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Fixed exchange rate regimes, real undervaluation and economic growth

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Abstract

This paper empirically studies how a fixed exchange rate regime (FERR) may promote economic growth by undermining the Balassa-Samuelson effect. When total factor productivity (TFP) is faster in the industrial sector than in the non-tradable sectors, an FERR can suppress the Balassa-Samuelson effect if adjustment of domestic prices is subject to nominal rigidities. With WDI data on sectoral value-added and data from the PPP converter provided by the Penn World Table, we are able to estimate the home country's industrial-service (quasi-) relative-relative TFP in comparison with the United States. Applying those estimates, our econometric exercises then provide robust results that an FERR dampens the Balassa-Samuelson effect and that the real undervaluation that ensues does indeed promote growth. We also explore the channels for undervaluation to promote growth. Lastly, we compare industrial countries and developing countries and find that an FERR has more significant impacts on developing countries than on industrial countries.

Keywords: fixed exchange rate regime, real undervaluation, economic growth.
JEL classification: F31, F43, O41.

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1 Introduction

It is received wisdom that the exchange rate regime should not matter for economic performance in a perfectly competitive market environment because changes in the nominal exchange rate cannot change any real price. Consistent with this theoretical underpinning, most empirical studies do not find a robust link between exchange rate regime and economic growth (Rose, 2011). However, nominal prices in the domestic market may be sticky when real shocks hit the economy; they may not adjust sufficiently to compensate for the distortions caused by the fixed exchange rate so that the desirable real prices are not attainable. If the distortions cause real undervaluation, faster growth is possible (Dollar, 1992; Rodrik, 2008; Gluzmann, Levy-Yeyati and Sturzenegger, 2012). Along this line, this paper provides an empirical study on whether a fixed exchange rate regime (FERR) can lead to real undervaluation and whether the real undervaluation that ensues promotes economic growth.

The link studied by this paper between exchange rate regime, real undervaluation and growth is the Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964). Due to this effect, faster growth of total factor productivity (TFP) in the industrial sector than in the service sector in the home country relative to the reference country will lead to real appreciation of the home country currency relative to the reference country's currency. This effect holds regardless of the exchange rate regime. However, this claim depends on the assumption that domestic nominal prices adjust quickly to TFP shocks, which may not hold in reality. In addition, the central bank may intervene to stabilize domestic nominal prices if it aims to maintain the fixed exchange rate in the face of appreciation pressure. As a result, a fixed rate regime may perform differently than a floating rate regime. Under a floating rate regime, the nominal exchange rate would adjust in response to the efficiency gains in the industrial sector, regardless of whether domestic prices adjust; the Balassa-Samuelson effect implies that real appreciation ends only after these gains are eliminated. When the nominal exchange rate is fixed, however, the Balassa-Samuelson effect may be dampened because the economy loses a rapidly adjusting parameter. Real undervaluation thus may occur, and the industrial sector may gain a price advantage over non-tradable sectors. This may then create three drivers that have the potential to promote overall growth. The first driver is a structural effect that allows the industrial sector to absorb more labor. Because the industrial sector improves its efficiency faster than the rest of the economy, the whole economy may grow faster. The second driver is exports. Real undervaluation makes it more profitable for domestic firms to produce for external demand. To the extent that external demand is autonomous with respect to domestic income, increased export growth may directly induce faster economic growth. The third driver is investment. In addition to its direct effect, exports may induce higher domestic savings (Dollar, 1992), which in turn would lead to a higher rate of domestic investment (Horioka and Feldstein, 1980).

The above mechanism may apply more to developing countries than to industrial countries. Developing countries are still in the process of industrialization, so their industrial sectors tend to experience faster efficiency improvement than their non-tradable sectors. In the meantime, markets tend to be less perfect in developing countries than in industrial countries. As a result, an FERR is more likely to cause undervaluation. In addition, the three drivers may play a more prominent role in developing countries than in industrial countries, so that undervaluation is more likely to promote overall growth in developing countries.

To conduct our empirical tests, we estimate home countries' industrial-service (quasi-) relative-relative TFPs against the United States by combining the sectoral value-added data provided by the World Bank Development Indicators (WDI) dataset and the PPP converters provided by the Penn World Table 8.0. To our knowledge, this is the first attempt to do such an estimation in the literature. We compare our estimates with the TFP estimates of the countries covered by the EU KLEMS Growth and Productivity Accounts and find that our estimates are reasonably aligned with the EU KLEMS estimates. Using our estimates, we are able to provide a precise estimate of the Balassa-Samuelson effect and study how the FERR dampens this effect. Then we study whether the real undervaluation created in this manner promotes economic growth. We also study how growth is obtained through the three channels of higher shares of industrial employment, higher shares of exports and a higher rate of investment. Lastly, we conduct a comparative study for industrial and developing countries.

It is widely acknowledged that different definitions of the FERR can lead to very different research results (Rose, 2011). We test real undervaluation under five prevailing definitions of the FERR provided, respectively, by the IMF, Ilzetzki, Reinhart, and Rogoff (2008, hereafter "IRR"), Reinhart and Rogoff (2002, "RR"), Levy-Yeyati and Sturzenegger (2003, "LS"), and Shambaugh (2004, "JS").[1] The FERR is found to cause real undervaluation relative to the floating regime under all five definitions.

[1] For better exposure, we would like to use at least two letters to indicate one type of categorization. So in this case, we add the first letter of Shambaugh's first name (Jay).

Our study of the impact of the FERR on growth is different than in the existing literature. The FERR often enters a growth equation as a stand-alone dummy variable and the focus is on whether the coefficient of this variable is positive (Rose, 2011). This practice ignores the underlying forces that drive growth. If a country's economic fundamentals are not ready to promote growth, the FERR may simply cause real an overvaluation that suppresses growth. Eichengreen (2007) puts this in context:

> *"A stable and competitive real exchange rate … enable[s] a country to exploit its capacity for growth and development—to capitalize on a disciplined labor force, a high savings rate, or its status as a destination for foreign investment. Absent these fundamentals, policy toward the real exchange rate will accomplish nothing."* (Eichengreen, 2007: p. 9)

The fundamental idea of our paper is that of faster technological progress in the industrial sector than in the rest of the economy. Rodrik (2008) identifies another kind of economic fundamental. In his model, the tradable sector is assumed to face more policy distortions than the non-tradable sector. Real exchange rate management thus is a means of overcoming those distortions. In contrast, real undervaluation is useful in our case because the industrial sector is technologically better prepared than the rest of the economy to promote growth. In addition, instead of treating real undervaluation as a ready policy tool, we empirically study whether an FERR can cause real undervaluation given the economic fundamentals considered here.

Next in Section 2, we form our strategy to estimate the (quasi-) relative-relative TFPs and present our econometric models to test the Balassa-Samuelson effect and the relationship between real undervaluation and growth. In Section 3, we discuss our data sources and the definitions of an FERR. The baseline empirical results are presented in Section 4. Then in Section 5 we explore the three channels for real undervaluation to promote growth, and in Section 6 we compare developing countries with industrial countries. Lastly, we conclude the paper and discuss the policy implications of our results in Section 7.

2 Econometric strategies

2.1 Estimating (quasi-) relative-relative TFPs

Let us consider a small open economy comprised of two sectors: industry and services. Industrial products are traded in both domestic and international markets. They are produced by capital and labor according to the following production function entailing constant returns to scale:

$$Y_I = A_I K_I^{\alpha_I} L_I^{1-\alpha_I}\ , \tag{1}$$

where Y_I is output, A_I is the total factor productivity (TFP) index of industry, K_I and L_I are the amounts of capital and workers hired, respectively, and α_I is the output elasticity of capital. Services are produced in a similar manner via the production function

$$Y_S = A_S K_S^{\alpha_S} L_S^{1-\alpha_S}\ , \tag{2}$$

where Y_S is output, A_S is the total factor productivity index of services, K_S and L_S are the amounts of capital and labor hired, respectively, and α_S is the output elasticity of capital in services. Services cannot be traded internationally and their output has to be balanced off by domestic demand.

Capital is perfectly mobile across borders. The real rate of return to capital, r^*, in the international capital market, measured in the international currency, is fixed for domestic firms. The same is true for the price of the industrial product in the international market, P_I^*, also measured in the international currency. Let the nominal exchange rate (indirect quote) be e. Denote the domestic nominal prices of industrial and service products by P_I and P_S, respectively and note that $P_I = eP_I^*$.

Firms in the industrial and service sectors choose the amounts of capital and labor to maximize their profits. Their maximization exercises yield the following first-order conditions:

$$P_I \alpha_I A_I K_I^{\alpha_I - 1} L_I^{1-\alpha_I} = P_S \alpha_S A_S K_S^{\alpha_S - 1} L_S^{1-\alpha_S} = r\ , \tag{3}$$

$$P_I \beta_I A_I K_I^{\alpha_I} L_I^{-\alpha_I} = P_S \beta_S A_S K_S^{\alpha_S} L_S^{-\alpha_S} = w\ , \tag{4}$$

where $r = er^*$ is the nominal rate of return of capital measured in domestic currency. The same is also true for the wage rate w. Let $V_{IS} = \frac{P_I Y_I}{P_S Y_S}$ be the ratio of (real) value added between the industrial sector and the service sector. Then, combining the two first-order conditions in (3) and (4), yields

$$\ln V_{IS} = \phi + \ln \frac{A_I}{A_S} + \ln \frac{P_I}{P_S} + \Lambda\ , \tag{5}$$

where ϕ is a constant and $\Lambda = (\alpha_I - \alpha_S)\ln\frac{w}{r} + \ln\frac{L_I}{L_S}$.

The WDI provides data for sectoral value-added, so that V_{IS} is known. It also provides data for sectoral labor allocations, so that we could replace V_{IS} by the ratio of labor productivity between the two sectors. However, labor data are highly unreliable, especially in developing countries, because either the statistical method is not sufficiently robust or a large part of the labor force is employed in the informal sector, which is not subject to rigorous national statistical surveillance. In addition, significant rigidities often exist in the labor market. This is even true in industrial countries. So data on labor productivity do not necessarily reflect the relative technological strengths of the two sectors.

In addition, the WDI does not provide data for wages. In light of these data issues, we assume that Λ is proportional to the logarithm of GDP per capita (ln*GDPPC*). Needless to say, this approximation will introduce noise into our estimation, but it makes sense in terms of economic theory and empirical regularities. The relative price of labor versus capital, *w*/*r*, is ultimately determined by the country's factor endowment, which is highly correlated with its per-capita GDP. On the other hand, in the medium and long run, sectoral labor allocations are consequences of structural change in the economy, which is also correlated with the country's per-capita income (Ngai and Pissarides, 2008; Mao and Yao, 2012). The proportionality between Λ and ln*GDPPC* can be considered as the result of first-order approximation.

Data on sectoral relative prices are scant; complete data are only available for industrial countries. But they can be estimated from the PPP converter provided by the Penn World Table. According to its definition, the PPP converter can be expressed as $PPP = \left(\frac{P_I^*}{P_I}\right)^{\theta_I}\left(\frac{P_S^*}{P_S}\right)^{\theta_S} = \frac{1}{e}\left(\frac{P_I}{P_S}\right)^{\theta_S}\left(\frac{P_S^*}{P_I^*}\right)^{\theta_S}$,

where θ_I and θ_S are the respective shares of industrial products and services in national consumption, $\theta_I + \theta_S = 1$, and P_I^* and P_S^* are the domestic prices of industrial products and services in the reference country (United States). To obtain the second equality, $P_I = eP_I^*$ is used. Taking logs of both sides and rearranging terms, we obtain

$$\ln\frac{P_I}{P_S} = \frac{1}{\theta_S}\left(\ln PPP + \ln e\right) - \ln\frac{P_S^*}{P_I^*}. \tag{6}$$

Plugging this equation into Equation (5) yields

$$\ln V_{IS} = \phi + \frac{1}{\theta_S}\left(\ln PPP + \ln e\right) + \beta \ln GDPPC + \left(\ln\frac{A_I}{A_S} - \ln\frac{P_S^*}{P_I^*}\right), \tag{7}$$

where β is the ratio of Λ to ln*GDPPC*. The term $\left(\ln\frac{A_I}{A_S} - \ln\frac{P_S^*}{P_I^*}\right)$, denoted as $\ln A_{IS}$ hereinafter, is what we are most interested in. Note that $\frac{P_S^*}{P_I^*}$ is the internal real exchange rate of the United States, which should be highly correlated with the country's sectoral relative TFPs. As a result, $\ln A_{IS}$ can be conveniently interpreted as the sectoral relative-relative TFP of the home country against the United States. Because the relative price, not the relative TFP, of the reference country is used, "quasi-relative-relative TFPs" is probably a more appropriate name for it. In the subsequent text, though, we will often simply use $\ln A_{IS}$ to denote it. Equation (7) suggests that we can first estimate the following equation county by country:

$$\ln V_{IS,t} = \phi + \kappa \ln P_t + \beta \ln GDPPC_t + \varepsilon_t\,, \tag{8}$$

where the newly added subscript is an index for calendar year, $P_t = PPP_t + e_t$ is the real exchange rate, κ is a parameter to be estimated, and ε_t is an error term. Then we can estimate country *i*'s $\ln A_{IS}$ for each year, by

$$\ln A_{IS,it} = \ln V_{IS,it} - \widehat{\ln V}_{IS,it}\,. \tag{9}$$

Note that by definition $\ln A_{IS,it}$ has zero mean. This can be understood as the result of a demeaning exercise. Ignoring noise, the mean should be the constant ϕ, estimated from Equation (8). It is noteworthy that demeaning does not affect within-country variations of the data. Therefore, our results will not be affected if our regressions are based on the country fixed-effect model. Note also that by Equation (6) κ has a theoretical value of $1/\theta_S$. In reality, the relationship between the real exchange rate and the sectoral ratio of value-added can be influenced by many other factors not modeled here, and the value of κ can substantially deviate from its theoretical value.

2.2 Real undervaluation and growth

Using the estimates for $\ln A_{IS}$, we can study whether the fixed regime leads to real undervaluation relative to the floating regime, within the framework of the Balassa-Samuelson effect. Because our key explanatory variable $\ln A_{IS}$ is equivalent to the relative-relative TFP, we define the left-hand-side variable by the logarithm of the home country's real exchange rate net of that of the reference country (United States), and conveniently denote it by $\ln RER_{it}$.[2] Then our specification for the study of real undervaluation is

$$\ln RER_{it} = \eta_0 + \eta_1 \ln A_{IS,it} + \eta_2 \ln A_{IS,it} \times FERR_{it} + \eta_3 FERR_{it} + \delta_i + e_{it}, \tag{10}$$

where the η's are parameters to be estimated, *FERR* is a dummy variable for the fixed exchange rate regime, δ_i is country *i*'s fixed effect, and e_{it} is an i.i.d. error term. To facilitate interpretation of the actual regressions, we define the real exchange rate as $1/P_t$, so that a larger value indicates appreciation. We do not control the year fixed effect because $\ln RER_{it}$ contains the reference country's real exchange rate, which is the same for all countries in the same year. The parameter η_1 is the elasticity of the Balassa-Samuelson effect under the floating regime, and $\eta_1 + \eta_2$ is the elasticity of the Balassa-Samuelson effect under the fixed regime. The Balassa-Samuelson effect requires that η_1 be positive. If the fixed regime causes real undervaluation relative to the floating regime, then η_2 must be negative. We add the FERR dummy as a stand-alone variable to allow for the possibility that the exchange rate regime itself has a direct effect on the level of the real exchange rate.

Let RER_{it}^{float} and RER_{it}^{fixed} denote the home country's real exchange rates relative to the reference country under the floating and fixed regimes, respectively, estimated from Equation (10). Then the rate of real undervaluation caused by the fixed regime relative to the floating regime can be measured by

$$UNDERVALUE_{it} = \frac{RER_{it}^{float} - RER_{it}^{fix}}{RER_{it}^{float}}.$$

[2] We could have obtained each country's sectoral relative TFP, $\ln(A_I / A_S)$, because data can be obtained from BEA on the prices of industrial goods and services in the United States. However, this extra step of calculation may introduce more noise into our estimation. In addition, using relative-relative TFPs as the explanatory variable is more consistent with the modern formulation of the Balassa-Samuelson effect (Tica and Druzic, 2006).

When the difference between RER_{it}^{float} and RER_{it}^{fixed} is not large, we can approximate it by

$$UNDERVALUE_{it} = \ln RER_{it}^{float} - \ln RER_{it}^{fix} = -\eta_3 - \eta_2 \ln A_{IS,it} . \tag{11}$$

The rate of real undervaluation under the floating regime is zero. The rate of real undervaluation under the fixed regime is comprised of two parts. One is measured by $-\eta_3$, which is directly linked to the choice of the exchange rate regime. The other is measured by $-\eta_2 \ln A_{IS,it}$ which is linked to the Balassa-Samuelson effect. Its sign depends on whether a country can grow its industrial TFP faster than its service TFP relative to the United States. Provided we have the expected estimate of η_2, the amount of real undervaluation increases (or real overvaluation decreases) if a country's industrial TFP grows faster than its service TFP relative to the United States.

Note that here we define real undervaluation differently from what is typical. The conventional approach is to estimate a linear relationship between the relative TFP or GDP per-capita and the real exchange rate and then define real undervaluation as the country's deviation from this average relationship. We are concerned with the difference between floating and fixed rate regimes. So, for a country with the floating regime, real undervaluation is set to zero. For a country with the fixed regime, real undervaluation is defined as the gap between its rate of response to an increase in $\ln A_{IS}$ and its counterfactual rate of response in the hypothetical case that it has a floating rate regime.

A direct way to study the impact of the fixed regime on growth through real undervaluation is to use $UNDERVALUE_{it}$ as an explanatory variable in a growth equation. But to compare our results with the existing results, we estimate the following growth equation:

$$GR\_GDPPC_{it} = b_0 + b_1 \ln GDPPC_{it-1} + b_2 \ln A_{IS,it} \times FERR_{it} + b_3 FERR_{it} + \delta_i ' + \delta_t ' + e_{it} ' , \tag{12}$$

where GR_GDPPC_{it} is the growth rate of real GDP per capita of country i in year t, $GDPPC_{it-1}$ is its lagged real GDP per capita, the b's are parameters to be estimated, and, to abuse notations, $\delta_i '$, $\delta_t '$ and $e_{it} '$ are the country fixed effect, year fixed effect and error term, respectively. The effect of real undervaluation on growth is comprosed of two parts, one related to the choice of the exchange rate regime and measured by b_3, and the other, measured by b_2, related to the fixed regime's ability to dampen the Balassa-Samuelson effect. If b_2 is positive, the dampening effect is conducive to growth.

3 Data and variables

Our sample includes annual data for 159 countries, from 1960 to 2010. In general, the number of countries in the sample increased over time, from an average of 40 countries each year in the 1960s to an average of 148 countries in the 2000s. The time span is long enough to enable us to overcome the power problem (Tica and Druzic, 2006). To estimate $\ln A_{IS}$, the ratio of value added between the industrial and service sectors (V_{IS}), the PPP converter and per capita GDP will be used. Data for the PPP converter are obtained from the Penn World Table 8.0. Data for the other two variables come from WDI, with per capita GDP measured by thousand US dollars in constant 2000 prices.

The estimated quasi-relative-relative TFPs, $\ln A_{IS}$, will then be used to test whether the adoption of FERR dampens the Balassa-Samuelson effect. Since this effect of FERR may depend on the flexibility of price levels and monetary policies, we will control for the speed of money supply changes. When a central government loses control of its the speed of money issuance, the growth rate of M2 increases sharply. The growth in the growth rate of M2 from the previous year, denoted by GGR_M2 and calculated from the M2 data provided by WDI, will thus be used as a measure.

As to the growth equation, we calculate the growth rate of per capita GDP and use it as the dependent variable. To identify growth channels, the share of industrial employment in total employment, the share of exports of goods and services in GDP, and the share of investment (measured by fixed capital formation) in GDP will be considered as potential intermediaries for real undervaluation to promote growth. We will also control for the share of population between 15 and 64 years old and the share of general government expenditure in GDP as two conventional growth determinants. Data for all these variables are provided by the WDI. A descriptive summary of these variables is available in Panel A of Table 1.

Table 1 Summary statistics

Variables	Obs.	Mean	Std.	Min	Max
		Panel A			
$\ln V_{IS}$	5465	–0.590	0.511	–1.982	1.131
$\ln P_{IS}$	5468	–0.511	0.464	–2.170	0.870
ln*GDPPC*	5507	0.545	1.580	–2.851	4.032
GR_GDPPC (%)	5433	2.002	5.751	–50.290	92.586
GGR_M2 (%)	4433	0.051	1.017	–5.289	7.762
Gov. exp.(% GDP)	5394	15.666	6.154	2.047	64.393
Pop. 15–64 (%)	5402	58.888	6.700	44.791	79.121
Ind. employment (%)	2164	24.737	7.552	2.1	48.9
Exports (% GDP)	5437	35.192	24.308	1.946	234.352
Investment (% GDP)	2806	14.023	7.666	–2.884	74.404
		Panel B			
IMF	3963	0.435	0.496	0	1
IRR	4118	0.461	0.499	0	1
RR	3816	0.359	0.480	0	1
LS	3227	0.522	0.500	0	1
JS	4116	0.422	0.494	0	1

Note: GDP per capita is measured in thousand 2000 US dollars; GR_GDP_PC is the growth rate of GDP per capita; GGR_M2 is the growth in the growth rate of M2; Pop. 15–64 is the share of population aged between 15 and 64; Gov. exp. is the share of government expenditure in GDP. Ind. employment is the share of industrial employment in total employment; Exports is the share of exports in GDP; Investment is the share of fixed capital formation in GDP.; IMF, IRR, RR, LS and JS are dummy variables for the fixed exchange rate regime defined by categorizations of IMF, IRR, RR, LS and JS.

The definition of FERR is of crucial here. Different classifications usually lead to different empirical outcomes. Concerning this issue, we construct five definitions of the FERR from five popular categorizations of the exchange rate regime. The first is the IMF's *de jure* classification system. It used to be a typical method to identify whether a country had a fixed exchange rate regime (e.g. Baxter and Stockman, 1989). However, it has been widely acknowledged that a country's actual regime may differ from its officially claimed one. Recently, alternative coding criteria have been proposed to revise the classification based on *de facto* behavior. We consider four prevailing alternatives along with the IMF's categorization.

The first two, RR (Reinhart and Rogoff, 2002) and IRR (Ilzetzki, Reinhart, and Rogoff, 2008), are related to each other. They are *de facto* classifications created from the same complicated algorithm taking into consideration parallel currency markets. Briefly speaking, the presence of dual or multiple exchange rates is first identified according to country chronologies. If a country had a unified rate and an officially alleged regime, the official regime would be verified based on the real exchange rate movements. If the country did not have a unified rate, or had a unified rate but the regime was not announced or failed to be confirmed, then a statistical classification would be used. However, when the 12-month inflation rate exceeded 40%, the exchange rate regime was labeled "freely falling". The coverage of RR is from 1970 to 2007; whereas the coverage of IRR, which is an updated RR, extends to 1940. IRR also provides finer grids than does RR.

The third is LS proposed by Levy-Yeyati and Sturzenegger (2003). This *de facto* classification system is based on cluster analysis according to three indicators: (1) exchange rate volatility as measured by the absolute change in the nominal exchange rate; (2) volatility of exchange rate changes as measured by the standard deviation of percentage changes; and (3) volatility of reserves as measured by the absolute change in dollar denominated reserves relative to the dollar value of base money. Exchange rate regimes are categorized into three groups: fix, intermediate, and float. The coverage of LS is from 1974 to 2004.

The four classification system, JS, is constructed by Shambaugh (2004) and is based on the *de facto* degree of exchange rate movements over a period. JS considers two groups of regimes: the group of "pegs", in which the monthly exchange rate stayed within ± 2% percent bands (i.e. the difference between the max and min of the log of the month-end exchange rate was within 0.04) for at least for two years; and the group of "non-pegs" otherwise. The coverage of JS is from 1970 to 2004.

Rose (2011) provides updates for the RR, LS and JS classifications. Data on these three classifications and the IMF classification are from Rose's personal website.[3] Reinhart's website provides updates for IRR.[4] The FERR dummy then is defined as follows.

For the IMF and RR classifications, we follow Rose (2011) and define FERR = 1 if the regime is categorized in the group of "currency union/fix", and define FERR = 0 if the regime is categorized in the group of "narrow crawl", "wide crawl/managed floating" or "float". Note that cases of "freely falling" classified by IMF and RR are excluded as in Rose

[3] http://faculty.haas.berkeley.edu/arose.
[4] http://www.carmenreinhart.com/data/browse-by-topic/topics/11/.

(2011). For the LS classification, we define FERR = 1 if the regime is categorized in the group of “fix” and define FERR = 0 if it is categorized in the group of “intermediate” or “float”. For the JS classification, FERR = 1 is defined for the group of “pegs” and FERR = 0 is defined for the group of “non-pegs”. Lastly, for the IRR classification, we define FERR according to its fine grid. In particular, we define FERR = 1 if a regime is in grids 1–4 (which range from cases of “no separate legal tender” to cases of “de facto peg”) and define FERR = 0 if it is in grids 5–13 (which range from cases of “pre-announced crawling peg” to cases of “freely floating”). But cases of “freely falling” are excluded again.

Table 2 Correlation coefficient matrix of different definitions of FERR

	IMF	IRR	RR	LS	JS
IMF	1				
IRR	0.321	1			
RR	0.427	0.900	1		
LS	0.402	0.251	0.385	1	
JS	0.433	0.368	0.431	0.414	1

Note: The numbers are simple averages of correlation coefficients between any two classifications for each country in the sample.

Panel B of Table 1 provides a descriptive summary of the five thusly defined FERR regimes (for simplicity, we label them by the names of the classification systems from which they are created). The correlation coefficients across these definitions are exhibited in Table 2. Not surprisingly, the IMF definition has low correlation coefficients with the other four definitions. A coefficient of 0.9 indicates that the RR and IRR coding systems are highly correlated. As a result, we expect to find similar empirical results when these two definitions are used. However, IRR is more distinctive from RR than are the other three definitions. It seems that IRR’s finer grids help it distinguish itself from the other categorizations.

4 Baseline results

4.1 Estimates of lnA_{IS}

We first estimate Equation (8) for each country and obtain the logarithm of the sectoral quasi-relative-relative TFP, $\ln A_{IS,it}$, via Equation (9). To gauge the reliability of our estimates, we compare them with those provided by EU KLEMS. We first note that EU KLEMS only reports sectoral TFP growth rates, so we need to convert our estimates into growth rates. Since

$$\ln A_{IS,it} = \ln \frac{A_{I,it}}{A_{S,it}} - \ln \frac{P_{St}^{\ *}}{P_{It}^{\ *}},$$

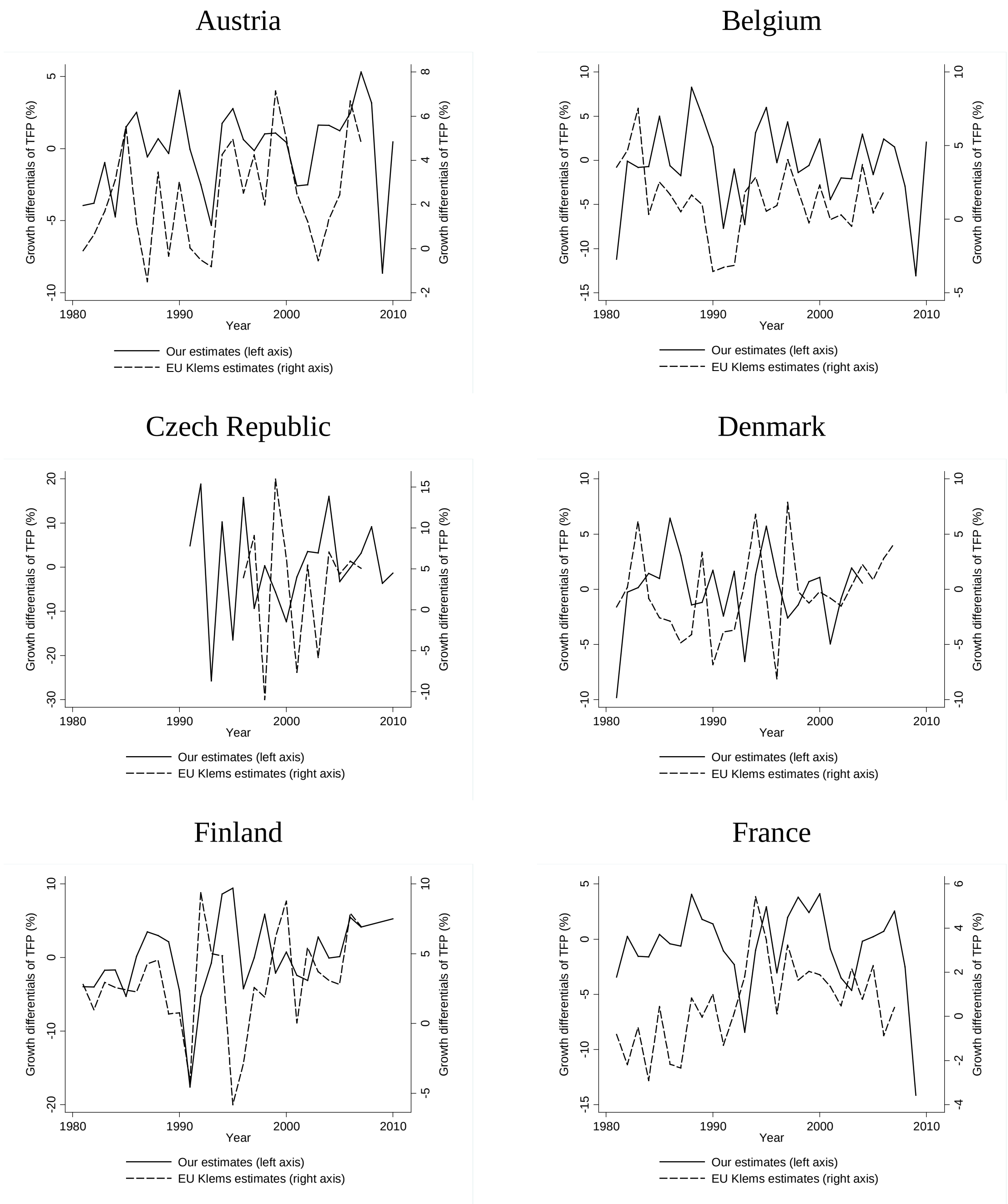
the growth differential of TFP between the industrial sector and the service sector is

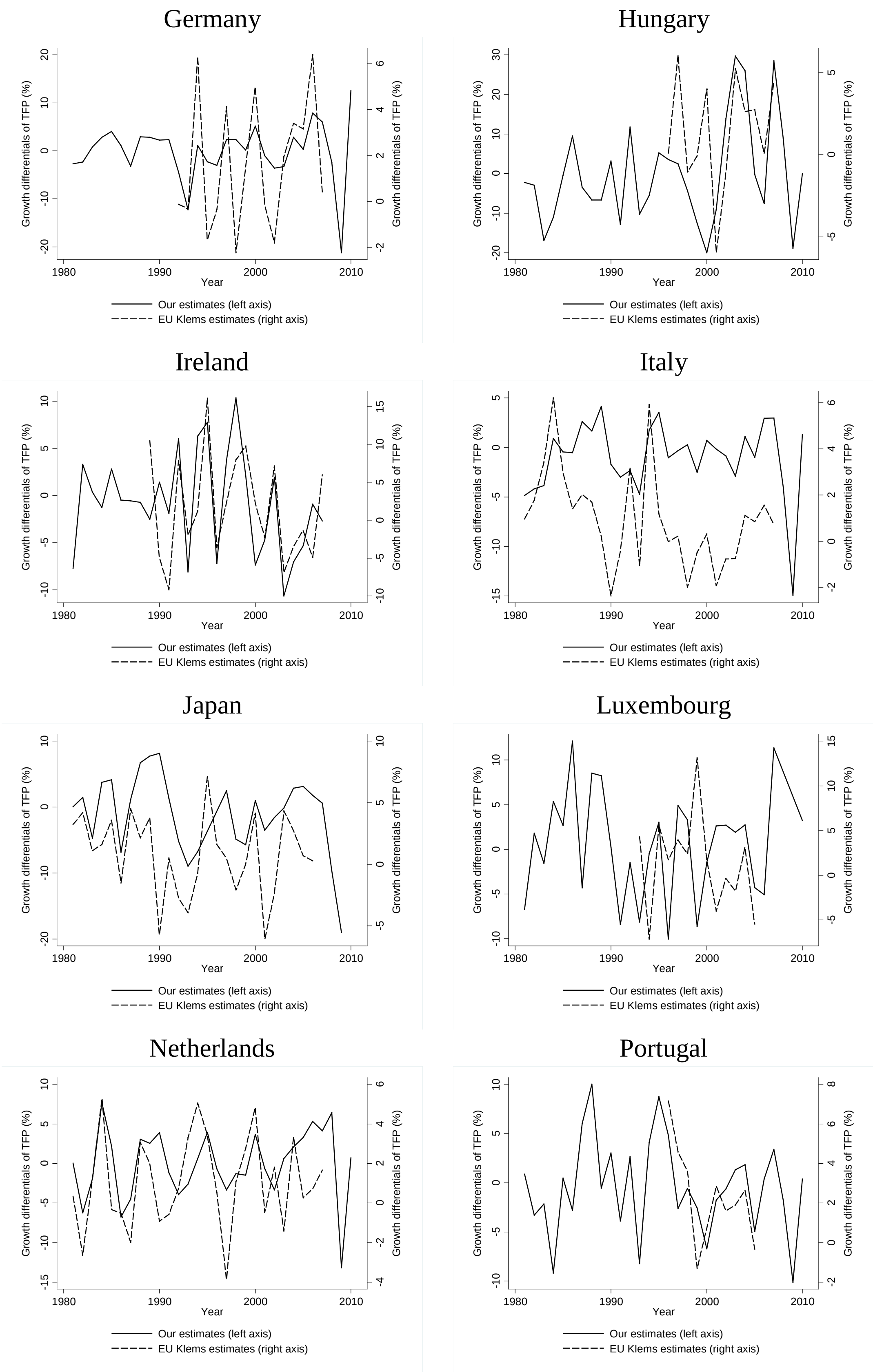
$$\hat{A}_{I,it} - \hat{A}_{S,it} = \left(\ln A_{IS,it} - \ln A_{IS,it-1}\right) + \left(\ln \frac{P_{St}^{\ *}}{P_{It}^{\ *}} - \ln \frac{P_{St-1}^{\ *}}{P_{It-1}^{\ *}}\right). \tag{13}$$

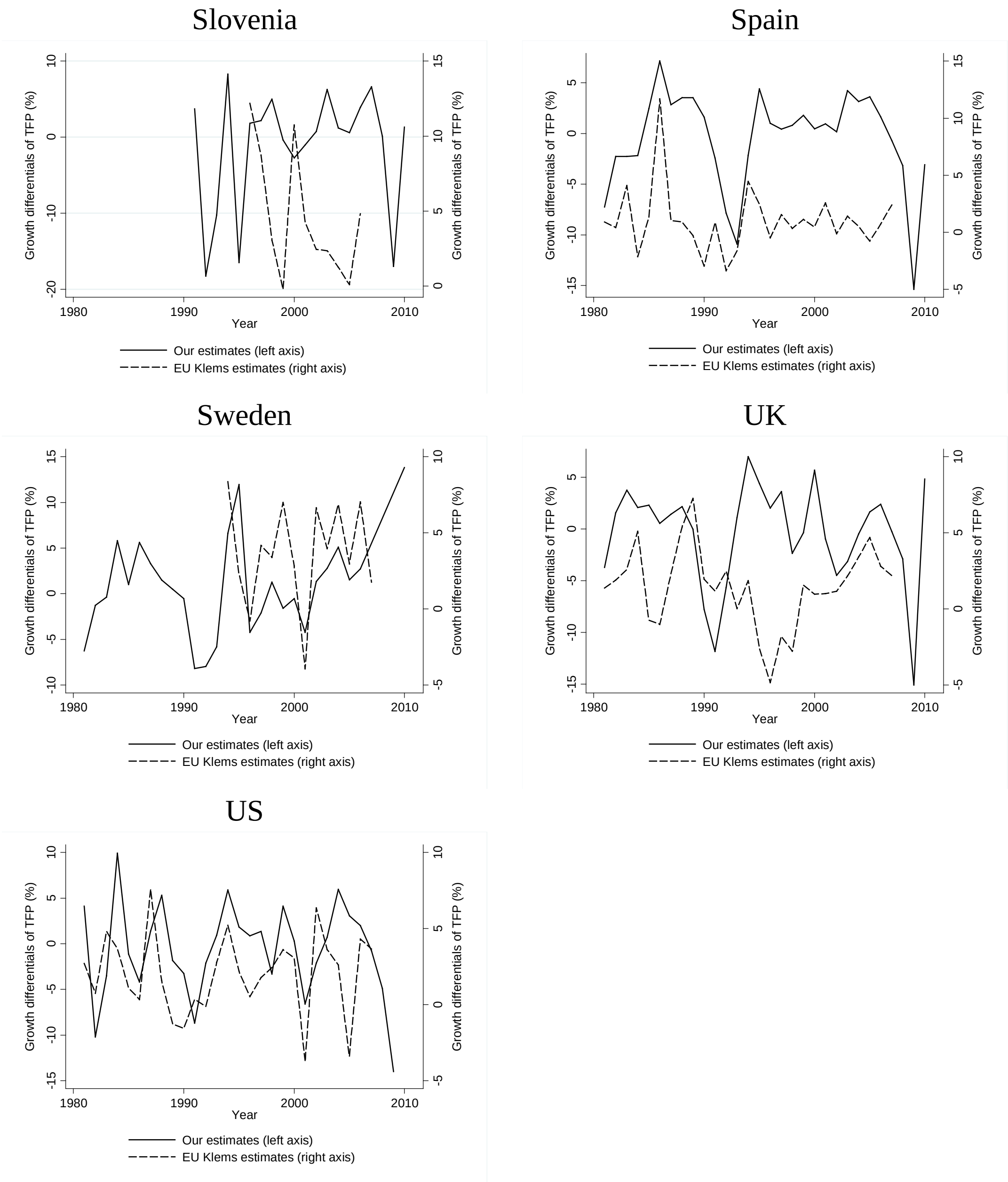
Data for the industrial and service prices in the United States are from the BEA (Bureau of Economic Analysis)'s National Income and Product Accounts. The growth differentials of TFP in EU KLEMS are obtained directly from its sectoral TFP growth rates.

Figure 1 then presents our estimates of the TFP growth differentials against those calculated from the EU KLEMS estimates for each country covered by EU KLEMS. Except for the Czech Republic, Denmark, Luxembourg, Slovenia and Great Britain, the countries have positive correlation coefficients between the two series. The average correlation coefficient for all 19 countries is 0.25. If we exclude the five countries with negative correlation coefficients, the average increases to 0.40. Austria, Germany, Ireland, Netherland and Portugal have coefficients higher than 0.50. Portugal has the highest, 0.67. Because both our estimates and the EU KLEMS estimates contain noise, we believe that the degree of match between the two series is reasonable.

Figure 1 Growth differentials of TFP: comparison with EU KLEMS



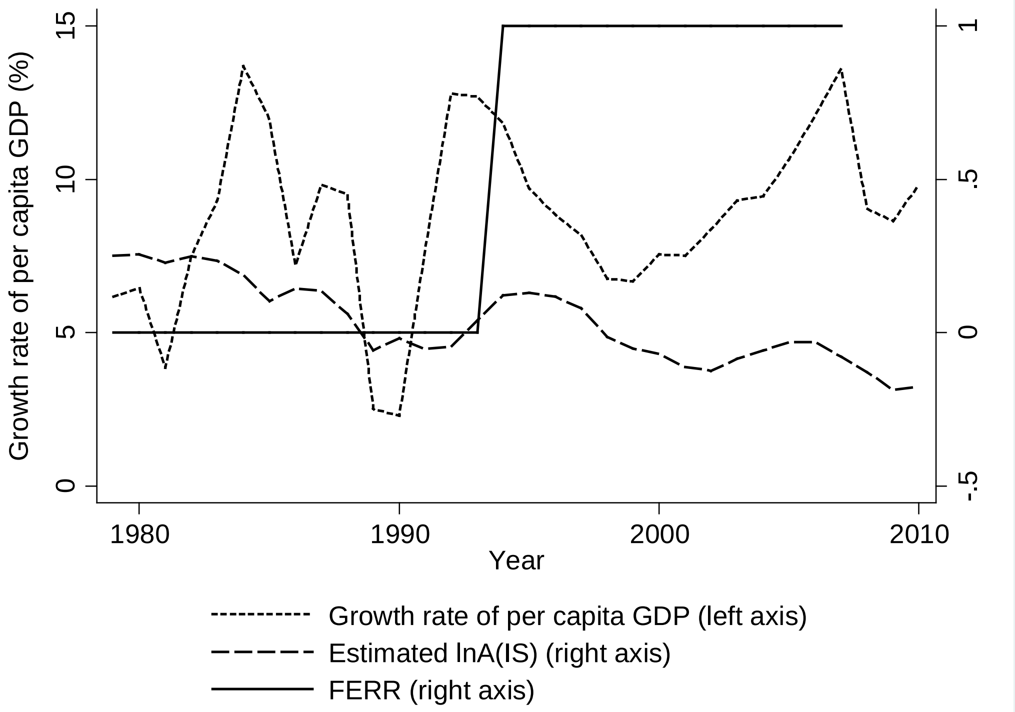

Germany
Hungary
Ireland
Italy
Japan
Luxembourg
Netherlands
Portugal
Growth differentials of TFP (%)
Year
Our estimates (left axis)
EU Klems estimates (right axis)



Our hypothesis states that the FERR regime dampens the Balassa-Samuelson effect, which induces an undervaluation of the real exchange rate when the TFP of the industrial sector increases relative to that of the service sector. This undervaluation can result in a higher growth rate for the economy. When the relative TFP decreases, however, the adoption of FERR renders an overvalued real exchange rate and the economic growth rate may instead be lower. That is, under FERR, we expect the growth rate to move together with the relative TFP. In contrast, under a floating regime, the Balassa-Samuelson effect is in full play and thus there may not be a co-movement between growth rate and relative TFP. As an example,

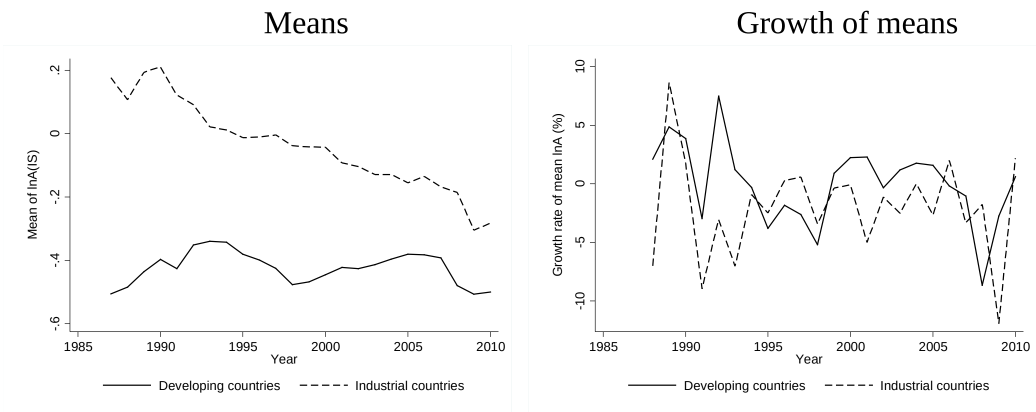
Figure 2 describes the relationship between the growth rate of per-capita GDP and the estimated quasi-relative-relative TFPs under different exchange rate regimes for the case of China. FERR here is defined according to the IRR classification. The history of China's exchange rate regime is divided into two phases according to IRR. Before 1994, China adopted a *de facto* floating regime; afterwards, the regime was fixed. Consistent with our hypothesis, in the first phase with a floating rate regime, there was no observable trend in China's growth rate whereas the quasi-relative-relative TFP displayed a downward trend in general. In the second phase in contrast, the two variables moved together, both exhibiting a "W-shaped" trajectory.

Figure 2 Exchange rate regime, quasi-relative-relative TFPs and growth in China



Another way to validate our estimates is to compare industrial countries with developing countries. Industrialization means the growth of the industrial sector, to which technological progress is a significant contributor. As a result, it is reasonable to expect that industrial countries have higher ratios of TFP between their industrial and service sectors than do the developing countries. To confirm this expectation, we add the constant ϕ estimated from Equation (8) to each country's estimates of $\ln A_{IS}$, to get their levels into the sample period. The left panel of Figure 3 shows the means of these levels for industrial and developing countries. It is indeed the case that industrial countries have higher levels of lnA_{IS} than developing countries in all years. However, consistent with the fact that industrial countries are deindustrializing, their average lnA_{IS} declines over time. For developing countries, lnA_{IS} exhibited an M curve. The right panel of Figure 3 compares the growth rates of average lnA_{IS} for industrial and developing countries. In the early 1990s and early 2000s, developing countries had higher growth rates than industrial countries. The average growth rate of developing countries in the whole sample period was 0.02%, 2 percentage points higher than the average growth rate of industrial countries. Because developing countries are in general experiencing industrialization, this result makes sense.

Figure 3 Quasi-relative-relative TFPs in industrial and developing countries



Note: Constant estimated from Equation (10) is added to the estimate of lnA_{IS} for each country. Growth rates are calculated for the means of lnA_{IS} in industrial and developing countries, respectively.

4.2 Testing for real undervaluation

Then we estimate Equation (10) to test for real undervaluation under the five definitions of the FERR. The results are presented in Table 3. Column (1) gives the results with only lnA_{IS} on the right-hand side in addition to the country dummies. This regression is intended to confirm the existence of the Balassa-Samuelson effect. This is shown by the significant and positive coefficient of lnA_{IS}. This coefficient indicates that the elasticity of the Balassa-Samuelson effect is 0.052. Compared with the results of empirical studies compiled by Tica and Druzic (2006), which use sectoral TFPs as independent variables, this elasticity is not small. In fact, several of those studies report negative coefficients.

Table 3 Testing real undervaluation under different definitions of a fixed exchange rate regime

Dep. variable: $\ln RER$	(1)	(2) IMF	(3) IRR	(4) RR	(5) LS	(6) JS	(7) IMF	(8) IRR	(9) RR	(10) LS	(11) JS
$\ln A_{IS}$	0.052***	0.116***	0.087***	0.138***	0.138***	0.081***	0.156***	0.159***	0.154***	0.164***	0.110***
	(0.018)	(0.031)	(0.032)	(0.030)	(0.035)	(0.026)	(0.034)	(0.034)	(0.032)	(0.039)	(0.030)
$\ln A_{IS}$ × FERR		–0.108**	–0.099**	–0.142***	–0.115**	–0.009	–0.184***	–0.232***	–0.237***	–0.166***	–0.101**
		(0.042)	(0.045)	(0.046)	(0.045)	(0.041)	(0.046)	(0.048)	(0.048)	(0.049)	(0.044)
FERR		0.129***	0.045***	0.029**	0.131***	0.112***	0.155***	0.050***	0.042***	0.134***	0.107***
		(0.011)	(0.011)	(0.013)	(0.012)	(0.011)	(0.011)	(0.013)	(0.015)	(0.013)	(0.012)
GGR_M2							0.000	0.000*	0.000*	0.001*	0.000*
							(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	–0.511***	–0.556***	–0.482***	–0.465***	–0.543***	–0.532***	–0.584***	–0.509***	–0.497***	–0.571***	–0.551***
	(0.003)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.008)	(0.007)
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# countries	156	153	148	148	150	151	152	148	148	149	151
# Obs.	5,419	3,883	4,050	3,748	3,159	4,047	3,332	3,453	3,272	2,818	3,450
Adjusted R^2	0.695	0.762	0.726	0.744	0.761	0.747	0.750	0.735	0.747	0.748	0.741

Note: Standard errors in brackets. ***: significant at 1% level, **: significant at 5% level, *: significant at 10% level.

In Columns (2) – (6), we estimate the full model of Equation (10) under different definitions of the FERR. The coefficient of lnA_{IS} is significantly positive in all the regressions, meaning that the Balassa-Samuelson effect holds for the floating regime under all the definitions. Moreover, the coefficient exceeds 0.052 in all the regressions. Except under JS, the coefficient of the interaction term, lnA_{IS} × FERR, is significantly negative, indicating that the fixed regime does lead to significant real undervaluation. The categorization of JS returns a different result; the fixed regime is not shown to perform significantly differently from the floating regime. This may be because JS has a coarse categorization system. It is noteworthy that the elasticity of the Balassa-Samuelson effect becomes negative under the fixed regime defined by IRR and RR. Because these two classifications are the most sophisticated in terms of capturing a country's *de facto* choice of exchange rate regime, this result is indicative for the role played by the fixed regime in causing real undervaluation when the Balassa-Samuelson effect is supposed to exist.

The coefficient of the stand-alone dummy FERR is significantly positive under all definitions. That is, the fixed regime itself causes real overvaluation provided its impact on the Balassa-Samuelson effect is controlled for. The overall effect of the fixed regime defined by Equation (11) depends on the gap between the level of TFP in the industrial sector and the level of the TFP in the service sector. Because by construction the average of this gap is zero, the average level of undervaluation caused by the fixed regime depends solely on the estimate of the stand-alone dummy FERR. Because this estimate is consistently positive across all the definitions, we conclude that on average the FERR causes real overvaluation. The amount of overvaluation is not negligible. By the LS definition, the real exchange rate on average is 13.1% higher under a fixed regime than under a floating regime. Using the IMF and JS definitions, the rates of overvaluation are 12.9% and 11.2%, respectively. The effects are much smaller under the IRR and RR definitions, which are 4.5% and 2.9%, respectively. This probably explains why most empirical studies do not find a growth effect for FERR: they in effect estimate the average contribution of the FERR.

Because the role of the fixed regime highly depends on the flexibility of domestic prices and/or the central bank's intervention, it would be a good idea to control for growth of the money supply. This is what we show in Columns (7) – (11). In the regressions, GGR_M2 is measured in decimal form. Except under the IMF definition, higher growth rates of money supply are found to cause real appreciation of the home country currency, as expected, but the estimated effects are all very small. The Balassa-Samuelson effect is still there under the floating regime by all definitions. It is noteworthy that its elasticity becomes larger under all the five definitions. This means that growth of money supply and lnA_{IS} are negatively correlated under the floating regime.[5] The coefficients of lnA_{IS} × FERR become significantly negative under all definitions. In addition, they all become larger than their corresponding figures for the case in which M2 growth is not controlled for. So the growth of money supply and lnA_{IS} are positively correlated under the fixed regime.[6] The coefficients of the stand-alone dummy FERR remain significantly positive under all definitions, and their magnitudes do not change much.

4.3 Real undervaluation and growth

Next we estimate Equation (12) to study whether real undervaluation caused by the fixed regime leads to higher rates of growth. The results are presented in Table 4. The first five columns are results for the original two-way fixed-effect model. The coefficients of lagged per-capita GDP are all significantly negative, implying strong convergence. Except under the IMF categorization, the coefficient of lnA_{IS} × FERR is significantly positive. That is, when defined by *de facto* choice of the exchange rate regime, the fixed regime promotes growth by dampening the Balassa-Samuelson effect. The insignificant result of the IMF definition implies that how a country actually manages its exchange rate is probably more important than the related announcements. A curious result, though, is that the direct effect of the fixed regime, measured by the coefficient of the stand-alone dummy FERR, is also positive under RR, LS and JS. This seems to contradict the results of the Balassa-Samuelson effect, which show that the fixed regime causes overvaluation when its dampening effect on the Balassa-Samuelson effect is controlled for.

[5] The reason may be that the nominal exchange rate tends to over-react to increases in lnA_{IS} so the growth of money can be slowed down to achieve the right level of the real exchange rate.
[6] The reason is that the nominal exchange rate is fixed so that the money supply has to grow faster to respond to a larger lnA_{IS} to accommodate the appreciation pressure.

Table 4 Real undervaluation and growth

Dep. variable: GR_GDPPC (%)	FE (1) IMF	(2) IRR	(3) RR	(4) LS	(5) JS	Two-stage FE (6) IMF	(7) IRR	(8) RR	(9) LS	(10) JS
Lagged ln*GDPPC*	–4.372***	–2.286***	–3.341***	–5.138***	–4.088***	–4.037***	–3.044***	–2.446***	–3.522***	–3.044***
	(0.379)	(0.301)	(0.342)	(0.469)	(0.371)	(0.881)	(0.598)	(0.757)	(1.207)	(0.957)
$\ln A_{IS}$ × FERR	–0.182	3.133***	2.535***	1.842***	1.221*	0.704	2.089*	2.757*	2.422**	1.335
	(0.630)	(0.604)	(0.731)	(0.671)	(0.688)	(1.153)	(1.147)	(1.408)	(1.211)	(1.440)
FERR	0.336	0.344	0.526*	0.972***	0.902***	3.234	–1.337	–1.378	–0.422	0.474
	(0.280)	(0.239)	(0.294)	(0.283)	(0.254)	(2.165)	(1.163)	(1.760)	(1.440)	(1.219)
Constant	8.690***	6.318***	7.622***	7.854***	7.193***					
	(0.594)	(0.517)	(0.576)	(0.619)	(0.528)					
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# countries	153	148	148	150	151	148	141	142	140	146
# Obs.	3,865	3,998	3,723	3,140	4,017	3,710	3,199	3,259	2,608	3,258
Adjusted R^2	0.187	0.194	0.203	0.170	0.154	0.147	0.123	0.142	0.119	0.110

Note: Standard errors in brackets. ***: significant at 1% level, **: significant at 5% level, *: significant at 10% level.

However, it is possible that a country chooses its exchange rate regime to promote economic growth. The contrasting results for *de jure* and *de facto* regimes reinforce this possibility. If that is the case, the estimation of Equation (12) is subject to the challenge of endogeneity.[7] To deal with this challenge, we adopt the method introduced by Levy-Yeyati and Sturzenegger (2002) and instrument FERR. In particular, five instrumental variables are used for the FERR dummy: (1) the surface area of a country measured in square kilometers; (2) the relative economic size measured by the ratio of a country's GDP to that of the U.S.; (3) the island dummy indicating whether a country is an island;[8] (4) the ratio of total reserves to the monetary base for the earliest year when a country became observed; (5) the average of exchange rate regimes among other countries in the IMF department to which a country belonged. Most variables are obtained from or calculated on the basis of the WDI data.

The results are presented in Columns (6) – (10) of Table 4. Now the coefficient of the dummy FERR is not significant in any regression, but the coefficient of $\ln A_{IS} \times$ FERR remains significantly positive under IRR, RR and LS. Therefore, the direct effect of the fixed regime is not robust; its positive effect is due mainly to the dampening of the Balassa-Samuelson effect. We then consider alone the contribution of real undervaluation for growth via the fixed regime's dampening effect. The amount of real undervaluation brought on in this way is equal to $-\eta_2 \ln A_{IS,it}$. But we put $\ln A_{IS,it} \times FERR_{it}$ in the growth equation. So to recover the contribution of real undervaluation, we need to divide b_2 by $-\eta_2$. Using the results provided by Table 3 and the IV results provided by Table 4, we then get the coefficients for real undervaluation for IRR, RR and LS: 0.09, 0.12, and 0.15. Following Rodrik (2008), these coefficients imply that a 50 percent undervaluation would increase the growth rate by 4.5, 6.0, and 7.5 percentage points, respectively. Those numbers are much larger than the numbers obtained by Rodrik (2008) and Gluzmann, et al. (2008), which are in the range of 1 to 2 percentage points. This can probably be explained by the different definitions of real undervaluation used in those two studies versus our study. In those two studies, undervaluation is defined by the gap between a country's actual real exchange rate and its counterfactual, which is fully explained by the country's per-capita GDP. That is, real undervaluation is based on the level of the real exchange rate. In contrast, we define real undervaluation based

[7] The estimation of Equation (8) is less likely so. A country does not change its exchange rate regime often, so FERR changes slowly. On the other hand, the real exchange rate can change very quickly. As a result, the exchange rate regime can be seen as predetermined when the real exchange rate is considered.
[8] For the list of island countries, see: https://en.wikipedia.org/wiki/List_of_island_countries.

on the elasticity of the Balassa-Samuelson effect, which is a rate of change of the real exchange rate in response to changes in lnA_{IS}. Thus our measure is more sensitive than the measure of the other two studies. As a result, the "intensity" of undervaluation is higher by our measure than by their measure, and our measure arrives at a larger growth effect than their measure for the same amount of undervaluation.

5 Exploring the growth channels

In this section, we explore possible channels for real undervaluation to promote economic growth. Because IRR is the most sophisticated categorization of a *de facto* real exchange rate regime and it, together with RR, consistently performs better than other categorizations in our study, we focus on IRR for the time being.

Following our arguments in the introduction, we explore three channels: industrial employment, export, and investment. Table 5 presents the results of regressing the share of industrial employment in total employment, the share of exports in GDP, and the share of investment in GDP, respectively, on lnA_{IS} × FERR and FERR as well as lagged per-capita GDP. For each share, we conduct two regressions. One adopts the FE model, and the other instruments FERR based on the FE model. Except for the two-stage regression for industrial employment, we obtain significant and positive results for the coefficient of lnA_{IS} × FERR. So by dampening the Balassa-Samuelson effect, adopting the fixed regime increases the share of industrial employment, the share of export and the share of investment, and the effect is more robust for the latter two shares. Using the method that we used to recover the effect of undervaluation on growth, we obtain the following result based on the FE regressions: a 10 percent real undervaluation increases the shares of industrial employment, export and investment by 1.71, 4.28 and 1.93 percentage points, respectively.

Table 5 Undervaluation and industrial employment, exports and investment

Dependent variable	Share of ind. employment (%)		Exports/GDP (%)		Investment/GDP (%)	
	FE	FE + IVs	FE	FE + IVs	FE	FE + IVs
Lagged ln*GDPPC*	5.696***	8.167***	10.993***	12.439***	2.027***	0.009
	(0.543)	(1.051)	(0.578)	(1.086)	(0.753)	(1.548)
$\ln A_{IS}$ × FERR	3.971***	5.587	9.931***	15.103***	4.476***	4.127*
	(1.101)	(3.486)	(1.143)	(1.883)	(1.030)	(2.415)
FERR	–1.040***	–5.120**	0.361	–4.312*	–1.073**	–15.787*
	(0.277)	(2.512)	(0.455)	(2.251)	(0.528)	(9.137)
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
# countries	130	106	148	141	106	93
# Obs.	1,665	1,473	3,977	3,189	1,882	1,623
Adjusted R^2	0.863	0.775	0.890	0.873	0.542	0.459

Note: Standard errors in brackets. ***: significant at 1% level, **: significant at 5% level, *: significant at 10% level.

The level effects of the fixed regime, though, are generally negative. The two-stage FE model shows that compared with countries with floating regimes, countries with fixed regimes have lower shares of industrial employment, export, and investment. This seems to contradict the results shown in Table 4, which indicate that the exchange rate regime by itself does not impact growth. To further explore the channels of growth, we run several regressions for the growth equation and present their results in Table 6. In Column (1) of the table, we include as explanatory variables the shares of industrial employment, exports and investment as well as two other usual candidates for growth determinants: the share of government spending in GDP and the share of population between 15 years old and 64 years old (working-age population). As expected, higher shares of government spending strongly dampens growth and higher shares of working-age population strongly promote growth. The share of industrial employment is not significant, but higher shares of exports and investment are associated with higher rates of growth. In Column (2), we leave out the shares of industrial employment, exports and investment but add the two variables measuring undervaluation of the fixed regime, $\ln A_{IS} \times$ FERR and FERR. The results for government spending and working-age population do not change qualitatively, and the coefficients of both $\ln A_{IS} \times$ FERR and FERR are significantly positive. In Columns (3) – (5), we add the share of industrial employment, the share of exports and the share of investment consecutively into the regression, to see if they affect the results of $\ln A_{IS} \times$ FERR and FERR. It turns out that the coefficient of FERR becomes insignificant as soon as the share of industrial employment is added, but the coefficient of $\ln A_{IS} \times$ FERR remains significantly positive until the share of investment is added. To be more exact, the coefficient of $\ln A_{IS} \times$ FERR actually becomes larger when only the share of industrial employment is added, but becomes smaller again when the share of exports is added in addition to the share of industrial employment, and it becomes insignificant when the share of investment is also added.

Table 6 Determinants of growth

Dep. variable: GR_GDPPC (%)	(1)	(2)	(3)	(4)	(5)
Lagged ln*GDPPC*	–12.094***	–1.980***	–4.092***	–4.543***	–6.278***
	(1.028)	(0.330)	(0.564)	(0.566)	(1.181)
Gov exp. (% GDP)	–0.348***	–0.148***	–0.285***	–0.265***	–0.176***
	(0.053)	(0.020)	(0.036)	(0.036)	(0.067)
Pop. of 15–64 (%)	0.755***	0.223***	0.313***	0.319***	0.564***
	(0.124)	(0.035)	(0.058)	(0.057)	(0.137)
Ind. employment (%)	–0.076		0.012	0.017	0.001
	(0.048)		(0.030)	(0.029)	(0.053)
Exports (% GDP)	0.062***			0.051***	0.051**
	(0.019)			(0.009)	(0.020)
Investment (% GDP)	0.132***				0.085***
	(0.033)				(0.032)
$\ln A_{IS}$ × FERR		1.851***	2.595**	1.990*	0.731
		(0.583)	(1.133)	(1.129)	(1.641)
FERR		0.553**	0.228	0.309	0.005
		(0.227)	(0.273)	(0.271)	(0.581)
Country FEs	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
# Countries	98	143	126	126	83
# Obs.	997	3,858	1,646	1,639	677
Adjusted R^2	0.454	0.207	0.464	0.474	0.470

Note: Standard errors in brackets. ***: significant at 1% level, **: significant at 5% level, *: significant at 10% level.

Two conclusions can be drawn from the above results. First, the dampening effect of the fixed regime on the Balassa-Samuelson effect is more robust than the level effect of the fixed regime. The dampening effect of the fixed regime is related to the higher rates of TFP growth in the industrial sector than in the service sector. The Balassa-Samuelson effect would eliminate any gain in growth caused by this differential of TFP growth. By dampening the Balassa-Samuelson effect, the fixed regime promotes growth. The level effect of the fixed regime is less robust because it is uncertain whether the fixed regime would cause undervaluation or overvaluation. Second, while dampening the Balassa-Samuelson effect increases all three shares of industrial employment, exports and investment, it is the share of exports and the share of investment that are the channels for undervaluation to promote growth. However, investment is a stronger channel than exports because the fixed regime's dampening effect only vanishes when investment is controlled for in the growth equation.

6 Industrial versus developing countries

We found that a fixed regime promotes growth by dampening the Balassa-Samuelson effect. But the Balassa-Samuelson effect only arises when a country's TFP growth is faster in its industrial sector than in its service sector. As Figure 3 shows, this is more likely to happen in developing countries than in industrial countries. In developing countries, the growth effect of a given amount of undervaluation may also be larger because export and capital accumulation, the two growth channels confirmed to exist in the last section, may be more important for growth in those countries than in industrial countries. In this section, we divide our sample into two subsamples, one for industrial countries and the other for developing countries, using the categorization provided by the World Bank based on per capita GNI.[9] In particular, high and higher middle income countries are defined as industrial countries, whereas low and lower middle income countries are defined as developing countries. Due to data availability for per capita GNI, some country-years could not be classified as industrial or developing countries and so are excluded from the analysis.

Table 7 Undervaluation and growth: Industrial versus developing countries

	Undervaluation		Growth	
	Industrial	Developing	Industrial	Developing
Lagged ln*GDPPC*			–9.188***	–10.424***
			(1.093)	(0.999)
$\ln A_{IS}$	0.303***	0.092**		
	(0.054)	(0.045)		
$\ln A_{IS}$ × FERR	–0.394***	–0.218***	0.795	2.815**
	(0.075)	(0.068)	(1.020)	(1.094)
FERR	–0.017	0.001	–0.501	1.369**
	(0.023)	(0.028)	(0.405)	(0.584)
GGR_M2	–0.001	0.000		
	(0.002)	(0.001)		
Constant	–0.220***	–0.811***	27.046***	2.914***
	(0.011)	(0.012)	(2.780)	(0.662)
Country FEs	Yes	Yes	Yes	Yes
Year FEs			Yes	Yes
# Countries	80	101	81	103
# Obs.	947	1,197	1,103	1,264
Adjusted R^2	0.825	0.699	0.359	0.347

Note: Standard errors in brackets. ***: significant at 1% level, **: significant at 5% level, *: significant at 10% level.

[9] http://siteresources.worldbank.org/DATASTATISTICS/Resources/OGHIST.xls.

We first study the fixed regime's undervaluation in the two subsamples. The first two columns of Table 7 present the results using the IRR definition of the fixed regime. The Balassa-Samuelson effect is found in both samples for the floating regime, and its magnitude is much larger in industrial countries than in developing countries. The fixed regime is found to dampen the Balassa-Samuelson effect in both samples, but the dampening effect is much stronger in developing countries. Indeed, while it is insignificantly different from zero for industrial-country fixers, the Balassa-Samuelson effect is significantly negative for developing-country fixers. That is, real depreciation occurs when TFP growth in the industrial sector is faster than in the service sector in developing countries with a fixed regime. This result is consistent with the fact that markets are less developed and thus prices are more rigid in developing countries than in industrial countries. However, the fixed regime alone is not found to have any level effect on the real exchange rate in either sample of countries. This result is different from the significantly positive effects we have found for the whole sample. Because industrial countries have higher real exchange rates than developing countries, the discrepancy is likely to derive from industrial countries' stronger tendency to adopt a fixed regime than developing countries. In our sample, the fixed regime is found for 43% of country-years among industrial countries while only 38% are found among developing countries.[10]

The rest two regressions presented in Table 7 help us study how real undervaluation impacts economic growth in the industrial-country sample and the developing-country sample, respectively. The contrast is stark. Among industrial countries, the fixed regime does not have a stand-alone effect on growth; nor does it promote growth by dampening the Balassa-Samuelson effect. Among developing countries, the fixed regime is found to promote growth either by itself alone or by dampening the Balassa-Samuelson effect. However, as before, we should not gauge the growth effect of undervaluation directly by the coefficients of FERR and $\ln A_{IS}$ × FERR. Because the fixed regime alone does not cause real undervaluation, its significantly positive growth effect must come from other sources that are not accounted for in our study. The channel by which the fixed regime impacts growth via real undervaluation is still the Balassa-Samuelson effect. Thus we rely solely on the coefficient of $\ln A_{IS}$ × FERR to gauge the impact of real undervaluation on growth. As before, this

[10] Note that in the full sample, the share of country-years with FERR is 46% under IRR. In both subsamples of industrial and developing countries, this share is less than 46% because it is 54% in the subsample of observations that could not be categorized as industrial or developing countries.

coefficient is then divided by $-\eta_2$. The final result is that a developing-country fixer grows 6.5 percent faster if faster TFP growth in its industrial sector allows it to gain a 50 percent undervaluation on the basis of the developing-country-floaters' average real exchange rate. This effect is larger than that obtained for the whole sample (4.5 percent).

Table 8 Undervaluation and shares of industrial employment, exports and investment in industrial countries

	Industrial employment		Exports		Investment	
	Industrial	Developing	Industrial	Developing	Industrial	Developing
Lagged ln*GDPPC*	–0.077	7.738***	6.093**	7.449***	–4.587	1.378
	(0.813)	(1.176)	(2.989)	(1.664)	(2.809)	(1.558)
$\ln A_{IS}$ × FERR	3.933***	–0.322	20.142***	7.638***	–7.128***	8.363***
	(0.950)	(2.384)	(2.783)	(1.744)	(2.460)	(1.370)
FERR	0.560**	–2.234***	2.554**	–1.101	–5.785***	–0.403
	(0.267)	(0.660)	(1.114)	(0.934)	(1.379)	(0.758)
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year Fes	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	74	81	81	103	38	95
# Obs.	886	510	1,095	1,262	302	1,093
Adjusted R^2	0.919	0.843	0.937	0.849	0.632	0.610

Note: Standard errors in brackets. ***: significant at 1% level, **: significant at 5% level, *: significant at 10% level.

Then in Table 8 we study how undervaluation impacts industrial employment, exports and investment in industrial countries and developing countries. Interesting contrasts also emerge from the two subsamples. Among industrial countries, undervaluation increases the share of industrial employment and the ratio of exports, but significantly reduces the share of investment, by either undermining the Balassa-Samuelson effect or simply having a fixed regime. Among developing countries, the stand-alone effect of the fixed regime is unstable, but undervaluation through the Balassa-Samuelson effect is found to have positive effects on the shares of exports and capital formation but no significant impact on the share of industrial employment.

Summarizing the above results, we conclude that we have found that the industrial-country sample and the developing-country sample share the same result for the share of exports but differing results for the share of industrial employment and the share of investment. Real undervaluation raises the prices of tradable goods relative to services, so it is natural that it would promote exports. The diverse results for investment can be explained by the stage of development. A developing country has not yet reached its steady state of growth, so accumulation of capital can still be a significant driver of growth. Real undervaluation can promote capital formation either by increasing savings through exports or by attracting more investment into its export sectors. In contrast, an industrial country has already reached its steady state, and capital accumulation is largely limited to compensating up for capital depreciation. The gain from real undervaluation is thus mostly absorbed by more imports and domestic consumption. The insignificant result for industrial employment in developing countries is harder to explain. One tentative explanation is that developing countries are diverse in terms of their efforts spent on industrialization. Real undervaluation stimulates more labor allocation to the industrial sector in countries that are striving for industrialization but may have little impact in countries that are industrializing only at a sluggish pace.

7 Conclusions

In this paper we develop a novel approach to estimate sectoral (quasi-) relative-relative TFPs for countries that have data on sectoral value-added in WDI. Using these estimates, we are able to test whether a fixed exchange rate regime dampens the Balassa-Samuelson effect. We find that under five definitions constructed from five popular classification schemes for exchange rate regimes, the fixed exchange rate regime does dampen the Balassa-Samuelson effect. Introducing the real undervaluation thus induced into a growth equation, we find that real undervaluation leads to higher growth rates. We also explore the channels for this result and find that exports and investment are the two most significant channels. Lastly, we compare industrial and developing countries and find that a fixed exchange rate regime is more likely to cause undervaluation and that undervaluation is more likely to promote growth in developing countries than in industrial countries. While our result that real undervaluation causes higher growth rates is consistent with results of existing studies, our result that the fixed exchange rate regime causes real undervaluation by dampening the Balassa-Samuelson effect is new to the literature. Our results have several policy implications for real exchange rate management.

First, our results confirm Eichengreen (2007)'s assessment that real exchange rate management only works when a country is well prepared in terms of economic fundamentals. The success of real undervaluation in promoting growth critically depends on the ability of a country's tradable sector, particularly its manufacturing sector, to generate higher rates of growth than the rest of the economy, because real undervaluation essentially provides a subsidy to the tradable sector.

Second, the stage of development is an important determinant of whether a fixed exchange rate regime is useful for achieving real undervaluation. For two reasons, developing countries are in a better position than industrial countries to succeed. The first is that developing countries are in the process of industrialization and, as our estimates of $\ln A_{IS}$ show, their industrial sectors thus tend to experience faster technological progress than the rest of the economy. That is, developing countries are better prepared in their economic fundamentals than industrial countries to benefit from a fixed exchange rate regime. The second is that domestic markets are less developed in developing countries than in industrial countries. As a result, a fixed exchange rate regime can more readily induce real undervaluation when a developing country experiences faster technological progress in its industrial sector than in other sectors.

Third, because economic fundamentals are important, real exchange rate management has to be contingent policy. As Figure 3 shows, the industrial sector is not always marked by faster rates of technological improvement than the service sector, even in developing countries. This suggests that the exchange rate regime should be changed accordingly in order to promote growth. However, in reality once an exchange rate regime is adopted, it is not easy to change it. This may explain why fixed exchange rate regimes often fail to promote growth. Real exchange rate management requires fine-tuned policy that adapts to changes in economic fundamentals.

Lastly, our results provide clues for assessing China's fixed exchange rate policy. As shown by Figure 2, China began to move to adopt a *de facto* pegging system in 1994, and its growth rates have closely followed the movements in its $\ln A_{IS}$. Two cycles can be observed. The first cycle occurred around the Asian Financial Crisis of 1997. Before the crisis the fixed exchange rate helped China to reap the gains generated by faster TFP growth in its industrial sector. However, these gains became negative after the crisis because TFP growth in the industrial sector was slower than in the service sector. The fixed exchange rate in effect hurt China's growth. The second cycle occurred around the Global Financial Crisis of 2008. After China joined the WTO in 2001, it began a new round of economic expansion, driven largely by unprecedented rates of export growth.[11] The fixed exchange rate helped China again. The Global Financial Crisis forced the global economy into a prolonged period of deep adjustment; China's export growth also slowed. Reflected on the technological side, the industrial sector began to have slower rates of TFP growth than the service sector again. Accordingly, the fixed regime again restrained China's economic growth. Because the Chinese economy achieved double-digit growth in the mid-1990s and early 2000s, on balance China might have gained from the fixed rate regime since 1994. However, it is highly unlikely that China's growth pattern of the mid-1990s and early 2000s will be repeated because of the adjustments that have taken place in the world economy and the structural changes in the Chinese economy that ha ensued as a natural result of economic growth. Therefore, continuing the fixed exchange rate regime may not be a good idea for China.

[11] Between 2001 and 2008, China's exports grew by a factor of five. See www.stats.gov.cn.

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