Currency Undervaluation and Comparative Advantage

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Abstract

This paper highlights a tradeoff implied by a policy of export-led growth through currency undervaluation. While undervaluation can foster domestic manufacturing in countries like China by sustaining trade surplus, it also can harm a country's comparative advantage by altering the composition of exports. Undervaluation may discourage specializing in high-value added manufacturing and instead favor specialization in non-differentiated goods with higher price elasticity. A dynamic general equilibrium model of two traded good sectors and capital account restrictions shows that undervaluation can either raise or lower welfare depending on two competing effects on comparative advantage: agglomeration versus an elasticity effect.

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1. Introduction

The coincidence of large reserve accumulation and rapid GDP growth in some Asian economies, most notably China, have raised the question of whether a policy of capital controls, reserve accumulation and currency undervaluation can contribute to export-led growth by sustaining a prolonged trade surplus.[1] Potential mechanisms for how a sustained trade surplus can promote growth include a home market effect (Epifani and Gancia (2017), and Corsetti, et al. (2007)) as well as learning-by-doing externalities (Rodrik (2008), Aizenman and Lee (2010), Korinek and Serven (2016), and Choi and Taylor (2017)). However, this paper argues theoretically that there is a potential drawback in such a policy of export-led growth, in terms of undesirable effects on a country's comparative advantage. Gains obtained by raising the overall level of a country's exports may be negated by implications of currency undervaluation for the composition of those exports.

The paper's main argument is that undervaluation may disproportionately encourage production and export of non-differentiated goods, which generally are characterized by a high elasticity substitution and hence greater sensitivity of demand to exchange rates compared to goods classified as differentiated. The undervaluation thus puts at a relative disadvantage the production and export of differentiated goods, which tend to confer certain welfare benefits. As an example, an undervalued currency could help China raise exports and become the workshop of the world in terms of assembly activities. But if China wished to move up the product ladder and become a creator of branded goods, a strategy based on simple price competitiveness may be counterproductive.

To consider this tradeoff between the potential benefits of a net trade surplus and the composition of trade, this paper uses a model with two traded good sectors. One sector consists of differentiated goods, characterized by monopolistic competition, free entry subject to a sunk entry cost, and roundabout production. The other sector consists of non-differentiated goods characterized by perfect competition. Given free entry in the differentiated goods sector, the model exhibits the production delocation externality and

[1] See for example, Dooley et al. (2004), Rodrik (2008), Aizenman and Lee (2010), Bacchetta, et al. (2013), and Michaud and Rothert (2014)).

home market effect studied in the trade literature (see Ossa (2007) and Epifani and Gancia (2017)), in which a large home market attracts greater entry of new firms and varieties of differentiated goods. Drawing on the macroeconomics literature, the model also features a capital market structure that includes capital controls on international asset trade by households, and government policy to accumulate reserves to maintain a low value of domestic currency.

The main findings are, first, that currency undervaluation can either encourage or discourage comparative advantage in differentiated goods depending on two competing mechanisms, and second, that the welfare implications of undervaluation depend upon which way comparative advantage shifts. On one hand, while the net trade surplus raises demand for all home goods, this can favor the differentiated sector, since the expansion of differentiated production gives rise to new home firm entry in this sector. This firm delocation mechanism is amplified by agglomeration, in which a rise in the number of differentiated goods varieties produced locally lowers home production costs, since differentiated goods use other differentiated goods as inputs.

On the other hand, the possibility that non-differentiated goods may have a higher elasticity of substitution between home and foreign types compared to differentiated goods implies that a currency undervaluation lowering the price of all home goods relative to their foreign counterparts by a common percentage could more strongly shift demand toward home non-differentiated goods. This elasticity mechanism favors home specialization in non-differentiated goods and tends to lower production of differentiated goods; it thereby works against the firm delocation mechanism explained above.

Model simulations indicate that either of these two mechanisms can dominate, depending on parameter values, and an undervaluation can foster specialization either in differentiated or non-differentiated goods. In particular, in the absence of agglomeration effects for differentiated goods arising from roundabout production, the undervaluation will favor specializing in non-differentiated goods whenever the non-differentiated elasticity of substitution is sufficiently greater than that among differentiated goods. However, in the presence of agglomeration of sufficient strength, the undervaluation favors home specialization in differentiated goods. Further, we find that for agglomeration sufficiently strong, the implication of the elasticity mechanism flips, so that a higher elasticity for non-differentiated goods actually further amplifies home specialization in differentiated goods. The reason is that a high degree of production specializing in differentiated goods becomes easier when it is easier for home consumers to substitute imported foreign non-differentiated goods for home non-differentiated goods no longer produced at home.

The paper finds that the welfare implications of currency undervaluation depend crucially on the direction of the resulting shift in comparative advantage. As is usual in the trade literature studying firm delocation, specialization in differentiated goods confers welfare gains to households, in that consumers do not need to pay trade costs associated with differentiated goods when they are produced at home, thus lowering the price index and raising overall consumption. Specialization in non-differentiated goods, on the other hand, implies greater imports of foreign differentiated goods and hence greater trade costs and a negative effect on home welfare. Model simulations indicate that if undervaluation confers a sufficiently strong specialization in differentiated goods, it can lead to a net rise in steady state welfare.

This work is related to the large trade literature studying production delocation and the home market effect. We differ in showing how exchange rate policy is an alternative to the usual tariff policy in enlarging the home market and generating production delocation. One significant difference between exchange rate policy and tariff policy in this regard is that while tariff policy can be targeted to a desired sector such as differentiated goods, an exchange rate undervaluation does not distinguish a-priori between sectors. This is why delocation created by exchange rate policy can either encourage or discourage firm entry in the desired sector, depending on the relative elasticities of substitution.

The paper is related to Epifani and Gancia (2017), which showed in an environment with one traded good (and one nontraded good) that transfers from one country to another can raise domestic welfare by encouraging firm delocation, and that such transfers can be interpreted as a currency depreciation. The present paper differs in several respects. Foremost, it shows important implications for comparative advantage by introducing more than one traded sector. Second, it develops a full dynamic macro environment that considers the dynamic implications of delocation, including the short run costs leading to gains in the steady state. Third, it explicitly models the asset market structure and policies needed to sustain a policy of currency undervaluation.

More broadly, the paper relates to the literature discussing how currency undervaluation and capital market restrictions could have contributed to the growth success in China (such as Dooley, et al. (2004), Rodrik (2008), Aizenman and Lee (2010), Bacchetta, et al. (2013), Jeanne (2013), Michaud and Rothert (2014), Korinek and Serven (2016) and Choi and Taylor (2017)). Again, this literature tends to focus on economic environments with one traded good, while the present paper differs in showing side effects of such a growth strategy on comparative advantage between two traded sectors, and the resulting limitations of such a strategy to raise welfare.

This paper shares with Bergin and Corsetti (2020) a focus on comparative advantage between two traded sectors, and the present model draws on the goods market structure of that paper. However, the present paper differs fundamentally in studying the effect of a currency undervaluation, rather than the effect of monetary stabilization policy on risk premia. Consequently this paper abstracts from monetary policy and from a stochastic environment needed to model business cycles.

The next section presents the theoretical model. Section 3 shows results from a benchmark version of the model in which undervaluation can have adverse effects on comparative advantage in the presence of a highly substitutable non-differentiated good. Section 4 shows results in a version with agglomeration effects dominant, and section 5 studies robustness and sensitivity. Section 6 draws implications for policy choices and concludes.

2. Model

Consider a dynamic two-country monetary model suitable for studying the effect of a sustained currency undervaluation on comparative advantage. The model features two tradable good sectors, which differ in terms of their substitutability between domestic and foreign versions. Comparative advantage is measured in terms of the share of each good in domestic production and exports. The model also features capital account restrictions segmenting the international asset market, which permits the home country to pursue a policy of prolonged currency undervaluation through reserve accumulation.

2.1 Goods market structure

The goods market specification largely follows that of Bergin and Corsetti (2020), whereby households consume goods produced in two sectors, one consisting of differentiated goods and the other non-differentiated. The differentiated goods come in many varieties, produced by an endogenous number of monopolistically competitive firms in the home and foreign country, n_t and n_t*. Each variety is an imperfect substitute for any other variety in this sector, either of home or foreign origin, with elasticity ϕ. The non-differentiated goods come in a home and foreign version, which are imperfect substitutes with elasticity η. However, within each country, all goods in this sector are perfectly substitutable with each other, and are produced in a perfectly competitive environment. The differentiated sector will be denoted with a *D* and the non-differentiated sector with a *N*.

The overall consumption index is specified as $C_t \equiv C_{D,t}^{\theta} C_{N,t}^{1-\theta}$, where

$C_{D,t} \equiv \left(\int_0^{n_t} c_t(h)^{\frac{\phi-1}{\phi}} dh + \int_0^{n_t^*} c_t(f)^{\frac{\phi-1}{\phi}} df \right)^{\frac{\phi}{\phi-1}}$ is the index over the endogenous number of home and foreign varieties of the differentiated manufacturing good, $c_t(h)$ and $c_t(f)$, and

$C_{N,t} \equiv \left(\nu^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + (1-\nu)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$ is the index over goods differentiated only by country of origin, $C_{H,t}$ and $C_{F,t}$, with $\nu \in [0,1]$ accounting for the weight on domestic goods. The corresponding welfare-based consumption price index is

$$P_t \equiv \frac{P_{D,t}^{\theta} P_{N,t}^{1-\theta}}{\theta^{\theta} (1-\theta)^{1-\theta}}, \tag{1}$$

where

$$P_{D,t} = \left(n_t p_t(h)^{1-\phi} + n_t^* p_t(f)^{1-\phi} \right)^{\frac{1}{1-\phi}} \tag{2}$$

is the index over the prices of all varieties of home and foreign differentiated goods, $p_t(h)$ and $p_t(f)$, and

$$P_{N,t} = \left(\nu P_{H,t}^{\ 1-\eta} + (1-\nu) P_{F,t}^{\ 1-\eta} \right)^{\frac{1}{1-\eta}} \tag{3}$$

is the index over the prices of home and foreign non-differentiated goods.

The relative demand functions for domestic residents implied from our specification of preferences are as follows:

$$C_{D,t} = \theta P_t C_t \,/\, P_{D,t} \text{ and } C_{N,t} = \left(1-\theta\right) P_t C_t \,/\, P_{N,t} \tag{4}$$

$$c_t(j) = \left(p_t(j) / P_{D,t}\right)^{-\phi} C_{D,t} \text{ for varieties } j = \{h, f\} \tag{5}$$

$$C_{H,t} = \nu\left(P_{H,t} / P_{N,t}\right)^{-\eta} C_{N,t} \text{ and } C_{F,t} = (1-\nu)\left(P_{F,t} / P_{N,t}\right)^{-\eta} C_{N,t} \tag{6}$$

2.2 Households

The representative home household derives utility from consumption (C_t) and from holding real money balances (M_t/P_t), and disutility from labor (l_t). The household derives income from working at the wage rate W_t and from profits rebated from home firms $\left(\Pi_t\right)$. Home households are precluded by government policy from international asset trade, so they are limited to holdings of home currency debt (B_{Ht}) which pays interest rate i_{t-1}, and which can only be traded domestically. Households pay lump-sum taxes (T_t).

Household optimization for the home country may be written:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, l_t, \frac{M_t}{P_t}\right)$$

where utility is defined by

$$U_t = \frac{1}{1-\sigma} C_t^{1-\sigma} + \ln \frac{M_t}{P_t} - \frac{1}{1+\psi} l_t^{1+\psi},$$

subject to the budget constraint:

$$P_t C_t + \left(M_t - M_{t-1}\right) + \left(B_{Ht} - B_{Ht-1}\right) = W_t l_t + \Pi_t + i_{t-1} B_{Ht-1} - T_t .$$

Household optimization implies an intertemporal Euler equation:

$$\beta\left(1+i_t\right) E_t\left[\frac{P_t C_t^{\sigma}}{P_{t+1} C_{t+1}^{\sigma}}\right] = 1, \tag{7}$$

which in the absence of international asset trade defines the domestic interest rate. Optimization also implies a labor supply condition:

$$\frac{W_t}{P_t} = l_t^{\psi} C_t^{\sigma}, \tag{8}$$

and a money demand condition:

$$\frac{M_t}{P_t} = C_t^{\sigma}\left(\frac{1+i_t}{i_t}\right). \tag{9}$$

Due to the full asset market segmentation, there is no interest rate parity condition.

The problem and first order conditions for the foreign household are analogous. While they do not face an explicit prohibition on international asset trade from their government, since neither home government nor home households are able to sell home currency bonds internally, foreign households are effectively limited to holding foreign currency bonds (B_{Ft}^{*}) which pay interest rate i_t^{*}.

2.3 Firms in the differentiated goods sector

In the manufacturing sector, the production of each differentiated variety follows

$$y_t(h) = \alpha_D \left[G_t(h)\right]^{\zeta} \left[l_t(h)\right]^{1-\zeta}, \tag{10}$$

where $l_t(h)$ is the labor employed by firm h, and $G_t(h)$ is a composite of differentiated goods used by firm h as an intermediate input. $G_t(h)$ is specified as an index of home and foreign differentiated varieties that mirrors the consumption index specific to differentiated goods ($C_{D,t}$). Productivity, α_D , is common to all firms in the sector.

There is free entry in the sector, but, once active, firms are subject to an exogenous death shock with probability δ . The number of firms active in the differentiated sector, n_t, at the beginning of each period evolves according to:

$$n_{t+1} = (1-\delta)(n_t + ne_t), \tag{11}$$

where ne_t denotes new entrants.

To set up a firm, managers incur a one-time sunk cost, K, and production starts with a one-period lag. Entry costs are in units of differentiated goods, allocated over varieties analogously to demands for consumption of differentiated good in equation (5).

Total demand facing a domestic differentiated goods firm is:

$$d_t(h) = c_t(h) + d_{G,t}(h) + d_{K,t}(h) \tag{12}$$

which includes the demand for consumption ($c_t(h)$) by households, and the demand by firms for intermediate inputs ($d_{G,t}(h)$), and firm entry investment ($d_{K,t}(h)$). We assume iceberg trade costs τ_D for exports, so that market clearing for a firm's variety is:

$$y_t(h) = d_t(h) + (1+\tau_D) d_t^*(h), \quad (13)$$

where $d_t^*(h)$ is foreign demand for home variety *h*. Firm profits are computed as:

$$\pi_t(h) = p_t(h) d_t(h) + e_t p_t^*(h) d_t^*(h) - mc_t y_t(h). \quad (14)$$

where $mc_t = \zeta^{-\zeta}(1-\zeta)^{\zeta-1} P_{D,t}{}^{\zeta} W_t^{1-\zeta} / \alpha_{D,t}$ is marginal cost.[2]

Thus the value function of firms that enter the market in period *t* may be represented as the discounted sum of profits of domestic sales and export sales:

$$v_t(h) = E_t\left\{\sum_{s=0}^{\infty}(\beta(1-\delta))^s \frac{\mu_{t+s}}{\mu_t}\pi_{t+s}(h)\right\},$$

where we assume firms use the discount factor of the representative household, who owns the firm, to value future profits. With free entry, new producers will invest until the point that a firm's value equals the entry sunk cost:

$$v_t(h) = P_{D,t} K, \quad (15)$$

where *K* is specified as an index of differentiated varieties that mirrors the consumption index specific to differentiated goods ($C_{D,t}$). By solving for cost minimization we can express the relative demand for labor and intermediates as a function of their relative costs:

$$\frac{P_{D,t} G_t(h)}{W_t l_t(h)} = \frac{\zeta}{1-\zeta}. \quad (16)$$

And we can solve for the optimal price setting by the firm:

$$p_t(h) = \frac{\phi}{\phi - 1} mc_t. \quad (17)$$

where *mc* is marginal cost defined above. The good price in foreign currency moves one-to-one with the exchange rate:

$$p_t^*(h) = (1+\tau_D) p_t(h) / e_t, \quad (18)$$

where recall the nominal exchange rate, *e*, measures home currency units per foreign.

Note that, since households own firms, they receive firm profits but also finance the creation of new firms. In the household budget, the net income from firms may be written:

$$\Pi_t = n_t \pi_t(h) - ne_t P_{D,t} K.$$

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[2] This marginal cost is implied by the optimal combination of inputs derived from cost minimization using the production function in equation (10).

In reporting quantitative results, we will refer to the overall home gross production of differentiated goods defined as: $y_{D,t} = n_t y_t\left(h\right)$, using the fact that all firms are the same size.

2.4 Firms in the non-differentiated sector

In the second sector firms are assumed to be perfectly competitive in producing a good differentiated only by country of origin. The production function for the home non-differentiated good is linear in labor:

$$y_{H,t} = \alpha_N l_{H,t} \,. \tag{19}$$

It follows that the price of the homogeneous goods in the home market is equal to marginal costs:

$$p_{H,t} = W_t / \alpha_N \,. \tag{20}$$

An iceberg trade cost specific to the non-differentiated sector implies prices of the home good abroad are

$$p^*_{H,t} = p_{H,t}\left(1+\tau_N\right)/ e_t \,. \tag{21}$$

Analogous conditions apply to the foreign non-differentiated sector.

2.5 Government policies

The home government issues money (M_t) and home currency bonds (B^s_{Ht}), and levies lump sum taxes on domestic households (T_t). The home government has the ability to purchase foreign currency bonds in the international asset market, to hold as foreign currency reserves (R_{Ft}). The model also allows for inter-governmental transfers (X_t), defined in foreign currency units, and defined as positive when home is the giver. The home government faces the following budget constraint:

$$T_t + \left(M_t - M_{t-1}\right) + \left(B^s_{H,t} - \left(1+i_{t-1}\right)B^s_{H,t-1}\right) = e_t\left(R_{F,t} - \left(1+i^*_{t-1}\right)R_{F,t-1}\right) + e_t X_t \,, \tag{22}$$

The corresponding budget constraint for the foreign government is:

$$T^*_t + \left(M^*_t - M^*_{t-1}\right) + \left(B^{s*}_{F,t} - \left(1+i^*_{t-1}\right)B^{s*}_{F,t-1}\right) + X_t = 0 \,. \tag{23}$$

where $B^{s*}_{F,t}$ is the issuance of foreign currency bonds by the foreign government.

The home government policy of international asset controls and sterilization of foreign exchange operations is similar to the model in Chang, Liu and Spiegel (2015), designed to represent Chinese-style capital account polices.[3] As in their case, the home country's net foreign assets are equal to its reserves, and the level of reserves completely determines the trade balance and the real exchange rate.

The closed home capital market allows the home government to adjust reserves as needed to target a desired nominal exchange rate, and equivalently, given the price levels in both countries, to target a desired real exchange rate:

$$rer_t = \overline{rer}, \tag{24}$$

where the real exchange rate is defined as usual: $rer_t = e_t P_t^* / P_t$. Currency devaluation will imply accumulation of foreign currency reserves by the home government. The closed capital account prevents private asset trades from undoing the effects of reserves accumulation on the exchange rate.

The government fully sterilizes the foreign exchange operations to insulate the domestic money supply, which is held constant:

$$M_t = \overline{M}. \tag{25}$$

Given the lack of nominal frictions in the model, the specification of monetary policy is irrelevant to the results reported below.[4] We further assume that the home government holds constant its supply of domestic currency bonds:

$$B_{H,t}^s = \overline{B_H^s}. \tag{26}$$

Given the fixed money and bond supplies, the home government budget constraint implies that the purchase of reserves is paid for by taxes on home households.

Since the exchange rate policy of the home country in simulation experiments will imply indefinite accumulation of reserves to maintain an undervalued currency, a mechanism must be specified to ensure stationarity of reserves levels. The model follows Korinek and Serven (2016) in specifying that a portion of debt claims in reserves will be forgiven. We

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[3] The model simplifies several details relative to Chang et al. (2015), such as assuming the capital market is completely closed, the home government issues no bonds, and monetary policy and sterilization work through direct transfers to domestic households rather than bond issuance.

[4] It is nonetheless useful to use money as a numeraire in the model, given the fact there are multiple traded goods.

model this in the form of international transfers set by a policy rule responding to the level of reserves:[5]

$$X_t = \psi R_{Ft-1}. \tag{27}$$

The activity of the foreign government is modeled as simply as possible. The foreign government holds foreign money supply and government issued foreign-currency bonds constant ($M_t^* = \overline{M^*}$, $B_{Ft}^{s*} = \overline{B_F^{s\,*}}$).

2.6 Market clearing

The market clearing condition for the differentiated goods market is given in equation (13) above. Market clearing for the non-differentiated goods market requires:

$$y_{H,t} = C_{H,t} + \left(1+\tau_N\right)\left(C_{H,t}^*\right) \tag{28}$$

Labor market clearing requires:

$$l_t = \int_0^{n_t} l_t\left(h\right)dh = n_t l_t\left(h\right). \tag{29}$$

Given the prohibition on home households purchasing foreign bonds or exporting domestic bonds, bond market clearing requires:

$$B_{Ht} = B_{Ht}^s \tag{30}$$

for the home bond, and

$$B_{Ft}^* + R_{F,t} = B_{Ft}^{s*} \tag{31}$$

for the foreign bond.

Combining household, firm and government budget constraints along with the goods market clearing condition implies a balance of payments constraint:

$$\int_0^{n_t} e_t p_t^*\left(h\right) d_t^*\left(h\right)dh + P_{Ht}^* C_{H,t}^* - \int_0^{n_t^*} p_t\left(f\right) d_t\left(f\right)df - P_{F,t} C_{F,t} = e_t\left(R_{Ft} - \left(1+i_{t-1}^*\right)R_{Ft-1}\right) + e_t X_t. \tag{32}$$

This states that a home trade surplus will imply an accumulation of home reserves or net unilateral transfers.

2.7. Parameterization for numerical experiments

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[5] Results are robust to alternative specifications of this rule, such as transfers fully deferred to a distant future period. This could be interpreted as a partial default by the foreign country on claims against it held by the home country as reserves.

See Table 1 for a summary of parameter values. Risk aversion is set at $\sigma = 2$. Labor supply elasticity is $1/\psi = 1.9$ following Hall (2009). Time preference is set at $\beta = 0.96$, consistent with an annual frequency.

Parameters for the differentiated and non-differentiated sectors are taken from Bergin and Corsetti (2020). We set θ =0.61, implying differentiated goods represent about 65 percent of production. The two countries are of equal size with no exogenous home bias, $\nu = 0.5$, but the model allows trade costs to determine home bias ratios. To set the elasticities of substitution for the differentiated and non-differentiated goods we draw on the estimates by Broda and Weinstein (2006), classified by sectors based on Rauch (1999). The Broda and Weinstein (2006) estimate of the elasticity of substitution between differentiated goods varieties is ϕ =5.2 (the sample period is 1972-1988). The corresponding elasticity of substitution for non-differentiated commodities is η = 15, which we use as a benchmark value, though sensitivity analysis will consider alternatives.

The firm death rate is set at $\delta = 0.1$, which is four times the standard rate of 0.025 to reflect the annual frequency. The mean sunk cost of entry is normalized, $\overline{K}$ =1.[6] The benchmark share of intermediates in differentiated goods production is set to ζ =1/3, from Bergin and Corsetti (2020).[7]

Regarding trade costs, τ_D is set so that exports represent 26% of GDP, as is the average in World Bank national accounts data for OECD countries from 2000-2017.[8] This requires a value of τ_D =0.33.[9] This is similar to the value of trade costs typically assumed by macro research, such as 0.25 in Obstfeld and Rogoff, 2001. But it is small compared to some trade estimates, such as 1.7 suggested by Anderson and van Wincoop (2004), and adopted by Epifani and Gancia (2017). We follow Bergin and Corsetti (2020) in setting the benchmark trade cost in the non-differentiated sector as τ_N = 0. Sensitivity analysis will consider alternative calibrations of trade costs in both sectors.

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[6] Changing the value of sunk entry cost simply rescales levels of variables in a way that leaves the percent changes in responses to undervaluation unaffected.
[7] There is a wide range of views regarding the appropriate calibration for this parameter. Sensitivity analysis will consider a range of values.
[8] See https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=OE.
[9] To coincide with standard accounting definitions, differentiated goods used as intermediates are included in the measure of exports, and excluded in the measure of GDP.

The calibration of the parameter governing international transfers, ψ , is adjusted in each experiment to consistently imply a steady state ratio of reserves to GDP of 0.81, which is the average ratio for Chinese data over the 2010-2019 span, computed from International Financial Statists from the IMF.

For simplicity, and without loss of generality, the money and government bond supplies are set at: $\overline{M} = \overline{M^*} = 0$ and $\overline{B_H^s} = \overline{B_F^{s*}} = 0$.

3. Simulation of benchmark model

The experiment consists of the home country pegging its real exchange rate at 1.01, which is an undervaluation by 1% relative to the ratio of 1.00, which otherwise would be the equilibrium in the symmetric steady state.[10] We initially study a case with no roundabout production and hence no use of differentiated goods as intermediates ($\varsigma = 0$); the subsequent section will consider a case with intermediates.

3.1 Implications for comparative advantage

Begin by considering the effect of the undervaluation policy on steady state. As a baseline for comparison, the first column of Table 2 reports the case when the exchange rate is pegged at 1.00, which implies complete symmetry in steady states across the two countries. Significant asymmetries appear when the home country instead pegs at 1.01, representing home undervaluation. Columns (2-5) report the percent change in steady state value for a set of variables due to currency undervaluation relative to the symmetric steady state in column (1).[11] Columns differ from each other in terms of the calibration of the elasticity of substitution between home and foreign non-differentiated goods, and we begin

[10] There is no consensus in the empirical literature regarding the relevant magnitude of undervaluation in China, due in part to the difficulty in estimating the equilibrium real exchange rate. For example, a prominent estimate in Cheung, et al. (2007) suggests an undervaluation of 50%, though an alternate estimate using revised data in Cheung, et al. (2011) suggest a smaller value around 10%. We study a small undervaluation in the numerical experiments, because it makes it possible to obtain a model solution under a range of values for the elasticities of interest. Robustness checks to follow will consider undervaluations of larger magnitude.

[11] The table does not report values for interest rates i and i^* since they are constant at $1/\beta - 1$ in steady state. Although not reported in the table due to space constraints, the currency undervaluation implies a rise in home reserves as a ratio to GDP by 81 percentage points, as required by the calibration explained above. It also implies a rise in home taxes as a share of GDP by 3.29 percentage points, in order to pay steady state international transfers.

by analyzing the case in column (2) of an elasticity standard in macroeconomic environments such as Backus et al. (1992), η=1.5.[12]

Undervaluation raises home production of both goods (a positive change from the symmetric case reported for y_D and y_H), while production of both goods falls in the foreign country. This rise in overall home production follows from the home trade surplus generated by the currency undervaluation. However, home production rises more for the differentiated good sector than for non-differentiated. The share of differentiated goods in overall home GDP rises 1.1% compared to the symmetric case of no currency undervaluation; the foreign share falls 1.2%. This asymmetry reflects a home comparative advantage in differentiated goods, which is also reflected in a rise in the share of differentiated goods in home exports by 4.8% and corresponding fall for foreign.[13]

The shift in specialization between sectors does not come from the usual comparative advantage mechanism involving differences in relative prices of goods across sectors and countries. The undervalued currency makes all home exports, both in differentiated and non-differentiated sectors, cheaper by the same percentage. So if we compute a ratio of home to foreign differentiated export prices, relative to home to foreign non-differentiated prices $\left(\left(p_t^*(h)/P_{H,t}^*\right)/\left(p_t(f)/P_{F,t}\right)\right)$, the table shows that this ratio does not change for an undervalued exchange rate.

Instead, the rise in home specialization in differentiated goods arises from a mechanism described in the trade literature as "firm delocation" or a "home market effect" (See Epifani and Gancia (2017) for a recent application).[14] The positive home trade balance creates a rise in the overall demand facing home producers, which encourages more firm entry in the home market, since the benefit of entry in terms of profits exceeds the sunk entry cost. The home country thus represents a greater share of the total varieties

[12] The values reported in column (1) are the same for all values of elasticity η, since the steady state under an exchange rate of 1.0 is symmetric across countries, so there is no difference between prices of home and foreign goods to make this price elasticity matter.

[13] The share of differentiated goods in home exports is computed as $\omega_{Ht} \equiv \frac{n_t p_t^*(h) d_t^*(h)}{n_t p_t^*(h) d_t^*(h) + P_{H,t}^* C_{H,t}^*}$; and $\omega_{Ft} \equiv \frac{n_t^* p_t(f) d_t(f)}{n_t^* p_t(f) d_t(f) + P_{Ft} C_{F,t}}$ for foreign.

[14] Earlier discussion of this mechanism include, among many others, Corsetti, et al. (2007) and Ossa (2011), and reach back to Krugman (1980).

of differentiated goods in global production and trade. One way to see the central role of firm entry in driving our result is to note that the rise in overall home production of differentiated goods, 4.6%, is more than fully accounted for by the rise in number of home firms, 5.2%.[15]

A key novel result seen in our simulations is that the strength, and even the sign, of this effect of currency undervaluation on comparative advantage depends critically on the degree of substitutability between home and foreign non-differentiated goods, η. Recall that the calibration of this elasticity at a value of 1.5 makes the non-differentiated sector mimic the market structure of standard macro real business cycle models such as Backus et al. (1992), where there is a distinct home and foreign national good, each of which is produced under perfect competition within its respective country. But as the elasticity is allowed to approach infinity and the home and foreign goods become perfect substitutes, the specification mimics the homogeneous good common to both countries that is typically employed in trade models. The table reports results for values of $\eta = 30$ (column (4)) which is the highest value for which we can robustly compute an equilibrium, and two intermediate values of $\eta = 15$ (column (3)), taken from Bergin and Corsetti (2020) which used estimates for the non-differentiated sector in Broda and Weinstein (2006). Simulations show that for elasticities high enough, the effect of currency undervaluation flips sign and implies a drop in home specialization in differentiated goods. The change in the home share of differentiated goods in production becomes negative for an elasticity of 15, and the home share of differentiated goods in exports becomes negative for an elasticity of 30. Figure 1 shows how both of these two measures of home specialization in differentiated goods fall progressively as the substitution elasticity increases.

The non-monotonicity in the effect of currency undervaluation can be attributed to two competing mechanisms. While the firm delocation mechanism discussed above favors specialization in differentiated goods, there is also a second mechanism favoring the opposite specialization, in non-differentiated goods. The logic for this second offsetting mechanism is simple, but not standard to the literature. While a currency undervaluation makes both differentiated and non-differentiated home goods cheaper than their foreign

[15] The rise in firm numbers is larger even than the rise in sales because the sunk cost of new firm entry is in units of differentiated goods, whose average price falls with more domestic varieties available.

counterparts, if we assume that a higher degree of substitutability is associated with less product differentiation, this means that the demand for home non-differentiated goods shifts more strongly from foreign to home goods in response to a given drop in home price. This implies that, in the absence of a firm delocation mechanism, a currency undervaluation should in general foster specialization in the non-differentiated good, and the strength of this mechanism grows as the cross-border price elasticity for non-differentiated goods rises relative to that for differentiated goods.

One way to partly disentangle the distinct effects of these two mechanisms is to consider a case in which firm entry is suspended, and the number of firms is fixed at the level from the symmetric equilibrium. Column (5) reports the case for elasticity $\eta = 15$. Compared to the case with free firm entry (column (3)), the effect of the undervaluation on home export specialization in differentiated goods flips sign to become negative, and the effect on production specialization becomes more strongly negative, by an order of magnitude. Without firm entry to facilitate production delocation, the elasticity mechanism clearly dominates.

We conclude this section with a discussion of how the firm delocation mechanism differs when fostered by a policy of currency undervaluation, compared to the more familiar context of tariff-induced delocation. A tariff can target a particular sector, say by imposing a tariff specifically on foreign differentiated goods and not non-differentiated goods. This degree of sector specificity is not possible for currency undervaluation, which impacts the cross-country relative price of all sectors equally. It is perhaps surprising, then, that a strong delocation effect is still possible for the cases of currency undervaluation. The assumption that free firm entry applies only to the case of differentiated goods in our model provides a rationale for why a common drop in price can disproportionately benefit production in the differentiated goods sector, and shift specialization in this direction. This assumption is generally thought reasonable, given that the profits arising from imperfect competition in the differentiated goods are logically justified in terms of the need to pay a sunk cost of firm entry to create a differentiated variety.

3.2 Welfare implications

Next turn to welfare implications of the undervaluation policy. Table 2 shows that the steady state level of consumption is lower following currency undervaluation, and labor is higher (leisure lower) for all elasticities, both of which would suggest a lower steady state level of utility. This is confirmed in Table 2, where steady state utility is reported as a percent change in consumption units, that is, the number of units of consumption a household would forego in order to move from a steady state where the exchange rate is unity to one where the exchange rate is 1.01.[16] Column (2) shows that home utility falls 3.4 percent for the case of a low elasticity (η=1.5). The utility loss grows larger for higher elasticities of substitution, which we saw above are associated with a deterioration in home specialization in differentiated goods.

In order to provide a more complete measure of the total welfare effects of undervaluation over time, one can conduct a dynamic simulation of a policy change. Assume the economy starts at a steady state where the exchange rate was pegged at 1.0, but beginning in period 1, policy is changed to peg at a value of 1.01, implying a 1% undervaluation. The simulation tracks the evolution of state variables until the new steady state is approached, and we compute welfare as the present discounted sum of utility over 200 periods. Figure 2a shows the dynamics of household welfare over these periods, indicating an initial fall in home utility relative to the steady state under the old policy, followed by a gradual rise in home utility to a new steady state level, which still remains lower than the steady state under the old policy. The bottom of row of Table2 reports the present discounted sum of utility over the periods of the simulation, converted to units of steady state consumption. It shows a fall in welfare of 3.5% consumption units for the case of elasticity η=1.5, with the fall swelling to 14.3% for an elasticity of η=30.

Part of the home welfare loss can be attributed to international transfers associated with sustaining currency undervaluation, which amount to 6.7% of GDP each year paid by the home government to foreign. This transfer reflects the need for the home country to purchase international reserves to maintain the undervalued real exchange rate, and then to forgive a fraction of the debt obligation in order to prevent explosive growth in debt. This inter-governmental transfer then implies a rise in home taxes and fall for foreign taxes,

[16] This comes from solving for the value of Δ satisfying $(1-\beta)\sum_{t=0}^{\infty}\beta^t U_t^{e=1.01} = \frac{1}{1-\sigma}\left(\overline{C}(1-\Delta/100)\right)^{1-\sigma} - \overline{l}^{1+\psi}/(1+\psi)$.

which lowers the wealth of home households. A second channel by which undervaluation affects welfare is the effect on firm delocation, which is the main focus of this paper. We attempt to disentangle these two channels. When we filter out the effect of firm delocation, by holding constant *n* at the initial steady state value, Figure 2a shows a constant fall in welfare for all periods starting the period after the change in exchange rate target. This is the effect of the international transfer, which under the benchmark specification in equation (27) rises in the period immediately after reserves increase, and then remains constant, as does the level of reserves.[17] Relative to this constant utility loss from transfers, the figure shows that introducing firm dynamics initially lowers welfare further in the initial period. This reflects the fact that investment in new firms is costly in terms of lost consumption, especially since capital controls prevent households from borrowing abroad to finance the investment expenditure. But as the rise in firm number allows a rise in production, consumption and hence utility rise. This rebound is not enough, however, under this parameterization to fully compensate for the loss in utility from the transfer, and the level of utility in the new steady state remains below that in the initial steady state.

4. Results with intermediates and agglomeration

Consider next a version of the economic environment where differentiated goods are used as intermediates in roundabout production. This introduces a type of firm agglomeration: as more firms locate domestically, domestic producers of differentiated goods enjoy lower production costs, as they avoid the trade costs associated with imported intermediates. Recall that the specification of production allows for a share, ς, of differentiated goods used as inputs. The benchmark calibration in Table 2 set $\varsigma = 0$; Table 3 considers a calibration of $\varsigma = 0.33$ (taken from Bergin and Corsetti (2020)). Table 3 now shows that undervaluation robustly leads to a rise in home specialization in differentiated goods. Further, higher values of the elasticity of substitution (η) imply greater firm delocation, as measured by the shares of differentiated goods in home exports and

[17] The onset of this permanent fall in welfare can be postponed if we postpone the onset of the transfer payments with a transfer rule with a larger lag. For example, simulation experiments with transfer rule $X_t = \psi e_t R_{Ft-100}$ imply an equilibrium path in which transfers and the associated welfare loss do not begin until period 100.

production.[18] This result is the opposite of what was observed in Table 2 in the absence of intermediates, where higher elasticity dampened delocation. Figure 3 shows how the two measures of firm delocation rise progressively with the substitution elasticity. Firm delocation also rises with a higher share of intermediates (ς), as shown in Figure 4.

The reason the effect of the substitution elasticity on firm delocation flips sign in the presence of intermediates is that substitution between home and foreign non-differentiated goods has two distinct channels for affecting firm delocation. On one hand, a high degree of substitutability between home and foreign non-differentiated goods makes this sector more responsive to the drop in home export prices, thus conferring home comparative advantage to the non-differentiated sector rather than the differentiated sector. But on the other hand, a high degree of substitutability can promote delocation by making it easier for the home country to specialize in the non-differentiated sector, and letting home consumers import foreign non-differentiated goods in place of domestic versions.

The presence of intermediates strengthens the pro-delocation effect through agglomeration, since it creates a positive feedback cycle of delocation and comparative advantage. As firm production of differentiated goods shift to home, the price index of differentiated goods drops at home, which then lowers the production costs of differentiated goods that rely on other differentiated goods as inputs. Table 3 shows that the home export price of differentiated goods, $p_t^*(h)$, now falls more than that for non-differentiated goods ($P_{H,t}^*$), creating a comparative advantage in differentiated goods seen in $\left(\left(p_t^*(h)/P_{H,t}^*\right)/\left(p_t(f)/P_{F,t}\right)\right)<1$, which was not observed for any column in Table 2.

The stronger delocation and agglomeration effect observed under a high elasticity improves the home welfare implications of undervaluation. While a policy of undervaluation still reduces steady state utility for the case of elasticity of substitution of 1.5 (column (2)), the change in steady state utility becomes positive for an elasticity of η =15, and strongly so for an elasticity of 30 (columns (3) and (4)). As an illustration of the essential role of firm delocation in this result, column (5) shows the effect of holding

[18] When reporting the ratio of differentiated goods production to GDP, the latter follows national accounts practice and is computed as final goods, excluding the value of differentiated goods used as intermediates.

constant the number of firms. With no firm delocation possible, the presence of intermediates fails to generate a steady state utility gain from undervaluation.

An additional reason why home experiences a net welfare gain in steady state is that a higher elasticity lowers the size of the international transfer. The reason again is tied to a stronger delocation effect under the higher elasticity. As home specializes in differentiated goods and consumers pay less in transport costs on their consumption bundles, the home price index (*P*) falls, as observed in Table 3. The lower home price index, and higher foreign price index, imply a deprecation in the home real exchange rate for a given nominal exchange rate. This means it takes a smaller nominal exchange rate devaluation for the home government to achieve its target of a 1% undervaluation of the home real exchange rate. As a result, the home government does not need to purchase as many reserves each period to push down the real exchange rate value, and so a smaller transfer is required each period to maintain the stable steady state reserve ratio. Since smaller transfers imply a smaller welfare loss associated with the undervaluation policy, the gains from delocation dominate and lead to a positive steady state welfare gain on net.

Nonetheless, despite the rise in home steady state utility, home welfare computed as the discounted stream of utility over the full simulation remains negative after the adoption of undervaluation. Figure 2b shows how home welfare drops with the initial adoption of the undervaluation policy, but eventually rises, and it shows that for an elasticity of 15 or 30, it reaches a new steady state above that of the original policy. However, given the discounting of distant future gains, the short run loss dominates, and the net effect on welfare is negative. In fact the figure shows that the fall in utility in initial periods is larger for a large elasticity. This is because a higher elasticity induces a larger trade surplus in response to a given real exchange rate depreciation, and a larger drop in home consumption relative to home production.

Let us here summarize implications from the simulations. While it is possible that a policy of reserve accumulation and undervaluation can promote home welfare in steady state by a mechanism of firm delocation and agglomeration, this result depends crucially on implications for comparative advantage between the two sectors. Specialization in differentiated goods tends to confer welfare gains by helping home consumers avoid trade costs associated with importing differentiated goods from abroad. Production delocation and agglomeration, arising from the need for imported intermediates, provide an engine by which a trade surplus created by undervaluation can promote comparative advantage in these differentiated goods. But in the absence of agglomeration, an elasticity effect instead dominates, favoring the opposite comparative advantage, with specialization in non-differentiated goods. Further, even if the equilibrium implies a rise in home welfare in steady state, this does not guarantee a rise in welfare in a dynamics sense, since the gains from firm delocation require up-front sunk investment in firm creation which is costly in the short-run transition.

5. Robustness

Table 4 reports sensitivity analysis for alternative economic environments. For simplicity, each column reports the percentage change in the undervaluation equilibrium from the symmetric equilibrium (when the real exchange rate is pegged at unity), without reporting the values in the symmetric equilibrium.

First, consider the more standard case of a single tradable sector, by setting the share of differentiated goods in consumption to $\theta = 1$. Measures of comparative advantage have no meaning in a one-good environment, but one can note a rise in the number of firms due to undervaluation in column (1), showing the case of no intermediates. However the percentage change in number of firms is smaller than the corresponding value in the two-good benchmark model (shown in column (2) in Table 2). Column 2 shows this firm delocation rises with the share of intermediates. However, the rise in firm number still is smaller than in the two-good benchmark environment. This result further illustrates how the presence of a second tradable sector has the potential to amplify the firm delocation effect, by fostering greater specialization in the differentiated sector while importing foreign production in the other sector.

The next two columns consider the effect of a higher trade cost, calibrated at τ_D =1.7 as in Epifani and Gancia (2017). The higher trade cost diminishes the production delocation effect compared to the benchmark case in Table 2, especially in the case of a high elasticity of substitution for non-differentiated goods. For the low elasticity calibration ($\eta = 1.5$), the rise in number of firms is smaller than in the benchmark case, and the share of differentiated goods in home production falls rather than rises. For a higher elasticity (η

=15), even the number of home differentiated goods firms falls due to undervaluation. For this higher elasticity, the elasticity effect raises comparative advantage of non-differentiated goods so much, that the home production of differentiated goods falls in absolute terms, despite the effect of a trade surplus which would otherwise tend to raise production of both goods.

The last column (5) considers the effect of a trade cost on non-differentiated goods that is the same as that on differentiated goods ($\tau_N = \tau_D$ =0.33). While firm delocation operates similarly as in the benchmark specification in Table 3, the effect on home steady state welfare flips sign from positive to negative. This supports the claim that the home welfare gains from specialization in differentiated goods in the benchmark model derive from savings on paying trade costs for imports.

The numerical experiments above were limited to a modest devaluation of 1 percent, as this was necessary to find numerical solutions to the model for the wide range of elasticities and other parameters of interest. However, Figure 5 shows results for larger degrees of undervaluation, where we instead limit the calibration to a small elasticity of substitution (η=1.5, while retaining the intermediate input share ς =0.33). The leftmost portion of the x-axis reproduces the benchmark results from a 1 percent undervaluation. The figure shows that progressively scaling up the percentage of currency undervaluation does not affect the sign of percent changes in key variables, and that the percent changes in these variables are scaled up nearly proportionately to the size of the currency undervaluation.

6. Conclusions

China's growth success has prompted research on the potential benefits of a policy of reserve accumulation and currency undervaluation. This paper argues that while undervaluation may promote net exports, it nonetheless may have the drawback of fostering comparative advantage and specialization of exports in disadvantageous sectors. The model developed in this paper highlights a tradeoff between two forces shaping comparative advantage over differentiated and non-differentiated goods. On one hand, the enlargement of the home market implied by a sustained trade surplus encourages investment in new firm and product creation in the differentiated goods sector. This effect can drive firm delocation from the foreign country and promote home comparative advantage in differentiated goods. This comparative advantage is reinforced by an agglomeration effect, in which the delocation of firms from foreign to the home market makes cheaper intermediate inputs available to domestic producers, as using a local supplier avoids trade costs associated with importing inputs from abroad. One may conceive that Chinese producers have benefited from the agglomeration of manufacturing of related goods nearby. Such a comparative advantage confers welfare gains in terms of lower trade costs incurred by consumers, implying a lower price index and higher level of consumption.

On the other hand, to the degree that non-differentiated goods are associated with a high degree of substitutability, their production may respond more strongly to the price competitiveness fostered by a currency undervaluation. If this elasticity effect dominates the home market effect, the undervaluation can shift home comparative advantage away from differentiated goods, and reverse the welfare gains implied by differentiated goods production.

This result does not negate other potential benefits from undervaluation and trade surplus, such as learning by doing or technological development that promote growth in the home economy. But it does add to the list of effects working counter to such benefits. Even in the absence of adverse comparative advantage, sustaining a trade surplus with undervaluation and reserve accumulation is a costly policy in pecuniary terms, with implicit taxes on households to subsidize foreign consumers. Our model highlights an additional mechanism augmenting this loss, in terms of discouraging comparative advantage in a sector that may be important for development of new goods.

The model presents the benefits of domestic production of differentiated goods in terms of lower trade costs associated with importing such goods, but this may be viewed as a proxy for a wider range of benefits, such as higher profit margins associated with branded products, higher quality and value added, and greater opportunities for technological improvement. Future research could explore how this tradeoff changes over time as an economy like China develops. A strategy of undervaluation that promotes growth in early stages of industrialization could become less desirable at later stages of development, when the sophistication of a country's products takes on greater importance.

7. References

Aizenman, Joshua and Jaewoo Lee, 2010. “Real Exchange Rate, Mercantilism and the Learning by Doing Externality,” *Pacific Economic Review* 15, 324–335.

Anderson, James E. and Eric van Wincoop, 2004. “Trade Costs,” *Journal of Economic Literature* 42, 691-751.

Bacchetta, Philippe, Kenza Benhima and Yannick Kalantzis, 2013. “Capital Controls with International Reserve Accumulation: Can This Be Optimal?” *American Economic Journal Macroeconics* 5, 229–262.

Backus, David K., Patrick J. Kehoe and Finn E. Kydland, 1992. “International Real Business Cycles,” *Journal of Political Economy* 100, 745-775.

Bergin, Paul R. and Giancarlo Corsetti, 2020. “Beyond Competitive Devaluations: The Monetary Dimensions of Comparative Advantage,” *American Economic Journal: Macroeconomics* 12(4), 246-86.

Broda, Christian and David E. Weinstein, 2006. “Globalization and the Gains from Variety,” *The Quarterly Journal of Economics* 121, 541-585.

Chang, Chun, Zheng Liu and Mark Spiegel, 2015. “Capital Controls and Optimal Chinese Monetary Policy,” *Journal of Monetary Economics* 74, 1-15.

Cheung, Yin-Wong., Chinn, Menzie. and Eiji Fujii, 2007. “The Overvaluation of Renminbi Undervaluation”, *Journal of International Money and Finance* 26(5), 762-785.

Cheung, Yin-Wong., Chinn, Menzie. and Eiji Fujii, 2011. "A Note on the Debate over Renminbi Undervaluation," *China and Asia in the Global Economy*, edited by Yin-Wong Cheung and Guonan Ma, World Scientific: Singapore.

Choi, Woo Jin, and Alan M. Taylor, 2017. Precaution Versus Mercantilism: Reserve Accumulation, Capital Controls, and the Real Exchange Rate (No. w23341). National Bureau of Economic Research.

Corsetti, Giancarlo, Philippe Martin and Paolo Pesenti, 2007. “Productivity, Terms of Trade and the `Home Market Effect',” *Journal of International Economics* 73(1), 99-127.

Dooley, Michael P., David Folkerts-Landau, and Peter Garber, 2004. The Revived Bretton Woods System. *International Journal of Finance and Economics* 9(4), 307–313.

Epifani, Paolo and Gancia, Gino, 2017. “Global Imbalances Revisited: The Transfer Problem and Transport Costs in Monopolistic Competition,” *Journal of International Economics* 108, 99-116.

Hall, Robert E., 2009. “By How Much Does GDP Rise If the Government Buys More Output?” *Brookings Papers on Economic Activity* 2, 183–231.

Jeanne, Oliver, 2013. “Capital Account Policies and the Real Exchange Rate.” In *NBER International Seminar on Macroeconomics*, 9: pp. 7–42. University of Chicago Press Chicago, IL.

Korinek, Anton and Luis Serven, 2016. "Undervaluation Through Foreign Reserve Accumulation: Static Losses, Dynamic Gains," *Journal of International Money and Finance* 64, 104-136.

Krugman, Paul, 1980. "Scale Economies, Product Differentiation, and the Pattern of Trade," *American Economic Review* 70(5), 950-959.

Michaud, Amanda, and Jacek Rothert, 2014. "Optimal Borrowing Constraints and Growth in a Small Open Economy," *Journal of International Economics* 94, 326–340.

Obstfeld, Maurice and Rogoff, Kenneth, 2001. "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?" in: NBER Macroeconomics Annual 2000, Volume 15, pages 339-412 National Bureau of Economic Research.

Ossa, Ralph, 2011. "A "New Trade" Theory of GATT/WTO Negotiations," *Journal of Political Economy* 119, 122-152.

Rauch, James E., 1999. "Networks Versus Markets in International Trade," *Journal of International Economics* 48, 7–35.

Rodrik, Dani, 2008. "The Real Exchange Rate and Economic Growth," *Brookings Papers on Economic Activity* 39(2), 769–797.

Table 1. Benchmark Parameter Values

Preferences	
Risk aversion	$\sigma = 2$
Time preference	$\beta = 0.96$
Labor supply elasticity	$1/\psi = 1.9$
Differentiated goods share	$\theta = 0.61$
Non-differentiated goods home bias	$\nu = 0.5$
Differentiated goods elasticity	$\phi = 5.2$
Non-differentiated goods elasticity	$\eta = 1.5, 15, 30$
Technology	
Firm death rate	$\delta = 0.1$
Intermediate input share	$\varsigma = 0, 0.33$
Differentiated goods trade cost	$\tau_D = 0.33$
Non-differentiated goods trade cost	$\tau_N = 0$
Firm sunk entry cost	$\overline{K} = 1$
Productivities	$\alpha_D = \alpha_N = 1$
Policy	
Monetary policy	$\overline{M} = \overline{M^*} = 1$
Exchange rate policy	$\overline{rer} = 1, 1.01$

Table 2. Steady State Values in Benchmark Model (no intermediates)

	(1)	(2)	(3)	(4)	(5)
	e=1	*e=1.01 (reported as %Δ from column (1))*			
		η=1.5	*η=15*	*η=30*	*η=15* *n,n* fixed*
n	0.733	5.212	4.972	4.579	0.000
*n**	0.733	-5.081	-4.796	-4.275	0.000
diff. export share, ω_H	0.456	4.792	2.174	-2.085	-5.319
diff. export share, ω_F	0.456	-4.906	-2.176	2.961	7.667
y_D	0.607	4.648	4.466	4.168	4.311
y_D^*	0.607	-4.605	-4.387	-3.988	-3.972
y_H	0.415	0.454	5.436	14.144	23.027
y_F^*	0.415	-0.436	-5.350	-13.872	-22.080
diff. prod. share	0.647	1.145	-0.623	-3.575	-6.217
*diff. prod. share**	0.647	-1.236	0.638	4.048	7.449
p_D	0.507	0.995	2.035	3.836	6.819
p_D^*	0.507	-1.050	-2.125	-4.009	-6.825
$p^*(h)$	0.666	-2.126	-3.243	-5.189	-8.947
$p(f)$	0.666	2.144	3.269	5.229	9.384
p^*_H	0.405	-2.126	-3.243	-5.189	-8.947
p_F	0.405	2.143	3.269	5.229	9.384
$(p^*(h)/p(f))/(p^*_H/p_F)$	1.000	0.000	0.000	0.000	0.000
home utility	-1.755	-3.389	-5.573	-9.195	-13.257
foreign utility	-1.755	3.578	6.102	10.739	16.544
C	0.928	-0.655	-1.163	-2.023	-3.374
*C**	0.928	0.685	1.237	2.226	3.788
P	0.464	1.324	2.367	4.173	7.106
*P**	0.464	-1.357	-2.429	-4.308	-7.167
L	1.022	2.944	4.860	8.220	11.914
*L**	1.022	-2.912	-4.778	-8.003	-11.328
W/P	0.872	0.212	0.158	0.070	-0.937
W/P**	0.872	-0.189	-0.118	0.013	1.115
GDP	1.068	2.713	4.292	7.066	10.189
*GDP**	1.068	-2.688	-4.201	-6.811	-9.557
X/GDP*	0.000	6.699	8.556	11.659	14.683
trade balance/GDP	0.000	0.033	0.051	0.083	0.113
PDV home utility		-3.534	-7.768	-14.364	-4.906
PDV foreign utility		3.825	8.862	18.421	5.348

Table 3. Steady State Values With Intermediates

	(1)	(2)	(3)	(4)	(5)
	e=1	*e=1.01 (reported as %Δ from column (1))*			
		η=1.5	*η=15*	*η=30*	*η=15* *n,n* fixed*
n	0.408	6.360	6.636	7.276	0.000
*n**	0.408	-6.233	-6.557	-7.158	0.000
diff. export share, ω_H	0.548	3.295	6.356	13.211	-7.212
diff. export share, ω_F	0.548	-3.462	-6.397	-11.925	10.000
y_D	0.388	5.517	5.725	6.209	5.162
y_D^*	0.388	-5.489	-5.737	-6.199	-4.658
y_H	0.566	-0.540	-7.098	-20.480	28.261
y_F^*	0.566	0.566	7.166	20.810	-26.822
diff. prod. share	0.753	1.243	2.910	6.474	-5.323
*diff. prod. share**	0.753	-1.353	-3.053	-6.398	6.315
p_D	2.094	0.249	-1.191	-4.182	8.682
p_D^*	2.094	-0.296	1.227	4.321	-8.667
p(h)*	2.395	-1.125	0.447	3.664	-10.747
p(f)	2.395	1.095	-0.439	-3.601	11.292
p^*_H	0.472	-0.737	0.872	4.176	-11.042
p_F	0.472	0.702	-0.866	-4.087	11.699
$(p^*(h)/p(f))/(p^*_H/p_F)$	1.000	-0.779	-0.849	-0.993	0.699
home utility	-2.767	-2.829	0.298	7.245	-15.955
foreign utility	-2.767	2.980	-0.296	-6.525	20.984
C	0.585	-0.284	0.446	2.015	-4.194
*C**	0.585	0.307	-0.444	-1.920	4.843
P	1.171	0.570	-0.887	-3.910	8.947
*P**	1.171	-0.611	0.895	3.953	-9.025
L	1.367	2.768	0.156	-5.144	14.927
*L**	1.367	-2.766	-0.159	5.259	-14.035
W/P	0.403	0.872	0.977	1.217	-1.239
W/P**	0.403	-0.860	-0.970	-1.172	1.510
GDP	0.967	3.410	2.019	-0.774	9.992
*GDP**	0.967	-3.410	-2.049	0.802	-9.160
X/GDP*	0.000	5.797	3.994	0.136	13.181
trade balance/GDP	0.000	0.024	0.006	-0.033	0.098
PDV home utility		-3.388	-6.918	-14.217	-15.378
PDV foreign utility		3.675	7.685	17.905	20.036

Table 4. Sensitivity Analysis
(percent change in state values with *e=1.01 versus e=1*)

	(1)	(2)	(3)	(4)	(5)
	$\theta = 1$		τ_D =1.7		τ_N =0.33
	ς =0	ς =0.5	η=1.5	η=15	η=15
n	2.990	4.185	0.444	-2.006	9.179
*n**	-2.931	-4.111	-0.435	2.145	-8.940
diff. export share, ω_H	0.000	0.000	6.144	-11.444	0.658
diff. export share, ω_F	0.000	0.000	-5.819	17.992	-0.859
y_D	2.698	3.605	0.363	-1.508	7.927
y_D^*	-2.673	-3.577	-0.358	1.603	-7.886
y_H	0.343	-0.907	1.053	23.955	-1.944
y_F^*	-0.328	0.945	-1.040	-23.089	2.003
diff. prod. share	0.000	0.000	-0.351	-5.843	1.988
*diff. prod. share**	0.000	0.000	0.348	6.183	-2.227
p_D	1.124	0.454	0.208	5.525	0.080
p_D^*	-1.155	-0.511	-0.211	-5.471	-0.148
p(h)*	-1.855	-0.944	-1.746	-7.471	-1.307
p(f)	1.865	0.896	1.777	7.832	1.257
p^*_H	-1.855	-0.389	-1.707	-7.702	-0.745
p_F	1.865	0.336	1.738	8.115	0.685
$(p^*(h)/ p^*_H)/(p(f) /p_F)$	0.000	-1.108	-0.078	0.513	-1.129
home utility	-3.006	-2.822	-0.846	-10.482	-3.553
foreign utility	3.156	2.986	0.853	12.399	3.798
C	-0.557	-0.226	-0.263	-2.778	-0.371
*C**	0.582	0.256	0.265	3.048	0.407
P	1.124	0.454	0.527	5.796	0.746
*P**	-1.155	-0.511	-0.527	-5.829	-0.808
L	2.698	3.028	0.625	9.176	3.483
*L**	-2.673	-3.039	-0.618	-8.773	-3.486
W/P	0.284	1.123	-0.198	-1.009	1.064
W/P**	-0.264	-1.106	0.202	1.180	-1.050
GDP	2.270	3.173	0.376	4.301	4.465
*GDP**	-2.241	-3.148	-0.366	-3.912	-4.499
X/GDP*	3.264	1.991	0.431	5.881	3.002
trade balance/GDP	0.032	0.020	0.004	0.058	0.030
PDV home utility	-3.010	-3.249	-0.817	-7.562	-3.324
PDV foreign utility	3.249	3.536	0.915	8.578	3.623

Figure 1. Effect of elasticity (η) on steady states of home variables, without intermediates

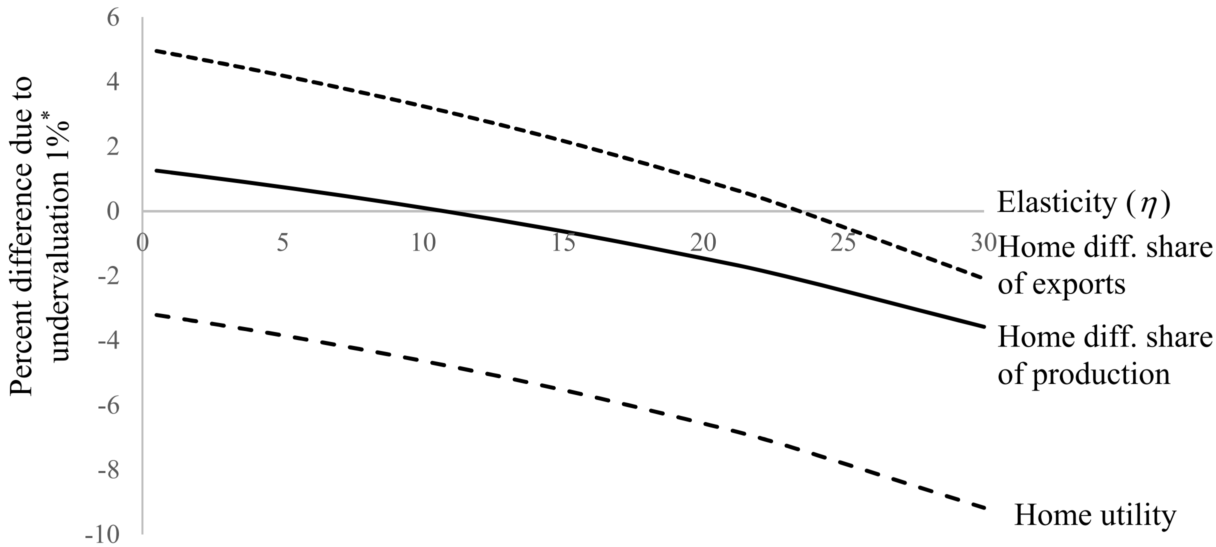
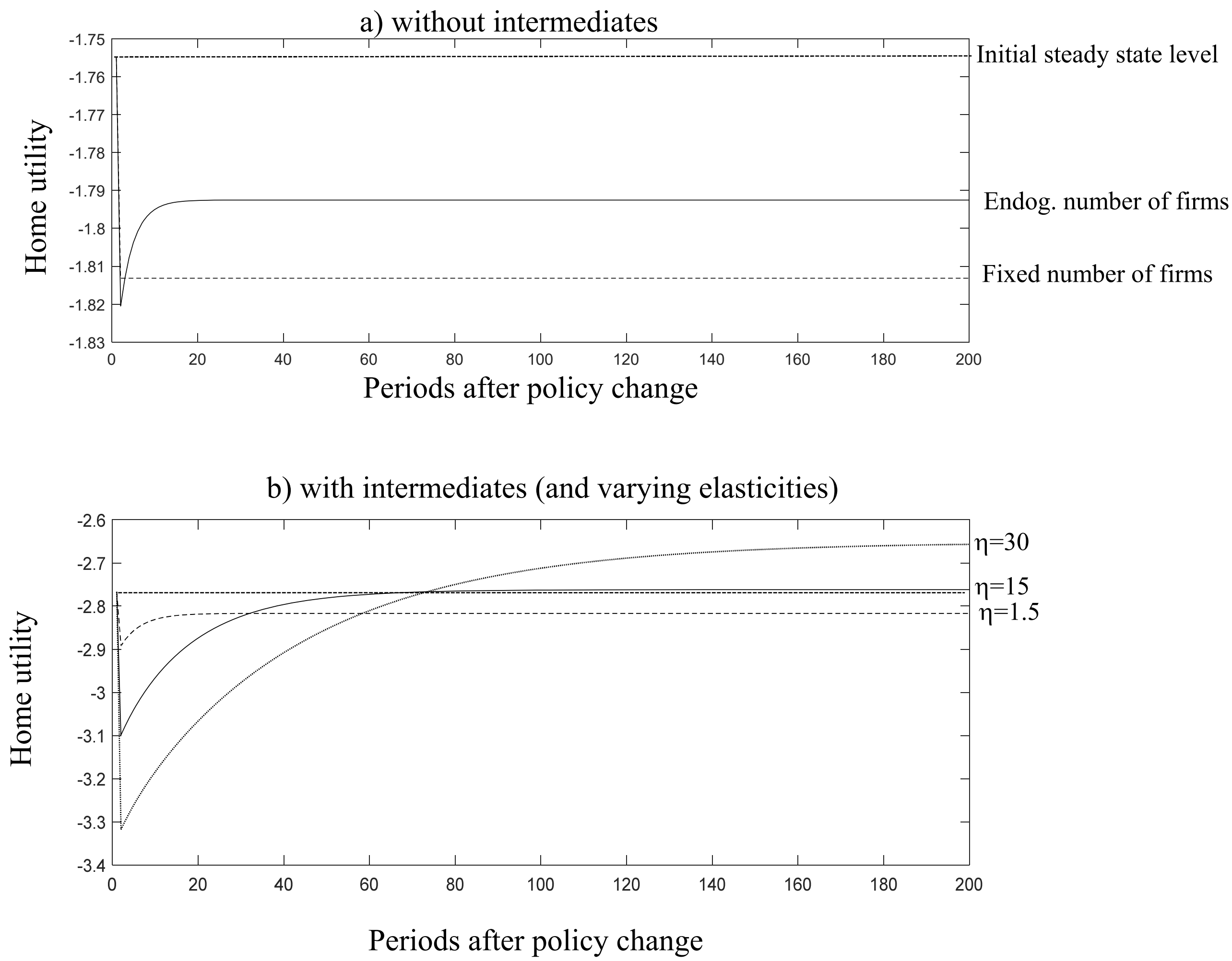


*Figure plots percent difference in steady state value when real exchange rate pegged at 1.01 compared to when pegged at 1.00.

Figure 2. Dynamic effects on home utility of adopting policy of undervaluation



Figures show levels of home utility for various periods after a change in policy from targeting exchange rate at 1.00 to targeting 1.01. Initial value is steady state utility under old policy, ending value approaches steady state under new policy. Panel (a) assumes no intermediates (ς =0), panel (b) assumes intermediates (ς =0.33).

Figure 3. Effect of elasticity (η) on steady states of home variables, with intermediates

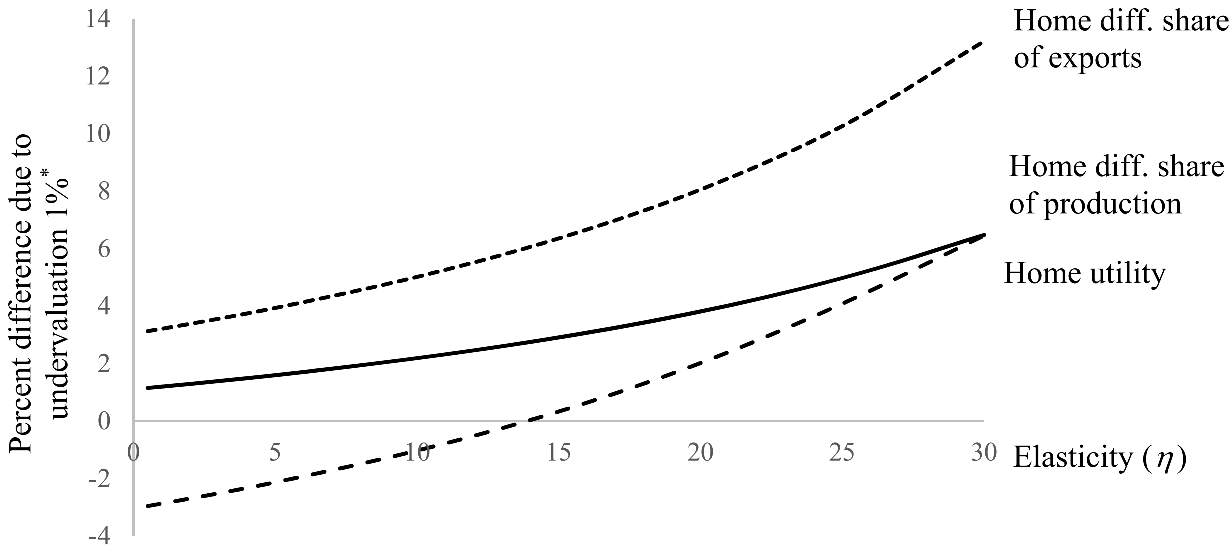


*Figure plots percent difference in steady state value when real exchange rate pegged at 1.01 compared to when pegged at 1.00.

Figure 4. Effect of intermediates share (ς) on steady states of home variables

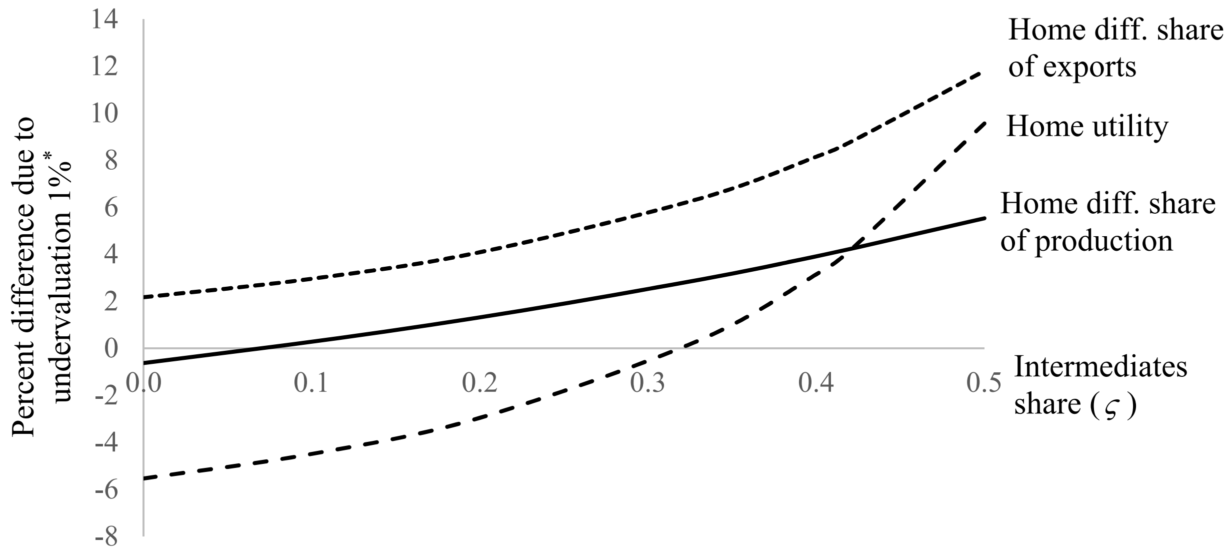


*Figure plots percent difference in steady state value when real exchange rate pegged at 1.01 compared to when pegged at 1.00.

Figure 5. Effect of increasing the size of undervaluation on steady states of home variables (η=1.5, ς=0.33)

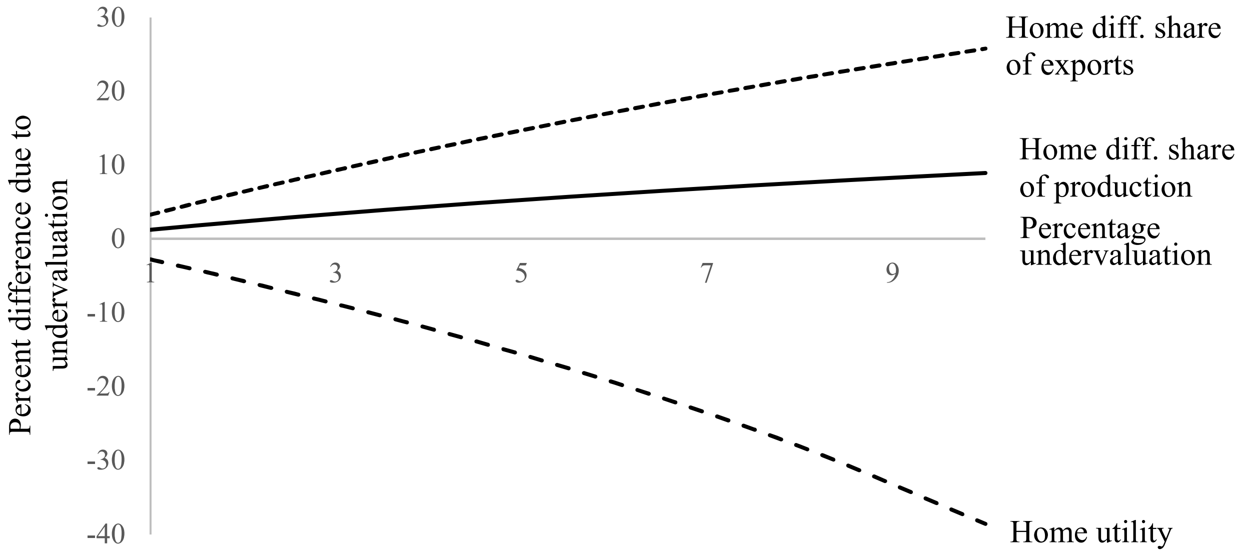


*Figure plots percent difference in steady state value when real exchange rate pegged at varying degrees of undervaluation compared to when pegged at 1.00.