, is produced by labor and capital, also being subject to the learning by doing [dubbed LBD] externality. Specifically, the productivity of the atomistic firm in the traded sector is determined by the "stock" of experience gained from past aggregate production of the traded good.[2] We focus on the implications of the LBD externality on the conduct of policies, and the robustness of the results to the nature of the LBD externality.

[2] See Krugman (1987), Young (1991), Ambler, Cardia and Farazli (1999) and Leahy and Neary (1999) for earlier studies dealing with the impact of policies in the presence of learning by doing.

2. Basic Model:

We consider a real model, where the periodic utility is

$$(1) \qquad U_t = \left(C_{Nt}\right)^{\gamma} \left(C_{Xt}\right)^{1-\gamma} \quad ,$$

where C_N and C_X are the consumption of the non-traded and the traded goods at time t. The subjective discount factor is β. The traded sector, dubbed manufacturing, is produced by a large number of competitive firms, *q*, and is subject to the learning by doing externality. Aggregate manufacturing output is

$$(2) \qquad X_t = q\left(A_t L_{r,x,t}\right)^{\alpha} \left(K_{r,t}\right)^{1-\alpha} \; ;$$

where index r refers to the representative firm in manufacturing, employing $L_{r,x,t}$, $K_{r,t}$ labor and capital at time t, respectively. To simplify exposition, we assume that capital is subject to full depreciation within a period, and that the traded good invested at time t provides the stock of capital stock at time t+1. The non-traded good is the tradition sector, produced using a Ricardian technology $L_{n.t} = \bar{L} - qL_{r,x.t}$, where the aggregate supply of labor is $\bar{L}$.

The productivity index *A* is affected by learning by doing: today's aggregate production increases future productivity by the experience and the know-how learned today. We assume that this effect is subject to depreciation overtime. Specifically, we assume that A increases with the lagged aggregate discounted output:

$$(3) \qquad A_t = \phi\Omega_t^{\varepsilon}; \qquad \Omega_t = c + X_{t-1} + \delta X_{t-2} + ...; \qquad \varepsilon \geq 0 \,,$$

and $0 < \delta \leq 1$ is the depreciation rate of the LBD stock, Ω_t . The number of firms, *q*, is large enough such that the learning by doing is external to each firm. This in turn implies that the laissez-faire equilibrium is inefficient, and welfare may be enhanced by proper policies. We illustrate these observations in two stages. First, we compare the first order condition characterizing the decisions of a centralized planner wishing to maximize agents' welfare, with

the decentralized allocation obtained in a competitive, laissez-faire equilibrium. The comparison reveals that in the laissez-faire equilibrium there is under-employment and under-investment in the traded sector, as each firm overlooks the contribution of its present production to the future productivity due to the LBD externality. Next, we identify the optimal tax-cum-subsidy by solving the policy intervention that will equate the planner's first order conditions with the first order conditions of the agent in the presence of the tax-cum-subsidy policy. This provides us with the policies that would replicate in the competitive equilibrium the optimal allocation.

The main effects of the LBD externality are illustrated clearly in a two period example (t = 1, 2), where the stock of capital in period 1 is given by history, and productivity is normalized to $A_1 = 1; \quad A_2 = (1+X_1)^{\varepsilon}$. Consider the planner's problem for the case where the investment is self financed, i.e. where we assume first a balanced current account. Since the consumption and the production are identical for both traded and non-traded goods ($C_{Xt} = X_t$ and $C_{Nt} = N_t$), the planner's problem is:

$$(4) \qquad \underset{L_{r,x,1};L_{r,x,2};K_{r,2}}{MAX} \left[\begin{array}{l} (\bar{L} - qL_{r,x,1})^{\gamma} \{q(L_{r,x,1})^{\alpha}(K_{r,1})^{1-\alpha} - qK_{r,2}\}^{1-\gamma} + \\ \frac{1}{1+\beta}(\bar{L} - qL_{r,x,2})^{\gamma} \{q([1+X_1]^{\varepsilon} L_{r,x,2})^{\alpha}(K_{r,2})^{1-\alpha}\}^{1-\gamma} \end{array} \right].$$

The first order conditions can be reduced to

$$(5a) \quad L_{x,1}: \qquad \frac{\gamma U_1}{\bar{L} - qL_{r,x,1}} = \alpha(1-\gamma)\frac{X_1}{qL_{r,x,1}}\left[\frac{U_1}{X_1 - qK_{r,2}} + \frac{\varepsilon\alpha}{1+\beta}\frac{U_2}{1+X_1}\right];$$

$$(5b) \quad K_2: \qquad \frac{(1-\gamma)U_1}{X_1 - qK_{r,2}} = \frac{(1-\gamma)(1-\alpha)}{1+\beta}\frac{U_2}{qK_{r,2}};$$

$$(5c) \quad L_{x,2}: \qquad \frac{\gamma U_2}{\bar{L} - qL_{x,2}} = \alpha(1-\gamma)\frac{U_2}{qL_{x,2}}; \quad \textit{hence} \quad L_{x,2} = \frac{\alpha(1-\gamma)\bar{L}}{q[\gamma + \alpha(1-\gamma)]}.$$

From which we infer that

(6) $$\frac{dL_{r,x,1}}{d\varepsilon}_{|\varepsilon=0} > 0; \quad \frac{dK_{r,2}}{d\varepsilon}_{|\varepsilon=0} > 0 \quad .$$

The above first order conditions correspond to the case where the policy maker adopt the needed tax-cum-subsidy policy that delivers the optimal allocation. To explore the implication of the LBD externality on the needed policies, note that in the laissez-faire equilibrium, consumer's first order conditions are:

(7) $$\frac{\gamma U_1}{\bar{L} - qL_{r,x,1}} = MU_{N,1} = p_{n,1}; \ \frac{(1-\gamma)U_1}{X_1 - qK_{r,2}} = MU_{r,X,1} = 1; \ \frac{(1-\gamma)U_2}{X_2} = MU_{r,X,2} = 1,$$

where $p_{n,1}$ is the real exchange rate, defined by the relative price of non-traded to traded goods [hence, our numeraire is the traded good].

Recalling that the LBD is external to the firm, in the laissez-faire equilibrium, competitive firm hires labor overlooking the LBD externality, thereby $MP_{L_x,1} = p_{n,1}$. In contrast, the social valuation of firm's marginal product takes into account the LBD externality. Applying (7) to (5a), the first order conditions of the planner's problem, (5a-c) can be rewritten as

(8a) $$p_{n,1} = MP_{L_x,1}[1 + \frac{dX_2}{dX_1}] = MP_{L_x,1}[1 + \alpha\varepsilon\frac{X_2}{\Omega_2}].$$

(8b) $$1 + \beta = MP_{K_2}.$$

(8c) $$p_{n,2} = MP_{L_x,2}.$$

The optimal first period employment equates the value of labor's marginal produce in the non-traded sector [= the real exchange rate] with the value of labor's marginal produce in the traded sector, inclusive of the LBD externality [the RHS of (8a)]. Optimal employment from the firm's perspective is determined by a similar first order condition, where the learning by doing externality is ignored (corresponding to $\varepsilon = 0$, $MP_{L_x,1} = p_{n,1}$). The gap between the private and the social FOC can be rectify by the proper policy, calling for subsidizing employment in the traded sector, and applies as long as the learning by doing is external to the firm. The optimal

wage subsidy in the traded sector, s_u, is set as to induce the firms to internalize the LBD externally depicted by the RHS of (8a), implying $s_u = \alpha\varepsilon \frac{X_2}{\Omega_2} / [1 + \alpha\varepsilon \frac{X_2}{\Omega_2}]$.[3] If such wage subsidy is not feasible, similar outcome may be obtained by undervaluing the real exchange rate to a level $\tilde{p}_{n,1}$, where $\tilde{p}_{n,1} = p_{n,1} / [1 + \alpha\varepsilon \frac{X_2}{\Omega_2}]$.[4]

To gain further insight into the implications of the LBD, Table 1 summarizes a simulation, tracing the optimal employment share in the traded sector out of the supply of labor ($qL_{r,x,t} / \bar{L}$), the second period stock of capital ($qK_{r,2}$), the optimal wage subsidy in the traded sector ($\tilde{s}_u$), and the optimal undervalued real exchange rate in circumstances when wage subsidy is not feasible, $\tilde{p}_{n,1}$.

ε	$qL_{r,x,1} / \bar{L}$	$qK_{r,2}$	$L_{r,x,2} / \bar{L}$	$\tilde{s}_u$	$\tilde{p}_{n,1}$
0	0.561667	0.54	0.43	0	0.289
0.2	0.585	0.59	0.43	0.1	0.27
0.4	0.613333	0.64	0.43	0.228	0.25

Table 1

LBD externality and optimal employment and investment, a two period example

The assumed parameter values are $L = 6, q = 10, \gamma = 0.4, \beta = 0.02, \alpha = 0.5, K_1 = 0.05$.[5]

[3] We find the optimal subsidy by solving the subsidy value that equates the demand for labor by the firm in the competitive equilibrium in the presence of policy (characterized by the firm's first order condition equating labor's marginal product to the net wage paid by the firm, $MP_{L_x,1} = p_{n,1}(1 - s_u)$) with the corresponding planner's optimal employment condition (characterized by (8a), $p_{n,1} = MP_{L_x,1}[1 + \alpha\varepsilon \frac{X_2}{\Omega_2}]$). Solving the system of these two FOCs provides the value of the optimal subsidy.

[4] One may view such a policy as a combination of export subsidy at a rate of $1 + \alpha\varepsilon \frac{X_2}{\Omega_2}$.

[5] Setting the labor share in the traded sector, α, to 0.5, is consistent with Young (2003).

The LBD externality increases the social marginal product of labor in the traded sector by increasing the future productivity, increasing thereby the optimal first period employment in the traded sector. The wage subsidy provided to the traded sector induces all firms to increase the first period employment to the optimal level. The resultant higher second period productivity increases also the first period investment determining the second period optimal stock of capital.[6] As the second period is the end of the planning horizon, the LBD externality is not impacting the second period employment patterns. This is an artifact of the two-period horizon, and will be shown not to hold if one extends the model's horizon.

Despite its effects on the level of employment and production, however, the LBD externality has no direct effect on the socially optimal level of trade surplus. Trade imbalance, or foreign lending and borrowing, can be introduced by variable F_t which denotes the stock of net foreign assets at the beginning (end) of period *t* (*t-1*): $F_{t+1} = (1+r^*)F_t + (X_t - C_{Xt}) + P_{Nt}(N_t - C_{Nt}) - I_t$ where I_t is the investment. In the two-period case, the net foreign assets at the end of period 2 would be optimally zero, and we assume the initial net foreign assets (at the beginning of period 1) to be zero. We can then write consumer's problem as follows.

$$\underset{L_{r,x,1};\, L_{r,x,2};\, K_{r,2}}{MAX} \left[\begin{array}{l} (\bar{L} - qL_{r,x,1})^{\gamma} \{ q(L_{r,x,1})^{\alpha} (K_{r,1})^{1-\alpha} - qK_{r,2} - F_2 \}^{1-\gamma} + \\ \frac{1}{1+\beta} (\bar{L} - qL_{r,x,2})^{\gamma} \{ q([1+X_1]^{\varepsilon} L_{r,x,2})^{\alpha} (K_{r,2})^{1-\alpha} + (1+r^*)F_2 \}^{1-\gamma} \end{array} \right].$$

We can see that the LBD externality has no effect of increasing trade surplus. The first-order condition is:

$$1 + r^* = U_1 \Big/ \left(\frac{U_2}{1+\beta} \right).$$

[6] Rational expectations implies that, once that all firms increase the first period employment due to the optimal wage subsidy, firms recognize that productivity will be higher next period, increasing thereby first period investment. Hence, the wage subsidy overcomes the "free rider" problem associated with LBD that is external to the firm.

This is the condition that is familiar from the standard intertemporal model of current account, according to which an economy borrows or lends to equate the intertemporal rate of substitution to the international rate of interest.

The strength of LBD externality thus has no direct effect on the level of trade surplus or deficit, and has an indirect effect by changing the incentive for intertemporal trade. The effect can be in the direction that a strong LBD externality would increase the incentive to borrow in the earlier period before the LBD externality has not materialized in the form of a high productivity. A strong LBD externality implies that, ceteris paribus, the output in later periods are higher because of a higher productivity. The economy in the initial periods is therefore looking forward to later periods of higher output, and thus would like to borrow to fund a higher consumption.

In the rest of the paper, we flash out the policy implications of the LBD externality on the basis of the balanced-trade assumption. We have seen that a strong LBD externality does not sway one way or the other, the trade surplus in the early phase of economic growth. This implication is broadly consistent with the growth experience of Japan and Korea, neither of which had particularly large current account or trade surpluses during their *early* years of economic growth (except in years of macroeconomic crises). In both countries, massive reserve accumulation had come around in later stages of growth, following crisis-driven economic slowdown [Aizenman and Lee (2008)].

In a short digression, note that if there were uncertainty about the degree to which the authorities would adopt the policies called by the LBD externalities, the early investors would enjoy a windfall gains following the adaptation of these policies. This follows from the observation that gross rent per unit of capital in the first period increases with the labor/capital ratio [note that $(1-\alpha)(K_1)^{1-\alpha}(L_{r,1,x})^{\alpha}/K_{r,1} = (1-\alpha)(L_{r,1,x}/K_{r,1})^{\alpha}$]. Hence, a policy that would reduce the cost of labor in period one would increase the rent of installed capital -- the prospect of adopting the policy that would internalize the externality in period 1 has the effect of increasing the rent to the capital invested in period zero, K_1. Our discussion can be extended to the case where capital depreciates overtime. In these circumstances, anticipation of the gains associated with adopting future polices that would internalize the LBD externality may induce potentially large inflows of FDI at early stages of the development process, even if the present fundamentals are mixed.

The above example provides a case for wage subsidy to the traded sector, or real exchange undervaluation. Yet, this result hinges on the nature of the LBD externality. To gain further insight, we review now several extensions dealing with the planning horizon and the nature of the LBD externality.

We first extend the model to a three period horizon, focusing on the planner's problem in period one, setting the investment determining the stock of capital in period two, and the optimal first period employment:

$$(9)\qquad \underset{L_{r,x,1};L_{r,x,2};L_{r,x,2};K_{r,2};K_{r,3}}{MAX}\left[\begin{array}{l} q(L_{r,x,1})^{\alpha}(K_{r,1})^{1-\alpha}-qK_{r,2}-w_1qL_{r,x,1}+ \\ \frac{1}{1+\beta}\{q(A_2L_{r,x,2})^{\alpha}(K_{r,2})^{1-\alpha}-qK_{r,3}-w_2qL_{r,x,2}\}+ \\ \frac{1}{(1+\beta)^2}\{q(A_3L_{x,3})^{\alpha}(K_3)^{1-\alpha}-w_3qL_{x,2}\} \end{array}\right].$$

The FOC characterizing the first period decisions are:

$$(10)\qquad \begin{array}{l} w_1=MP_{L_x,1}[1+\frac{1}{1+\beta}\frac{\partial X_2}{\partial X_1}(1+\frac{1}{1+\beta}\frac{\partial X_3}{\partial X_2})+\frac{1}{(1+\beta)^2}\frac{\partial X_3}{\partial X_1}] \\ 1+\beta=MP_{K_2,2}[1+\frac{1}{1+\beta}\frac{\partial X_3}{\partial X_2}] \end{array}.$$

Alternatively,

$$(10')\qquad \begin{array}{l} w_1=MP_{L_x,1}[1+\frac{1}{1+\beta}\alpha\varepsilon\frac{X_2}{\Omega_2}(1+\frac{\alpha\varepsilon}{1+\beta}\frac{X_3}{\Omega_3})+\frac{\alpha\varepsilon\delta}{(1+\beta)^2}\frac{X_3}{\Omega_3}] \\ 1+\beta=MP_{K_2,2}[1+\frac{\alpha\varepsilon}{1+\beta}\frac{X_3}{\Omega_3}] \end{array}.$$

The firm's FOC is a special case of (10'), where $\varepsilon = 0$. Hence, optimality calls for subsidizing *both* employment and investment in the traded sector, at a rate that increases with the LBD externality. Note that extending the planning horizon implies that, with the exception of

the terminal employment and capital levels, the LBD externality increases the social marginal product of both labor and capital due to the impact of the present output on future productivity.

Our discussion can be extended to the case of infinite horizon, where the problem is:

$$(11)\quad \underset{\substack{L_{r,x,1+t};K_{r,2+t}\\ t=0,1,2...}}{MAX}\left[\sum_{j=0}^{\infty}\left\{\frac{q(L_{r,x,1+j})^{\alpha}(K_{r,1+j})^{1-\alpha}-qK_{r,2+j}-w_{1+j}qL_{r,x,1+j}}{(1+\beta)^{j}}\right\}\right].$$

Similar FOC applies: the social marginal product of each input is inclusive of the NPV of the marginal impact of firms MP on future productivity:

$$(12)\quad \begin{aligned} w_{t+1} &= MP_{L_x,t+1}[1+\sum_{j=1}^{\infty}\frac{1}{(1+\beta)^{j}}\frac{\partial X_{t+j+1}}{\partial X_{t+1}}] \\ 1+\beta &= MP_{K,t+1}[1+\sum_{j=1}^{\infty}\frac{1}{(1+\beta)^{j+1}}\frac{\partial X_{t+j+2}}{\partial X_{t+1}}] \end{aligned}.$$

Note that the LBD externality calls for subsidizing the inputs used in the production of manufacturing, at a rate that increases with the externality, as is reflected by ε. The magnitude of the subsidy to labor and capital differs due to timing issues, as the capital used at time t was invested at t – 1, whereas labor used in time t is hired in the spot market. The gap between the optimal subsidy to labor and capital depend negatively on the LBD deprecation rate, δ, and the discount factor, β. In the limiting case, where $\beta \to 0 \quad \& \quad \delta \to 0$, the two subsidies rates are identical.

In assessing these results, one should keep in mind the dependence of the optimal policy on the nature of the LBD externality. Suppose that the externality is embodied in the capital, as has been modeled frequently by the endogenous growth literature that followed Romer (1986).[7] This would be the case when knowledge creation is a side product of investment, as is when

[7] This literature frequently assumed that productivity increases with the aggregate capital stock, $A_t = \phi(\sum_i K_{i,t})^{\varepsilon}$.

productivity at time t increases with aggregate capital. In terms of our model, the LBD stock at time t would be:

$$(13) \quad A_t = \phi\Omega_t^{\varepsilon}; \qquad \Omega_t = c + \sum_{i=1}^{q} K_{i,t} + \delta \sum_{i=1}^{q} K_{i,t-1} + ...; \qquad \varepsilon \geq 0,$$

where i, $1 \leq i \leq q$ is the index of firms. In these circumstances, optimal policy calls for subsidizing only the cost of capital, and that real exchange rate undervaluation would not deal with this type of LBD externality.[8] In contrast, if the LBD externality is embodied in the aggregate employment [i.e., $\Omega_t = c + \sum_{i=1}^{q} L_{x,i,t} + \delta \sum_{i=1}^{q} L_{x,i,t-1} + ...$], optimal policy calls for real exchange rate undervaluation instead of subsidizing capital. The endogenous growth literature frequently assumed that the LBD externality is embodied in aggregate investment, apparently due to the more convenient modeling associated with it. Yet, there is no clear empirical evidence that provides support the "aggregate investment" externality instead of an "aggregate production" or "aggregate employment" externalities.

We add now rudimentary monetary considerations. Suppose that we start with a configuration of a fixed exchange rate, where the nominal exchange rate is pegged to 1, and the law of one price under which the foreign currency price of the traded good is normalized at 1. We assume that individuals choose to hold domestic currency so as to economize on the transactions costs of exchange associated with producing the GDP, leading to a demand for money

$$(14) \quad \frac{M_t^d}{1} = k[p_{n,t} N_t + X_t].$$

[8] This follows form the observation that when the LBD externality is given by (13); the FOC for the optimal employment of capital and labor are: $w_{t+1} = MP_{L_{x,t+1}}; \quad 1+\beta = MP_{K_{t+1}}[1 + \sum_{j=1}^{\infty} \frac{1}{(1+\beta)^{j+1}} \frac{\partial X_{t+j+2}}{\partial X_{t+1}}]$.

Let the initial supply of money $\bar{M}_t^s$ be set to accommodate a given path of production and expenditure, assuring zero balance of payment.

Suppose that a shock induces monetary expansion of $(1-s)F_t$, where F_t is the original shock [reflecting inflow of capital, favorable trade shock; etc.], and *s* is the coefficient of sterilization. Hence, the new short run equilibrium at time t is:

$$(15) \qquad \bar{M}_t^s + (1-s)F_t = k[p_{n,t}N_t + X_t].$$

Maintaining the assumption of price and wage flexibility, we infer that[9]

$$(16) \qquad \frac{dp_{n,t}/p_{n,t}}{dF_t/\bar{M}_t^s}\Big|_{s=0} = \frac{\bar{M}_t^s}{kp_{n,t}N_t} = \frac{p_{n,t}N_t + X_t}{p_{n,t}N_t}$$

$$\frac{dp_{n,t}/p_{n,t}}{ds(F_t/\bar{M}_t^s)} = -\frac{\bar{M}_t^s}{kp_{n,t}N_t} = -\frac{p_{n,t}N_t + X_t}{p_{n,t}N_t}$$

A monetary disturbance F_t induces the real appreciation at a rate that depends inversely on the openness of the economy, as measured by the GDP share of the traded sector. Similarly, sterilization mitigates the real appreciation at a rate that depends inversely on the openness of the economy. This in turn suggests that keeping the real exchange rate at a level that internalizes the LBD externality calls for the sterilization of financial inflows.

The sterilization has to be of a real variety, which can keep the real exchange rate at the optimal level and maintain the nominal exchange rate at its peg (assumed to equal 1 in equation (14)). The combination of BOP inflows and offsetting stabilizations can result in the pattern that was or has been observed in several emerging markets. In an effort to sterilize the effect of large BOP inflows—via current or financial account—the government accumulates large external assets in the form of international reserves. While this sterilization by pumping out BOP inflows

[9] Note that the envelope theorem implies that $d[p_{n,t}N_t + X_t]/dL_{x,t} = 0$, hence we ignore second order GDP effects associated with employment changes induced by the real appreciation.

continues, the real exchange rate can be maintained at a level that stimulates production and consequent improvement in productivity via the LBD channel.

3. Discussion

Our analysis suggests circumstances under which policies promoting sectors characterized by the LBD externality may be desirable. Yet, the details of these policies hinge on the exact nature of this externality, and the quality of the governance which ultimately determines the efficacy of policy intervention. It would be too simplistic to view the successful growth of China as stemming from a deliberate undervalued exchange rate by means of large reserves hoardings. First, similar success stories in East Asia have happened without active hoarding policies. Second, depending on the nature of the LBD externality, it may call for subsidizing the cost of capital, subsidizing the cost of labor, or both. Real exchange rate undervaluation would be the suggested policy only if the LBD externality calls for subsidizing employment in the traded sector, and if this end can't be accomplished by more effective means. After all, hoarding international reserves is a policy that impacts the stance of monetary policy and the domestic interest rates. Such a policy may backfire if the needed sterilization would lead to markedly higher interest rate, reducing thereby capital accumulation in the traded sector. The adverse financing effects of hoarding reserves are more likely to be larger in countries characterized with shallow financial system, low saving rates, and more costly sterilization; conditions that on balance apply to Latin America. Finally, the adaptation of similar hoarding policies by countries competing in the same third market may lead to competitive hoarding, dissipating the competitive gains of most involved countries [see Aizenman and Lee (2008)]. Yet, hoarding reserves may be an effective short-intermediate run policy dealing with balance of payment effects of shocks whose permanency is not known, like terms of trade improvements and capital inflows [see Aizenman and Riera-Crichton (2006)].

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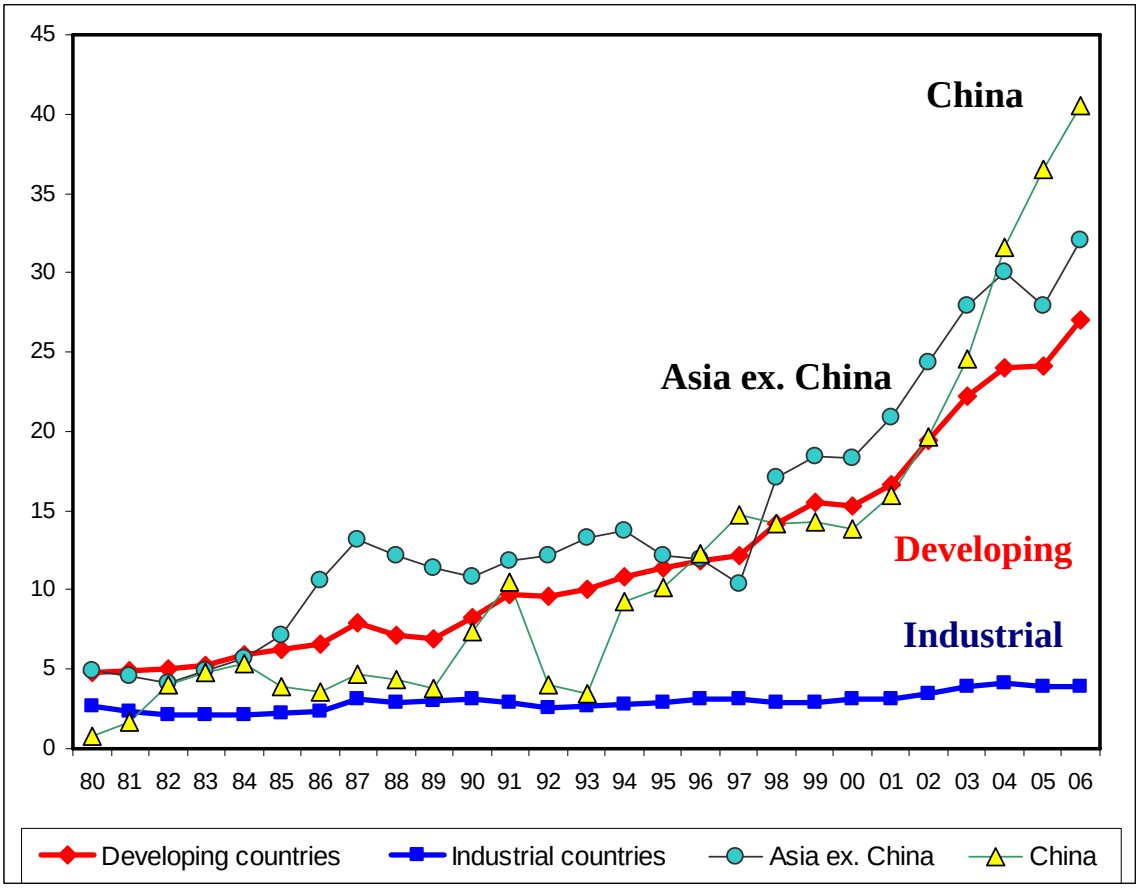

Figure 1

IR/GDP, 1980-2006

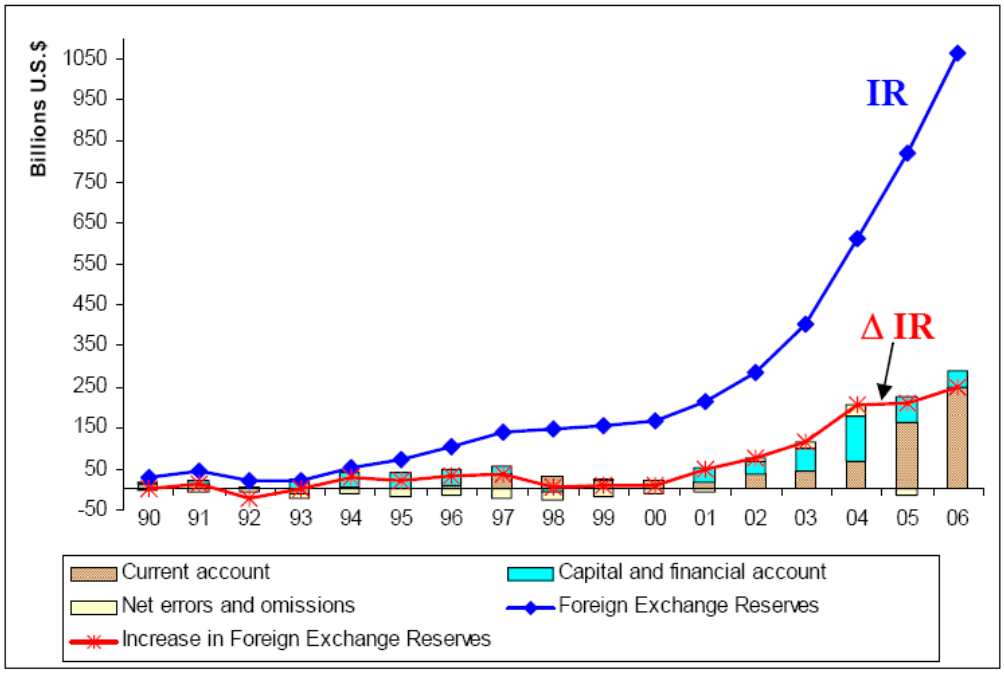

Figure 2

IR hoarding in China, 1990-2006

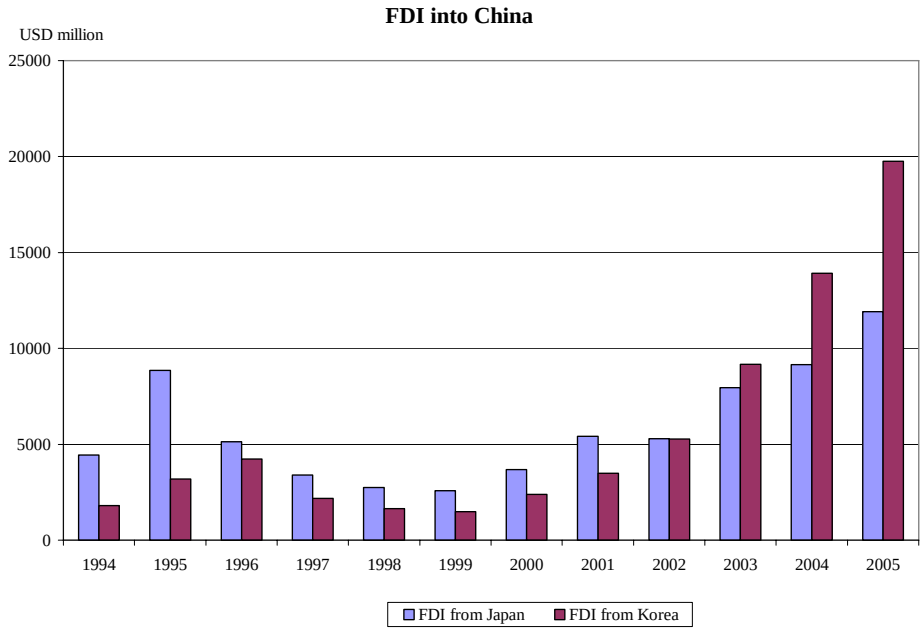

Figure 3

FDI inflows to China from Korea and Japan, 1994-2006