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# Currency Undervaluation, Firm-Dynamics, and Export-led Growth

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The growth success of China and other Asian economies has spurred interest in reserve accumulation and currency undervaluation as a policy to promote export-led economic growth. This paper proposes a novel channel by which this may occur, by promoting growth in new firm entry and the extensive margin of trade. This explanation complements, but is distinct from the widespread theory of export-led growth based on learning-by-doing; it instead builds on recent developments in the firm dynamics literature, and extends the concept of firm delocation developed in trade theory. A novel prediction of the theory is that undervaluation promotes agglomeration through the redirection of inputs in production chains. We provide empirical evidence that a capital account policy combining capital controls with reserve accumulation promotes growth in manufacturing labor productivity, and this works in part through a channel reshaping firm dynamics, the extensive margin, and production chains.

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## 1. Introduction

The growth success of China and other Asian economies has spurred interest in mercantilist capital account policies, involving currency undervaluation via capital controls and reserve accumulation, as a means to pursue export-led growth. See for example, Rodrik (2008).[1] While a number of channels have been suggested linking currency undervaluation to productivity growth, the most common formalization is based on net exports promoting a form of learning by doing (see Aizenman and Lee (2010), Korinek and Serven (2016), and Choi and Taylor (2017)).[2]

This paper proposes a novel channel by which reserve accumulation and currency undervaluation may promote growth, which is a distinct but complementary channel to learning by doing. This new channel is rooted in recent developments in the firm dynamics literature, and builds on a "firm delocation" mechanism widely used in trade theory (see Ossa, 2011). This approach has the benefit of accounting for observations in the growth literature that export-led growth is associated with expansion in the extensive margin of trade, and that it depends on the complexity in a country's manufacturing sector. The central logic is that capital controls combined with reserve accumulation generate currency undervaluation and a sustained net trade surplus, which provide an environment promoting domestic manufacturing firm creation at home geared toward export, with a corresponding decline in the number of manufacturing firms abroad. Such firm delocation is associated with efficiency gains due to agglomeration and avoidance of international trading frictions in production chains.

We provide empirical evidence for this channel using panel data from 45 countries during the period of 1985 to 2007. First, we document that the combination of capital controls with positive reserve accumulation is associated with gains in aggregate labor productivity in the manufacturing sector. Second, this capital account policy is also associated with gains in the extensive margin of trade, domestic firm creation, and domestic sourcing of inputs. Third, we instrument the gains in

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[1] Other prominent examples include Dooley, et al. (2004), Aizenman and Lee (2007, 2010), Bacchetta et al. (2013), Jeanne (2013), McMillan et al. (2014), Michaud and Rothert (2014), Korinek and Serven (2016), Choi and Taylor (2017) and Benigno et al. (2021).

[2] Aizenmann and Lee (2010) rely on a standard learning by doing mechanism, in which the total factor productivity rises with the level of production in the previous period. Korinek and Serven (2016) assume the economy exhibits aggregate learning-by-investing spillover effects, where the aggregate level of productivity in the intermediate goods sectors rises in proportion to the change in the aggregate capital stock. Michaud and Rothert (2014) use a model where financial repression depressing consumption as a tool to correct learning-by-doing externality. Benigno et al. (2021) introduce a model that the government uses reserves policies to internalize the growth externality that appears only in the tradable sector and to provide liquidity to private agents during financial crises.

aggregate productivity on these measures of firm dynamics, and show that indeed the gains in production work through them as a channel. In particular, we find that the agglomeration effect of redirecting supply chains toward domestic suppliers is a particularly significant channel transmitting the capital account policy to aggregate productivity growth.

These empirical findings support the predictions of a dynamic micro-founded general-equilibrium model formalizing our new channel. The model merges the asset market structure of a macro model suited to study capital account policy and reserve accumulation, with a goods market structure drawing on elements from the trade literature to study firm dynamics and the delocation effect. On the asset market side, we model one country that restricts private trade in international assets and then adopts a reserves accumulation policy implying currency undervaluation and net trade surplus. The goods market includes traded (manufacturing) and nontraded sectors. The traded sector features firm entry subject to a one-time sunk entry cost, as well as production chains in the form of roundabout production, where firms use as inputs a bundle of domestic and imported manufacturing goods. (The model intentionally abstracts from any reduced-form specification of learning by doing in the technology of a firm's production process.) The model is calibrated and then used to generate a 20-year deterministic simulation tracing dynamics after the adoption of the reserves policy.

The main finding is that a policy of sustained reserves accumulation can induce a substantial rise in labor productivity in the traded goods sector, and that the dynamics of this productivity growth depend closely on the dynamics of new firm creation. Reserves accumulation, in the presence of capital controls, translates directly into a trade surplus, which stimulates production in the traded goods sector. Initially this implies a drop in labor productivity in this sector, as the rise in production is generated by a more than proportionate rise in labor input. But labor productivity rises over time as the number of domestic firms in this sector rises gradually, and the level of labor productivity quickly surpasses the initial productivity level prior to the adoption of the reserves policy. In contrast with a transitory exchange rate depreciation commonly studied in the macroeconomic literature, the sustained currency undervaluation and trade surplus made possible by a sustained policy of reserves accumulation creates the expectation of future profits needed to motivate significant firm entry. There is a corresponding fall in the number of manufacturing firms abroad, hence firm delocation. The calibrated model implies the rise in labor productivity arising from this firm delocation mechanism can explain between one-quarter and one-third of the rise in productivity estimated from the empirical regressions. We conclude that our new channel is quantitatively significant, but it is best viewed as complementary to alternative theories such as learning-by doing within the firm.

In contrast with existing theories, our channel is based explicitly on the rise in the extensive margin of trade identified with export-led growth, and with the industrial complexity implied by production chains. Sensitivity analysis confirms that free entry is essential to our result. It also indicates that the role of production chains is important. In particular, while a currency undervaluation initially hurts manufacturing productivity by making imported intermediates more expensive, the gradual agglomeration of manufacturing firms in the home country over time lowers domestic production costs and raises productivity.

This paper contributes to multiple literatures. It is, of course, closely related to the large literature on export-led growth (See Rodrik (2008), Aizenman and Lee (2010), Korinek and Serven (2016,) and Choi and Taylor (2017)).[3] It contributes by proposing firm delocation as an alternative to the common explanation of learning by doing at the firm level. Our theory implies that gains in aggregate productivity are less associated with learning within a given firm, but rather with the interconnected relationships among firms. In this sense, our model of firm dynamics provides a formalization to the claim in Rodrik (2008) that the gains from export-led growth depend crucially upon the degree of complexity in a country's manufacturing sector. Our theory also provides a formal theoretical explanation for the empirical finding in the literature that currency devaluations are associated with export booms, in particular at the extensive margin of trade (Freund and Pierola, 2012). Such shifts in the extensive margin are an integral and essential part of our firm dynamics story.

This paper also contributes something new to the trade literature studying firm delocation. While the trade literature has studied firm delocation in the context of tariffs that raise demand and hence firm creation, we study the use of capital account policy and exchange rate management as an alternative to tariffs. Further, while the trade literature was limited to an environment of balanced trade, we show that allowing for unbalanced trade (net exports), provides a powerful tool for generating a large amount of firm delocation. In this regard, our work is related to Epifani and

[3] We note that in a similar vein, Brunnermeier et al. (2020) document the relation of net exports with sectoral productivity. They, however, argue that net export surpluses relative to domestic absorption provide a more favorable environment for R&D of the tradable sector, and this is the key for the endogenous sectoral growth.

Gancia (2017), which studies the interaction of the classic transfer problem with firm delocation. We differ in taking a macro perspective that explicitly models the capital account and exchange rate policy needed to generate the net trade flows, in studying the implications for productivity growth, and in providing empirical evidence for this mechanism.

Finally, we also contribute to the macro literature studying currency devaluations. While competitive devaluations have long been a staple of international macro theory and policy, our work shows how they can be particularly effective in the context of capital controls and firm dynamics. An appropriate combination of capital controls and reserve accumulation can generate sustained undervaluation and net exports. While the macro literature has often argued that exchange rate fluctuations are too transitory to elicit large responses in firm entry and extensive margins, the capital account policy we study implies a rise in foreign demand that may well be sufficiently large and long-lasting for firms facing sunk entry costs to respond. In turn, such shifts in the extensive margin and firm location significantly amplify the macroeconomic effects of exchange rates.

The next section of the paper describes the data and presents empirical evidence. Section 3 presents a theoretical model. Section 4 derives theoretical implications by model simulation. Section 4 concludes.

## 2. Empirical Motivation

### 2.1. Data

Our sample includes 45 countries—22 emerging market economies and 23 advanced economies for 1985-2007 before the global financial crisis. A novel feature of this paper is to construct sectoral labor productivity data. We split sectors into manufacturing and non-manufacturing, where the latter includes all other sectors but manufacturing. We use the manufacturing sector as the tradable goods sector, and all other sectors are to be the non-tradable goods sector. For the labor productivity measure for country j, we use the following,

$$LP_{j,t}^{s} = \left(\frac{VA_{it}^{s}}{PVA^{s}{}_{it}}\right)/L^{s}{}_{it} \quad , \tag{1}$$

where $s$ stands for the sector; $VA_i, PVA_i, L_i$ stand for values added, price deflator, and the employment of sectors $i$, respectively. Sectoral value added is first deflated by the sectoral price index. Then we further divide real value added by employment to construct average labor productivity. Our sectoral data come from several different sources, including World Input Output Database (WIOD), EU KLEMS and WKLEMS, OECD, STAN, and GGDC 10 sector database. See Appendix A.1 for more detailed productivity measure construction.

Our main variables of interest include the firm dynamics channels of capital account policy on productivity growth. We first construct a variable that captures firms' new entry and exit in the export market using the extensive margins of trade (e.g., Bergin and Lin, 2012). We employ panel data which cover product exports from 1985 to 2007. The trade data of 1985–2000 come from the NBER-UN World Trade Data set, developed by Feenstra et al. (2005). The trade data after 2000 come from the UN Comtrade dataset (https://comtrade.un.org/). We use annual bilateral trade flows at the four-digit Standard International Trade Classification with some adjustments for UN trade data.[4]

The extensive margin of exports is measured following Hummels and Klenow (2005), which is based on the consumer price theory in Feenstra (1994). The extensive margin of exports from country *j* to country *m* in year *t*, denoted by $EXM_{jt}^{m}$, is defined as

$$EXM_{jt}^{m} = \frac{\sum_{i \in I_{m,t}^{j}} X_{m,i,t}^{W}}{X_{m,t}^{W}} \tag{2}$$

where $X_{m,i,t}^{W}$ is the export value from the world to country *m* of product category *i* in year *t*. $I_{m,t}^{j}$ is the set of observable product categories in which country *j* has positive exports to country *m in year t*, and $X_{m,t}^{W}$ is the aggregate value of world exports to country *m at t*. The extensive margin is a weighted count of *j*'s categories relative to all categories exported to *m*, where the categories are weighted by their importance in the world's exports to country *m*. Then, we calculated an average of $EXM_{jt}^{m}$ over countries m and derive $EXM_{jt}$.

The intensive margin of exports from country *j* to *m*, denoted as $INM_{jt}^{m}$ is defined as

$$INM_{jt}^{m} = \frac{X_{m,t}^{j}}{\sum_{i \in I_{m,t}^{j}} X_{m,i,t}^{W}} \tag{3}$$

where $X_{m,t}^{j}$ is the total export value from country *j* to country *m* at t. The intensive margin is measured as *j*'s export value relative to the weighted product categories in which country *j* exports

[4] The data for 1984–2000 only had values in excess of $100,000, for each bilateral flow. Thus, for the data since 2001, we set the cutoff of exports as $100,000, which implies that goods are considered nontradable if an export value of the product category is less than $100,000. See also Bergin and Lin (2012)

to country $m$.[5] We also calculate an average of $INM_{jt}^{m}$ over countries $m$ and derive $INM_{jt}$. With the same level of share of world exports to country *m* at time *t*, the measurement implies that country *j* has a higher extensive margin measure if it exports many different categories of products to country $m$, whereas it has a higher intensive margin if country *j* only export a few categories to country $m$.

While the extensive margins capture a firm's entry and exit in the export market, we also introduce the number of domestic firms listed on the country's stock exchanges to explicitly count changes in the number of firms in the domestic market. Note that this variable is reported per million people at the end of each year and does not include investment companies, mutual funds, or other collective investment vehicles. The data is collected from the Global Financial Development Database, World Bank. We convert it by multiplying by population.

Another important variable for firm dynamics is domestic intermediate input share (DIS), which is defined as a ratio of domestic intermediate input to total intermediate input (the sum of domestic intermediate input and imported intermediate input). To construct this measure, we utilize two data sources. First, we obtain the total intermediate input value from KLEMS.[6] The World KLEMS project provides gross output, labor, capital, and intermediates in current local currency by industry, which are available for 27 countries in our sample (see Table 1 for the list of countries). Second, we collect imported intermediate input value in the current US dollars from WITS, World Bank.[7] Since the total intermediates from the KLEMS are in the local currency unit, we convert it to the current price US dollars using the nominal exchange rate. Then, we compute domestic intermediate input by subtracting imported intermediate input from total intermediates in the manufacturing industry. For robustness check, we use intermediate in total industries, but the results are consistent.

**[Insert Table 1 about here]**

For capital account policy (CAP), we utilize capital controls and reserves accumulation. For capital control measures, we modify Chinn and Ito (2008)'s capital control index, which they

[5] Therefore, multiplying the intensive margin by the extensive margin can get country *j*'s share of world exports to country *m*.

[6] World KLEMS (https://www.worldklems.net/wkanalytical). Also see EU(https://euklems.eu) and Latin America KLEMS(http://laklems.net/)

[7]Please check (https://wits.worldbank.org/CountryProfile/en/Country/WLD/Year/1988/TradeFlow/Import/Partner/all/Product/UNCTAD-SoP2)

construct using the Annual Report on Exchange Arrangements and Exchange Restrictions at IMF, as follows,

$$CC = 1 - KAOPEN, \tag{4}$$

where *KAOPEN* is a standardized measure of *de jure* financial openness, which is ranged from 0 (closed) to 1 (open). Note that we will interchangeably use the index of capital control with financial closedness. For productivity growth regression, we compute reserves growth, $\Delta RSRV_{it}$ is 5 year average of annual difference in reserves to GDP in the period t. Having the government's policy behavior of reserve accumulation combined with capital controls (say Pigouvian tax), private agents will decide international asset transactions endogenously (see Bergin et al. (2022) for more discussion).

We collect foreign reserves, terms of trade, trade openness from standard data sources from the World Development Indicator (WDI). Private credit is collected from the Global Financial Development Database, World Bank. For the quality of institutions, we use proprietary data, namely investment profiles from the International Country Risk Guide (ICRG). Human capital index is a percentage of complete tertiary schooling attained in the population from Barro and Lee (2013). A crisis variable contains historical banking, currency, and debt crisis events recorded by Laeven and Valencia (2020). Please also check Appendix Table A.2. for the descriptive statistics.

Following the standard cross-country growth literature, we construct annual data then take the average of 1985-1990, 1990-1995, 1995-2000, 2000-2005, and 2005-2007 (see Bergin et al. 2022). Owing to the global financial crisis, we use only three years of information within the last period. Before moving to systematic analysis on the effect of capital account policy on productivity growth via firm dynamics. Appendix Figure 1, selecting China, plots its capital account policy and the three variables related to our firm dynamics mechanism. Here, the degree of capital account policy (CAP) can be measured as capital controls (*CC*) times reserves growth ($\Delta RSRV_{it}$). Since capital controls range between 0 (full capital mobility) and 1 (full capital control) and annual reserves growth is also between -0.03 to 0.1 in our data, the higher positive value of CAP (its maximum is 0.1) means the more aggressive CAP. First, China's CAP (solid blue line with circle marks) had been above the average of other countries' CAP, particularly, in the late 1990s and the early 2000s, China seemed to use reserve accumulation combined with capital controls more actively. With this trend of aggressive China's CAP, we find that China's number of listed domestic firms and extensive margins of exports also increased and were above the average of other countries. Also, while domestic intermediate shares of all countries show a decreasing trend since 1985, a decline in China's domestic intermediate share has been much slower than the average, consistent with China's CAP pattern.

## 2.2. Empirical Specifications

Our baseline analysis for sectoral productivity is a cross-country panel regression, using 5-year averaged data as shown in Bergin et al. (2022). We analyze within-country variation over time to identify the effect of the capital account policy on sectoral productivity and its channels. First, we identify the effect of the capital account policy on manufacturing and non-manufacturing labor productivity growth. We have the following specification:

$$\Delta \ln(LP_{it}) = \alpha_0 + \alpha_1 \ln\left(LP_{it,0}\right) + \alpha_2 CC_{it} + \alpha_3 \Delta RSRV_{it} + \alpha_4 (CC_{it} \times \Delta RSRV_{it}) + X_{it}'\gamma + \eta_i + period_t + \varepsilon_{it}, \quad (5)$$

where the subscripts $i$ and $t$ represent specific countries and time periods. $\Delta \ln(LP_{it}) = \ln\left(LP_{it,T}\right) - \ln\left(LP_{it,0}\right)$ is the labor productivity growth in tradable and non-tradable goods sectors in period t. $\ln\left(LP_{it,T}\right)$ is a log productivity at last year, T , in the period t. $\ln\left(LP_{it,0}\right)$ is the initial level of productivity at the beginning of each period t. $CC_{it}$ is our measure for capital controls in the period $t$, and we incorporate the full capital control measure and its interaction with reserves. $\Delta RSRV_{it}$ is a 5 year average of annual differences in reserves to GDP in the period t. $X_{it}$ represents a vector of explanatory variables (as described in the previous section). In particular, all controls are averaged during each period. $\eta_i$ captures unobserved and time-invariant country-specific effects. This regression equation also includes a time dummy, $period_t$, to control for the common effect of a specific period. $\varepsilon_{it}$ is the error term.

We first implement not only country fixed effect estimations but also a system GMM approach to address dynamic panel data. Arellano and Bond (1991) assert that it is crucial to allow for dynamics (i.e., including a lagged dependent variable among the regressors) in the panel estimation, and suggest a correction method that uses instruments to control for endogeneity. Particularly, we use the system generalized method of moments (GMM) estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998).[8] As the validity of the GMM estimator depends on whether

[8] They pointed out that difference GMM estimator proposed by Arellano and Bond (1991) cannot account for cross-country variations and that the regressors' lagged levels might be weak instruments for the first-differences if the

the explanatory variables' lagged values are valid instruments, we conduct a weak instrument test (Sanderson, and Windmeijer, 2016), and an over-identification restriction test where failure to reject the null hypothesis gives support for the valid instruments. Lastly, we implement the specification test to check whether the error term, $\varepsilon_{it}$, is serially correlated; if it is not, then the first order differenced error terms ($\varepsilon_{it} - \varepsilon_{it-1}$) are expected to have a serial correlation, and the second-order differenced error terms ($\varepsilon_{it} - \varepsilon_{it-2}$) will have no serial autocorrelation.

Second, we discuss how the combined reserves and capital controls affect firm dynamics (e.g., firm's delocation). We stick to 5 year averaged data and the following specification analyzes the effect of the policy mix on the entry of new firms in domestic and export markets (extensive margins), and their domestic intermediate shares:

$$FD_{it}^{S} = \beta_0 + \beta_1 CC_{it} + \beta_2 \Delta\overline{RSRV}_{it} + \beta_3 (CC_{it} \times \Delta\overline{RSRV}_{it}) + H_{it}'\gamma + \eta_i + period_t + e_{it}, \quad (6)$$

where dependent variables, $FD^S$ refers to firm dynamics variables such as the number of firms in a sector $s$, the extensive (or intensive) margins of exports, and domestic intermediate shares. $CC_{it}$ is the measure for capital controls in the period t. Since we are focusing on the "level" dependent variables, we slightly modify our reserve variable as follows: $\Delta\overline{RSRV}_{it}$ is a difference in 5 year average of reserves to GDP from period *t-1* to period *t*. We also include the interaction terms of the two policies. $H_{it}$ includes trade openness, the terms of trade, institution quality, and crisis indicators that can affect firm dynamics variables. For the robustness of the results, we also implement analysis with annual data. Our model provides the testable hypothesis that a policy mix of reserves and capital controls would prop up the manufacturing sector's share by increasing the firm's extensive margins and its domestic intermediate input shares (for differentiated goods). Thus, we would expect the coefficients of the combined $CC$ and $\Delta\overline{RSRV}_{it}$ to be positive.

Based on the channel regression in (6), we finally examine how capital control policy affects sectoral productivity via the three channels of the extensive margins of exports, the number of domestic firms and domestic intermediate shares. Our productivity regression is as follows:

$$\Delta \ln(LP_{it}) = \varphi_0 + \varphi_1 \ln(LP_{it-1}) + \varphi_2 EXT_{it} + \varphi_3 NF_{it} + \varphi_4 DIS_{it} + W_{it}'\gamma + \eta_i + period_t + u_{it} \quad (7)$$

regressors are persistent over time (close to a random walk process).Thus, the difference-GMM performs poorly because the past levels convey little information about future changes.

where the subscripts $i$ and $t$ represent specific countries and time periods. Again, $\Delta \ln(LP_{it})$ is productivity growth in tradable and non-tradable goods sectors in period $t$. $\ln(LP_{it-1})$ is the initial level of productivity at the beginning of each period in the manner of cross country growth regression to capture the convergence hypothesis. $EXT_{it}$ is the extensive margins of exports in the period t. $NF_{it}$ is the number of listed domestic firms and $DIS_{it}$is domestic intermediate shares. $W_{it}$ represents a vector of explanatory variables (as described in equation (5). We exclude trade openness due to our full controls of extensive and intensive margins of exports on the right-hand side but include the education variable to measure the effect of human capital on productivity growth. Again, all controls are averaged during each 5 year-period. $\eta_i$ and $period_t$ are country- and period fixed effects, respectively. $u_{it}$ is the error term.

Here, we have four endogenous variables — $ln(y_{it-1})$, $EXT_{it}$, $NF_{it}$, $DIS_{it}$ —, which are correlated to $u_{it}$. In particular, we provide possible empirical evidence that a country's capital account policy significantly influences the latter three variables in Appendix Figure 1. Thus, to estimate equation (7), we instrument these three variables with capital account policy such as capital controls, reserves growth, and its mix to control for endogeneity. We also instrument its lagged variable for initial productivity, conventionally used in previous studies. As the validity of the IV estimators depends on whether our instruments are weak (null hypothesis), we conduct a weak instrument test for multiple endogenous regressors. We also conduct an over-identification restriction test where failure to reject the null hypothesis supports the valid instruments.

### 2.3. Empirical Results: Capital Account Policy Effects on Growth and Sectoral Productivity via firm dynamics

Columns (1)-(3) of Table 2 show the results with the manufacturing (tradable) sector labor productivity, and columns (4)-(6) display the results with non-manufacturing (non-tradable) sector productivity. We first show a benchmark panel regression and then two-step GMM to control for dynamic panel structure. In the dynamic panel, we consider the initial productivity level at the beginning of each period as only the endogenous variable because expanding multiple endogenous regressors causes serious weak instrument problems.

**[Insert Table 2 about here]**

Interestingly, the results on capital control plus reserve accumulation are starkly different between tradable sector productivity and nontradable sector productivity. While the coefficients on the interaction terms of capital control and reserves growth are positive and significant in columns (1)-(3), those on the interaction terms turn out to be insignificant in columns (4)-(6). This means that capital account policy stimulates productivity growth in the tradable sector, but not in the nontradable sector. Our results also echo Bergin et al. 's (2022) findings on real GDP and TFP growth by analyzing at a disaggregate level. Column (1) shows that if an economy that fully restricts its capital account increases reserves to the GDP by one percentage point (0.01) in the period (5 years), it has higher labor productivity growth by 1.37 percentage points or 0.0137 [=(1.82-0.45)×0.01] during 5 years. However, those statistically strong coefficients cannot be found in the non-manufacturing sector. Note that AR(1) and AR(2) tests and the over identification test in all columns support not only the validity of specification, but also that of instruments. A weak IV test rejects the null of weak instruments at the 10% level in columns (2), (3) and (6), except for the results with non-manufacturing labor productivity in column (5).

Then, we study the effect of capital account policy on three variables that reflect firm dynamics—the extensive margins of trade, the number of listed domestic firms and domestic intermediate input shares. We again use 5 year averaged data and report the results in Table 3. We also compute the marginal effects of reserves to GDP changes at full capital controls and the marginal effects of capital controls with respect to possible ranges of reserves to GDP changes (from minimum to maximum). Column (1) of Table 3 shows the result with manufacturing labor shares. The coefficient of interaction term of capital controls and reserves growth is significantly positive, suggesting that capital account policy leads to an expansion of manufacturing labor shares. Columns (2) and (3) of Table 3 indicate that the capital account policy interaction term has a large and significant effect on the extensive margin of trade, but there is not a significant effect on the intensive margin. This partly echoes results in Freund and Pierola (2012), who found that export surgest in emerging markets tend to be associated with the expansion of the extensive margin of trade, and often are preceded by currency devaluations reversing previously overvalued currencies. Our results show that this set of results also occurs for currency undervaluations associated specifically with capital account policies of capital controls and reserve accumulation. While it has been conjectured (Ruhl, 2008) that currency movements should not have an effect on extensive margins because real currency depreciations are too short-lived to affect firm decisions subject to sunk costs, the currency undervaluations we describe are not dependent on price stickiness, and hence can be much more long-lasting, sustained by capital account policies and reserve accumulation. They last long enough to affect firms' decisions about paying up-front sunk costs regarding export entry.

**[Insert Table 3 about here]**

Table 3 also studies effects on another extensive margin, domestic firm creation. To our knowledge, no one has studied firm dynamics in this context previously, even though extensive recent literature on firm dynamics has shown that firm creation can be an important margin of output dynamics and growth. Estimates in column (4) indicate that firm creation rises significantly with the capital account policy with reserve accumulation. An increase in capital account policy by one standard deviation (capital controls are more restrictive and reserves growth is higher) increases domestic firm creation by 0.036% from the mean (about 30 listed domestic firms can be created). The findings that capital account policy affects the extensive margins of exporting and firm creation will motivate our theoretical work below regarding channels by which capital account policy promotes growth.

Column (5) also introduces a new channel, the share of intermediates that are of domestic origin. Rodrik (2008) notes that one reason traded goods benefit from undervaluation is greater complexity in production, such as the prevalence of complex production chains and the use of inputs and the outputs of other firms. Our theory in the next section will predict that the share of intermediates of domestic origin will be an important predictor of gains from undervaluation. To preview, the claim is that when the devaluation raises exports and lowers imports, it also shifts domestic firms to reduce imports of intermediate inputs. The estimated coefficient on capital controls (CC) is significantly positive at the 1% level and that on the interaction term is positive but loses statistical significance. However, when computing marginal effects of capital control with respect to all possible ranges of reserves growth, we find that capital account policy indeed increases the share of domestic intermediate input.

Bergin et al. (2022) also shed light on the part of the (previous) mechanism by which capital controls affect labor and real value-added in the traded goods sector. First, Bergin et al. (2022) find a hump-shaped pattern of manufacturing share in a country’s economic development, implied by the negative coefficients of the squared real log GDP terms (See their Figure 1 for a graphical representation.) This reflects the finding in Rodrik (2016) that the share of labor and real value-added in manufacturing sector initially rises with real GDP, but then decreases as the economy expands. Rodrik (2016) further notes that while this hump-shaped relationship between labor share and incomes has shifted downward in Latin American countries, Asian countries have retained a high degree of manufacturing labor share despite their rise in income. In our sample, Asian countries represent the group of countries with high reserves and relatively severe financial account restrictions. Our work suggests that the different experiences of deindustrialization by Asian countries might be related to the capital account policies adopted by these countries, fostering trade surpluses that sustain a manufacturing sector.

**[Insert Table 4 about here]**

Table 4 next tests more directly how extensive margins can act as channels through which capital account policy affects productivity. We first instrument our capital account policies and their interaction term on the extensive margin of trade (EXM) in a regression of manufacturing labor productivity growth. We also consider the endogeneity of initial productivity by including its lagged value as another instrument. Columns (1) and (2) of Table 4 show that the instrumented regressor of EXM is not significant when estimated for the full sample of countries, but is significant when the sample is restricted to emerging market countries. As Rodrik (2008) and others have argued, undervaluation promotes productivity growth mainly in emerging markets and developing countries not developed. Here, we also show the summary of first stage results that capital account policy mix; the interaction term of capital controls and reserves growth has significant and positive effects on EXM. Furthermore, we report the test statistics for our IV use. For example, in column (1), weak IV tests reject the null hypothesis that instruments are weak for two endogenous regressors. Over-id test cannot reject the null hypothesis that instruments are valid at the 5% level. Columns (3) and (4) show that an instrument based on the number of domestic firms is not quite significant at the 10% level, with a p-value of 0.118.

We also examine the channel that capital account policy influences the share of domestic intermediate inputs. In Columns (5) and (6), we find that this regressor of domestic intermediate shares is highly significant in both the full sample and that limited to emerging markets. This finding supports the role of intermediates as a channel by which the capital account policy works to raise productivity in the manufacturing sector. Further, when all three instruments are included together, columns (7) and (8) show that the intermediates share dominates the other endogenous regressors.

## 3. Theoretical Model

We develop a dynamic theoretical model of two-countries useful for studying the effect of capital market and exchange rate policies on firm dynamics and productivity growth. The model includes capital controls on home country residents, which allow the home government to peg the real exchange rate at a desired level through reserve accumulation. Given the pegging of exchange rates in real terms, the model dispenses with sticky prices or other nominal rigidities. The goods market features two sectors, where the traded sector is characterized by firm entry.

### 3.1 Goods market structure

The goods market consists of two sectors, one consisting of differentiated goods which can be internationally traded, and the other non-traded non-differentiated goods. The differentiated goods come in many varieties, produced by a time-varying number of monopolistically competitive firms in the home and foreign country, $n_t$ and $n_t$* respectively, each producing a single variety. Each variety is an imperfect substitute for any other variety in this sector, either of home or foreign origin, with elasticity $\phi$. We will denote the traded sector with $T$; we will denote the nontraded sector with $N$.

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

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

$$P_t \equiv \frac{P_{T,t}^{\theta} P_{N,t}^{1-\theta}}{\theta^{\theta}(1-\theta)^{1-\theta}}, \tag{8}$$

where

$$P_{T,t} = \left( n_t p_t(h)^{1-\phi} + n_t^* p_t(f)^{1-\phi} \right)^{\frac{1}{1-\phi}} \tag{9}$$

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

The relative demand functions for domestic residents implied from our specification of preferences are listed below:

$$C_{T,t} = \theta P_t C_t \;/\; P_{T,t} \tag{10}$$

$$C_{N,t} = \left(1-\theta\right) P_t C_t \;/\; P_{N,t} \tag{11}$$

$$c_t(j) = \left(p_t\left(j\right) / P_{T,t}\right)^{-\phi} C_{T,t} \text{ for varieties } j = \left\{h, f\right\} \tag{12}$$

### 3.2 Households

The representative home household derives utility from consumption ($C_t$), and from holding real money balances ($M_t/P_t$); it suffers disutility from labor ($l_t$). The household derives income from working at the nominal wage rate $W_t$, profits rebated from home firms denoted with $\left(\Pi_t\right)$ in real terms and defined below, interest income on bonds in home currency ($i_{t-1}B_{H,t-1}$), net of government lump-sum taxes ($T_t$). Home households are precluded by government policy from international asset trade, and only have access to domestic currency bonds, which only can be traded domestically.

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:

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

In the utility function, the parameter σ denotes risk aversion and ψ is the inverse of the Frisch elasticity.

Household optimization implies an intertemporal Euler equation:

$$\beta\left(1+i_t\right) E_t\left[\frac{P_t C_t^{\sigma}}{P_{t+1} C_{t+1}^{\sigma}}\right] = 1 , \tag{13}$$

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

$$\frac{W_t}{P_t} = l_t^{\psi} C_t^{\sigma} \tag{14}$$

And a money demand condition:

$$\frac{M_t}{P_t} = C_t^{\sigma}\left(\frac{1+i_t}{i_t}\right). \tag{15}$$

The problem and first order conditions for the foreign household are analogous, except the foreign household does not face an explicit prohibition on international asset trade.

### 3.3 Firms in traded goods sector

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

$$y_t(h) = \alpha_T \left[G_t(h)\right]^{\zeta}\left[l_t(h)\right]^{1-\zeta}, \tag{16}$$

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 ($C_{T,t}$). If we sum across firms, $G_t = n_t G_t(h)$ represents economy-wide demand for differentiated goods as intermediate inputs, and given that the index is the same as for consumption, this implies demands for differentiated goods varieties analogous to equation (12).

There is free entry in the sector, but, once active, firms are subject to an exogenous death shock. Since all differentiated goods producers operating at any given time face the same exogenous probability of exit $\delta$, a fraction $\delta$ of them exogenously stop operating each period. The number of firms active in the differentiated sector, $n_t$, at the beginning of each period evolves according to:

$$n_{t+1} = (1-\delta)(n_t + ne_t), \tag{17}$$

where $ne_t$ denotes new entrants.

To set up a firm, managers incur a one-time sunk cost, $K_t$, 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 (12).

We now can specify total demand facing a domestic differentiated goods firm:

$$d_t(h) = c_t(h) + d_{G,t}(h) + d_{K,t}(h) \tag{18}$$

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 $\tau_D$ for exports, so that market clearing for a firm's variety is:

$$y_t(h) = d_t(h) + (1+\tau)\,d_t^*(h), \tag{19}$$

Firm profits are computed as:

$$\pi_t(h) = p_t(h)d_t(h) + e_t p_t^*(h)d_t^*(h) - mc_t y_t(h). \tag{20}$$

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

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:

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

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:

$$v_t(h) = P_{T,t}K_t\ . \tag{21}$$

By solving for cost minimization we can express the relative demand for labor and intermediates as a function of their relative costs:

$$\frac{P_{T,t}G_t(h)}{W_t l_t(h)} = \frac{\zeta}{1-\zeta}\ . \tag{22}$$

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

$$p_t(h) = \frac{\phi}{\phi-1} mc_t\ . \tag{23}$$

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

$$p_t^*(h) = (1+\tau)\,p_t(h)/e_t\,, \tag{24}$$

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:

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

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

### 3.4 Firms in non-traded sector

In the second sector firms are assumed to be nontraded, as well as perfectly competitive. The production function for the home non-traded good is linear in labor:

$$y_{N,t} = \alpha_N l_{N,t} \,. \qquad (25)$$

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

$$p_{N,t} = W_t / \alpha_N \,. \qquad (26)$$

Analogous conditions apply to the foreign non-traded sector.

### 3.5 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:

$$T_t + \left(M_t - M_{t-1}\right) + \left(B^s_{H,t} - \left(1+i_{t-1}\right)B^s_{H,t-1}\right) = e_t\left(R_{F,t} - \left(1+i^*_{t-1}\right)R_{F,t-1}\right) + e_t X_t \,, \qquad (27)$$

The corresponding budget constraint for the foreign government is:

$$T^*_t + \left(M^*_t - M^*_{t-1}\right) + \left(B^{s*}_{F,t} - \left(1+i^*_{t-1}\right)B^{s*}_{F,t-1}\right) + X_t = 0 \,. \qquad (28)$$

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 policies.[9] 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 affect the real exchange rate by adjusting the level of government holdings of reserves. To match the empirical specification above, the reserves policy will be defined as a time path for the change reserves as a ratio to home GDP

$$e_t\left(R_{F,t} - \left(1-i^*_{t-1}\right)R_{F,t-1}\right)\Big/GDP_t = \Omega_t \,.^{10} \qquad (29)$$

[9] 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.

[10] We net out interest on reserves holdings in our definition of the policy rule. This would be zero in the case where the reserve currency offers zero interest.

Define the real exchange rate as usual: $rer_t = e_t P_t^* / P_t$ . Reserve accumulation will imply depreciation of the home real exchange rate, since the closed capital account prevents private asset trades from undoing the effect of official reserves purchases.

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

$$M_t = \overline{M} . \tag{30}$$

Given the lack of nominal frictions in the model, the specification of monetary policy is irrelevant to the results reported below.[11] We further assume that the home government holds constant its supply of domestic currency bonds:

$$B_{H,t}^s = \overline{B_H^s} . \tag{31}$$

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.

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 ( $M_t^* = \overline{M^*}$ , $B_{Ft}^{s*} = \overline{B_F^{s*}}$ ).

### 3.6 Market clearing

The market clearing condition for the traded goods market is given in equation (19) above. Market clearing for the home non-traded good market requires:

$$y_{N,t} = C_{N,t} \tag{32}$$

Labor market clearing requires:

$$l_t = \int_0^{n_t} l_t(h) dh = n_t l_t(h) . \tag{33}$$

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

$$B_{Ht} = B_{Ht}^s \tag{34}$$

for the home bond, and

$$B_{Ft}^* + R_{F,t} = B_{Ft}^{s*} \tag{35}$$

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

for the foreign bond.

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

$$\int_0^{n_t} e_t p_t^*(h) d_t^*(h) dh + P_{Ht}^* C_{H,t}^* - \int_0^{n_t^*} p_t(f) d_t(f) df - P_{F,t} C_{F,t} = e_t \left( R_{Ft} - \left(1 + i_{t-1}^*\right) R_{Ft-1} \right) + e_t X_t . \quad (36)$$

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

### 3.7. Model calibration

Where possible, parameter values are taken from standard values in the literature. Risk aversion is set at $\sigma = 2$ . Labor supply elasticity is set at $1/\psi = 1.9$ following Hall (2009). Time preference is set at $\beta = 0.96$, consistent with an annual frequency.

We assume the two countries are of equal size with no exogenous home bias, $\nu = 0.5$, but allow 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 $\phi$ =5.2 (the sample period is 1972-1988).

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 to the value $\overline{K}$ =1. The benchmark calibration of share of intermediates in differentiated goods production is set to a modest value of $\zeta$ =0.55.

To set trade costs, we calibrate $\tau$ so that exports represent 26% of GDP, as is the average in World Bank national accounts data for OECD countries from 2000-2017.[12] This requires a value of $\tau_D$ =0.33.[13] 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).

[12] See https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=OE.

[13] 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, as is appropriate.

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

See Table 5 for a summary of parameter values.

**[Insert Table 5 about here]**

## 4. Model Simulation Results

We study an experiment where the home country adopts a policy of purchasing reserves each period at the rate of 5% of GDP starting in period 1. The effects of this policy are tracked for 20 years, assuming agents expect this policy to continue indefinitely. In the initial period prior to the adoption of this reserves policy, the two countries start from a symmetric steady state with zero reserves holdings, balanced trade, and where the real exchange rate is 1.0.

### 4.1 Benchmark model simulations

Figure 1 plots the dynamic responses of key variables as percent deviations from the initial steady state, and Table 6 reports the value of the cumulative percentages after 20 years. The accumulation of reserves implies an immediate depreciation of the home real exchange rate of nearly 3%. This currency undervaluation attenuates over time, as growth dynamics described below create pressure for real exchange rate appreciation. The reserves purchase each period translates directly into a trade surplus of equal size, given the balance of payments identity along with capital controls that preclude offsetting adjustment in private asset transactions. The trade surplus implies a shift in production from the nontraded sector to the traded sector, which is observable in the fact that employment in the traded sector rises and that in the nontraded sector falls. Overall labor rises, contributing to an immediate rise in aggregate home GDP. Figure 1 shows a large rise in investment in new firm creation. Given that capital controls prevent the home country from borrowing abroad to finance this investment, it requires a rise in domestic saving and hence a fall in domestic consumption in the short run. We note that the rise in the number of firms is gradual, and requires nearly 20 years to approach its new long-run level. Investment spending is spread over time since it is costly to households in terms of consumption, which cannot be smoothed due to capital controls.

**[Insert Table 6 about here]**

**[Insert Figure 1 about here]**

The gradual accumulation of firms becomes the source of growth dynamics in subsequent periods. By the end of 20 years the number of home firms rises 8.8%, even somewhat above the rise in domestic production of traded goods by 7.8%, which indicates that production in this sector is entirely at the extensive margin of new firms. Home production in the nontraded sector falls, confirming the shift in production between sectors. Foreign variables move in the opposite direction to home variables, with a fall in the number of foreign firms and production in the traded goods sector. This reflects the so-called firm delocation effect, as discussed in Ossa (2007) and Epifani and Gancia (2017). 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 of traded goods in global production.

Of special interest is the implication of the reserves policy and associated currency undervaluation for labor productivity. Following the definition of labor productivity for the empirical section above, we compute the ratio of value-added divided by labor input. To compute a measure of labor productivity specific to the traded goods sector, we compute value-added by netting out the use of traded goods as inputs: $\frac{n_{t-1}\left(p_t(h)y_t(h)-p_{Tt}G_t(h)\right)}{n_{t-1}l_t(h)}$. For the economy as a whole, labor productivity is measured as total value-added over both sectors divided by total labor input: $\frac{n_{t-1}\left(p_t(h)y_t(h)-p_{Tt}G_t(h)\right)+p_{Nt}y_{Nt}}{n_{t-1}l_t(h)+L_{Nt}}$. Figure 1 shows that labor productivity in the traded sector initially falls, then rises over time to a higher level than initially. The initial fall in productivity is due to the fact that the initial rise in output is generated primarily by raising labor input. Currency devaluation makes imported intermediates more expensive, shifting the input demand from intermediates to labor. But this changes as the number of home firms rises. Table 6 shows that once the firm dynamics have reached their long run level after 20 years, labor productivity in the differentiated goods sector has risen 2% compared to the initial period before the reserves policy adoption.

The benefits of firm delocation for productivity are similar to the benefits for consumers, which have been studied extensively in the trade literature. A rise in the share of varieties in the traded goods bundle that are produced domestically means that consumers pay less trade cost, lowering the price index of traded goods and raising overall consumption. Similarly, the price index of intermediate inputs falls over time since a smaller share of prices in this bundle are affected by trade costs. This shifts the mix in inputs toward intermediates, and raises the productivity of home traded goods producers. Figure 1 shows that the share of domestic varieties in the intermediates bundle rises on impact due to the rise in the cost of foreign intermediates, and then rises further as the rise in the number of home producers increase the share of home traded varieties in the world.

Table 6 reports two ways of comparing the magnitude of the simulation's rise in productivity to that of the empirical regressions above. One metric is to take the long-run rise in labor productivity as a ratio to the average annual rise in reserves ratio (0.05). This ratio is 0.399 for the benchmark case in column (1), measuring the long-run effect of a sustained policy of an annual 1% accumulation of reserves. This value may be compared to the effect of an average annual reserve accumulation of 1% in the empirical regression, which is the sum of the coefficient on the interaction term and that on reserves to GDP changes, which equals 1.82 – 0.45 = 1.37 for column (1) of Table 6, 1.24 in columns (2), and 1.11 in column (3), for varying estimation methods. By this metric, the theoretical model is able to explain about a third of the rise in productivity in terms of firm dynamics without appealing the learning by doing at the firm level. This reinforces our view that the firm dynamics mechanism is complementary to learning by doing rather than a replacement.

A second metric is to apply more literally the empirical regression methodology to simulated data. A separate simulation is conducted for 30 scenarios, for reserve policies with constant annual reserve accumulations ranging from 1% to 30%. The 20-year time series for each simulation is then divided into five-year intervals, where the initial period prior to the adoption of the reserves policy is treated as the first observation. This forms a panel of simulated data. We then regress the log change in labor productivity during the 5-year periods on the average annual level of reserve accumulation, as well as on a constant and the lagged level of productivity. The coefficient on the reserve accumulation in this simulated regression is 0.306. Again the model is able to explain about one-quarter of the rise in productivity purely in terms of our firm dynamics mechanism.

We conclude by highlighting three features of the rise in home labor productivity implied by this model. First, it is gradual, tracking the accumulation in the number of domestic firms in this sector. Second, it is associated with a rise in the domestic share of intermediates. And third, productivity in this model rises despite the absence of standard stories of learning by doing at the firm level. Instead, our story is based on a rise in industry-level productivity derived from the interaction of domestic producers in a complex production structure.

### 4.2 Sensitivity Analysis

Sensitivity analysis is useful to highlight the essential roles of two model features: endogenous firm delocation and roundabout production. Figure 2 plots the dynamics of variables assuming the number of firms is held constant at its initial value. All variables now jump immediately to their long run level in the absence of firm dynamics. Without a gradual rise in firm number, there is no additional rise over time in home GDP or traded goods production. There is no pressure for real exchange rate appreciation. And most importantly, there is no force raising home productivity in the traded goods sector. Labor productivity falls in the initial period, as in the previous figure, but rather than rising over time to a net positive value as in that earlier scenario, it now stays at the lower level of productivity. Clearly the firm dynamics are an essential element in our mechanism raising productivity.

**[Insert Figure 2 about here]**

Figure 3 plots dynamics when roundabout production using intermediates is removed ($\varsigma = 0$), while still allowing free firm entry. While the dynamics are qualitatively similar to Figure 1, Table 6 (column 6) shows that the long-run rise in labor productivity in the traded sector is a quarter of the magnitude of the benchmark case. Clearly roundabout production is an important source of amplification for the effects of firm creation on productivity.

**[Insert Figure 3 about here]**

## 5. Conclusion

The growth success of China and other Asian economies has spurred interest in reserve accumulation and currency undervaluation as a policy to promote export-led economic growth. This paper proposes a novel channel by which this may occur, by promoting growth in new firm entry and the extensive margin of trade. This explanation complements, but is distinct from the widespread theory of export-led growth based on learning-by-doing; it instead builds on recent developments in the firm dynamics literature, and extends the concept of firm delocation developed in trade theory. A novel prediction of the theory is that undervaluation promotes agglomeration through the redirection of inputs in production chains. We provide empirical evidence that a capital account policy combining capital controls with reserve accumulation promotes growth in manufacturing labor productivity, and this works in part through a channel reshaping firm dynamics, the extensive margin, and production chains.

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**Table 1. Sample countries (45 countries, 1985-2007)**

Panel A. list of countries

| Advanced countries | | Emerging market countries | |
|---|---|---|---|
| Australia | Italy* | Argentina | Indonesia |
| Austria* | Japan* | Bolivia※ | Israel⊙ |
| Belgium* | Netherlands* | Brazil | Korea, Rep.* |
| Canada* | New Zealand※ | Chile* | Malaysia |
| Denmark* | Norway | China* | Mexico* |
| Finland* | Portugal* | Colombia | Peru* |
| France* | Spain* | Costa Rica* | Philippines |
| Germany* | Sweden* | Cyprus* | Russian Federation* |
| Greece* | Switzerland | Egypt | Singapore |
| Iceland | United Kingdom* | Hong Kong, China | Thailand |
| Ireland* | United States* | India* | Turkey |
| | | | Venezuela |

*domestic intermediate share data are available ※sectoral productivity data is available after 1990. ⊙ setoral productivity data is available after 2000.

Panel B. Average share of total intermediate input to gross output

| Low group (lower 33%) | | Middle group (33~66%) | | High group (over 66%) | |
|---|---|---|---|---|---|
| Austria | 0.632485 | Russia† | 0.660526 | Mexico† | 0.7042505 |
| Denmark | 0.636164 | Colombia† | 0.66201 | Portugal | 0.7171726 |
| United Kingdom | 0.639832 | Finland | 0.662856 | Italy | 0.7200581 |
| Germany | 0.649829 | Cyprus† | 0.668226 | Spain | 0.7206021 |
| Ireland | 0.651942 | Greece | 0.675283 | Belgium | 0.7247325 |
| Japan | 0.650326 | Peru† | 0.677565 | Chile† | 0.7263173 |
| United States | 0.655565 | Canada | 0.678246 | China† | 0.7295762 |
| Sweden | 0.655894 | France | 0.683684 | Korea, Rep. † | 0.7612507 |
| Costa Rica† | 0.656546 | Netherlands | 0.6981 | India† | 0.7707036 |

† Emerging market countries

**Table 2. Capital account policy and manufacturing productivity growth**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent variable | Manufacturing productivity growth | | | Non-Manufacturing productivity growth | | |
| Methods | Panel within | System GMM | System GMM | Panel within | System GMM | System GMM |
| Sample | Full sample | | Emerging market | Full sample | | Emerging market |
| Initial productivity | -0.0666*** | 0.0124 | 0.0076 | -0.0145 | 0.0117 | 0.0175 |
| | (0.0132) | (0.0078) | (0.0073) | (0.0321) | (0.0136) | (0.0109) |
| Capital controls (CC) | 0.0068 | -0.0061 | 0.0106 | 0.0040 | -0.0008 | 0.0038 |
| | (0.0145) | (0.0234) | (0.0272) | (0.0126) | (0.0246) | (0.0312) |
| d.Reserves/GDP | -0.4464** | -0.3574 | -0.2349 | -0.0824 | 0.0202 | 0.2951 |
| | (0.2054) | (0.2495) | (0.4409) | (0.1899) | (0.2410) | (0.3401) |
| Capital controls | 1.8161*** | 1.5981*** | 1.3395* | -0.0179 | 0.0816 | -0.2946 |
| × d.Reserves/GDP | (0.3014) | (0.5009) | (0.7183) | (0.4886) | (0.6196) | (0.7129) |
| Private credit/GDP | -0.0086 | 0.0079 | 0.0015 | -0.0166* | -0.0118 | -0.0140 |
| | (0.0113) | (0.0157) | (0.0159) | (0.0083) | (0.0116) | (0.0222) |
| (log) terms of trade | -0.0116 | 0.0123 | 0.0051 | -0.0007 | -0.0011 | 0.0024 |
| | (0.0158) | (0.0201) | (0.0273) | (0.0123) | (0.0200) | (0.0334) |
| Trade openness | -0.0415** | 0.0064 | 0.0109* | -0.0041 | 0.0021 | 0.0010 |
| | (0.0179) | (0.0048) | (0.0065) | (0.0165) | (0.0061) | (0.0090) |
| Population growth | -0.4013 | -0.5994 | -0.1512 | -1.1166** | -0.3840 | -0.6052 |
| | (0.5559) | (0.4789) | (0.7399) | (0.4374) | (0.4083) | (0.7527) |
| Human capital | 0.0029* | -0.0001 | 0.0008 | -0.0012 | -0.0020 | -0.0043* |
| | (0.0016) | (0.0009) | (0.0015) | (0.0010) | (0.0021) | (0.0026) |
| Institution quality | -0.0012 | -0.0027 | -0.0074 | -0.0011 | -0.0012 | -0.0013 |
| | (0.0025) | (0.0027) | (0.0045) | (0.0016) | (0.0030) | (0.0041) |
| Crisis | -0.0038 | -0.0170 | -0.0379** | -0.0121* | -0.0201* | -0.0202 |
| | (0.0111) | (0.0149) | (0.0178) | (0.0061) | (0.0116) | (0.0193) |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Period FE | Yes | Yes | Yes | Yes | Yes | Yes |
| AR(1) (p-value) | | 0.001 | 0.002 | | 0.018 | 0.03 |
| AR(2) (p-value) | | 0.827 | 0.892 | | 0.958 | 0.654 |
| Weak IV (p-value) | | 0.11 | 0.07 | | 0.34 | 0.04 |
| Over-id test (p-value) | | 0.611 | 0.773 | | 0.125 | 0.1 |
| # of instruments | | 19 | 19 | | 19 | 19 |
| # of countries | 45 | 45 | 23 | 45 | 45 | 23 |
| Observations | 177 | 177 | 102 | 175 | 175 | 101 |
| R-squared | 0.612 | | | 0.597 | | |

Note: Clustered robust standard errors at country level are reported in parentheses. *, ** and *** are the significance level at 10%, 5% and 1%, respectively.

**Table 3. Captial account policy and channels**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent variable | (log) manufacturing labor shares | Extensive margins of exports | Intensive margins of exports | (log) # of listed firms | Domestic intermediate shares | Domestic intermediate input growth |
| Capital controls | 0.017 | -0.0003 | -0.0003 | -0.007 | 0.180** | 0.179 |
| | (0.011) | (0.014) | (0.010) | (0.219) | (0.073) | (0.122) |
| d.Reserves to GDP | -0.096** | -0.317*** | -0.019 | -1.156 | 0.514 | -0.548 |
| | (0.036) | (0.103) | (0.051) | (1.093) | (0.396) | (0.517) |
| Capital controls | 0.134** | 0.856*** | -0.005 | 5.784** | -0.196 | 1.789* |
| × d.Reserves to GDP | (0.057) | (0.204) | (0.098) | (2.441) | (0.490) | (0.926) |
| (log) RGDP per capita | 0.423*** | 0.624*** | 0.145** | -2.346* | -0.008 | -0.803 |
| | (0.083) | (0.132) | (0.072) | (1.392) | (0.209) | (0.613) |
| (log) RGDP per capita squared | -0.023*** | -0.031*** | -0.008** | 0.159** | -0.003 | 0.032 |
| | (0.005) | (0.007) | (0.004) | (0.074) | (0.014) | (0.031) |
| Marginal effects of d.Reserve to GDP at CC=1 | 0.038 | 4.628** | 0.538*** | -0.238 | 0.353* | 1.24** |
| Marginal effects of CC with d.Reserve to GDP | 0.003, 0.02*, 0.04*** | -0.09***, 0.01, 0.17*** | 0.0002, -0.0003, -0.001 | -0.59, 0.05, 1.15*** | 0.19*, 0.18*, 0.15* | 0.03, 0.196, 0.5** |
| d.Reserve to GDP range [min, mean, max] | [-0.1, 0.012, 0.2] | [-0.1, 0.012, 0.2] | [-0.1, 0.012, 0.2] | [-0.1, 0.012, 0.2] | [-0.08, 0.01, 0.18] | [-0.08, 0.01, 0.18] |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Period FE | Yes | Yes | Yes | Yes | Yes | Yes |
| R-squared | 0.908 | 0.976 | 0.935 | 0.963 | 0.958 | 0.717 |
| Observations | 179 | 182 | 182 | 169 | 91 | 90 |

Note: Clustered robust standard errors at country level are reported in parentheses. *, ** and *** are the significance level at 10%, 5% and 1%, respectively.

**Table 4. Manufacturing labor productivity and firm dynamics channels driven by captial account policy**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Dependent variable | (log) Manufacturing productivity growth | | | | | | | |
| Sample | Full sample | Emerging markets | Full sample | Emerging markets | Full sample | Emerging markets | Full sample | Emerging markets |
| **Endogenous regressors:** | | | | | | | | |
| **Extensive margins** | 0.4650 | 1.2976** | | | | | 0.2479 | 0.8858 |
| | (0.3408) | (0.5712) | | | | | (0.5794) | (0.8024) |
| **Number of domestic firms** | | | 0.0704 | 0.0734 | | | -0.0238 | -0.0132 |
| | | | (0.0421) | (0.0427) | | | (0.0489) | (0.0425) |
| **Domestic intermediate shares** | | | | | 0.1873* | 0.2327*** | 0.1956** | 0.2224** |
| | | | | | (0.0945) | (0.0713) | (0.0909) | (0.0690) |
| Initial productivity | -0.1217*** | -0.2096** | -0.2080*** | -0.2385*** | -0.0787*** | -0.1770*** | -0.0571 | -0.2471** |
| | (0.0445) | (0.0811) | (0.0595) | (0.0744) | (0.0253) | (0.0517) | (0.0663) | (0.0913) |
| Private credit/GDP | 0.0066 | 0.0699 | 0.0372 | 0.0569 | -0.0210 | 0.2042* | -0.0227 | 0.3457** |
| | (0.0159) | (0.0536) | (0.0303) | (0.0384) | (0.0176) | (0.0954) | (0.0292) | (0.1333) |
| (log) terms of trade | -0.0371 | -0.0031 | -0.0439 | -0.0387 | -0.0014 | 0.0709 | 0.0098 | 0.1176** |
| | (0.0254) | (0.0349) | (0.0277) | (0.0369) | (0.0240) | (0.0395) | (0.0315) | (0.0428) |
| Human capital | 0.0018 | 0.0073 | -0.0007 | 0.0010 | 0.0003 | -0.0006 | 0.0022 | 0.0062 |
| | (0.0025) | (0.0043) | (0.0023) | (0.0023) | (0.0022) | (0.0017) | (0.0050) | (0.0071) |
| Institution quality | 0.0031 | 0.0045 | -0.0040 | -0.0066 | 0.0019 | -0.0105 | 0.0100 | -0.0003 |
| | (0.0037) | (0.0053) | (0.0031) | (0.0050) | (0.0038) | (0.0070) | (0.0165) | (0.0084) |
| Crisis | 0.0024 | 0.0025 | -0.0280* | -0.0448* | -0.0047 | -0.0231 | 0.0107 | 0.0056 |
| | (0.0153) | (0.0196) | (0.0152) | (0.0227) | (0.0181) | (0.0299) | (0.0344) | (0.0345) |
| Intensive margins | 0.0728 | 0.1950 | 0.1098 | 0.4328 | 0.2918 | 2.0418* | 0.2412 | 1.3368 |
| | (0.2465) | (0.5476) | (0.2352) | (0.2520) | (0.1752) | (0.9798) | (0.2025) | (1.2728) |
| Country & Period FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **IV 1st stage summary** | | | | | | | | |
| Extensive margins | CC×dRes (+)*** | CC×dRes (+)*** | | | | | CC×dRes (+)** | CC×dRes (+) |
| # of listed firms (log) | | | CC×dRes (+)** | CC×dRes (+)* | | | CC×dRes (+)** | CC×dRes (-) |
| Domestic int. share | | | | | CC×dRes (+) | CC×dRes (+) | CC×dRes (+) | CC×dRes (+) |
| Weak IV test (p-value) | 0.00/ 0.00 | 0.12/ 0.01 | 0.04/0.17 | 0.1/0.26 | 0.00/ 0.00 | 0.01/ 0.00 | 0.03/0.09 /0.16/0.00 | 0.03/ 0.17 /0.34/ 0.07 |
| Over-id test (p-value) | 0.1 | 0.31 | 0.94 | 0.88 | 0.72 | 0.34 | -- | -- |
| Observations | 145 | 81 | 134 | 76 | 82 | 36 | 78 | 36 |
| # of countries | 44 | 22 | 41 | 21 | 27 | 10 | 26 | 10 |

Note: Clustered robust standard errors at country level are reported in parentheses. *, ** and *** are the significance level at 10%, 5% and 1%, respectively.

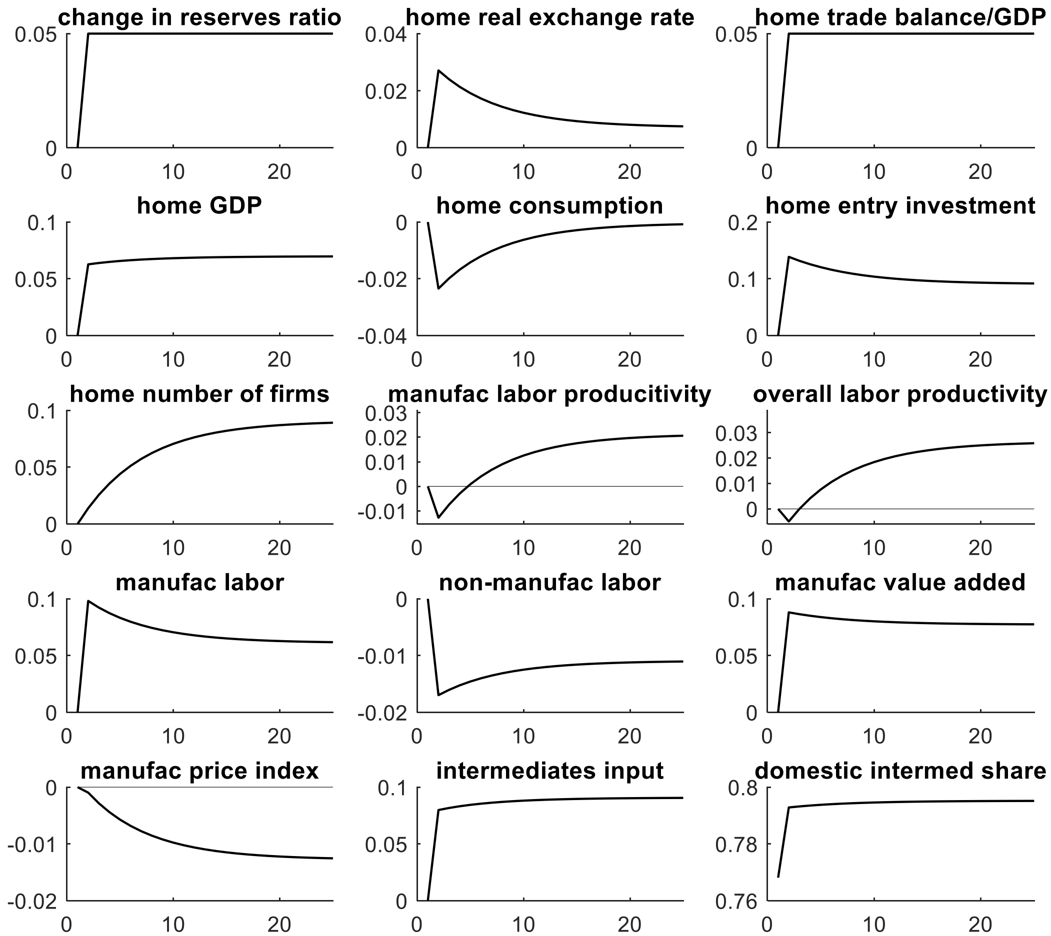
**Table 5. Benchmark Parameter Values**

| | |
|---|---|
| Time preference | $\beta$ =0.96 |
| Labor supply elasticity | $1/\psi = 1.9$ |
| Differentiated goods elasticity | $\phi$ = 5.2 |
| | |
| <u>Technology</u> | |
| Firm death rate | $\delta = 0.1$ |
| Intermediate input share | $\varsigma = 0.55$ |
| Trade cost | $\tau_D$ =0.33 |
| Firm sunk entry cost | $\overline{K}$ = 1 |
| Productivities | $\alpha_T = \alpha_N = 1$ |
| | |
| <u>Policy</u> | |
| Monetary policy | $\overline{M} = \overline{M^*} = 1$ |
| Reserves | $\Omega_t = 0.05, t > 1$ |

## Table 6. Effect of undervaluation policy on long run values (20 years)

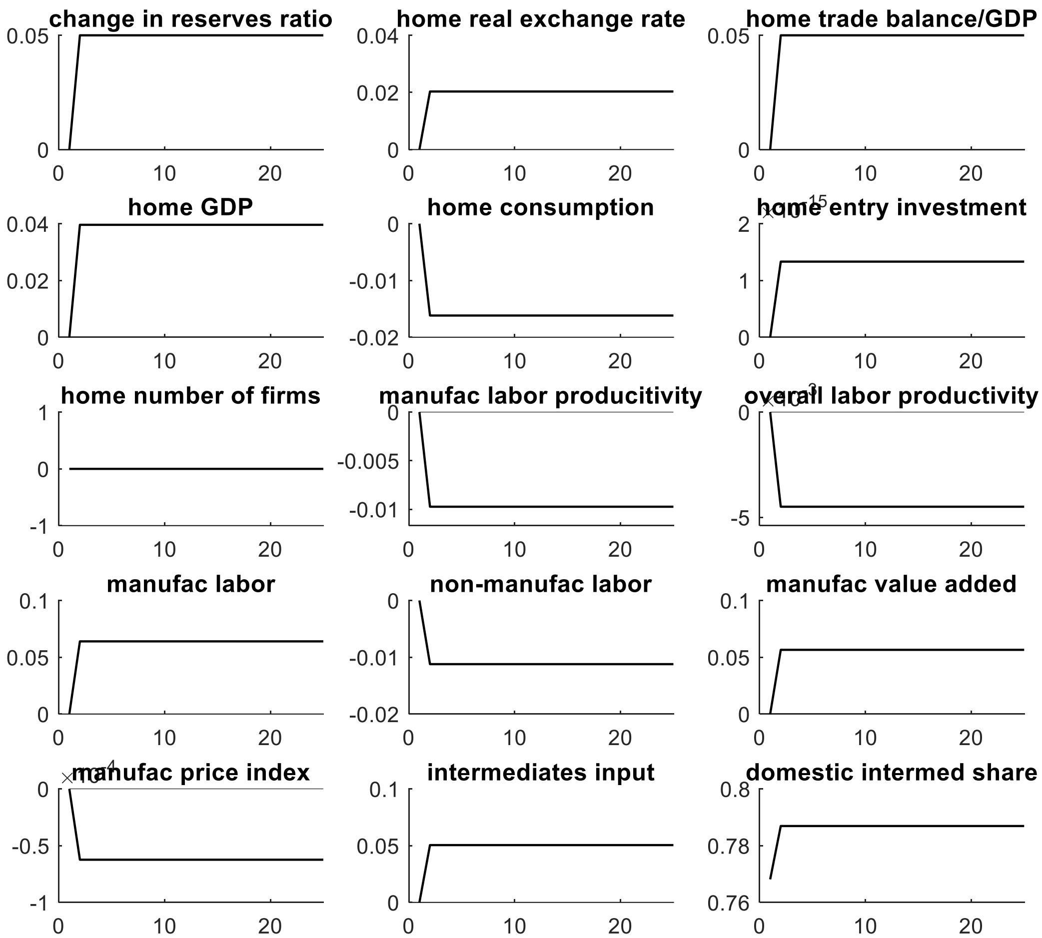
| | benchmark model | | no firm entry | | no intermediates | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | year 1 | year 20 | year 1 | year 20 | year 1 | year 20 |
| | level | (%Δ) | level | (%Δ) | level | (%Δ) |
| Number of firms: | | | | | | |
| Home ($n$) | 0.390 | 8.759 | 0.390 | 0.000 | 0.598 | 10.068 |
| Foreign ($n^*$) | 0.390 | -8.564 | 0.390 | 0.000 | 0.598 | -9.658 |
| Production by sector: | | | | | | |
| Home, traded ($y_T$) | 0.375 | 7.773 | 0.375 | 5.654 | 0.519 | 8.912 |
| Foreign, traded ($y_T^*$) | 0.375 | -7.725 | 0.375 | -5.479 | 0.519 | -8.806 |
| Home, nontraded ($y_N$) | 0.437 | -1.117 | 0.437 | -1.121 | 0.495 | -1.064 |
| Foreign, nontraded ($y_N^*$) | 0.437 | 1.199 | 0.437 | 1.144 | 0.495 | 1.102 |
| Home traded prod. share | 0.812 | 1.323 | 0.812 | 1.349 | 0.578 | 4.019 |
| GDP (home) | 0.512 | 6.956 | 0.512 | 3.961 | 0.985 | 5.302 |
| Labor (home) | | | | | | |
| Overall ($L$) | 1.669 | 4.321 | 1.669 | 4.431 | 1.041 | 4.162 |
| Traded sector ($L_T$) | 1.232 | 6.250 | 1.232 | 6.400 | 0.546 | 8.901 |
| Nontraded sector ($L_N$) | 0.437 | -1.117 | 0.437 | -1.121 | 0.495 | -1.064 |
| Labor productivity (home): | | | | | | |
| Traded. sector | 0.337 | 1.996 | 0.337 | -0.974 | 1.043 | 0.582 |
| Overall | 0.307 | 2.526 | 0.307 | -0.450 | 0.947 | 1.094 |
| Ratio of home manufacturing productivity growth to reserve accumulation (year 20): | | | | | | |
| | | 0.399 | | -0.195 | | 0.116 |
| Regression coefficient of manufacturing productivity: | | | | | | |
| Change in reserves | | 0.306 | | | | |
| Constant | | -0.755 | | | | |
| Lag productivity level | | -0.672 | | | | |

**Figure 1. Simulation for benchmark model**
(adoption of reserves policy starting in year 2)



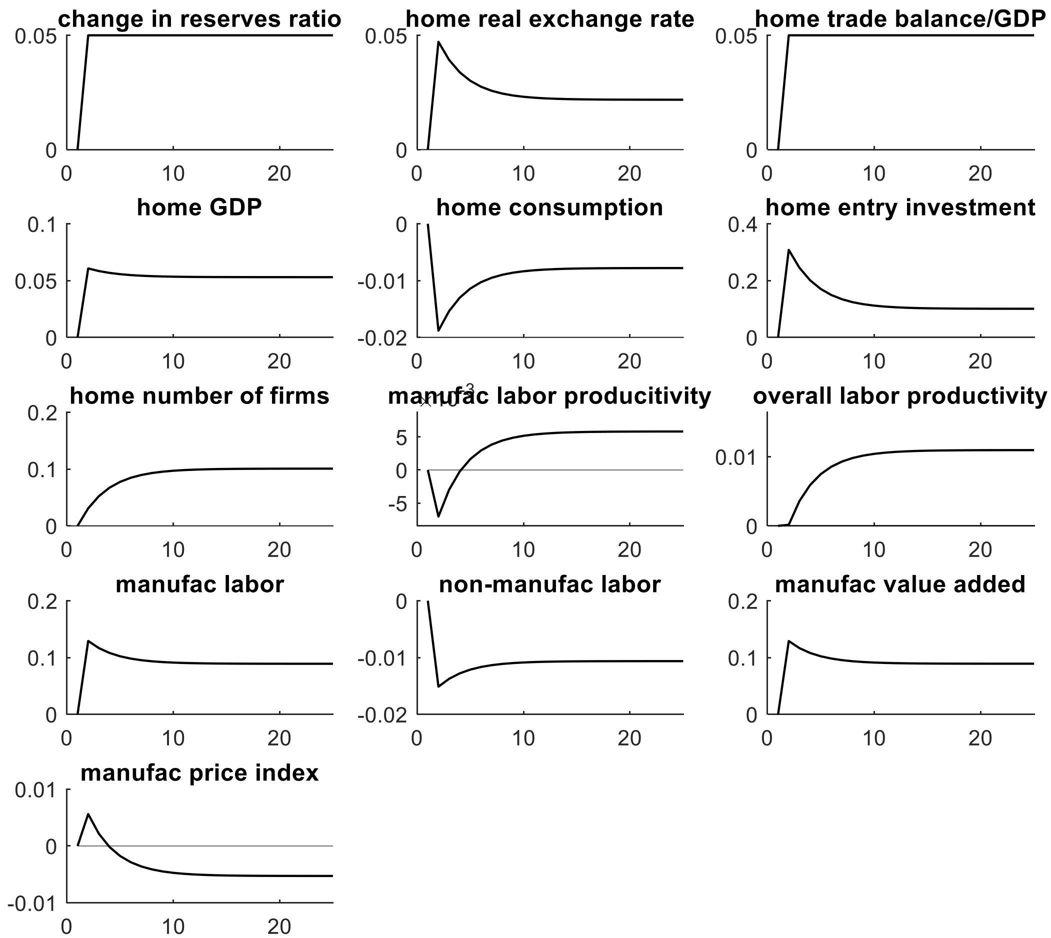

Vertical axes show percent change from value prior to change in reserves policy. Horizontal axes show years.

**Figure 2. Simulation for model with no firm entry**
(adoption of reserves policy starting in year 2)




Vertical axes show percent change from value prior to change in reserves policy. Horizontal axes show years.

**Figure 3. Simulation for model with no firm entry**
(adoption of reserves policy starting in year 2)




Vertical axes show percent change from value prior to change in reserves policy.
Horizontal axes show years.

## Appendix

### A.1.Data Construction for Sectoral Value Added, Price Index, and Labor

Our data comes from various sources. First, we use sectoral real value added per worker as our measure for labor productivity. Our baseline data for sectoral real value added comes from World Input Output Table (WIOD), Socio Economic Accounts.[14] To cover as many observations as possible, we directly incorporate nominal value added and the deflator, instead of incorporating gross output and intermediate input using respective price indices(double deflation). Nominal value added is denominated in current national currencies(millions). Price deflator index is re-anchored at 1995=100. For labor, we use the number of employement engaged(thousands). Manufacturing or non-manufacturing data is aggregated using the share of current nominal value added.

First, we take the WIOD November 2016 release as our baseline benchmark, and then supplement the WIOD July 2014 release if needed.[15] Among ten sectors (agriculture, mining, manufacturing, utilities, construction, trade service, transport service, business service, and government service), we take the manufacturing sector as a tradable goods sector, and all other sectors as a non-tradable goods sector. For the manufacturing sector, we aggregate C10-C12 to C33 of ISIC Rev.4 code; and 15t16 to 36t37 of ISIC Rev.3 code.

We further combine EU KLEMS, GGDC, and STAN from the OECD data. We take EU KLEMS Growth and Productivity Accounts, March 2007 Release as our benchmark ones for KLEMS data.[16] The sectoral data is constructed based on ISIC Rev.3. For the manufacturing sector, we aggregate the following industries; 15t16 to 36t37. Groningen Growth and Development Centre(GGDC) 10-sector data comes with three variables, VA, QVA, and EME, which stands for valued added, value added at constant 2005 prices, and persons engaged.[17] Sectoral deflator is calculated by dividing VA with QVA. We use EME for our measure for labor.

Lastly, we combine STAN from the OECD data for Norway, Switzerland, New Zealand, Iceland, and Israel.[18] We use SNA08, ISIC Rev.4 data as our benchmark data and supplement with SNA93, ISIC Rev.3 data if needed. For the manufacturing sector, we aggregate D10T33 of ISIC Rev.4 code; and 15tt37 of ISIC Rev.3 code.

KLEMS data from 1985 to 2005 and WIOD from 2005 to 2012 covers the United States, the United Kingdom, Belgium, Denmark, France, Germany, Italy, Netherland, Sweden, Japan, Finland, Greece, Ireland, Portugal, Spain. STAN data covers Norway(1989-2012), Switzerland, New Zealand(1989-2012), Iceland(1991-2012), and Israel(2000-2007). WIOD data from 1995 to 2012 covers Canada, Turkey, Australia, Argentina, Russia. GGDC data from 1985 to 2010 covers Bolivia, Chile, Colombia, Peru, Egypt, Hong Kong, Malaysia, Philippines, Singapore, Thailand. GGDC data from 1985 to 1994 and WIOD from 1995 50 2012 covers Brazil, Mexico, Indonesia, India, Korea and China.

For a few countries, slight discrepancies between ISIC Rev.3 and ISIC Rev.4 or between different sources of data rise. To prevent the discontinuity of the series, we impute the data using the growth rate of the supplement data.

[14] http://www.wiod.org/home.
[15] Please see Timmer et al. (2015) for further details.
[16] http://www.euklems.net/.
[17] https://www.rug.nl/ggdc/productivity/10-sector.
[18] http://www.oecd.org/industry/ind/stanstructuralanalysisdatabase.

**Table A.1. Summary statistics based annual observations (45 countries, 1985-2007)**

| | Full sample | | | | | Emerging markets countries | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variables | Obs. | Mean | Std. Dev. | Min | Max | Obs. | Mean | Std. Dev. | Min | Max |
| (log) manufacturing productivity | 795 | 0.029 | 0.035 | -0.077 | 0.180 | 464 | 0.027 | 0.041 | -0.077 | 0.180 |
| (log) non-manufacturing productivity | 795 | 0.017 | 0.023 | -0.033 | 0.122 | 464 | 0.021 | 0.027 | -0.033 | 0.122 |
| Capital controls (CC) | 795 | 0.344 | 0.349 | 0 | 1 | 464 | 0.525 | 0.326 | 0 | 1 |
| d.Reserves to GDP | 795 | 0.006 | 0.016 | -0.029 | 0.109 | 464 | 0.010 | 0.018 | -0.029 | 0.109 |
| CC×d.Reserves to GDP | 795 | 0.003 | 0.008 | -0.022 | 0.046 | 464 | 0.005 | 0.010 | -0.022 | 0.046 |
| Extensive margins | 795 | 0.217 | 0.140 | 0.018 | 0.599 | 464 | 0.156 | 0.093 | 0.018 | 0.494 |
| Intensive margins | 795 | 0.123 | 0.050 | 0.026 | 0.295 | 464 | 0.112 | 0.040 | 0.026 | 0.207 |
| # of listed domestic firms | 708 | 822.852 | 1423.942 | 12 | 8090 | 401 | 582.451 | 1018.193 | 12 | 5978 |
| Domestic intermediate shares[a] | 386 | 0.855 | 0.134 | 0.341 | 0.990 | 175 | 0.883 | 0.117 | 0.356 | 0.986 |
| Private credit to GDP | 795 | 0.741 | 0.486 | 0.109 | 2.681 | 464 | 0.538 | 0.404 | 0.109 | 1.649 |
| (log) terms of trade | 795 | 4.631 | 0.169 | 3.845 | 5.178 | 464 | 4.619 | 0.181 | 3.845 | 5.178 |
| Institutional quality | 795 | 8.126 | 2.358 | 2.9722 | 12 | 464 | 7.172 | 1.927 | 2.972 | 12 |
| Human capital (% of tertiary complete)[b] | 795 | 8.712 | 5.646 | 0.7616 | 24.370 | 464 | 6.705 | 5.229 | 0.762 | 24.370 |
| Crisis dummy | 795 | 0.184 | 0.317 | 0 | 1 | 464 | 0.276 | 0.362 | 0 | 1 |

a.Domestic intermeidate shares are only avaiable for 27 countries. b. Human capital index comes from Barro and Lee (2013), which is only available in 5 year period term.

**Figure A.1. China's capital account policy and firm dynamics**