Undervaluation, Financial Development, and Economic Growth

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This paper analyzes the effect of undervaluation on economic growth in the presence of borrowing constraints. Based on a two-sector, small open-economy model, we show that undervaluation can promote economic growth by partly correcting distortions in financial markets through the channels of increased within-sector productivity and the relative share of the tradable sector in an economy. Such an effect is magnified amid tight borrowing constraints. We empirically test the theoretical conclusions using cross-economy data for the period 1980–2011. For economies whose level of financial development lies at the 25th percentile of our sample, a 50% undervaluation can boost the economic growth rate by 0.3 percentage points. There is an additional 0.045 percentage point increase in economic growth with a 10% decline in the financial development measure.

I. Introduction

There have been heated discussions over the effects of undervaluation on economic growth. On one side of the debate, there is a consensus that overvaluation, especially those of a large magnitude, can do great harm to economic growth. First, overvaluation discourages investment by lowering returns in the tradable sector (Bhaduri and Marglin 1990, Gala 2008). Second, overvaluation is often associated with problems like an unsustainable current account deficit or significant macroeconomic volatility (Dornbusch and Fischer 1980). Severe balance-of-payment crises due to exchange rate overvaluation were observed in many Latin American (e.g., Chile and Mexico) and African economies (e.g., Gabon and Zambia) in the early 1980s, as well as in Argentina, Brazil, and Mexico in the 1990s (Ngongang 2011). In developing economies, the deterioration in the current account deficit may encourage the government to tighten import quotas, which

increases the probability of rent-seeking and corruption (Krueger 1974, Bleaney and Greenaway 2001).

On the other side, several empirical works (Dooley, Folkerts-Landau, and Garber 2004; Levy-Yeyati and Sturzenegger 2007; Rodrik 2008) find that undervaluation can play a significant role in promoting economic growth.[1] The reasons suggested in these papers diverge, with the former group emphasizing the role of capital deepening and savings accumulation driven by undervaluation, while the latter group views undervaluation as a correction for institutional defects and market failure. Even though there is no consensus on how undervaluation might promote economic growth, a consistent empirical fact is that the growth effect of undervaluation is much more prominent in developing economies than in developed economies. However, the existing literature does not provide a sound answer as to why there is such a difference in undervaluation's growth effect between developing and developed economies. Keeping this question in mind, the explanation we put forward in this paper is centered on an economy's level of financial development.

In the theoretical discussion below, we illustrate how borrowing constraints might amplify the growth effect of real currency undervaluation. Our model is closely related to that of Aghion et al. (2009), which show that, in the presence of a liquidity shock and wage stickiness, volatility in the real exchange rate will reduce the success probability of firms' research and development activities, thus lowering the aggregate growth rate. Such an effect is magnified in developing economies due to the existence of borrowing constraints. Based on their work, we establish a two-sector (tradable and nontradable), small open-economy model. There are two sources driving economic growth in our model: technological progress within the tradable sector and resource reallocation from the nontradable to the tradable sector. We also introduce firms' financial constraints in our model. At the end of the first period, each individual firm faces a stochastic liquidity shock after which only firms with sufficient funds can conduct the research and development needed to achieve a technology upgrade.

One of our conclusions is that if the exchange rate is sustained at the expected equilibrium level, the tradable sector suffers greater distortion due to binding financial constraints, as reflected in the lower probability of a technology upgrade in the tradable sector, which is driven by the difference in output elasticity of production between the tradable and nontradable sectors. If instead the policy of undervaluation is adopted under the assumption of wage stickiness, then domestic currency undervaluation is equivalent to an unexpected windfall for exporters.

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[1]For example, the People's Republic of China has long been accused of manipulating its exchange rate by undervaluing the renminbi to promote exports and economic growth (Frankel 2003, Krugman 2003, Goldstein 2004).

Increased domestic product prices, coupled with sticky wages, can effectively raise a firm's profit, which effectively relaxes the financial constraint and facilitates technological progress, leading to a within-sector productivity increase. Moreover, since the tradable sector is typically the sector with the faster rate of technological progress, the expansion of the tradable sector will accelerate the resource reallocation effect between sectors. In sum, domestic currency undervaluation can be seen as a way to correct a distortion in the finance sector by increasing both within-sector productivity and resource allocation efficiency between sectors.

How significant such a promotion effect can be depends on the level of development of an economy's financial market. Specifically, the impact corresponds to the tightness of the financial constraint. In an economy that is characterized as having sufficient financial liquidity, all of its firms can survive a liquidity shock by engaging in intertemporal borrowing. Under such circumstances, there is no room for domestic currency undervaluation as a means of relaxing the financial constraint. Following such logic, we propose that the effect of domestic currency undervaluation on economic growth should be more significant at lower levels of financial development, which partly explains why developing economies have a preference for undervaluation.

This paper incorporates the findings in two distinct branches of literature. The first branch reviews the effects of currency undervaluation on economic growth, which has always been a major area of interest for both academics and policy makers. Most of the early empirical evidence supports the view that real exchange rate misalignment, when used as a form of price distortion, will have negative impacts on macroeconomic variables such as imports, exports, industrial structure, resource allocation, and income distribution. (Edwards 1988; Cottani, Cavallo, and Kahn 1990). At the same time, there is no difference found between the effects of currency overvaluation or undervaluation on economic growth in this research. Razin and Collins (1997) put forward that there might be some nonlinear correlation between real exchange rate misalignment and economic growth. According to their results, only very large overvaluations appear to be associated with slower economic growth. Moderate and high (as opposed to very high) undervaluations appear to be associated with more rapid economic growth. Specifically, a 10% overvaluation in the real exchange rate leads to a 0.6 percentage point decrease in the economic growth rate, while a 10% undervaluation contributes 0.9 percentage points to economic growth.

There are two traditional approaches in the literature to measuring the equilibrium real exchange rate. One is to use the fundamental equilibrium exchange rate (FEER) first proposed by Williamson (1985), who assumed macroeconomic balance. The other popular measurement is the behavioral equilibrium exchange rate (BEER), which focuses on the determinants of the exchange rate in the medium to long run (Baffes, Elbadawi, and O'Connell 1997; Maeso-Fernandez, Osbat, and

Schnatz 2002). Both approaches have pros and cons, but a common challenge is the availability of data, especially for developing economies.[2]

To include developing economies in our analysis, we refer to a different measure used by Rodrik (2008). Our equilibrium value of the real exchange rate is defined as the predicted real exchange rate based on gross domestic product (GDP) per worker after controlling for the fixed effects of economy and year. Real exchange rate misalignment is defined as the difference between the real value and fitted value, with a positive difference referring to currency undervaluation and a negative difference to overvaluation. The intuition behind such an approach is to conceive of the Balassa–Samuelson adjusted rate as the equilibrium. Prices in the nontradable sector should be lower in poorer economies, which will influence the real exchange rate through lower overall domestic prices. The advantage of this approach is to enable the comparison of currency undervaluation both in terms of cross-section and time series analysis. Moreover, it does not require as many economy-level macroeconomic variables as the two traditional measures, which makes it ideal for analyzing long-term panel data containing many developing economies.

A second branch of literature relates to the role of financial market development in economic growth. Financial activities have often been seen as responses to developments in the real economy and therefore the topic previously did not assume much importance within academia (Robinson 1972, Meier and Seers 1984). A case in point is Lucas (1988), who once commented that the role of finance on economic growth had been overstressed. As the understanding of incomplete information and market frictions deepened, a number of people realized the impact of finance on economic growth, especially on how financial intermediaries help to overcome the problem of adverse selection and improve the efficiency of credit allocation (Bagehot 1873, McKinnon 1973, Miller 1998). According to Levine (2005), there are five channels through which finance can stimulate economic growth: (i) producing information ex ante about possible investments and the allocation of capital; (ii) monitoring investments and exerting corporate governance after providing finance; (iii) facilitating the trading, diversification, and management of risk; (iv) mobilizing and pooling savings; and (v) easing the exchange of goods and services. Levine concludes that financial market development can stimulate economic growth by improving resource allocation and investment returns.

This paper contributes to the literature in three aspects. First, we try to explain the divergent effects of currency undervaluation on economic growth between developing and developed economies, which has become a stylized empirical fact lacking a solid explanation. What we find both theoretically and empirically is that the level of financial development is important in determining

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[2]For a more detailed methodological comparison of BEERs and FEERs, please refer to Clark and MacDonald (1999).

currency undervaluation's effect on economic growth. We illustrate that currency undervaluation can partially compensate for the underdevelopment of financial markets and such an effect is magnified in less financially developed economies. Second, by using cross-economy data covering the period 1980–2011, we empirically quantify the effects of currency undervaluation on economic growth and separately examine the two channels through which currency undervaluation contributes to economic growth: (i) raising productivity within the tradable sector, and (ii) expanding the size of the tradable sector relative to the nontradable sector.

With regard to the policy implications, this paper deepens our understanding of why some developing economies have a preference for currency undervaluation. According to our explanation, developing economies with underdeveloped financial markets can use undervaluation as a remedy for tight financial constraints through the relaxation of such constraints in the tradable sector, which in turn stimulates economic growth.

The rest of the paper is organized as follows. Section II introduces our theoretical model and predictions. Section III describes the data and variables we have constructed. Section IV presents the benchmark estimates, describes a series of robustness checks, and explores the two channels through which undervaluation affects economic growth. Section V concludes.

II. Theoretical Model

In this section, we introduce our theoretical framework for further analysis. We consider a small, open-economy model in which wage stickiness is assumed in the short run. There are two sectors in the economy: tradable (T) and nontradable (N). The price for sector N is denoted as P_t^N. The tradable sector produces only a single good whose price is denoted as P_t^T. P_t^T is determined by the international market in our model. Normalizing the world price for the tradable good as 1, we have

$$P_t^T = S_t P_t^{T^*} = S_t \tag{1}$$

where $P_t^{T^*}$ and S_t are the world price and nominal exchange rate, respectively.

The exchange rate, S_t, fluctuates around its equilibrium value, $E(S_t) = \bar{S}$. The equilibrium is the expectation value based on all historical information, which is consistent with the idea that the predicted value is formed using all available fundamentals.

We assume that wages are sticky in the short run. Following Aghion et al. (2009), it is assumed the wage rate at t-period is determined by

$$W_t^T = E\left(P_t^T\right) \kappa A_t^T = \bar{S} \kappa A_t^T, W_t^N = P_t^N \kappa A_t^N \tag{2}$$

which means the real wage in each of the two sectors is equal to sectorial productivity (A_t^T, A_t^N) times κ, where $\kappa < 1$ is the reservation utility (the utility gained while not working). Since the prices in the tradable sector are also influenced by fluctuation in the nominal exchange rate, the wage rate is determined by the expected equilibrium exchange rate, $E(P_t^T) = E(S_t) = \bar{S}$. The free mobility of labor will equalize wages in the two sectors ($W_t^T = W_t^N \overset{\Delta}{=} W_t$); such an equation can also be used to determine the price level of the nontradable sector (P_t^N).

A.   Firm Decision

The wage rate at the beginning of the first period is the function of the expected equilibrium exchange rate so that a firm's decision is a two-period problem. First, based on the known distribution of a liquidity shock, the firm speculates the probability of achieving a technology upgrade. The labor demand is determined by maximizing the expected sum of revenues over the two periods. At the end of each period, the stochastically distributed liquidity shock is realized and only those firms that succeed in raising sufficient funds can complete the technology upgrade and realize the associated profit (υ_{t+1}). The sectorial productivity is determined by the proportion of firms succeeding in innovation (ρ_t).

Assuming labor is the only input, the production functions in the tradable and nontradable sectors take the following forms:

$$y_t^T = A_t^T (l_t^T)^{\alpha^T}$$
$$y_t^N = A_t^N (l_t^N)^{\alpha^N} \tag{3}$$

To guarantee that profits can be allocated for technological innovations, we consider the case of decreasing returns to scale. Moreover, it is assumed that the output elasticity of labor is larger in the nontradable sector:[3]

$$1 > \alpha^N > \alpha^T \tag{4}$$

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[3]We discuss more on the validity of assumption $1 > \alpha^N > \alpha^T$ here. If the production function takes the Cobb–Douglas form, then the assumption $\alpha^N > \alpha^T$ implies that the nontradable sector is more labor intensive than the tradable sector, which is also a basic assumption in Herrendorf, Rogerson, and Valentinyi (2013). To measure labor intensity, several major indexes are used. For data at the firm level, these include employer's compensation/total assets (Dewenter and Malatesta 2001) and employer's compensation/sales (Grubaugh 1987). For data at the industry level, a frequently used index is industrial labor compensation/industrial nominal value-added output (Acemoglu and Guerrieri 2006). In order to enable summary statistics covering as many economies as possible, we use industrial labor compensation/value-added output from the World Bank's World Development Indicators to proxy for labor intensity. Our sample includes 214 economies covering the period 1960–2014. The mean value of labor intensity is 0.81 in the manufacturing sector and 1.01 in the service sector. Broken down into subperiods, the mean values for the manufacturing and service sectors in 1960–1980 are 0.72 and 0.98, respectively. For 1981–2014, the corresponding figures are 0.83 and 1.02, respectively. Therefore, on average, the nontradable (services) sector is more labor intensive than the tradable (manufacturing) sector, which is compatible with the assumption $\alpha^N > \alpha^T$.

The profits at the end of the first period are

$$\pi_t^T = P_t^T y_t^T - W_t l_t^T = A_t^T S_t (l_t^T)^{\alpha^T} - \bar{S} \kappa A_t^T l_t^T$$

$$\pi_t^N = P_t^N y_t^N - W_t l_t^N = A_t^N P_t^N (l_t^N)^{\alpha^N} - P_t^N \kappa A_t^N l_t^N \tag{5}$$

We need to assume that wages are sticky in the short run because the wage level is determined by the expectation formed at the beginning of each period. When the realized exchange rate value (S_t) deviates from $\bar{S}$, the wage paid will not change in the short run. Instead, only the product price and labor demand will be affected. Only when there is a divergence of the realized value with the equilibrium level can the profit in the tradable sector be altered, which further impacts the tightness of the borrowing constraint.

In the maximization problem of the firm, the decision variable is labor demand (l_t), which affects the firm's profit at the end of the first period (π_t) and further determines the upper bound of the borrowing constraint in the presence of a liquidity shock. All of these factors affect the chance for success of a technology upgrade in the second period (ρ_t) as the firm maximizes the expected sum of revenues over two periods:

$$\max_{l_t^S} \left\{ \pi_t^S + \beta \rho_t^S E_t \upsilon_{t+1} \right\}, S = T, N \tag{6}$$

B. Technology Upgrading and Borrowing Constraint

In each period, both sectors T and N can upgrade their technology by the multiplier $\gamma > 1$, meaning that in the next period the productivity of firms achieving innovation will be the following:[4]

$$A_{t+1}^S = \gamma A_t^S, S = T, N \tag{7}$$

Furthermore, we assume the realized value after innovation is proportional to the nominal productivity in the next period:

$$V_{t+1}^S = \upsilon P_{t+1}^S A_{t+1}^S, S = T, N \tag{8}$$

υ is assumed to be sufficiently large so that innovation is profitable for firms in both sectors. That is to say, in the absence of a borrowing constraint, all firms will choose to make a technology upgrade, which will result in a growth rate of $\gamma > 1$

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[4]For simplicity, the rates of technology upgrading are assumed to be equalized across the two sectors. In cases of the tradable sector having a faster rate ($\gamma^T > \gamma^N$), our main conclusions still hold. In fact, the results are strengthened.

for the whole economy. However, firms face a borrowing constraint in our setup: it is assumed that the funds a firm can borrow should be no more than $\mu - 1$ times its realized profit (π_t) at the end of period t. Equivalently, the maximum amount of capital available is $\mu\pi_t$. The parameter μ indicates the level of development of the financial market (or, more explicitly, the tightness of the borrowing constraint). The smaller μ is, the harder it is for firms to borrow. Contrarily, if μ is sufficiently large, then all capital demands can be satisfied and there is no borrowing constraint.

Firm i will confront a liquidity shock at the end of period t, $(C_t)_i$, which can also be seen as the amount of liquidity needed for innovation. Whether or not the liquidity requirement is satisfied determines the success or failure of innovation. If the financial market is perfect, then all firms can survive the liquidity shock by relying on intertemporal borrowing. The probability of firms successfully achieving a technology upgrade is 1, and the overall growth rate is constant. It is the presence of a borrowing constraint that leads to only some firms achieving a technology upgrade. The impact of such a shock is assumed to be proportional to a firm's nominal productivity at period t:

$$(C_t^S)_i = c_i P_t^S A_t^S, \, S = T, N \tag{9}$$

where c_i is assumed to be independent and identically distributed across all firms with a cumulative distribution function of $F(.)$.

Consequently, only those firms satisfying $\mu\pi_t^S \geq C_t^S$ (those firms with sufficient funds) can survive a liquidity shock and achieve a technology upgrade. As a result, the probabilities of firms achieving innovation in each of the two sectors are

$$\rho_t^S = Pr\left(c_i \leq \frac{\mu\pi_t^S}{P_t^S A_t^S}\right) = F\left(\frac{\mu\pi_t^S}{P_t^S A_t^S}\right), \, S = T, N \tag{10}$$

C.   Equilibrium Profit

Plugging the expression ρ_t^S into the maximization problem of the firm results in

$$l_t^T = \left(\frac{\alpha^T S_t}{\kappa \bar{S}}\right)^{\frac{1}{1-\alpha^T}}, l_t^N = \left(\frac{\alpha^N}{\kappa}\right)^{\frac{1}{1-\alpha^N}} \tag{11}$$

Plugging l_t^S into the profit functions of each sector results in

$$\pi_t^T = A_t^T S_t \left(1 - \alpha^T\right)\left(\frac{\alpha^T S_t}{\kappa \bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}} \triangleq A_t^T S_t \Psi^T \left(\frac{S_t}{\bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}}$$

$$\pi_t^N = A_t^N P_t^N \left(1 - \alpha^N\right) \left(\frac{\alpha^N}{\kappa}\right)^{\frac{\alpha^N}{1-\alpha^N}} \triangleq A_t^N P_t^N \Psi^N \tag{12}$$

From equation (10), we know the probability of completing the innovation is

$$\rho_t^T = F\left(\mu \Psi^T \left(\frac{S_t}{\bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}}\right), \rho_t^N = F\left(\mu \Psi^N\right) \tag{13}$$

where $\Psi^S = (1 - \alpha^s)\left(\frac{\alpha^s}{\kappa}\right)^{\frac{\alpha^S}{1-\alpha^S}}$, $S = T, N$

From equation (13), we can see that if the exchange rate remains at its equilibrium value ($S_t = \bar{S}$), then the probabilities of a technology upgrade in the tradable and nontradable sectors are time invariant. Instead, they depend only on the borrowing constraint parameter (μ), the reservation utility (κ), and the labor intensity parameter ($\alpha^S, S = T, N$). Producers will adjust their factor demands at the beginning of each period. For a comparison between sectors, the relative magnitudes of the technology upgrade probabilities depend only on the parameters Ψ^T, Ψ^S. Since the output elasticity of labor is larger in the nontradable sector ($\alpha^N > \alpha^T$), it proves that $\Psi^T < \Psi^N$.[5] Further, we have $\rho^T < \rho^N$. Our conclusions based on these findings are summarized below.

Conclusion 1: If the exchange rate remains at the equilibrium level and the borrowing constraint is binding, then the probability of achieving innovation is lower in the tradable sector than in the nontradable sector.

As we have proved, real currency undervaluation ($S_t > \bar{S}$) will have two effects on the tradable sector. One is the relative expansion of the tradable sector, both in terms of employment and output, with the magnitude amplified if measured in nominal terms. The other effect is the increased probability of a technology upgrade in this sector when μ is finite. This explains why some developing economies have a preference for an exchange rate policy based on undervaluation. One possible reason is that intentional undervaluation relaxes the borrowing constraint in the tradable sector, which is characterized as having higher productivity than the tradable sector (Rodrik 2008). However, when μ is sufficiently large, the financing demands of all firms can be satisfied and there is no borrowing constraint. Then $\rho_t^T, \rho_t^N \to 1$ holds and the effect on ρ_t^T due to the increase in S_t will be very trivial, which implies the increased probability of a technology upgrade in the tradable sector will be more significant in economies with a less developed financial market.

Conclusion 2: Real exchange rate undervaluation will lead to the expansion of the tradable sector.

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[5]To derive $\Psi^T < \Psi^N$ from $\alpha^T < \alpha^N$, we can define a function $\Psi(\alpha) = (1 - \alpha)(\alpha/\kappa)^{\frac{\alpha}{1-\alpha}}$. By calculating the log of both sides and then calculating the derivative with respect to α, $\Psi(\alpha)$ increases in α so that $\Psi^T < \Psi^N$.

Conclusion 3: Real exchange rate undervaluation will increase the probability of technology upgrading in the tradable sector. Such an effect is magnified in economies with less developed financial markets.

D.   Economic Growth Rate

Next, we come to evaluate the impact of the real exchange rate on the economic growth rate. If we assume that the nominal exchange rate at period $t-1$ remains $\bar{S}$ (equilibrium level), then the real output in each of the two sectors is

$$y_{t-1}^T = A_{t-1}^T \left(\frac{\alpha^T}{\kappa}\right)^{\frac{\alpha^T}{1-\alpha^T}}, \, y_{t-1}^N = A_{t-1}^N \left(\frac{\alpha^N}{\kappa}\right)^{\frac{\alpha^N}{1-\alpha^N}} \tag{14}$$

When there is misalignment in the real exchange rate at period t, which means the realized value (S_t) deviates from $\bar{S}$, then the output in each of the two sectors is

$$y_t^T = [\rho_t^T \gamma A_{t-1}^T + \left(1 - \rho_t^T\right) A_{t-1}^T]\left(\frac{\alpha^T S_t}{\kappa \bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}} = y_{t-1}^T [\rho_t^T \gamma$$

$$+ \left(1 - \rho_t^T\right)]\left(\frac{S_t}{\bar{S}}\right)^{\frac{\alpha^T}{1-\alpha^T}}$$

$$y_t^N = [\rho_t^N \gamma A_{t-1}^N + \left(1 - \rho_t^N\right) A_{t-1}^N]\left(\frac{\alpha^N}{\kappa}\right)^{\frac{\alpha^N}{1-\alpha^N}} = y_{t-1}^N [\rho_t^N \gamma + \left(1 - \rho_t^N\right)] \tag{15}$$

Consequently, the gross growth rate of real output is

$$g_t = \frac{y_t}{y_{t-1}} = \frac{y_t^T + y_t^N}{y_{t-1}^T + y_{t-1}^N} = \frac{y_t^T}{y_{t-1}^T} v_{T,t-1} + \frac{y_t^N}{y_{t-1}^N} \left(1 - v_{T,t-1}\right)$$

$$= [\rho_t^T \gamma + \left(1 - \rho_t^T\right)] \left(S_t/\bar{S}\right)^{\frac{\alpha^T}{1-\alpha^T}} .v_{T,t-1} + [\rho_t^N \gamma + \left(1 - \rho_t^N\right)](1 - v_{T,t-1}) \tag{16}$$

where $v_{T,t-1} = \frac{y_{t-1}^T}{y_{t-1}^T + y_{t-1}^N}$, which is the output share of the tradable sector at period $t-1$.

Given equations (11) and (13), we know that neither the probability of a technology upgrade in the nontradable sector (ρ_t^N) nor the output at different phases will be changed by nominal exchange rate movement. Instead, the only channel for nominal exchange rate movement to affect the gross growth rate is through output change in the tradable sector. It can be seen clearly from equation (16) that, in the presence of a borrowing constraint, undervaluation affects the growth rate of real output mainly in two ways: (i) by increasing ρ_t^T (more firms can achieve a

technology upgrade in period t), which leads to an accelerated technology growth rate in the tradable sector; and (ii) by changing the relative price between sectors (increase in $S_t / \bar{S}$), which will result in more labor and more output in the tradable sector (industrial structure change).

If the price factor is taken into consideration, the nominal effect of real exchange rate undervaluation on the growth rate will be even larger. This is because, on one side, the relative price in the tradable sector rises as expressed in the increase of $S_t / \bar{S}$. On the other side, due to the equalization of wages across the two sectors, the price in the nontradable sector also increases. From equation (2), we know

$$P_t^N / P_{t-1}^N = (A_t^T / A_{t-1}^T)/(A_t^N / A_{t-1}^N)$$
$$= \frac{\rho_t^T \gamma + \left(1 - \rho_t^T\right)}{\rho_t^N \gamma + \left(1 - \rho_t^N\right)}$$

When there is an undervaluation, ρ_t^T increases while ρ_t^N remains unchanged. Therefore, a technology upgrade in the tradable sector will pull up the price in the nontradable sector, which is consistent with the spirit of the Balassa–Samuelson effect. In the case of the nominal growth rate, nominal exchange rate undervaluation, which is associated with undervaluation, will increase prices in both sectors, making the nominal increase larger in magnitude than the result measured in real terms.

Conclusion 4: *Real exchange rate undervaluation will affect the real economic growth rate in two ways: (i) increased productivity within the tradable sector and (ii) the expansion of the tradable sector since increased relative prices will attract more resources into the sector. When measured in terms of the nominal growth rate, the effect of undervaluation on growth is further magnified because of increased prices in both sectors.*

III. Data and Variables

A. Key Variables

In this section, we test conclusions 2–4 by using cross-economy data. One conclusion from the model is that real exchange rate undervaluation can promote economic growth and that such an effect is greater in economies at lower levels of financial development. To test this hypothesis, we define our key explained variable—real exchange rate misalignment—as the difference between the realized value of the real exchange rate and its equilibrium. The accuracy of the "equilibrium real exchange rate" determines the precision of the explained variable. As discussed in the introduction, commonly used approaches such as FEER and BEER are more suitable for time series data for a single economy and panel data for developed economies. However, the data set we prefer is a sample covering most developed

and developing economies over a longer span. Due to the limitations of the data, especially for developing economies, we prefer the measure introduced by Rodrik (2008) for the sake of comparisons between different economies and time spans.

Following Rodrik (2008), we construct the measurement of real exchange rate undervaluation in three steps. First, we calculate the real exchange rate

$$\ln RER_{ct} = \ln \left(\frac{XRAT_{ct}}{PPP_{ct}} \right)$$

where the subscripts c and t denote economy and year, respectively. *XRAT* represents the US dollar-denominated value of the domestic currency and *PPP* is the relative purchasing power conversion factor. When RER_{ct} is less than 1, the nominal currency value in economy c is lower than the equilibrium level measured in terms of purchasing power parity. However, it does not necessarily indicate an undervalued currency in economy c since less developed economies are associated with lower prices for nontradable goods, which is the essence of the Balassa–Samuelson effect.

To deconstruct the Balassa–Samuelson effect, we then regress the real exchange rate on GDP per capita ($RGDPPC_{ct}$) with the time fixed effect controlled:

$$\ln RER_{ct} = \alpha + \beta \ln RGDPPC_{ct} + f_t + u_{ct}$$

where f_t is the time fixed effect. The regression result indicates that $\hat{\beta} = -0.3$ with an associated t-value of -3.6, which means that given a 10% increase in GDP per capita, there will be a 3% appreciation in the real exchange rate.

The third step is to define the undervaluation index as the difference between the realized exchange rate and the predicted value derived from the first two steps.

$$\ln UNDERVAL_{ct} = \ln RER_{ct} - \ln \widehat{RER}_{ct}$$

$\ln \widehat{RER}_{ct}$ is the expected equilibrium value for the exchange rate and $\ln RER_{ct}$ is the realized value. When $UNDERVAL_{ct}$ for economy c is greater than 1, the domestic currency is undervalued. The real exchange rate misalignment index can be compared between different economies and periods. Plotting the distribution of exchange rate misalignment (after taking the logarithm), we observe in Figure 1 that most of the dots are scattered near zero and the standard deviation is 0.77.

The measurements for financial development are consistent with Levine, Loayza, and Beck (2000). We use two measures: (i) private credit/GDP and (ii) M2/GDP. The first index is used for the benchmark result (Figure 2) and the second is used as a robustness check (Figure 3).

To examine how the correlation between undervaluation and economic growth varies in economies with different levels of financial development, we divide

Figure 1. **Distribution of Real Exchange Rate Undervaluation**
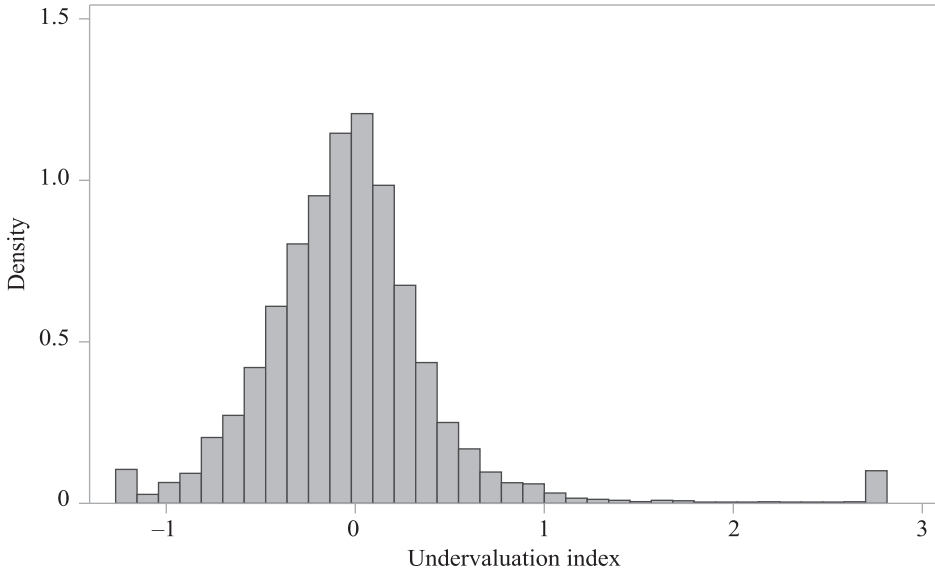
Note: The value of real exchange rate undervaluation is in logarithmic form and the 1% outliers have been dropped.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org
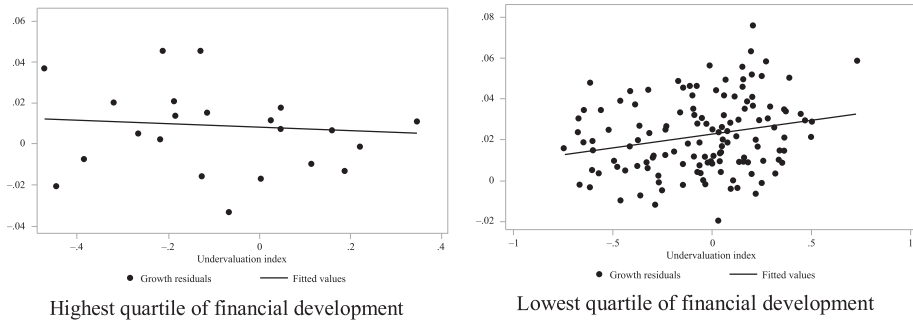/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc
/data/pwt/

Figure 2. **Correlation between Undervaluation and Economic Growth**

Highest quartile of financial development   Lowest quartile of financial development
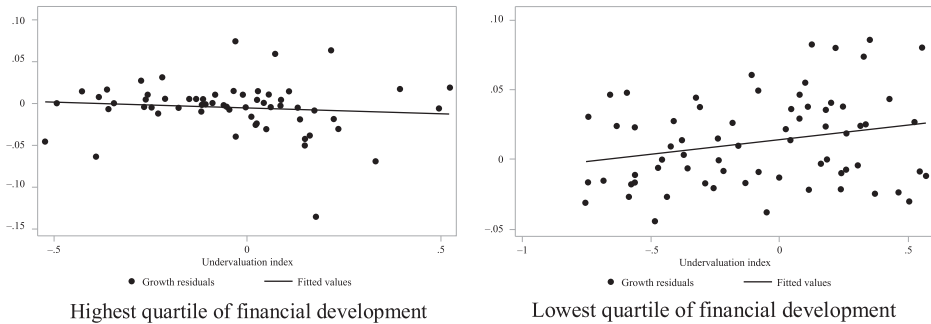
Notes:
1. Financial development is measured by private credit/gross domestic product (GDP).
2. The economic growth rate is the residual of regressing real GDP per worker on a series of control variables (real
GDP per worker in last period, private credit/GDP, dependency ratio, investment ratio, and government expenditure
ratio).
3. The currency undervaluation is measured based on Rodrik, Dani. 2008. "The Real Exchange Rate and Economic
Growth." *Brookings Papers on Economic Activity* 2 (2008): 365–412.
4. The data are averaged over the period 1908–2011.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank
.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research
/ggdc/data/pwt/

Figure 3. **Correlation between Undervaluation and Economic Growth**

Highest quartile of financial development   Lowest quartile of financial development

Notes:
1. Financial development is measured by M2/gross domestic product (GDP).
2. The economic growth rate is the residual of regressing real GDP per worker on a series of control variables (real GDP per worker in last period, private credit/GDP, dependency ratio, investment ratio, and government expenditure ratio).
3. The currency undervaluation is measured based on Rodrik, Dani. 2008. "The Real Exchange Rate and Economic Growth." *Brookings Papers on Economic Activity* 2 (2008): 365–412.
4. The data are averaged over the sample period.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank .org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research /ggdc/data/pwt/

economies into four groups according to their financial development performances (measured in terms of either private credit/GDP or M2/GDP), and we compare the economies in the lowest quartile with the ones in the highest quartile. The right panel of Figure 2 shows that when using private credit/GDP to measure financial development, there is a significant positive correlation between undervaluation and economic growth in the lowest quartile.[6] However, the left panel of Figure 2 shows that this correlation disappears in economies whose financial markets rank in the top quartile. This divergent pattern of correlation holds when we replace the financial market development index with M2/GDP as shown in Figure 3.

B.   Empirical Analysis

The regression takes the following specification based on Rodrik (2008):

$$growth_{ct} = \alpha + \beta . lny_{c,t-1} + \gamma_1 . Underval_{ct} + \gamma_2 . Underval_{ct} * Fin\, devt_{ct}$$
$$+ \gamma_3 . Fin\, devt_{ct} + \delta . Z_{c,t-1} + \theta_c + \theta_t + \varepsilon_{ct} \tag{17}$$

where $growth_{ct}$ is the growth rate of domestic output per worker for economy c in year t. $lny_{c,t-1}$ is real GDP per worker in period $t-1$. $Underval_{ct}$ is our

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[6]For economies whose level of financial development falls in the bottom one-third of our sample there is a consistent positive correlation between undervaluation and economic growth.

Table 1. **Summary Statistics**

Variable	Mean	Standard Deviation
Real GDP per worker	9.5	1.2
Undervaluation	−0.1	0.8
Dependency ratio	0.7	0.2
Trade openness	0.6	0.7
Government expenditure share (% of GDP)	0.2	0.1
Investment share (% of GDP)	0.2	0.1
M2/GDP	3.7	0.7
Private credit (% of GDP)	3.4	1.0

GDP = gross domestic product.
Notes: Real gross domestic product (GDP) per worker, undervaluation, M2/GDP, and private credit/GDP are in logarithmic form.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

constructed measurement of undervaluation for economy c. $Fin\ devt_{ct}$ indicates the financial development for economy c. θ_c and θ_t are the fixed effects for economy and year, respectively. $Z_{c,t-1}$ includes several control variables at the economy level, including the dependency ratio (ratio of people younger than 15 or older than 64 years of age to the working-age population comprising those aged 15–64 years), trade openness (sum of exports and imports of goods and services as % of GDP), government expenditure share (% of GDP), and investment share (gross fixed capital formation as % of GDP). All control variables except for $Underval_{ct}$ and $Fin\ devt_{ct}$ are uniformly in lagged form in order to alleviate the concern of reverse causality or other endogeneity problems.

Our sample covers 156 economies for the period 1980–2011. The summary statistics are listed in Table 1.

IV. Empirical Results

A. Effect of Undervaluation on Economic Growth

Based on equation (17), we estimate the overall effect of undervaluation on the economic growth rate. The results are listed in Table 2. As to the measure of financial market development, we use private credit (value of credit extended to the private sector by banks and other financial intermediaries) as a share of GDP, which is a standard indicator in the related literature. This is superior to other measures of financial development in that it excludes credit granted to the public sector and funds provided from central or development banks. For a robustness check, we present results with financial market development measured as M2/GDP.

The impact of undervaluation on economic growth is generally positive, though sometimes insignificant. The significantly negative sign of the interactive

Table 2. **Effect of Undervaluation on Economic Growth Rate**
Dependent variable: economic growth rate ($growth_{ct}$)

	(1) fin_devt = private credit/GDP	(2) fin_devt = private credit/GDP	(3) fin_devt = 1(private credit/GDP > 25th percentile)	(4) fin_devt = 1(private credit/GDP > 50th percentile)	(5) fin_devt = 1(private credit/GDP > 75th percentile)
Real GDP per worker$_{t-1}$	−0.063*	−0.064*	−0.063*	−0.065*	−0.065*
	(−11.56)	(−11.68)	(−12.11)	(−12.30)	(−12.35)
Underval	0.005	0.030***	0.008	0.015**	0.011
	(0.85)	(1.95)	(1.41)	(2.29)	(1.43)
Fin devt	0.002	0.002	−0.014*	−0.006	0.003
	(0.63)	(0.48)	(−3.23)	(−1.44)	(0.59)
Underval ∗ fin devt		−0.009***	−0.031*	−0.032*	−0.016***
		(−1.76)	(−3.33)	(−3.74)	(−1.80)
Dependency ratio$_{t-1}$	−0.000	−0.000	−0.000	−0.000***	−0.000
	(−1.22)	(−1.44)	(−1.52)	(−1.81)	(−1.51)
Trade openness$_{t-1}$	0.010*	0.010*	0.010*	0.011*	0.010*
	(3.19)	(3.19)	(3.18)	(3.35)	(3.20)
Govt. expenditure share$_{t-1}$	−0.069*	−0.076*	−0.064*	−0.072*	−0.074*
	(−3.23)	(−3.50)	(−3.16)	(−3.55)	(−3.59)
Investment share$_{t-1}$	0.041***	0.038***	0.032	0.029	0.026
	(1.85)	(1.70)	(1.52)	(1.40)	(1.26)
Fixed effects					
Economy fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	4,019	4,019	4,019	4,019	4,019
R^2	0.084	0.084	0.087	0.086	0.083

GDP = gross domestic product.
Notes:
1. All observations are annual data for the period 1980–2011.
2. The measure of financial development is private credit as a percentage of GDP.
3. Undervaluation and private credit/GDP are in logarithmic form.
4. All regressions include a constant term and economy and year fixed effects, and control for the main effects of all three shocks.
5. t-statistics are in parenthesis.
6. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

term (*underval* × *fin devt*) suggests that the effect of undervaluation is much greater in economies at lower levels of financial development. In column (1), we find no significant effect on the economic growth rate. However, when the interactive term for undervaluation and financial development is added in column (2), we find its sign is significant and negative, indicating a stronger growth stimulation effect of undervaluation in economies with less developed financial markets. For instance, in economies whose financial development lies at the 25th percentile of the distribution, the mean value of financial development is 2.67. Therefore, a 50% undervaluation

can increase the economic growth rate by 0.3 percentage points (50% ∗ [0.03–0.009 ∗ 2.67]). Moreover, the coefficient of the interactive term implies that given a 50% undervaluation, there will be an additional 0.045 percentage point increase in economic growth with every 10% decline in the level of financial development (50% ∗ 0.009 ∗ 10%).

The first two columns are derived using a continuous measurement for financial development. However, the effect of finance on economic development may be nonlinear. To deal with this possibility, in columns (3), (4), and (5) we divide economies into two groups (less developed and more developed) according to their relative rank of financial development, with thresholds set at the 25th, 50th, and 75th percentiles, respectively. The dummy value is set as 1 for the more developed group and then this dummy variable is interacted with the undervaluation index. The coefficients of the interactive term are significantly negative, proving again the weaker effect of undervaluation on economic growth in economies with more advanced finance sectors.

In column (3), the coefficient of the interactive term is –0.031, suggesting that compared with economies whose financial development falls below the 25th percentile, the effect of a 50% undervaluation on economic growth is 1.5 percentage points (50% ∗ 0.031) less in those economies with more advanced financial markets. Similarly, in columns (4) and (5), where the dividing lines are set at the 50th and 75th percentiles of the financial development distribution, respectively, the interactive terms remain uniformly negative, reinforcing the idea that economies with less developed financial markets benefit more from undervaluation in terms of growth.

The results for other control variables are by and large consistent with the literature in that higher GDP per worker in the previous period is associated with a slower growth rate, which is in line with convergence theory (Barro and Sala-i-Martin 1992). As for the magnitude, in a related empirical study on undervaluation, Rodrik (2008) reports the coefficients for lagged real income per capita for developed and developing economies as –0.055 and –0.065, respectively. As for the partial derivative of *findevt*, the relationship between *findevt* and growth can be ambiguous. Compared with less developed economies, advanced economies may perform better in terms of both *findevt* and growth. On the other hand, advanced economies with more developed financial markets may grow more slowly than some emerging economies. The significantly negative role of *findevt* may be explained by the faster growth rate of those economies that are catching up, which is the essence of the convergence theory of economic growth. For the demographic variable, a higher dependency ratio lowers the economic growth rate (Krugman 1995, Higgins and Williamson 1997).

Assessing the impact of government expenditure on economic growth is quite controversial. Barro (1990) proposes the promotion effect of government expenditure in an endogenous growth model in which public expenditure is seen as

part of the production input. Conversely, many empirical works provide evidence of the opposite (Landau 1983, Grier and Tullock 1989), which coincides with what we find in our paper that government expenditure has a negative effect on growth. Empirically, the magnitude of government spending on economic growth varies and depends largely on the selection of the sample and the definition of government spending. Likewise, a possible mechanism for trade openness may be what is stressed by Young (1991) and Yanikkaya (2003), who note that open trade may hurt an individual economy even though it is beneficial for economies as a whole.

B.   Robustness Check

In Table 3, we test the robustness of our results in two directions: (i) by altering the measures of our key variables: financial development and undervaluation and (ii) by further reporting the results using 5-year-averaged panel and cross-section data instead of adopting yearly panel data.

First, for an alternative measure of financial development, we refer to M2/GDP (Levine and Zervos 1996, 1998; Demirgüç-Kunt and Levine 1996). In column (1), the results are qualitatively consistent with the benchmark. To be more specific, the sample mean of financial development is 3.72, implying that the growth effect driven by a 50% undervaluation is 0.14 percentage points (50% ∗ [0.081–0.021 ∗ 3.72]) on average. Furthermore, given a 50% undervaluation, with every 10% decline in financial development, the marginal effect on economic growth is amplified by 0.11 percentage points (50% ∗ 10% ∗ 0.021).

Another key variable is undervaluation, which depends on the accuracy of the real exchange rate. In the benchmark regression, the real exchange rate is constructed based on Penn World Tables 8.0. For a robustness check, we turn to the counterpart variable from the International Monetary Fund and the results are listed in column (2). Compared with the Penn World Tables 8.0, the International Monetary Fund sample is much smaller, which leads to a sharp decrease in observations from 4,019 to 1,960. However, despite such a drop in the number of observations, the results are still qualitatively consistent and remain highly significant.

In columns (3) and (4), we report the results using data in 5-year-averaged panel and cross-sectional forms, respectively. In the cross-sectional regression, all of the control variables are averaged over the sample year, while real GDP per worker$_{t-1}$ refers to the value at the beginning year. The main conclusion that undervaluation can promote economic growth still holds. Such an effect is more prominent in less developed financial markets.

We will now discuss the threshold of *findevt* that makes the partial effect of undervaluation positive. According to equation (17), the threshold equals $-\gamma_1/\gamma_2$. When *findevt* is measured as private credit/GDP (in logarithmic form), the threshold values range from 2.9 to 4.7 (see column [2] of Table 2 and columns [2]–[4] of Table 3), depending on the data source of the real effective exchange rate

Table 3. **Robustness Check**
Dependent variable: economic growth rate ($growth_{ct}$)

Financial development measure	M2/GDP	Private credit/GDP	Private credit/GDP	Private credit/GDP
RER construction source	PWT 8.0	IMF	PWT 8.0 5-year-averaged	PWT 8.0
Data	panel	panel	panel	cross-section
	(1)	(2)	(3)	(4)
Real GDP per worker$_{t-1}$	−0.060*	−0.047*	−0.099*	−0.013*
	(−10.91)	(−6.66)	(−15.71)	(−8.15)
Underval	0.081*	0.066*	0.047**	0.020***
	(3.32)	(5.81)	(2.34)	(1.97)
Fin devt	−0.016*	−0.011*	0.002	0.001
	(−2.94)	(−2.70)	(0.60)	(0.34)
Underval × fin devt	−0.021*	−0.020*	−0.010**	−0.007***
	(−3.09)	(−5.42)	(−2.31)	(−1.72)
Dependency ratio$_{t-1}$	−0.000	0.000	−0.000	−0.001*
	(−1.60)	(1.01)	(−1.32)	(−6.75)
Trade openness$_{t-1}$	0.010*	0.045*	0.014**	0.006**
	(3.18)	(5.32)	(2.26)	(2.49)
Govt. expenditure share$_{t-1}$	−0.065*	−0.022	−0.054**	−0.029***
	(−3.00)	(−0.76)	(−2.08)	(−1.83)
Investment share$_{t-1}$	0.037***	0.013	0.037	0.059*
	(1.65)	(0.43)	(1.23)	(3.23)
Fixed effects				
Economy fixed effect	Yes	Yes	Yes	
Year fixed effect	Yes	Yes	Yes	
Observations	3,682	1,960	677	127
R^2	0.090	0.110	0.388	0.488

GDP = gross domestic product, IMF = International Monetary Fund, PWT = Penn World Tables, RER = real effective exchange rate.
Notes:
1. Observations are annual data for the period 1980–2011.
2. The measures of financial development are the same as indicated in the column headings.
3. Both undervaluation and private credit/GDP are in logarithmic form.
4. Panel regressions in columns (1)–(3) include both economy and year fixed effects. Column (4) reports the estimates of cross-sectional data where all of the control variables are averaged over the period 1980–2011 and real GDP per worker$_{t-1}$ refers to the value at the beginning year.
5. t-statistics are in parenthesis.
6. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

(International Monetary Fund or Penn World Tables 8.0) and the structure of data (yearly panel, 5-year-averaged panel, or cross section). In our sample, the threshold value lies around the 50th percentile of the whole distribution. As an example, the threshold is close to the financial development level of economies like Mexico and Peru in 2011, which implies that for economies whose financial markets are less developed than the threshold level, the adoption of undervaluation may promote

economic growth. Similarly, when *findevt* is measured as M2/GDP (in logarithmic form) in column (1) of Table 3, the corresponding threshold value is 3.86, which is very close to the relative rank suggested by using private credit/GDP.

C.   Endogeneity

The possible endogeneity of an economy's financial development level leads to concerns of biased estimates (Arellano and Bond 1991, Blundell and Bond 1998). To tackle this issue, we adopt a generalized moment method. By taking the differences of the forward term of explanatory variables together with the lagged explained variables as instrument variables, we try to alleviate the possible endogeneity of the dynamic panel data.

Table 4 shows that the results are still very robust with the generalized moment method estimation: the positive effect of undervaluation on economic growth is again more prominent for economies with less developed financial markets. Moreover, the coefficient of the interactive term is close to the results presented in Table 2. To check the fitness of our specifications, we report the value of AR(2) to test whether there is autocorrelation of the second order residuals; our result rejects this possibility. The validity of instrument variable gains is also supported by the results shown in the last row of Table 4.

D.   Channels Verification

We have thus far examined the overall effect of undervaluation on economic growth. In this section, we go a step further to verify the two channels implied in the theoretical model. Equation (16) shows that undervaluation can stimulate economic growth via two channels: (i) expanding the share of the tradable sector in the economy, and (ii) increasing productivity within the tradable sector.

The quantified results for the first channel are reported in Table 5. When using the ratio of industrial output to GDP as a proxy for the tradable sector's share of the economy, we find that undervaluation increases this share. This effect is more prominent at lower levels of financial development. The sample mean of financial development is 3.38. As shown in column 2, on average, a 50% undervaluation can increase the ratio of industrial output to GDP by 0.54 percentage points (50% ∗ [0.021–0.003 ∗ 3.38]). Given a 50% undervaluation, an additional 10% drop in the financial development index has the marginal effect of enlarging the industrial sector's share of the economy by 0.015 percentage points (50% ∗ 10% ∗ 0.003). As the mean value of the ratio of industrial output to GDP is 25% in our sample, the marginal effect is very significant.

Next, we test the effect of undervaluation on productivity in the tradable sector. As discussed earlier, when the borrowing constraint is binding, undervaluation can promote productivity in the tradable sector and this effect is more noticeable in

Table 4. **Endogeneity**
Dependent variable: economic growth rate ($growth_{ct}$)

	Difference GMM	System GMM
$Growth_{c,t-1}$	0.018	0.038**
	(0.91)	(2.11)
Underval	0.013	0.037**
	(0.36)	(2.46)
Fin devt	0.053*	0.004
	(3.90)	(1.08)
Underval × fin devt	−0.003*	−0.017*
	(−0.23)	(−2.75)
Dependency ratio$_{t-1}$	−0.001***	−0.000*
	(−1.86)	(−2.67)
Trade openness$_{t-1}$	−0.028*	−0.009*
	(−5.38)	(−4.18)
Govt. expenditure share$_{t-1}$	−0.496*	−0.072*
	(−8.98)	(−4.97)
Investment share$_{t-1}$	0.247*	0.085*
	(5.60)	(5.51)
Fixed effects		
Economy fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	3,529	1,889
AR(2)	0.101	0.187
Sargan	0.103	0.201

GMM = generalized moment method.
Notes:
1. t-statistics are in parenthesis.
2. Columns (1) and (2) report the results of difference GMM and system
GMM, respectively.
3. Lagged periods are t-2 and t-3.
4. *** = 10% level of statistical significance, ** = 5% level of statistical
significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development
Indicators." http://databank.worldbank.org/data/reports.aspx?source=world
-development-indicators; Penn World Tables 8.0. http://www.rug.nl
/research/ggdc/data/pwt/

economies with less developed financial markets. One empirical challenge is that cross-economy data cannot be used to estimate productivity in the tradable sector of individual economies. Therefore, we turn to the relative productivity of the tradable and nontradable sectors. In fact, our model tells us undervaluation will only have an effect on productivity in the tradable sector. Consequently, if we can find a significant increase in relative productivity between the two sectors (with a more prominent result in economies with less developed financial markets), we can still identify the channel through which undervaluation promotes growth by generating a within-sector productivity increase.

Relative productivity between the two sectors is estimated as follows. First, relative nominal output is denoted as occurring in period *t*. Plugging this into

Table 5. **Channel I: Effect of Undervaluation on Expanding the Tradable Sector's Share of Gross Domestic Product**
Dependent variable: Share of industrial output in GDP

	(1)	(2)
Share of industrial output in GDP$_{t-1}$	0.795*	0.795*
	(76.56)	(76.55)
Underval	0.013*	0.021*
	(5.79)	(3.78)
Fin devt	−0.002***	−0.002***
	(−1.77)	(−1.92)
Underval × fin devt		−0.003*
		(−3.61)
Dependency ratio$_{t-1}$	−0.000*	−0.000*
	(−2.92)	(−3.11)
Trade openness$_{t-1}$	0.000	0.000
	(0.27)	(0.31)
Govt. expenditure share$_{t-1}$	−0.014***	−0.017**
	(−1.78)	(−2.08)
Investment share$_{t-1}$	0.021**	0.020**
	(2.53)	(2.41)
Fixed effects		
Economy fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	3,338	3,338
R^2	0.681	0.682

GDP = gross domestic product.
Notes:
1. Observations are annual data for the period 1980–2011.
2. Both undervaluation and private credit/GDP are in logarithmic form.
3. t-statistics in parenthesis.
4. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators; Penn World Tables 8.0. http://www.rug.nl/research/ggdc/data/pwt/

equation (11) results in

$$V_t^{TN} = \frac{P_t^T y_t^T}{P_t^N y_t^N} = \frac{P_t^T A_t^T}{P_t^N A_t^N} \frac{\left(\alpha^T S_t/\kappa \bar{S}\right)^{\frac{\alpha^T}{1-\alpha^T}}}{\left(\alpha^N/\kappa\right)^{\frac{\alpha^N}{1-\alpha^N}}}$$

Taking the log of both sides results in

$$\ln\left(\frac{A_t^T}{A_t^N}\right) = \ln V_t^{TN} - \ln\left(\frac{P_t^T}{P_t^N}\right) - \frac{\alpha^T}{1-\alpha^T}\ln\left(\frac{S_t}{\bar{S}}\right) - \frac{\alpha^T}{1-\alpha^T}\ln\left(\frac{\alpha^T}{\kappa}\right)$$
$$- \frac{\alpha^N}{1-\alpha^N}\ln\left(\frac{\alpha^N}{\kappa}\right) \tag{18}$$

where both V_t^{TN} and S_t can be observed in the data. The last two terms on the right side of the equation are constant (allowing for differences across economies). What remains to be estimated is the relative price (P_t^T / P_t^N) at period t. Following Mao and Yao (2014), we assume the overall domestic price level at each period is the geometric mean of the price level in two sectors:[7]

$$P_t = \left(P_t^T\right)^\theta \left(P_t^N\right)^{1-\theta}$$

Based on the definition of purchasing power parity, we have

$$PPP = \left(\frac{P^{T*}}{P^T}\right)^\theta \left(\frac{P^{N*}}{P^N}\right)^{1-\theta} = \left(\frac{1}{S_t}\right)^\theta \left(\frac{P^{N*}}{P^N}\right)^{1-\theta}$$

For the simplicity of expression, the subscript t is omitted here. Rearranging the equation above results in

$$\ln\left(\frac{P^{N*}}{P^N}\right) = \frac{1}{1-\theta}\left(\ln PPP + \theta \ln S_t\right)$$

Plugging this into the identity $\ln\left(\frac{P^T}{P^N}\right) = \ln\left(\frac{P^T}{P^{T*}}\right) + \ln\left(\frac{P^{T*}}{P^{N*}}\right) + \ln\left(\frac{P^{N*}}{P^N}\right)$ results in

$$\ln\left(\frac{P^T}{P^N}\right) = \frac{1}{1-\theta}\left(\ln PPP + \ln S_t\right) + \ln\left(\frac{P^{T*}}{P^{N*}}\right)$$

Since the world relative price P^{T*}/P^{N*} between the two sectors is exogenous for a single economy, it can be absorbed into a time fixed effect. We estimate the relative price between the two sectors at period t as $P_{TN,t}$ in the specification below:

$$\ln P_{TN,t} = \gamma \left(\ln PPP_{ct} + \ln S_{ct}\right) + \delta_c + \delta_t + \varepsilon_{ct}$$

Plugging this into equation (18) results in

$$\ln A_{TN,ct} = \ln V_t^{TN} - \widehat{\ln V_t^{TN}}$$

where $A_{TN,ct}$ is the relative productivity between the tradable (T) and nontradable (N) sectors, which are replaced by the industrial (I) and service sector (S),

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[7]This form can be derived from the utility function $U_t = \left(c_t^T\right)^\theta \left(c_t^N\right)^{1-\theta}$. The specific function form has a trivial impact on our estimation results since we only need a specification establishing the relationship between overall prices and sectorial prices.

Table 6. **Channel II: Effect of Undervaluation on Increasing the Relative Productivity of the Tradable Sector**

Relative productivity of tradable to nontradable sector	(1)	(2)
Relative productivity of tradable to nontradable sector$_{t-1}$	0.792*	0.791*
	(75.45)	(75.41)
Underval	0.081*	0.159*
	(6.47)	(5.01)
Fin devt	−0.018*	−0.020*
	(−2.69)	(−3.00)
Underval × fin devt		−0.028*
		(−2.69)
Dependency ratio$_{t-1}$	−0.001***	−0.001**
	(−1.72)	(−2.08)
Trade openness$_{t-1}$	0.005	0.006
	(0.83)	(0.91)
Govt. expenditure share$_{t-1}$	−0.089**	−0.113*
	(−2.06)	(−2.58)
Investment share$_{t-1}$	0.061	0.052
	(1.34)	(1.15)
Fixed effects		
Economy fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	3,317	3,317
R^2	0.666	0.667

GDP = gross domestic product.
Notes:
1. Observations are annual data for the period 1980–2011.
2. Both undervaluation and private credit/GDP are in logarithmic form.
3. t-statistics are in parenthesis.
4. *** = 10% level of statistical significance, ** = 5% level of statistical significance, * = 1% level of statistical significance.
Sources: Authors' calculations based on World Bank. "World Development Indicators." http://databank.worldbank.org/data/reports.aspx?source=world -development-indicators; Penn World Tables 8.0. http://www.rug.nl/research /ggdc/data/pwt/

respectively. $\widehat{\ln V_t^{TN}}$ is estimated as

$$\ln V_t^{TN} = \delta_1 \ln PPP_{ct} + \delta_2 \ln S_{ct} + \delta_c + \delta_t + \varepsilon_{ct}$$

The effect of undervaluation on raising the relative productivity of the tradable sector compared with that of the nontradable sector is shown in Table 6. Such an effect is significant and is amplified in economies with less developed financial markets. Quantitatively, column (2) informs us that for economies with an average level of financial market maturity, a 50% undervaluation can lead to a relative productivity increase of 3.22 percentage points (50% ∗ [0.159–0.028 ∗ 3.38]), which is economically significant. In terms of the interactive effect, given

a 50% undervaluation and a 10% decline in financial market development, relative productivity increases by an additional 0.14 percentage points (50% ∗ 10% ∗ 0.028).

V. Conclusion

We have tested our hypothesis using cross-economy data for the period 1980–2011 and the results support our predictions. For economies at the 25th percentile of financial development distribution, a 50% undervaluation can increase the economic growth rate by 0.3 percentage points. With a 10% decline in the financial development level, the stimulating effect of undervaluation is an additional 0.045 percentage points. Verifying the two channels included in our theoretical discussion, we find that for economies with an average level of financial market development a 50% undervaluation is associated with a 0.54 percentage point increase in the tradable sector's share of GDP. Meanwhile, the relative productivity of the tradable versus nontradable sector increases by 3.22 percentage points. Given a 10% decline in financial market development, the marginal effects of undervaluation on expanding the tradable sector's share of GDP and the relative productivity of the tradable sector are 0.015 and 0.14 percentage points, respectively.

These findings have substantial policy implications in that they offer a deeper understanding of why policy makers in many developing economies favor an undervalued exchange rate and the related export-oriented development strategies. According to our results, undervaluation will lead to relaxed borrowing constraints in the tradable sector, which will facilitate increased industrial output (as a % of GDP) and an accelerating technological growth rate in the tradable sector. Both of these channels can boost economic growth, with the impacts being more prominent in economies with less developed financial markets. If we take the technological spillover effects into consideration, the growth effect is further magnified. Since developing economies are typically characterized as having underdeveloped finance sectors and tighter borrowing constraints, their likelihood of adopting an undervaluation policy will consequently be higher.

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[*]ADB recognizes "China" as the People's Republic of China.

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