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# Productivity Growth, Fixed Exchange Rates, and Export-Led Growth*

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**Abstract.** This paper studies how the fixed exchange rate regime (FERR) may promote growth when a country experiences faster rates of productivity growth in its tradable sector than its nontradable sector. In a simple two-sector model, we show that the FERR can reduce the Balassa-Samuelson effect if the adjustment of domestic prices is subject to nominal rigidities. The undervaluation suppresses wage growth but increases the size of the tradable sector and leads to higher growth rates for the entire economy. Using cross-country panel data, our econometric exercises provide robust evidence that supports the results. Meanwhile, other fundamentals, including the external balance position, export share in the tradable sector, and the stage of development, play roles in determining the effects of FERR. Last, we apply the empirical results to run simulations on China from 1994 to 2007 to highlight the role

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of FERR in the country's export-led growth.

**Keywords:** fixed exchange rate regimes; real undervaluation; export-led growth

**JEL classification:** F31, F43, O41

## Productivity Growth, Fixed Exchange Rates, and Export-Led Growth

### 1. Introduction

Peripheral countries often adopt the fixed exchange rate regime (FERR) to bid for a faster pace of catch-up through export-led growth (Dooley, Folkerts-Landau, and Garber 2003). Some of them, noticeably, Western Germany and Japan under the Bretton Woods System, the East Asian Tigers and China in more recent years, have succeeded. Theory, however, predicts that fixing the exchange rate normally would not matter for real prices (Rose, 2011). The empirical work by Chin and Wei (2013) indeed finds that the exchange rate regime does not matter for the real exchange rate. In addition, the FERR tends to cause larger damages than a floating regime when negative shocks hit a country (Levy-Yeyati and Sturzenegger 2003). On balance, empirical research does not find a robust relationship between the FERR and growth (Rose, 2011); Levy-Yeyati and Sturzenegger (2003) even find that the FERR systematically hurts growth in developing countries. The gap between the reality and the existing literature thus begs a more careful study.

In this paper, we offer a study on how different rates of productivity growth in the tradable and nontradable sector, coupled with nominal wage rigidities, could warrant a role of the FERR in promoting faster growth. In a country on a successful path to full industrialization, labor productivity often grows much faster in its tradable sector than its nontradable sector. In the meantime, its labor market often has slacks, which undermines workers' bargaining power, so nominal wages may not fully rise to respond to productivity growth. As a result, the Balassa-Samuelson effect (BS effect) (Balassa 1964; Samuelson 1964) may be suppressed by the FERR. Compared with a floating regime, the FERR causes real undervaluation, which may in turn promote growth by encouraging more export.

In a simple two-sector model that features a tradable sector with technical barriers and a competitive nontradable sector, we show how nominal wage rigidities allow the FERR to dampen the BS effect. A positive shock to the labor productivity of the tradable sector requires that the nominal wage rate be adjusted upward. However, technical barriers provide firms in the tradable sector some monopsony power in the labor market, so some of the firms can resist wage increases. The tradable sector as a whole, thus, faces a lower average nominal wage, which, because of free movement of labor across sectors, puts downward pressures on the nominal price of the nontradable good. Under a floating regime, the nominal exchange rate would adjust upward, but this channel is shut down under the FERR. As a result, real appreciation, measured by the real price of the nontradable good, is smaller under the FERR than under the floating regime. In turn, it leads to a smaller increase in the real wage rate so the profit in the tradable sector increases. Therefore, whether real undervaluation caused by the FERR promotes faster growth depends on the tradeoff between wage losses and profit increases in the tradable sector. To make faster growth possible, undervaluation has to draw more labor into the tradable sector.

We use data provided by the World Development Indicators (WDI) and the Penn World Table 9.0 (PWT9.0) to empirically test our theoretical results. Specifically, we test four hypotheses derived from our model concerning, respectively, the FERR's role in causing real undervaluation, slower rates of wage growth, faster expansion of tradable-sector employment, and its advantage in promoting growth. We also study how the external balance position and the share of export in the tradable sector interact with the FERR to depress the BS effect. In addition, we conduct a comparative study for developed and developing countries. Last, we provide a simulation study for China's export-led growth based on our empirical results.

It is acknowledged in the literature that different definitions of the FERR can lead to very different research results (Rose 2011). We adopt five definitions of the FERR derived from the exchange rate regime categorization systems provided by the International Monetary Fund (IMF); Reinhart and Rogoff (2004; RR); Ilzetzki, Reinhart, and Rogoff (2008; IRR); Levy-Yeyati and Sturzenegger (2003; LS); and Shambaugh (2004; JS).[1] The suppressive role of FERR on the BS effect holds relative

[1] For the purpose of exposure, we use at least two letters to indicate one type of categorization. JS includes the first

to the floating regime under RR and IRR, the two prevailing categorization systems for de facto exchange rate regimes.

The main methodological novelty of our paper is that we consider a key economic fundamental, namely, faster productivity growth in the tradable sector than the nontradable sector, when we study the role of the FERR. Our approach concurs with Eichengreen (2007)'s emphasis on the role of economic fundamentals (a disciplined labor force, a high saving rate, etc.) in shaping effective real exchange rate management. The existing empirical studies often treat the fixed regime as a stand-alone dummy variable in regressions, so they only study the average effects of the fixed regime and may ignore the economic fundamentals that could differentiate the roles of the fixed and floating regimes.

Our study also differs from some of the other studies on real exchange rate management. For example, Rodrik (2008) assumes that in developing countries there are more distortions in the tradable sector than the nontradable sector. His model then shows how real exchange rate management can serve as a way to overcome those distortions. In contrast, real undervaluation is useful in our case because labor productivity in the tradable sector is progressing more quickly than the rest of the economy. In addition, instead of treating real undervaluation as a ready policy tool, we show how the FERR can serve as a policy tool to cause real undervaluation.

Next, in Section 2, we use a two-sector small open economy model to explain how the FERR could suppress the BS effect and, thus, impact real wage and real gross domestic product (GDP) per capita. Section 3 discusses our data sources and the definitions of the FERR. The empirical results are presented in Section 4. Section 5 then conducts simulations on China based on the empirical results. The simulations are useful because China is the most significant and successful case of the export-led growth model in the past three decades. Section 6 concludes the paper and discusses the policy implications of our results.

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letter of Shambaugh's first and last name.

## 2. A Two-Sector Model

### *2.1 Nominal wage rigidity and the internal real exchange rate (IRER)*

Consider an economy with one tradable sector (*T*) and one nontradable sector (*S*). Each sector produces a homogenous good, and the production technology is identical in each sector. Labor is the only input used in both sectors. A typical firm's production function can be described by the following:

$$y_i = A_i L_i,\ i = T, S,$$

where $y_i$ is output, $L_i$ is the number of workers, and $A_i$ is the labor productivity in sector $i = T, S$. Although the technology of the nontradable sector is accessible to any firm, there are technical barriers for firms operating in the tradable sector.[2] We assume that there are a fixed number of firms in that sector. Those firms sell their products in the international and domestic markets. In the international market, they only compete "locally" with foreign firms, and their competitive behavior does not affect the international price of the tradable good.[3] Now, let that price be normalized to unit. Let $e$ denote the nominal exchange rate measuring the domestic currency by the foreign currency, so a larger value of $e$ means appreciation. The domestic price of the tradable good then is $1/e$. Firms in the tradable sector takes this price as given when they make production decisions. If they also did not have any power to influence the wage rate, then the competition for labor would eventually drive down profits to zero. And so, let $W^1$ be the realized nominal wage rate. Then, $W^1 = A_T / e$.

Labor can move freely between the two sectors. The nontradable sector features perfect competition with free entry, so the profit of its firms is zero. Let $P$ be the nominal price of the nontradable good. Then $W^1 = PA_S$. Let $p = eP$ be the nontradable

[2] In reality, tradable goods are often produced by modern technologies. In contrast, the nontradable sector admits technologies at any level, such as domestic services that virtually do not need any formal training.
[3] We will define exactly what we mean by local competition in the international market in Section 2.3.

good's price relative to the price of the tradable good. It is also the internal real exchange rate (IRER). We then immediately obtain the BS effect such that

$$p = A_{TS}, \tag{1}$$

where $A_{TS} = A_T / A_S$ is the relative labor productivity between the tradable and nontradable sector.

Technical barriers, however, allow the firms in the tradable sector to exercise some power in the labor market by negotiating the nominal wage rate with the workers. To proceed, we consider two adjacent periods, period 0 and period 1, between which the productivity in the tradable sector increases while the productivity of the nontradable sector remains unchanged. Let $A_T^0$, $W^0$, and $P^0$ be, respectively, the tradable sector productivity, nominal wage, and nominal price of the nontradable good in period 0. By the free entry condition in the nontradable sector, we have $W^0 = P^0 A_S$. To abuse the notation, let the realized productivity of the tradable sector in period 1 be denoted by $A_T$. To dramatize the situation, we assume that $\delta$ share of firms in the tradable sector can completely resist any wage increase, and 1 - $\delta$ share of firms have to yield in and pay $W^1$ to workers. As a result, the average wage in the tradable sector is the following:

$$W = \delta W^0 + (1-\delta) W^1, \quad 0 \le \delta \le 1.$$

This setup presents a model of nominal wage stickiness. In line with Krause and Lubik (2007), $\delta$ is a measure of the stickiness. A larger value of $\delta$ implies a slower rate of wage adjustment. Firms that operate in the tradable sector as a whole make a profit because the average nominal wage they pay is smaller than the nominal value that a worker can produce. Firms in the nontradable sector pay each worker $W$ as given. Again, free entry drives down the profit to zero. Thus, $W = PA_S$, or

$$\delta \left( P^0 A_S \right) + (1-\delta) A_T / e = PA_S .$$

By rearranging terms, we obtain the following expression for the BS effect under nominal wage rigidity:

$$p = \delta\left(\frac{e}{e^0} p^0\right) + (1-\delta) A_{TS}, \tag{2}$$

where $e^0$ is the exchange rate before the shock. By this equation, the IRER is now a weighted average of the relative productivity $A_{TS}$ and the original IRER adjusted by the rate of nominal appreciation, with the weights being the probability of wage adjustment and the probability of no wage adjustment, respectively. Note that $p$ is bounded by $A_{TS}$ because otherwise all firms lose money. Nominal wage rigidity retards the adjustment of the IRER. When the nominal wage becomes less sticky, that is, when $\delta$ becomes smaller, the IRER moves closer to $A_{TS}$. However, when the nominal wage becomes stickier, the IRER stays closer to $(e/e^0)p^0$, or $eP^0$. Equation (2) establishes a relationship between the IRER and the nominal exchange rate, as well as the real variable $A_{TS}$. This feature allows us to study the differences between the FERR and the floating regime.

Equation (2) also defines the dynamic path of the IRER if the model is made dynamic. It is straightforward to show that in the balanced growth path, we have $p = A_{TS}$ regardless of the exchange rate regime. Therefore, the exchange rate regime is only meaningful when the economy is on the transition path. For this reason, we assume that the economy starts at a point where the IRER is smaller than the relative productivity, that is, $p^0 < A_{TS}^0$, and we consider the consequences of a positive shock happening to $A_T$ at the beginning of the next period. Because $A_S$ does not change, the shock is equivalent to a shock to the relative productivity $A_{TS}$ scaled up by the factor $A_S$. Our question is, how would outcomes be different if the FERR or the floating regime is adopted to respond to the shock?

### *2.2 Domestic consumption and the allocation of labor*

Labor allocation has to be determined by the demand side because the production functions of both sectors are linear. We assume that the representative consumer has a

Cobb-Douglas utility function on the tradable and nontradable goods with their expenditure shares being $\alpha$ and $1 - \alpha$, respectively. The nontradable good is entirely consumed within the home country, but the tradable good can be traded internationally. So, let $x$ be its export.[4] Then, after receiving the productivity shock, the consumer's utility maximization implies the following:

$$\frac{L_T - L_x}{\omega L_S} = \beta , \tag{3}$$

where $\omega = p / A_{TS} = w / A_T$ is the unit labor cost of the tradable sector, $\beta = \alpha / (1-\alpha)$ is the ratio of expenditure between the tradable and nontradable good, and $L_x = x/A_T$ is the number of workers needed to produce the export (when $L_x$ is positive) or the number of workers saved from import (when $L_x$ is negative). Because we focus on export-led growth, we assume that $L_x$ is positive.

The domestic market closes by the labor market clearing condition:

$$L_T + L_S = L , \tag{4}$$

where $L$ is the number of workers in the country. Taking the two variables determined by the international markets, $e$ and $x$, tentatively as given, we can solve the three domestic variables, $p$, $L_T$, and $L_S$, from equations (2), (3), and (4). Equation (2) alone determines $p$. Then from Equations (3) and (4), we can solve $L_T$ and $L_S$:

$$L_T = \frac{\beta\omega}{1+\beta\omega} L + \frac{1}{1+\beta\omega} L_x , \qquad L_S = \frac{1}{1+\beta\omega} L - \frac{1}{1+\beta\omega} L_x . \tag{5}$$

Note that a higher unit labor cost in the tradable sector actually increases this sector's employment and reduces the nontradable sector's employment. This occurs because a higher unit labor cost can be a consequence of either a higher wage rate or lower labor productivity in the tradable sector. In the former case, the price of the nontradable good increases so the demand for the nontradable good declines; in the latter case, the

[4] Here $x$ is both the total export and the net export of the tradable good because our model does not specify intermediate inputs for production.

supply of the tradable good cannot meet its demand, so its production has to expand. Labor moves into the tradable sector in both cases.

### *2.3 The international markets*

To fully characterize the model, we need to specify how the nominal exchange rate and the net export are determined in international markets. While it is fixed under the FERR, the nominal exchange rate is endogenous under the floating regime. To determine the nominal exchange rate under the floating regime, we need to specify the rule of money supply or interest rate formation. In the literature (for example, Engel 2014), however, there is no good model that can fully account for the formation of the nominal exchange rate. Realizing that issue, we simply assume that the productivity shock in the tradable sector causes positive nominal appreciation under the floating regime.[5]

To determine the amount of export $x$, we consider the following market structure in the international goods market. First, the international market is very large, so exports from the home country do not affect the international price of the tradable good. Second, there are numerous potential producers in the world with a mass of 1, each with a different level of unit labor cost. Third, firms from the home country are engaged in a latent price competition with those producers; they can beat the producers that have higher levels of unit labor cost. Suppose that each foreign producer can potentially produce 1 unit of the tradable good, and the distribution of the unit labor cost in the world follows a CDF (cumulative distribution function) $G(.)$. Then,

$$x = 1 - G(\omega) . \tag{6}$$

[5] This assumption can be justified by the Cambridge equation with a constant rate of money growth. In our framework, the growth version of the equation can be expressed as $\hat{e} + m = \hat{y}$ , where $m$ is the constant growth rate of money supply and $y$ is real GDP. Apparently, the rate of nominal appreciation increases if a positive shock to labor productivity leads to a higher growth rate of real GDP, which we will show later in the text.

Because $\omega = p / A_{TS}$, Equation (6) establishes a negative relationship between the IRER and export *x*. This is straightforward — a larger IRER raises the real wage of the home country and, thus, reduces the competitiveness of the home producers.

***2.4 A comparison of the FERR and the floating regime***

With those setups, we are ready to compare the outcomes of the FERR and floating regime. We first study the elasticity of the IRER, or the elasticity of the BS effect, $\eta$, in response to a positive shock $\Delta A_{TS}$ happening to $A_{TS}$. From Equation (2), we obtain the following:

$$\eta = \frac{\Delta p}{\Delta A_{TS}} \bigg/ \frac{p^0}{A_{TS}{}^0} = \frac{1}{\omega^0}\left[\delta P^0 \frac{\Delta e}{\Delta A_{TS}} + (1-\delta)\right]. \tag{7}$$

This equation provides a nice interpretation for the BS effect under wage rigidity. From the equation, the effect can be decomposed into two parts. One part, which is represented by the first term in the bracket on the right-hand side, is the increase caused by nominal appreciation. The other part, which is represented by $1-\delta$, is the increase caused by the adjustment of the domestic price. In theory, $\eta$ can be larger than unit. However, if that were the case, a country receiving continuous positive productivity shocks for a period of time (such as China in the twenty years before 2008) would soon see that real appreciation raises the unit labor cost over unit in the tradable sector and that every firm ends up losing money. Therefore, we maintain the assumption that $\eta$ is positive but less than unit.[6]

Under the floating regime, nominal appreciation happens, so $\Delta e / \Delta A_{TS}$ is positive. Under the FERR, *e* is fixed, so $\Delta e / \Delta A_{TS} = 0$. Thus, the elasticity of the BS effect under the floating regime, $\eta_{Float}$, is larger than the elasticity of the BS effect under the

[6] Our empirical analysis works with a country's real exchange rate (RER), which is related to the IRER in the form $RER = p^{1-\alpha}$. Its elasticity of the BS effect is $(1-\alpha)\eta$. We find that it is less than 0.1. So unless the consumption share of the nontradable sector is smaller than 0.1, $\eta$ cannot be larger than unit.

FERR, $\eta_{FERR}$. The difference is positive only when the wage rate is sticky, that is, when $\delta$ is positive. In addition, it increases as $\delta$ approaches 1. We summarize those results in an empirically testable hypothesis:

***H1.*** *When a country's tradable sector experiences productivity growth relative to the nontradable sector,*

***H1.1.*** *the BS effect holds, but its elasticity is smaller under the FERR than under the floating regime, and*

***H1.2.*** *the gap of the BS elasticity between the FERR and the floating regime increases in the amount of wage rigidities.*

Next, we study whether real undervaluation caused by the FERR will lead to higher growth rates of the total output. Because the nontradable sector features zero profit, its output is equal to its wage bill, which is $wL_S$. Firms in the tradable sector as a whole make a profit:

$$R = (A_T - w)L_T = (1-\omega)A_T L_T . \tag{8}$$

The unit labor cost $\omega$ is less than unit before the balanced growth path is reached. The total output of the tradable sector is $wL_T + R$. The real GDP of the entire country measured in the tradable good is then the following:

$$y = wL + R . \tag{9}$$

We are interested in the growth rate $\Delta y / y^0$ under the two exchange rate regimes when a positive shock $\Delta A_T$ happens to $A_T$. Because $y^0$ is the same under the two regimes, we can just compare $\Delta y$.

Compared with the floating regime, the FERR creates a tradeoff between the wage rate and the tradable sector profit. Apparently, the FERR suppresses the wage rate by suppressing the IRER. Therefore, the FERR would have to raise the tradable sector profit to compensate for the loss if it were to outperform the floating regime. There are two channels for the FERR to do so: one is through the savings created by the lower wage rate, and the second is to increase the number of workers employed in the tradable sector. However, savings on the wage bill cannot compensate for the loss of labor income in the entire country because the former is only reaped on workers employed in the tradable sector whereas the latter is shouldered by every worker in the country. Therefore, the only possibility for the FERR to bring a higher growth rate than the floating regime is to create more employment in the tradable sector.

More specifically, the rate of change of the real wage rate in response to the shock $\Delta A_T$ is exactly the rate of change of the IRER in response to the shock $\Delta A_{TS}$:

$$\frac{\Delta w}{\Delta A_T} = \frac{\Delta p}{\Delta A_{TS}} = \frac{p^0}{{A_{TS}}^0}\eta .$$

As a result,

$$\left.\frac{\Delta w}{\Delta A_T}\right|_{FERR} - \left.\frac{\Delta w}{\Delta A_T}\right|_{Float} = \omega^0 \left(\eta_{FERR} - \eta_{Float}\right) < 0 .$$

So the FERR indeed suppresses real wage growth. In addition, the gap of the rate of wage growth between the two regimes is proportional to the gap of the BS elasticity between them. We summarize this result in the following testable hypothesis:

***H2.*** *The wage rate increases with the labor productivity in the tradable sector, but the increase is smaller under the FERR than under the floating regime.*

To study tradable-sector employment, we return to the two equations in Equation (5), which determine the allocation of labor. We then easily obtain:

$$\frac{\Delta L_T}{\Delta A_{TS}} = \left(L - {L_x}^0\right)\frac{\beta}{\left(1+\beta\omega^0\right)^2}\frac{\Delta\omega}{\Delta A_{TS}} + \frac{1}{1+\beta\omega^0}\frac{\Delta L_x}{\Delta A_{TS}} . \tag{10}$$

The change of the tradable-sector employment is decomposed into two parts. The first part accounts for the change induced by the change in the unit labor cost. So, let the elasticity of $\omega$ with respect to $A_{TS}$ be $\eta_\omega$. Then, $\eta_\omega = -(1-\eta)$ . The result is between –

1 and 0 because $\eta$ is between 0 and 1. The second part accounts for the change induced by the change in the number of workers engaged in the production of exports. Let $\eta_x < 0$ be the elasticity of $x$ with respect to $\omega$. We easily find that $\Delta L_x / \Delta A_{TS} = L_x^{\,0}\left(\eta_x \eta_\omega - 1\right) / A_{TS}^{\,0}$. Because $\eta_\omega$ takes values between –1 and 0, $\Delta L_x / \Delta A_{TS}$ can be positive if $\eta_x < -1$. From the first equation in Equation (5), we can express the total labor force as $L = \left[\left(1+\beta\omega^0\right)L_T^{\,0} - L_x^{\,0}\right] / \beta\omega^0$. Substituting all the earlier results and $\eta_\omega = -(1-\eta)$ into Equation (10), as well as rearranging terms, we obtain the following:

$$\frac{\Delta L_T}{\Delta A_{TS}} = \frac{1}{1+\beta\omega^0}\frac{L_T^{\,0}}{A_{TS}^{\,0}}\left\{\left[(1-\eta_x)\frac{L_x^{\,0}}{L_T^{\,0}} - 1\right](1-\eta) - \frac{L_x^{\,0}}{L_T^{\,0}}\right\}.$$

So $\Delta L_T / \Delta A_{TS}$ can be positive if the following inequality is satisfied:

$$\left[(1-\eta_x)(1-\eta) - 1\right]\frac{L_x^{\,0}}{L_T^{\,0}} > 1-\eta .$$

To make this inequality hold for an export-led country (so $L_x^{\,0}$ is positive), exports have to have a large elasticity with respect to the unit labor cost. As such, a large export sector helps. However, we are more interested in the comparison of performance between the FERR and the floating regime. The gap between the two regimes is the following:

$$\left.\frac{\Delta L_T}{\Delta A_{TS}}\right|_{FERR} - \left.\frac{\Delta L_T}{\Delta A_{TS}}\right|_{Float} = \frac{1}{1+\beta\omega^0}\frac{L_T^{\,0}}{A_{TS}^{\,0}}\left[(1-\eta_x)\frac{L_x^{\,0}}{L_T^{\,0}} - 1\right]\left(\eta_{Float} - \eta_{FERR}\right).$$

Whether the gap is positive depends critically on the number of workers in the tradable sector who are engaged in producing exports. Apparently, the gap is always negative if a country runs a trade deficit. In this case, the floating regime is always better than the FERR. We infer that the FERR causes undervaluation of the domestic currency and that the country has to pay higher prices for its imports. For a country running a surplus, we need the following condition to make sure that the FERR outperforms the floating regime:

Condition X: $\frac{L_x{}^0}{L_T{}^0} > \frac{1}{1-\eta_x}$

To summarize, we have the following empirically testable hypothesis:

***H3.*** *When a country's tradable sector experiences productivity growth relative to its nontradable sector,*

***H3.1.*** *a necessary condition for the FERR to maintain a higher level of employment in the tradable sector than the floating regime is that the country runs trade surplus, and*

***H3.2.*** *the gap between the two regimes is larger when a larger share of workers in the tradable sector is engaged in the production of exports.*

Now to the profit of the tradable sector, we easily obtain from Equation (8) the following:

$$\frac{\Delta R}{\Delta A_T} = \left(1 - \frac{\Delta w}{\Delta A_T}\right) L_T{}^0 + \left(1-\omega^0\right) A_{TS}{}^0 \frac{\Delta L_T}{\Delta A_{TS}}.$$

Then, moving to real output, we have

$$\frac{\Delta y}{\Delta A_T} = \frac{\Delta w}{\Delta A_T} L + \frac{\Delta R}{\Delta A_T}$$

$$= L_T{}^0 + \frac{\Delta w}{\Delta A_T} L_S{}^0 + \left(1-\omega^0\right) A_{TS}{}^0 \frac{\Delta L_T}{\Delta A_{TS}}. \quad (11)$$

That is, the impact of a positive shock to $A_T$ can be decomposed into three components, which are captured by the three terms on the right-hand side of Equation (11), respectively. The first component is the direct effect to increase the labor productivity, which is captured by the number of workers employed in the tradable sector $L_T{}^0$. The second component is the effect on the wage rate. Because wage increases in the tradable sector are offset by the decline of profit in the same sector, the gain from wage is only captured by the workers employed in the nontradable sector. The third component captures a structural factor that goes through the change of the employment in the tradable sector. As we have shown, the direction of this change is undetermined. But even if the change is negative (that is, when employment in the tradable sector declines as a response to the shock $\Delta A_{TS}$), it is unlikely to cover the positive impacts of the first two components because it is only secondary compared with the shock's direct productivity effect. Therefore, we conclude that a positive shock to $A_T$ leads to a higher growth rate of the real output.

The performance gap between the FERR and the floating regime is

$$\left.\frac{\Delta y}{\Delta A_T}\right|_{FERR} - \left.\frac{\Delta y}{\Delta A_T}\right|_{Float} = L_T{}^0 \left\{ \frac{1-\omega^0}{1+\beta\omega^0}\left[(1-\eta_x)\frac{L_x{}^0}{L_T{}^0} - 1\right] - \omega^0 \frac{L_S{}^0}{L_T{}^0} \right\} \left(\eta_{Float} - \eta_{FERR}\right).$$

It is proportional to the gap of the BS elasticity between the two regimes. For the FERR to triumph over the floating regime, Condition X is not enough because we not only need the FERR to keep more employment in the tradable sector, but we also require that the increase more than compensate for the loss of wages in the nontradable sector. To be exact, we need this condition:

Condition XW: $\dfrac{1-\omega^0}{1+\beta\omega^0}\left[(1-\eta_x)\dfrac{L_x{}^0}{L_T{}^0} - 1\right] > \omega^0 \dfrac{L_S{}^0}{L_T{}^0}$.

In addition to having a larger export sector, a smaller unit labor cost in the starting period, $\omega^0$, helps a country meet Condition XW, which is more likely to happen in developing countries where labor is abundant. In contrast, to the extent that developed countries have either reached or have moved very close to the balanced growth path, the FERR is strictly dominated by the floating regime because $\omega^0$ is very close to unit, nullifying the gains from increased exports.

We summarize these results into the following testable hypothesis:

***H4.*** *When a country's tradable sector experiences productivity growth,*

***H4.1.*** *a necessary condition for the FERR to reach a higher rate of economic growth than the floating regime is that the country runs a trade surplus, and*

***H4.2.*** *the gap of output growth between the two regimes is larger in developing countries than in developed countries.*

## 3. Data and Variables

To empirically test the four hypotheses derived in Section 2, we compiled a sample of 159 countries from 1980 to 2007. The starting year was set to 1980 because it is the earliest year for which we could construct some of the key variables necessary for our empirical testing. The ending year was set to 2007 to maintain consistency among the exchange rate regime categorization systems that we use to define the FEER and to avoid the confounding effects of the 2008 Global Financial Crisis. The time span is long enough to overcome the power problem (Tica and Druzic 2006). We relied on the WDI, PWT9.0, and the websites of Andrew Rose and Carmen Reinhart to construct our variables. The WDI provides good sectoral data, and PWT9.0 is famous for its international income comparison. We consulted PWT9.0 for data about purchasing power parity (PPP), real GDP, and capital stock. The websites of Andrew Rose and Carmen Reinhart provide information for defining the FERR.

Our theory works with the IRER, but because the country-wide real exchange rate (RER) is readily available from PWT9.0, our empirical tests work with the RER. Recall from footnote 6 that $\ln RER = (1 - \quad)\ln IRER$, so all the results applied to IRER also apply to RER. The variable for the real exchange rate, *RER*, in indirect quote, is the nominal exchange rate divided by PPP, which is equal to the inverse of "pl_gdpo" (2011 price level of the United States set at 1) reported by PWT9.0.

H1.1 establishes a relationship between a shock to the relative labor productivity $A_{TS}$ and the IRER. This relationship also applies to the RER. The WDI reports the shares of value added in GDP and the shares of employment for the manufacturing and service sectors. We use those two sectors to represent the tradable and nontradable sectors, respectively. Then, $A_{TS}$ simply equals the ratio of value-added share between the two sectors divided by the ratio of employment share between the two sectors, without the need to calculate sectoral productivities. Although sectoral shares of value added can be traced back to 1960, the WDI's report of sectoral shares of employment only starts in 1980, which is the major reason our sample starts in the same year.

In the literature on the BS effect, the share of government in GDP and the growth rate of M2 are often controlled. Both variables (labeled by *gov_GDP* and *g_M2*) are obtained from the WDI. To avoid the compounding effects of hyperinflation and large-scale monetary contractions (often resulting from economic depressions), we exclude outliers below the 5th or above the 95th percentile of *g_M2*.

H1.2 involves the role of nominal wage rigidity. We use the share of rural population as a proxy for it, with the following rationale. We are interested in how the FERR dampens the BS effect when a positive productivity shock causes real appreciation, particularly when a country adopts the export-led growth model. In such a country, there are often surplus workers in the countryside, which reduces the bargaining power of workers in the country's nonagricultural sectors and, by our theory, suppresses the BS effect. When labor is being drawn out of agriculture, both the rural population and the number of surplus labor decline. Therefore, the share of rural population (*rural*) can be an indicator for nominal wage rigidity. This variable is obtained from the WDI. To alleviate the problem of endogeneity, the variable is lagged by one year in regressions (denoted by *l.rural*).

To test H2, we need data for the real wage, which is estimated using three variables in PWT9.0. The database offers a consistent and good measure across the many countries and the period of time covered by our study. We first back out the total real wage income by multiplying the share of labor compensation in GDP by real

GDP. It is then divided by the total employment to obtain a proxy of the real wage rate (*rwage*). To remove the effects associated with the level of wage, we introduce the number of workers hired by $1,000 capital stock (*L/K*) as a control variable. This variable is equal to the number of workers divided by the amount of capital stock (in 2011 current PPP dollars), which are both obtained from PWT9.0. As with other control variables, *L/K* is lagged by one year in regressions.

To test H3, we measure tradable sector employment by the industrial sector's share in total employment (*Ind_emp*) reported by the WDI. This hypothesis involves the status of trade surplus and the size of the export sector. The status of trade surplus (*d_surp*) is defined as a dummy variable according to the current account balance information reported by the WDI. The dummy equals 1 when the current account balance is positive and 0 otherwise. It is lagged one year when it enters regressions (*l.d_surp*). There are no ready data for the size of the export sector. We use the value share of export in industrial value added as its proxy. This share (*exp_ind*) is obtained by dividing the share of export in GDP by the share of the industrial sector's value added in GDP, both available in the WDI. As with other conditional variables, the obtained variable is lagged one year when it enters regressions.

And finally, H4 needs a definition for developing countries and data for per-capita GDP. For the latter, we used the data provided by PWT9.0 (*rgdppc*, in 2011 current PPP dollars) because it provides a more accurate international comparison.[7] We use the World Bank definition to define developing countries. This definition considers four income groups: high income, upper middle income, lower middle income, and low income. The last three groups are combined to form the group of developing countries in our tests. A descriptive summary of all the variables is available in Panel A of Table 1.

[Table 1 about here]

The definition of the FERR is important for our study. We construct five

[7] PWT reports two GDP series. We use RGDPCH, which is a chain index that uses current price weights of C, I, and G. The other series, RGDPL, is a fixed-base index using reference year shares.

definitions of the FERR from five popular categorizations of the exchange rate regime. The first is the IMF's de jure classification system, which used to be the typical method for the categorization of exchange rate regimes (for example, Baxter and Stockman 1989). However, the regime a country actually adopts may differ from the one it officially claims. More recently, alternative classification systems based on a country's de facto behavior have been proposed.

RR (Reinhart and Rogoff 2004) and IRR (Ilzetzki, Reinhart, and Rogoff 2008), are two of such classification systems. They are created from the same algorithm that takes into consideration parallel official and unofficial currency markets. Detailed information about the algorithm can be found in Reinhart and Rogoff (2004). The coverage of RR and IRR both start from 1946. While RR stops at 2001, IRR continues to 2007, with its first release in 2008. It has been updated in 2010 and 2017.[8] The main difference between IRR and RR, according to Ilzetzki, Reinhart, and Rogoff (2017), is that IRR advances RR as it "tackle[s] the critical question of anchor currencies directly."

Another de facto definition is LS (Levy-Yeyati and Sturzenegger 2003). It is constructed by cluster analysis based on three measures of volatility: (a) the absolute change in the exchange rate, (b) the standard deviation of percentage changes in the exchange rate, and (c) the absolute change in dollar-denominated reserves relative to the dollar value of the base money. Exchange rate regimes are categorized into three groups: fixed, intermediate, and floating. The original coverage of LS ranges from 1974 to 2004.

The last definition JS (Shambaugh 2004) is based on the de facto degree of exchange rate movements over a period. JS only considers two groups of regimes: the group of "pegs," in which the monthly exchange rate stays within ± 2 percent bands for at least two years; and the group of "nonpegs" if otherwise. The original coverage

[8] The 2008 version is reported on Reinhart's personal website at http://www.carmenreinhart.com/data/browse-by-topic/topics/11/; The 2010 update is available at Ilzetzki's personal website at personal.lse.ac.uk/ilzetzki/data/ERA-Annual%20fine%20class.xls; and the 2017 update is reported by a working paper (Ilzetzki, Reinhart, and Rogoff 2017) at http://www.nber.org/papers/w23135.pdf.

of JS ranges from 1970 to 2004.

Rose (2011) updates RR, LS, and JS to 2007. The longest period covered for the classifications is 1970–2007. We obtained data of these classifications as well as that of IMF from Rose's personal website.[9] We've found that the classifications of some countries (including China) have been changed by IRR over its updates. To keep IRR consistent with Rose (2011), we used its 2008 version downloaded from Reinhart's website (reported in footnote 8). This is another reason our sample stops at 2007. The FERR dummy is then defined in the following way.

For the IMF and RR classifications, we follow Rose (2011) to define FERR = 1 if a regime is categorized in the group of "currency union/fix" and FERR = 0 if a 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 (2011). The IRR classification is more complicated. 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 FERR = 0 if a regime is in grids 5–13 (which range from cases of "preannounced crawling peg" to cases of "freely floating"). But cases of "freely falling" are excluded again. For the LS classification, we define FERR = 1 if a regime is categorized in the group of "fixed" and FERR = 0 if it is categorized in the group of "intermediate" or "floating." For the JS classification, FERR = 1 for the group of pegs and FERR = 0 for the group of nonpegs. Panel B of Table 1 provides a descriptive summary of the five definitions of FERR.

## 4. Empirical Results

### *4.1 The FERR dampens the BS effect*

Before testing H1, we check whether the BS effect holds on average in our sample. Table 2 reports three sets of results. Column (1) presents the results of a panel

[9] http://faculty.haas.berkeley.edu/arose.

regression of ln$RER$ on ln$A_{TS}$ with country and year fixed effects. Because $RER$ is in indirect quote, a larger value means real appreciation. The BS effect tells us that when a country observes a productivity progress in the tradable sector relative to the nontradable sector, then it should expect real exchange rate appreciation. The coefficient of ln$A_{TS}$ implies that elasticity of RER is 0.053 (that is, when the relative productivity increases by 1 percent, there will be a 0.053 percent appreciation in the RER). The elasticity of RER and the elasticity of IRER is related by the equation $\eta_{IRER} = \eta_{RER} / (1-\alpha)$. Recall that $1 - \alpha$ is the expenditure share of the nontradable good in a country; it is usually higher than 0.5. So the elasticity of IRER is likely to be less than 0.1. Tica and Druzic (2006) provide a comprehensive review of empirical studies on the BS effect. The elasticity of IRER ranges from negative numbers to numbers as high as 2.0 in the papers under the review. Our result is definitely not an outlier.

[Table 2 about here]

Column (2) then adds lagged *gov_GDP* and *g_M2* as controls in the regression. As expected, a higher share of government expenditure in GDP causes real undervaluation. The coefficient of money growth is positive, but highly insignificant both economically and statistically. The BS elasticity is still positive, but becomes statistically insignificant. Following some studies in the literature (see Tica and Druzic (2006) for some of the examples), we then remove the year fixed effects and rerun the regression. The results are presented in column (3) of Table 2. While the results of *gov_GDP* and *g_M2* are qualitatively unchanged, the BS elasticity becomes significant. In addition, its magnitude becomes much larger than the estimate provided by column (1). We acquire different results between column (2) and column (3), probably because money growth was correlated with labor productivity in a specific country but was highly heterogeneous across countries in a specific year. With the year fixed effects in the regression, the comparison has to be made within specific years, which could reduce the significance of labor productivity. In contrast, when the year fixed effects are taken out, the comparison is made across all sample years, so the impact of temporal shocks to money growth can be averaged out.

To continue, we test H1.1 by the following two-way fixed effect panel regression:

$$\ln RER_{it} = \eta_0 + \eta_1 \ln A_{TS,it} + \eta_2 \ln A_{TS,it} \times FERR_{it} + \eta_3 FERR_{it} + \theta_i + \theta_t + \varepsilon_{it}\,, \qquad (12)$$

where $i$ is an index for country, $t$ is an index for year, and $\theta_i$ and $\theta_t$ are the country and year fixed effects, respectively. In the equation, $\eta_1$ corresponds to $\eta_{Float}$ in the model and should be positive.[10] Meanwhile, H1 says that the effect would be dampened by the FERR, which suggests a negative value of $\eta_2$. Then, $\eta_{FERR} = \eta_1 + \eta_2$. We add the FERR as a standalone variable in the equation to capture the FERR's impact on the RER independent of the BS effect. We do not include the two control variables *gov_GDP* and *g_M2* in the regression because we want to keep the year fixed effects. Including those two variables does not affect our results concerning $\eta_2$, the parameter of our main concern, mainly because $\eta_2$ is estimated by a kind of difference-in-difference estimator that explores the within differences created by the exchange rate regime among countries with the same level of relative sectoral labor productivity. For a comparison, we present the results with the control variables in the Appendix.

Table 3 presents the estimation results of Equation (12) for the five definitions of the FERR. It shows that $\eta_1$ is significantly positive under the IMF, RR, and IRR definitions of the FERR. Its magnitude is larger than the estimate provided by column (1) of Table 2. So the BS effect holds under the floating regime if those three definitions of the exchange rate regime are used. Under the RR and IRR definitions, $\eta_2$ is negative and significant, which is consistent with the prediction of H1.1. As mentioned, RR and IRR are highly correlated, so we are not surprised that they offer similar results. They are also by far the most comprehensive and probably the most accurate classification systems for the de facto exchange rate regime. From the estimates provided by RR and IRR, $\eta_{FERR}$ is negative. That is, real devaluation happens when the relative sectoral labor productivity increases under the FERR. However, this does not mean that the FERR causes real devaluation. The coefficient of the standalone dummy FERR is always positive and significant. The average effect of FERR is $\eta_2 \ln A_{TS} + \eta_3$; the sample mean of $\ln A_{TS}$ is 0.124,so together with the estimates provided in Table 2 we know that the average effect of FERR is always positive regardless of which definition is used. That is, on average the FERR causes real overvaluation, which may explain why some studies have found that the FERR is

[10] To be exact, up to the factor 1 – . See footnote 6 for more explanations.

detrimental for growth.

[Table 3 about here]

To test H1.2, we add to the baseline regression in Equation (12) a triple interaction term $\ln A_{TS} \times FERR \times l.rural$. To control the level effect of the share of rural population, we also include the variable *l.rural*. Table 4 presents the results. The BS elasticity under the floating regime (the coefficient of $\ln A_{TS}$) is significant under the IMF, RR, and IRR definitions. The coefficient of the triple interaction term, $\ln A_{TS} \times FERR \times l.rural$, is also significant and negative, as H1.2 predicts. The mean value of *l.rural* is 0.49 in the sample, suggesting that the difference of the BS elasticity between the floating regime and the FERR is 0.007, 0.177, and 0.240, respectively, under the three definitions. The estimates provided by RR and IRR are very close to their corresponding estimates of $\eta_2$ presented in Table 2. In summary, H1 is confirmed when RR or IRR is adopted to define the FERR.

[Table 4 about here]

### *4.2 Wage growth is slower under the FERR*

H2 tells us that by dampening the BS effect, FERR will also have a suppressive effect on real wage growth when the tradable sector receives a positive productivity shock. In fact, the gap of wage growth between the FERR and the floating regime is proportional to their gap of the BS elasticity. To account for this finding, we could first calculate the amount of real undervaluation, $-\eta_2 \ln A_{TS}$, and then regress the wage rate on it. However, for a more flexible representation of the gap between the two exchange rate regimes and for a comparison with other studies, we estimate the following model for the wage rate:

$$\ln wage_{it} = b_0 + b_1 \ln A_{TS,it} + b_2 \ln A_{TS,it} \times FERR_{it} + b_3 FERR_{it}$$
$$+ b_4 (K/L)_{it-1} + \theta_i + \theta_t + \varepsilon_{it} \,. \quad (13)$$

This specification is slightly different from what is required by H2, which makes an assessment about an increase in $A_T$ conditional on $A_S$, not an increase in $A_{TS}$. However, because $A_{TS}$ enters the regression in a logarithm term, the specification is equivalent to adding both $\ln A_T$ and $\ln A_S$ in the equation, albeit their coefficients are forced to have exactly the same absolute value but opposite signs. This restriction allows us to see how real undervaluation caused by the FERR suppresses wage growth. In the equation, $b_1$ measures the elasticity of wage with respect to the relative labor productivity under the floating regime, and $b_2$ measures the FERR's strength to suppress wage growth and should be negative. Let $b$ be the rate of response of wage growth to real undervaluation, so then $b = -b_2 / \eta_2$. Because capital is absent in our model but can affect the wage rate, we add lagged labor-capital ratio in the regression. This variable also controls the level of the wage rate in each country.

The results are reported in Table 5. Because there are many missing values for the share of labor compensation in the WDI, the number of observations declines substantially. However, our results are quite consistent with H2.

[Table 5 about here]

The coefficient of $\ln A_{TS}$ is positive in all regressions, which suggests that an increase in the relative labor productivity leads to higher wage growth under the floating regime. This result is not part of our theoretical model, but rather an empirical regularity. It shows that, on average, wage growth has been driven by the growth of labor productivity in the industrial sector in our sample countries. The effect is very strong. For a 1 percent increase in the relative productivity, the wage rate would grow 1.46 percent (IRR) to 3.19 percent (LS) faster, depending on the definition of the exchange rate regime. However, the coefficient of the interaction term, $b_2$, is estimated to be significantly negative under all the definitions, confirming H2. Under the FERR, wage still grows in response to the growth of relative labor productivity, but its growth rate is substantially smaller than under the floating regime. The gap ranges from 0.46 percent (RR) to 1.34 percent (IMF) for a 1 percent growth of relative productivity. Taking the estimate of $b_2$ produced by IRR and the corresponding estimate of $\eta_2$ reported by Table 2, we obtain $b$ = –2.85. That is, a 1 percent real undervaluation caused by the FERR would bring down wage growth by 2.85 percentage points for 1 percent growth of relative productivity.

As expected, more workers hired by $1,000 capital significantly reduce the wage rate. In contrast, FERR alone does not affect the wage rate except when it is defined by IMF.

### *4.3 The FERR promotes industrial employment*

H3.1 states that the FERR creates higher employment in the tradable sector than the floating regime when a positive shock happens to the relative productivity $A_{TS}$ in countries with a trade surplus. Consequently, we estimate the following equation:

$$\ln ind\_emp_{it} = \gamma_0 + \gamma_1 \ln A_{TS,it} + \gamma_2 \ln A_{TS,it} \times FERR_{it} + \gamma_3 \ln A_{TS,it} \times FERR_{it} \times l.d\_surp_{it}$$

$$+\gamma_4 FERR_{it} + \gamma_5 l.d\_surp_{it} + \gamma_6 \ln A_{TS,it} \times l.d\_surp_{it} + \theta_i + \theta_t + \varepsilon_{it} . \quad (14)$$

Because *l.d_surp* is a dummy variable, controlling it and its interaction with $\ln A_{TS}$ is necessary to obtain the correct estimates for the coefficients of the other two interaction terms—$\ln A_{TS} \times FERR$ and $\ln A_{TS} \times FERR \times l.d\_surp$. The coefficient of $\ln A_{TS}$, $\gamma_1$, measures the elasticity of tradable-sector employment with respect to the relative labor productivity under the floating regime, although we do not have prior knowledge about its sign. So then, $\gamma_1 + \gamma_2$ and $\gamma_1 + \gamma_2 + \gamma_3$ measure that elasticity under the FERR in countries without trade surplus and in countries with a surplus, respectively. According to H3.1, $\gamma_2$ shall not be significant and $\gamma_3$ shall be significantly positive.

Table 6a presents the regression results. It shows that $\gamma_1$ is significantly negative regardless of which definition of the FERR is adopted. That is, faster growth of labor productivity in the tradable sector than in the nontradable sector squeezes labor out of the tradable sector under the floating regime. Consistent with H3.1, $\gamma_2$ is insignificant under all the definitions of the FERR, and $\gamma_3$ is significantly positive under all definitions except for LS. Inspecting the magnitudes of $\gamma_1$, $\gamma_2$, and $\gamma_3$, we know that industrial employment also declines under the FERR. This decline is true even in surplus countries adopting the FERR. However, the positive impacts of the FERR and trade surplus are economically meaningful and are shown to be the largest under IRR. When the relative labor productivity is increased by 10 percent in a country adopting the FERR, that country's industrial sector would hire 1.7 percent more workers if it runs a trade surplus instead of a trade deficit. However, for the same amount of increase in the relative labor productivity, countries adopting the FERR on average would hire 0.8 percent more workers in their industrial sector than countries adopting the floating regime.

[Table 6a about here]

H3.2 highlights the role of the share of exports in the tradable sector. To test the hypothesis, we replace the dummy variable *l.d_surp* with the variable *l.exp_ind* in Equation (14) and replicate the regressions reported by Table 6a. The results are reported in Table 6b. The estimates for the coefficients of $\ln A_{TS}$ and $\ln A_{TS} \times FERR$ are qualitatively the same as those reported in Table 6a. Consistent with H3.2, the coefficient of $\ln A_{TS} \times FERR \times l.exp\_ind$ is positive and significant under the IMF, RR, and IRR definitions of the FERR. The effect of the FERR would be reinforced by 0.1 to 0.2 percent for every 10 percent increase in the share of exports. On average, for every 10 percent increase in the relative labor productivity, a country would hire 0.9 (IMF) to 1.8 (IRR) percent more workers in its industrial sector when it adopts the FERR than the floating regime.

[Table 6b about here]

### *4.4 The FERR promotes growth for surplus countries*

H4.1 predicts that when labor productivity increases in the tradable sector, surplus countries will have faster growth under the FERR than the floating regime. As in the case of the wage rate, we study the relative productivity $A_{TS}$ instead of $A_T$ conditional on $A_S$. Replacing the dependent variable in Equation (14) by ln*rgdppc* and adding ln(*l.rgdppc*) on the right-hand side to make a growth equation, we then test H4.1 and present the results in Table 7a. The coefficient of $\ln A_{TS}$ is significantly positive under IMF, LS, and JS, indicating that, under those three definitions, the overall growth of a country adopting the floating regime is driven by the advancement of labor productivity in the industrial sector over that in the service sector. The coefficients of $\ln A_{TS} \times FERR$ and $\ln A_{TS} \times l.d\_surp$ are insignificant in most regressions. That is, the FERR or running trade surplus alone does not help growth. However, the coefficient of $\ln A_{TS} \times FERR \times l.d\_surp$ is significantly positive in all regressions, which suggests that the FERR works in favor of surplus countries. For every 10 percent progress in the relative productivity, surplus countries will grow 0.2–0.4 percent faster than deficit countries in the short run when both groups of countries adopt the FERR. The sum of the coefficients of $\ln A_{TS} \times FERR$ and $\ln A_{TS} \times FERR \times l.d\_surp$ is positive. Therefore, the FERR performs better than a floating regime on average.

[Table 7a about here]

Two somewhat surprising results are found for the independent roles of trade surplus and the FERR. Running trade surplus is shown to have an independent and positive effect on growth, and this effect is robust regardless of which definition of the FERR is adopted in the regression. On average, a surplus country grows 0.6–1.0 percent faster than a deficit country. In addition, the FERR is also shown to have an independent and significantly positive effect on growth under IMF, LS, and JS. However, because significant results are not obtained when the two most comprehensive definitions, RR and IRR, are used in the regressions, we are not sure whether the positive results reflect the FERR's true contribution.

H4.2 predicts that the effect of FERR on economic growth should be more significant in developing countries. The reason for differentiating developing and developed countries is because of the role of the initial unit labor cost $\omega^0$ in the tradable sector. Recall that $\omega = w / A_T = p / A_{TS}$. Figure 1 then depicts the kernel density of ln($RER/A_{TS}$) for the four World Bank income groups, L (low income), LM (lower middle income), UM (upper middle income), and H (high income). Because ln*RER* is proportional to ln*p*, the distributions are the same as those of ln(□). We find clear stochastic dominance of higher income groups over lower income groups. That is, statistically speaking, low-income countries have smaller unit labor costs. This provides an empirical rationale to study the developing country and developed country subsamples separately.

[Figure 1 about here]

Table 7b reports the results of the same regressions reported by Table 7a, albert on the developing country subsample. The estimates for ln$A_{TS}$ are essentially unchanged compared with their counterparts reported in Table 7a, as are the estimates for ln$A_{TS}$×*FERR*×*l.d_surp*. The statistical significances of some other variables have been changed, but apparently those changes have not altered our main results. The results can be contrasted with the results of the developed country subsample, which are reported by Table 7c. Among developed countries, no estimate for ln$A_{TS}$, or any estimate for ln$A_{TS}$×*FERR*×*l.d_surp* is statistically significant. Clearly, the positive role of relative labor productivity in driving economic growth is only found in developing countries, just as the FERR augments that role only in developing countries.

[Tables 7b and 7c about here]

## 5. Simulations on China

China offers one of the most successful stories of export-led growth in the past several decades. China is also one of the most significant examples of using the FERR to promote exports. In this section, we adopt the previous empirical results to conduct some simulations to see how the FERR has led to real undervaluation and faster economic growth at the cost of slower real wage growth in China during the period of fast-growing industrial labor productivity.

Briefly speaking, China's exchange rate regime has experienced three phases in the reform era (see Figure 2): (1) 1979–1993, a transition period when a dual-track exchange rate regime prevailed; (2) 1994– a period of a peg system that pegged the yuan to the dollar (1 U.S. dollar = 8.25 Chinese yuan); and (3) July 2005 onward, a period of a crawling peg system that makes reference to a basket of currencies. Because our empirical models perform the best under RR and IRR, we adopt their classifications to define China's exchange rate regimes. Although in the first phase the government track fixed the exchange rate, the market track allowed the exchange rate to float. Licensed exporters could tap into the benefits offered by the market track. For this reason, this phase is defined as floating by RR and IRR. The period 1994-2007 is defined as a period of fixed regime by Rose's updates of RR and IRR's initial 2008 version. According to IRR's most recent update in 2017, the third phase is changed to a floating regime. We keep the classification we used in our econometric exercises (the 2008 version of IRR) because we believe that it is more consistent with the popular view about China's exchange rate regime.

[Figure 2 about here]

The period we study is 1994–2007. In this period, China had a fixed regime, always ran trade surplus, and, as we will see in a while, registered faster growth of labor productivity in its industrial sector than in its service sector during most of the period.

Figure 3a presents China's annual growth rates of labor productivity in the industrial and service sectors, respectively, and their differences from 1981 to 2008. The growth rate of industrial labor productivity increased in the early years and peaked in the early part of the 1990s. Between 1991 and 1994, the annual growth rate remained above 13 percent. After that, the growth slowed down, albeit the average remained at a respectable 9 percent. In comparison, the service sector did not show a clear pattern. The average growth rate was 7.6 percent. The difference between the two sectors, which we are more interested in, was negative before 1987 (except 1984) and after 2005 (except 2008) and was positive from 1987 to 2004. With an average of 4.2 percent, the gap for 1987–2004 was very substantial.

[Figure 3a about here]

Figure 3b presents the cumulative growth of labor productivity in the two sectors and their gaps between 1980 and 2008. Growth in the two sectors was phenomenal. In the service sector, one worker in 2008 was equivalent to eight workers in 1980; in the industrial sector, the corresponding number was 12. The figure shows that the departure point was the early 1990s. Before that date, the gap between the two sectors was almost constant, but by 2005, it was increased to about twice the initial value. Since 2005, the gap has narrowed because of slower growth in the industrial sector versus the service sector.

[Figure 3b about here]

By our theory and empirical analysis, this large gap of labor productivity in the industrial and service sectors should allow the FERR to cause real undervaluation and higher economic growth, albeit with the cost of slower wage growth. To keep our exercise consistent with our theory, we only focus on the FERR's effects associated with faster growth of industrial labor productivity and ignore its other effects.

Based on the results of Table 3, we first construct China's counterfactual *RER* growth if the country had adopted a floating regime from 1994 to 2007 when it had actually adopted the FERR:

$$d \ln X^{simu} = d \ln X^{actual} + \Delta\eta \times d \ln A_{TS} . \quad (15)$$

In the equation, $X$ is the outcome variable we are concerned about. In the case of the real exchange rate, $X = RER$. The superscript *simu* indicates the simulated value of the outcome variable, and the superscript *actual* indicates its actual value. Because China adopted the FERR in 1994–2007, the actual values are supposed to be created by the FERR. So $\Delta\eta$ in the equation is the gap of elasticity between the floating regime and the fixed regime. In the case of the RER, it is equal to $\hat{\eta}_{float} - \hat{\eta}_{FERR}$, where $\hat{\eta}_{float}$ and $\hat{\eta}_{FERR}$ are the estimated BS elasticities for the floating regime and FERR, respectively. By Equation (12), $\Delta\eta$ is equal to $-\eta_2$. According to Table 2, which reports the results of Equation (12), $\Delta\eta$ is 0.13 under RR and 0.21 under IRR.

The actual RER appreciated by 4.78 percent annually during 1994–2007. In the meantime, the relative labor productivity of the industrial and service sectors grew by 1.50 percent annually. So by Equation (15), the RER would have appreciated 0.20 percent (RR) to 0.32 percent (IRR) faster every year if China had adopted a floating regime during the study period. Figure 4 presents the cumulative growth of the actual RER and two counterfactuals (1994 = 100), corresponding to RR ($\Delta\eta = 0.13$) and IRR ($\Delta\eta = 0.21$), respectively, if China had adopted a floating regime in 1994–2007. The actual RER index grew to 217, while in the two counterfactuals the RER indexes would have been 223 and 226, respectively. The differences are not large, but we will see that the impacts on wage, industrial employment, and GDP growth are substantial.

[Figure 4 about here]

Next, we study the repression of wage growth using the results provided by Table 5. Replacing the RER with the real wage in Equation (15), we can then obtain simulated wage growth rates for our study period. Now, $\Delta\eta$ corresponds to $-b_2$ in

Equation (13). According to Table 5, which reports the results of Equation (13), we take 0.46 (RR) or 0.61 (IRR) as values for simulation. The real wage would have been expected to grow by 11.75 percent (RR) to 12.09 percent (IRR) annually if a floating regime had been adopted. Because of the suppressive effect of FERR, the actual growth rate was 10.66 percent, effectively dampening real wage growth by 1.09 (RR) to 1.43 (IRR) percentage points. In the end, the FERR took a heavy toll on the real wage (Figure 5): the actual wage index grew from 100 in 1994 to 378 in 2007, 9.52 percent (RR, 414 in 2007) to 12.69 percent (IRR, 426 in 2007) short of the simulated growth.

[Figure 5 about here]

Our third simulation is for the share of industrial employment. In Equation (15), *X* is now the share of industrial employment. According to Equation (14), which we used to study industrial employment, $\Delta\eta$ should include the effects of the two interaction terms and is equal to $-(\gamma_2+\gamma_3)$ this time. We use the results provided by Table 6a to conduct our simulation. This time, $\Delta\eta$ is equal to –0.14 (RR) or –0.15 (IRR). The simulation results, together with the actual data, are presented in Figure 6. The share of industrial employment declined during the aftermath of the 1997 Asian Financial Crisis, but began to increase drastically since 2002 after China joined the World Trade Organization the previous year. In 2007, the share of industrial employment was 4.1 percentage points higher than in 1994 (22.7 percent in 1994 and 26.8 percent in 2007). According to our simulation, the FERR contributed 0.83 (RR) to 0.88 (IRR) percentage points to that growth.

[Figure 6 about here]

Last, we study the growth of real GDP per capita. We still use Equation (15), and *X* is now real GDP per capita. As in the case of industrial employment, $\Delta\eta$ is still equal to $-(\gamma_2+\gamma_3)$. We take the results of developing countries, provided by Table 7b, to conduct our simulation. This time, $\Delta\eta$ is equal to 0.019 (RR) or 0.023 (IRR). The simulation results are presented in Figure 7. The actual annual growth rate between 1994 and 2008 was 9.32 percent, and the cumulative growth during this period was 3.11 times. If China had adopted a floating regime, though, the average annual growth rate would have been reduced to 7.95 percent (RR) and the accumulative growth would have been reduced to 2.75 times. That is, China's GDP per capita would have been reduced by 11.37 percent. Because wage growth was suppressed, the gain from the FERR has been entirely accrued to capital.

[Figure 7 about here]

One of the phenomenal developments in China between the early 1990s and 2008 was the decline of labor share in national income. In 1996, the share of labor compensation in national income reached the historical record of 53 percent; by 2007, it declined to 39.7 percent.[11] There are many possible explanations for this sharp decline: the existence of a large amount of surplus labor, an inefficient financial market (Song, Storesletten, and Zilibotti 2011), and structural change driven by industrialization (Mao, Liu, and Yao 2016) are all credible candidates. The results of this paper provide another explanation, namely, the FERR promoted faster economic growth but suppressed wage growth. By our simulation results under RR, out of the total amount of decline of 13.7 percent in the labor share, the FERR contributed 3.26 percent.

## 6. Conclusion

In this paper, we develop a simply theoretical model to show that the FERR dampens the BS effect in the presence of nominal wage rigidities when a country experiences faster growth of labor productivity in its tradable sector than its nontradable sector. Based on this core conclusion, we have further developed several hypotheses concerning the effects of the FERR on real wage, sectoral labor allocation,

[11] Figures are from the Flow of Funds Table from the National Bureau of Statistics.

and economic growth. We also find that other fundamentals, such as the external balance position, the export share in the tradable sector, and development stages, have interactive effects with the exchange rate regime. Based on panel data assembled from the WDI and PWT9.0, we test the hypotheses developed by our theoretical model under five popular categorization systems of exchange rate regimes and find robust and supportive results under RR and IRR, the two most comprehensive categorization systems for de facto exchange rate regimes.

Our results about the role of the FERR fill the gap between the reality and the existing academic literature. The novelty of our theory is that we take into account a key economic fundamental, namely, faster productivity growth in the tradable sector than the nontradable sector. Our work highlights several key elements of the FERR as a policy tool to promote export-led growth. First, real undervaluation caused by the FERR is essentially a subsidy for export; it pays off when the tradable sector leads the country in productivity growth. This explains why the FERR and export-led growth are often adopted together. Second, because the tradable sector is more likely to register high growth rates of labor productivity when a country is on its way to industrialization, export-led growth and the FERR work the best in a country's catching-up period. This was exactly what the successful peripheral countries did (for example, Japan and Western Germany in the 1950s and 1960s and South Korea and Taiwan before 1997). Third, the FERR promotes export-led growth not without any cost; it obtains higher overall growth rates by suppressing wages. Essentially, it trades long-term growth with lower current consumption of wage earners.

Our simulation exercise on China illuminates those elements and provides an explanation for the declining share of labor income in the country's national income. It also provides a clue for the urge for China to adopt a more flexible exchange rate today because the country as a whole has finished industrialization.

One element that our study does not tackle is the financial costs of the FERR. To maintain the FERR under the export-led growth model, the central bank has to build up excessive foreign reserves. Because the export-led growth model is often adopted when a country experiences fast growth, the domestic rate of return to capital is often higher than what foreign reserves can get in the international market. As a result, building up foreign reserves often entails financial losses. It is interesting to find that countries adopting the export-led growth model often ignore those losses. Explaining this finding, though, is beyond the scope of this paper.

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Table 1. Summary Statistics of Variables

| Variables | Obs. | Mean | Std. | Min. | Max. | Unit |
|---|---|---|---|---|---|---|
| Panel A | | | | | | |
| *RER* | 3,463 | 0.389 | 0.788 | 0.018 | 47.815 | |
| $A_{TS}$ | 2,410 | 1.282 | 0.913 | 0.311 | 15.608 | |
| *gov_GDP* | 9,923 | 15.722 | 6.960 | 0 | 156.5315 | % |
| *g_M2* | 6,380 | 16.576 | 11.750 | -2.893 | 57.732 | % |
| *rwage* | 2,982 | 18635.500 | 16911.270 | 214.566 | 147586.400 | dollars |
| *rural* | 12,739 | 0.496 | 0.247 | 0.000 | 0.975 | |
| *L/K* | 8,244 | 0.102 | 0.245 | 0.0006 | 3.943 | persons /1000 dollars |
| *ind_emp* | 2,826 | 24.853 | 7.702 | 2.100 | 51.800 | % |
| *d_surp* | 10,331 | 0.334 | 0.472 | 0 | 1 | |
| *exp_ind* | 5,691 | 5.383 | 5.841 | 0.125 | 87.435 | % |
| *rgdppc* | 6,575 | 9,782.760 | 11,837.560 | 153.165 | 111,730.400 | dollars |
| Panel B | | | | | | |
| IMF | 3,963 | 0.435 | 0.496 | 0 | 1 | |
| RR | 3,816 | 0.359 | 0.480 | 0 | 1 | |
| IRR | 4,118 | 0.461 | 0.499 | 0 | 1 | |
| LS | 3,227 | 0.522 | 0.500 | 0 | 1 | |
| JS | 4,116 | 0.422 | 0.494 | 0 | 1 | |

Note: All monetary figures are measured in 2011 purchasing power parity dollars; *g_M2* excludes outliers below the 5th or above the 95th percentile.

**Table 2. Evidence for the BS Effect**

| Dep. variable<br>ln*RER* | (1) | (2) | (3) |
|---|---|---|---|
| $\ln A_{TS}$ | 0.0528** | 0.0118 | 0.314*** |
| | (0.0255) | (0.0278) | (0.0337) |
| *l.gov_GDP* | | -0.00497* | -0.0122*** |
| | | (0.00255) | (0.00341) |
| *l.g_M2* | | 6.09e-05 | 8.41e-05 |
| | | (3.84e-05) | (5.16e-05) |
| Country FEs | Y | Y | Y |
| Year FEs | Y | Y | N |
| Constant | -0.449*** | -0.460*** | -0.688*** |
| | (0.0263) | (0.0486) | (0.0527) |
| Observations | 1,934 | 1,403 | 1,403 |
| R-squared | 0.895 | 0.898 | 0.809 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 3. FERR Suppresses the BS Effect**

| Dep. variable<br>ln*RER* | (1)<br>IMF | (2)<br>RR | (3)<br>IRR | (4)<br>LS | (5)<br>JS |
|---|---|---|---|---|---|
| $\ln A_{TS}$ | 0.0907*** | 0.0823*** | 0.118*** | 0.0487 | 0.0440 |
| | (0.0299) | (0.0319) | (0.0320) | (0.0396) | (0.0330) |
| $\ln A_{TS} \times FERR$ | 0.00997 | -0.127*** | -0.213*** | 0.0166 | -0.0198 |
| | (0.0351) | (0.0459) | (0.0388) | (0.0336) | (0.0329) |
| *FERR* | 0.108*** | 0.0999*** | 0.119*** | 0.0534*** | 0.0902*** |
| | (0.0174) | (0.0178) | (0.0170) | (0.0164) | (0.0159) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | -0.466*** | -0.417*** | -0.454*** | -0.573*** | -0.598*** |
| | (0.0220) | (0.0213) | (0.0212) | (0.0220) | (0.0203) |
| Observations | 1,653 | 1,613 | 1,581 | 1,322 | 1,517 |
| R-squared | 0.904 | 0.903 | 0.909 | 0.895 | 0.905 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 4. Wage Rigidity Enlarges the Gap of BS Effect**

| Dep. variable | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| ln*RER* | IMF | RR | IRR | LS | JS |
| $\ln A_{TS}$ | 0.0922*** | 0.0894*** | 0.118*** | 0.0460 | 0.0451 |
| | (0.0296) | (0.0317) | (0.0320) | (0.0396) | (0.0331) |
| $\ln A_{TS} \times FERR$ | 0.338*** | 0.248** | 0.0182 | 0.124 | 0.0935 |
| | (0.0821) | (0.103) | (0.0864) | (0.0769) | (0.0767) |
| $\ln A_{TS} \times FERR \times l.rural$ | -0.705*** | -0.868*** | -0.526*** | -0.215 | -0.220 |
| | (0.156) | (0.218) | (0.185) | (0.138) | (0.135) |
| *FERR* | 0.116*** | 0.107*** | 0.117*** | 0.0528*** | 0.0906*** |
| | (0.0174) | (0.0177) | (0.0170) | (0.0164) | (0.0159) |
| *l.rural* | 0.782*** | 0.379** | 0.439** | -0.0111 | 0.0760 |
| | (0.195) | (0.188) | (0.191) | (0.229) | (0.206) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | -1.534*** | -1.295*** | -1.318*** | -1.122*** | -1.190*** |
| | (0.0952) | (0.0896) | (0.0904) | (0.112) | (0.0989) |
| Observations | 1,653 | 1,613 | 1,581 | 1,322 | 1,517 |
| R-squared | 0.906 | 0.904 | 0.910 | 0.895 | 0.906 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 5. FERR Suppresses Wage Growth**

| Dep. variable | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| ln*wage* | IMF | RR | IRR | LS | JS |
| $\ln A_{TS}$ | 2.318*** | 1.484*** | 1.458*** | 3.186*** | 2.583*** |
| | (0.485) | (0.154) | (0.160) | (0.632) | (0.460) |
| $\ln A_{TS} \times FERR$ | -1.345** | -0.462** | -0.607*** | -1.118** | -1.109** |
| | (0.548) | (0.235) | (0.233) | (0.548) | (0.506) |
| *FERR* | -0.747*** | -0.0328 | -0.0322 | -0.107 | -0.229 |
| | (0.223) | (0.0858) | (0.0884) | (0.247) | (0.207) |
| $l.(L/K)$ | -9.949*** | -9.224*** | -9.289*** | -17.82*** | -12.94*** |
| | (3.187) | (0.943) | (0.952) | (4.689) | (3.012) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | 4.411*** | 4.701*** | 4.601*** | 4.402*** | 4.336*** |
| | (0.121) | (0.0395) | (0.0426) | (0.177) | (0.124) |
| Observations | 912 | 814 | 796 | 765 | 958 |
| R-squared | 0.781 | 0.955 | 0.953 | 0.770 | 0.779 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 6a. FERR Creates More Industrial Employment in Surplus Countries**

| Dep. variable<br>ln(*ind_emp*) | (1)<br>IMF | (3)<br>RR | (5)<br>IRR | (2)<br>LS | (4)<br>JS |
|---|---|---|---|---|---|
| $\ln A_{TS}$ | -0.367*** | -0.436*** | -0.429*** | -0.369*** | -0.367*** |
| | (0.0219) | (0.0232) | (0.0247) | (0.0255) | (0.0230) |
| $\ln A_{TS} \times FERR$ | 0.0342 | 0.0147 | -0.0244 | -0.0273 | -0.0388 |
| | (0.0349) | (0.0383) | (0.0322) | (0.0245) | (0.0271) |
| $\ln A_{TS} \times FERR \times l.d\_surp$ | 0.0979** | 0.125** | 0.174*** | 0.0101 | 0.0820** |
| | (0.0461) | (0.0513) | (0.0456) | (0.0373) | (0.0381) |
| *FERR* | -0.00873 | 0.00895 | -0.0400*** | 0.0114 | 0.0232** |
| | (0.0123) | (0.0122) | (0.0123) | (0.0102) | (0.0107) |
| *l.d_surp* | 0.0193** | 0.0167* | 0.0161 | 0.00819 | 0.0125 |
| | (0.00970) | (0.00974) | (0.00988) | (0.00955) | (0.00930) |
| $\ln A_{TS} \times l.d\_surp$ | 0.00207 | 0.0366* | 0.0109 | 0.0150 | -0.00754 |
| | (0.0239) | (0.0221) | (0.0234) | (0.0279) | (0.0241) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | 3.163*** | 3.172*** | 3.183*** | 3.166*** | 3.158*** |
| | (0.0155) | (0.0150) | (0.0156) | (0.0141) | (0.0140) |
| Observations | 1,639 | 1,592 | 1,561 | 1,315 | 1,500 |
| R-squared | 0.895 | 0.904 | 0.906 | 0.922 | 0.913 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 6b. A Larger Export Sector Strengthens the Effects of FERR**

| Dep. variable<br>ln(*ind_emp*) | (1)<br>IMF | (2)<br>RR | (3)<br>IRR | (4)<br>LS | (5)<br>JS |
|---|---|---|---|---|---|
| $\ln A_{TS}$ | -0.385*** | -0.414*** | -0.414*** | -0.421*** | -0.402*** |
| | (0.0254) | (0.0308) | (0.0328) | (0.0340) | (0.0296) |
| $\ln A_{TS} \times FERR$ | 0.0472 | -0.0121 | -0.0626 | 0.0138 | 0.0141 |
| | (0.0338) | (0.0460) | (0.0404) | (0.0341) | (0.0342) |
| $\ln A_{TS} \times FERR \times l.exp\_ind$ | 0.0119** | 0.0133* | 0.0228*** | -0.00824 | -0.00443 |
| | (0.00564) | (0.00733) | (0.00740) | (0.00745) | (0.00713) |
| *FERR* | -0.0109 | 0.00686 | -0.0364*** | 0.00826 | 0.0220** |
| | (0.0122) | (0.0122) | (0.0122) | (0.0103) | (0.0108) |
| *l.exp_ind* | -0.00169 | -0.00280 | -0.000659 | -0.00517** | -0.00344 |
| | (0.00216) | (0.00269) | (0.00269) | (0.00256) | (0.00227) |
| $\ln A_{TS} \times l.exp\_ind$ | 0.00630* | 0.000226 | -0.00410 | 0.0151*** | 0.0125** |
| | (0.00355) | (0.00546) | (0.00569) | (0.00582) | (0.00512) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | 3.184*** | 3.196*** | 3.204*** | 3.193*** | 3.176*** |
| | (0.0174) | (0.0172) | (0.0176) | (0.0165) | (0.0161) |
| Observations | 1,608 | 1,572 | 1,542 | 1,288 | 1,470 |
| R-squared | 0.896 | 0.903 | 0.904 | 0.920 | 0.911 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 7a. Surplus Countries Have Faster Growth Under the FERR**

| Dep. variable | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| ln(*rgdppc*) | IMF | RR | IRR | LS | JS |
| $\ln A_{TS}$ | 0.0300*** | 0.000980 | 0.00522 | 0.0269*** | 0.0233*** |
| | (0.00716) | (0.00616) | (0.00650) | (0.00909) | (0.00793) |
| $\ln A_{TS} \times FERR$ | 0.00406 | -0.0163 | -0.0106 | -0.00939 | -0.00667 |
| | (0.0112) | (0.0100) | (0.00846) | (0.00863) | (0.00883) |
| $\ln A_{TS} \times FERR \times l.d\_surp$ | 0.0241* | 0.0387*** | 0.0227** | 0.0309*** | 0.0246** |
| | (0.0134) | (0.0131) | (0.0111) | (0.0115) | (0.0125) |
| *FERR* | 0.0154*** | 0.00442 | 0.00130 | 0.0157*** | 0.0154*** |
| | (0.00399) | (0.00324) | (0.00326) | (0.00368) | (0.00376) |
| *l.d_surp* | 0.00684** | 0.00711*** | 0.00593** | 0.0100*** | 0.00929*** |
| | (0.00314) | (0.00254) | (0.00257) | (0.00341) | (0.00326) |
| $\ln A_{TS} \times l.d\_surp$ | 0.0165** | 0.00570 | 0.00801 | -0.00378 | 0.00470 |
| | (0.00738) | (0.00560) | (0.00574) | (0.00877) | (0.00763) |
| *ln(l.rgdppc)* | 0.923*** | 0.962*** | 0.965*** | 0.921*** | 0.912*** |
| | (0.00817) | (0.00684) | (0.00701) | (0.00991) | (0.00891) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | 0.758*** | 0.400*** | 0.373*** | 0.765*** | 0.854*** |
| | (0.0772) | (0.0652) | (0.0667) | (0.0926) | (0.0832) |
| Observations | 1,626 | 1,591 | 1,560 | 1,314 | 1,495 |
| R-squared | 0.998 | 0.999 | 0.999 | 0.998 | 0.998 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 7b. The Effects of the FERR Are More Pronounced in Developing Countries**

| Dep. variable ln(*rgdppc*) | (1) IMF | (2) RR | (3) IRR | (4) LS | (5) JS |
|---|---|---|---|---|---|
| $\ln A_{TS}$ | 0.0391*** | 0.00527 | 0.0124 | 0.0407*** | 0.0353*** |
| | (0.00967) | (0.00855) | (0.00890) | (0.0120) | (0.0106) |
| $\ln A_{TS} \times FERR$ | -0.00106 | -0.0297** | -0.0232*** | -0.0221* | -0.0200* |
| | (0.0155) | (0.0144) | (0.0108) | (0.0116) | (0.0117) |
| $\ln A_{TS} \times FERR \times l.d\_surp$ | 0.0336* | 0.0441** | 0.0348** | 0.0426** | 0.0356* |
| | (0.0185) | (0.0209) | (0.0171) | (0.0167) | (0.0197) |
| *FERR* | 0.0276*** | 0.00707 | 0.00720 | 0.0264*** | 0.0230*** |
| | (0.00662) | (0.00595) | (0.00588) | (0.00605) | (0.00621) |
| *l.d_surp* | -0.00685 | -0.00642 | -0.00849** | -0.00753 | -0.00691 |
| | (0.00504) | (0.00424) | (0.00428) | (0.00553) | (0.00541) |
| $\ln A_{TS} \times l.d\_surp$ | 0.0236** | 0.0126 | 0.0148* | 0.000981 | 0.0112 |
| | (0.0107) | (0.00769) | (0.00775) | (0.0121) | (0.0109) |
| *ln(l.rgdppc)* | 0.922*** | 0.967*** | 0.967*** | 0.925*** | 0.910*** |
| | (0.0115) | (0.00997) | (0.00982) | (0.0141) | (0.0126) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | 0.729*** | 0.347*** | 0.347*** | 0.690*** | 0.825*** |
| | (0.101) | (0.0876) | (0.0861) | (0.123) | (0.110) |
| Observations | 953 | 872 | 856 | 774 | 889 |
| R-squared | 0.994 | 0.997 | 0.997 | 0.995 | 0.995 |

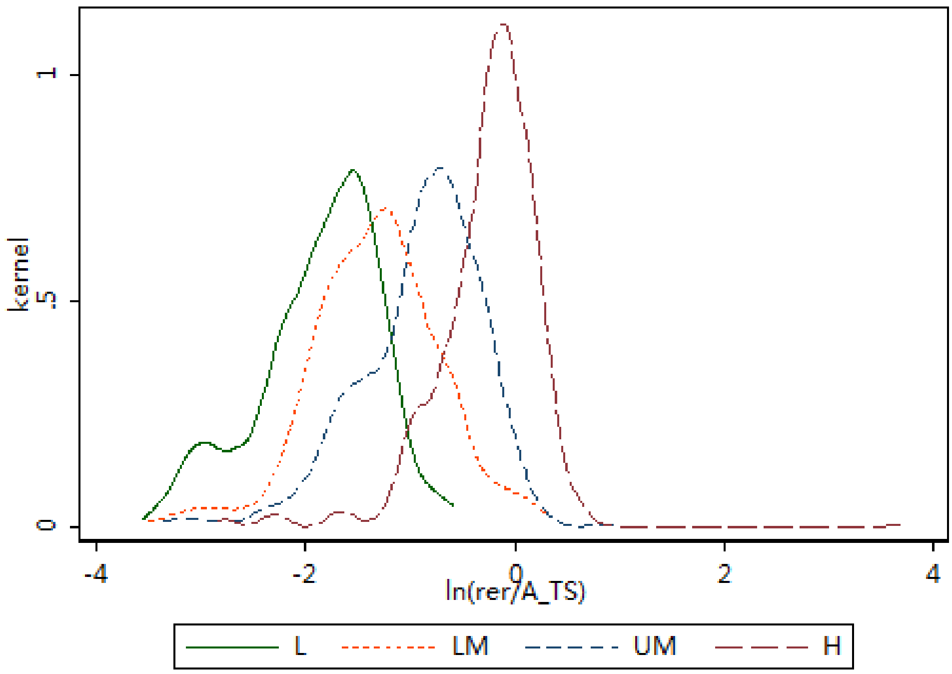
Note: The regressions are run on the sample of less developed countries. Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

**Table 7c. The Effects of the FERR Are Less Pronounced in Developed Countries**

| Dep. variable ln(*rgdppc*) | (1) IMF | (2) RR | (3) IRR | (4) LS | (5) JS |
|---|---|---|---|---|---|
| $\ln A_{TS}$ | 0.0129 | 0.00519 | 0.00250 | -0.0204 | -0.0178 |
| | (0.0130) | (0.0122) | (0.0129) | (0.0171) | (0.0150) |
| $\ln A_{TS}\times FERR$ | -0.0295* | 0.00864 | 0.0258* | 0.0140 | 0.0164 |
| | (0.0156) | (0.0178) | (0.0144) | (0.0168) | (0.0202) |
| $\ln A_{TS}\times FERR\times l.d\_surp$ | 0.0251 | 0.0118 | -0.0161 | 0.00361 | -0.0137 |
| | (0.0187) | (0.0189) | (0.0165) | (0.0191) | (0.0205) |
| *FERR* | -0.00234 | 0.00252 | 0.00315 | 0.00541 | 0.00573 |
| | (0.00378) | (0.00404) | (0.00398) | (0.00410) | (0.00427) |
| *l.d_surp* | 0.00638** | 0.00716** | 0.00582** | 0.00986*** | 0.00739** |
| | (0.00272) | (0.00284) | (0.00286) | (0.00354) | (0.00321) |
| $\ln A_{TS}\times l.d\_surp$ | 0.0170* | 0.0139 | 0.0210** | 0.0212 | 0.0313*** |
| | (0.00953) | (0.00903) | (0.00971) | (0.0133) | (0.0101) |
| *ln(l.rgdppc)* | 0.929*** | 0.929*** | 0.935*** | 0.900*** | 0.915*** |
| | (0.0153) | (0.0128) | (0.0127) | (0.0172) | (0.0148) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | 0.753*** | 0.764*** | 0.696*** | 1.047*** | 0.901*** |
| | (0.158) | (0.133) | (0.131) | (0.176) | (0.152) |
| Observations | 673 | 719 | 704 | 540 | 606 |
| R-squared | 0.995 | 0.995 | 0.995 | 0.993 | 0.994 |

Note: The regressions are run on the sample of developed countries. Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent.

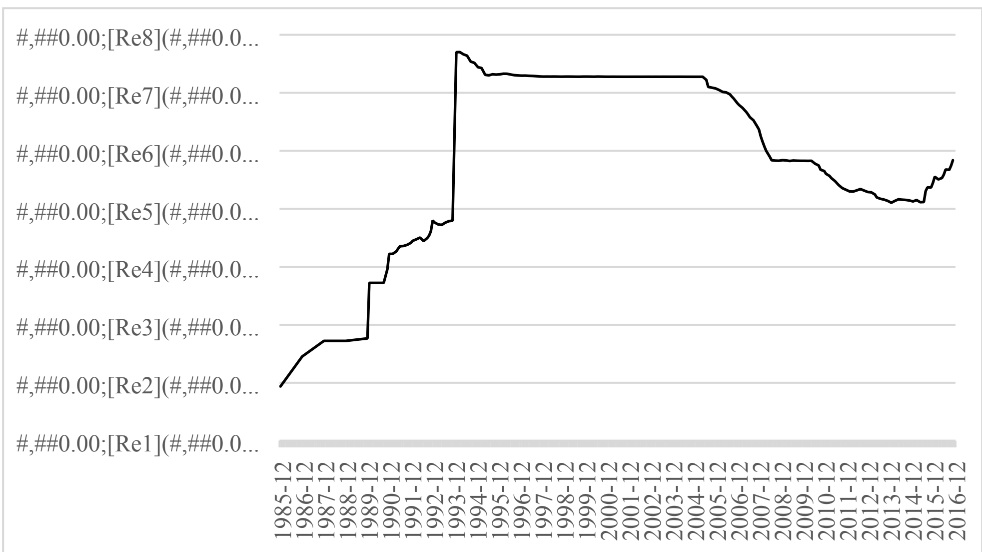
**Figure 1. Kernel Density of $\ln\left(RER/A_{TS}\right)$ by Income Group**




Source: World Development Indicators and Penn World Table 9.0.

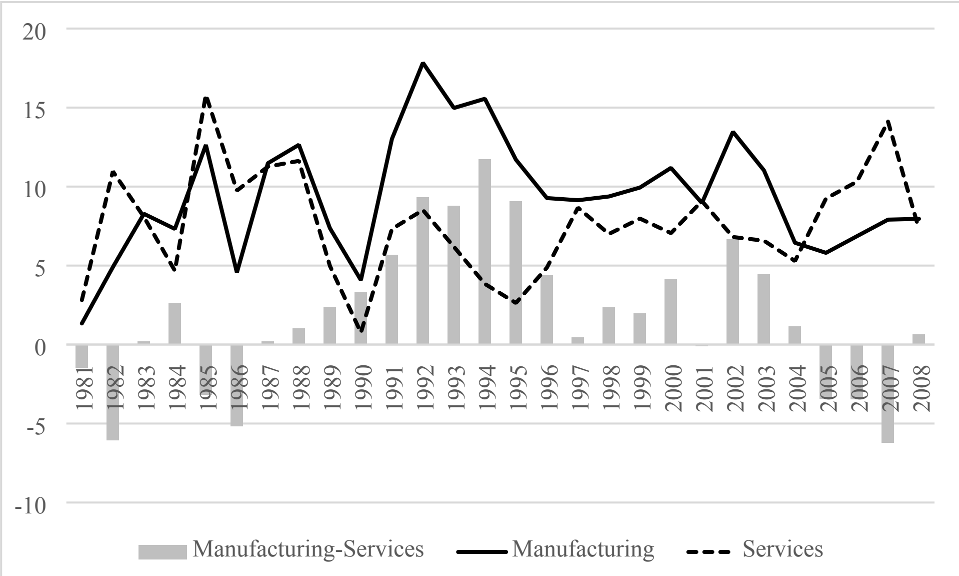
Note: L, LM, UM, and H represent low-income, lower middle-income, upper middle-income, and high-income countries, respectively.

**Figure 2. Nominal Exchange Rate of CNY/USD (1985.12-2016.11)**



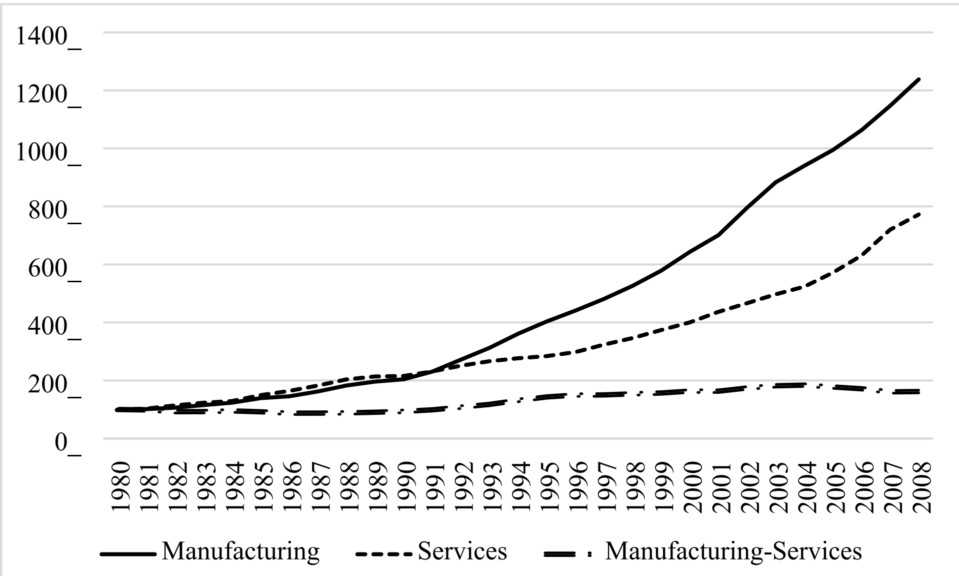

Source: Penn World Table 9.0.

**Figure 3a. Annual Growth Rates of Labor Productivity in China, 1980–2008 (percent)**



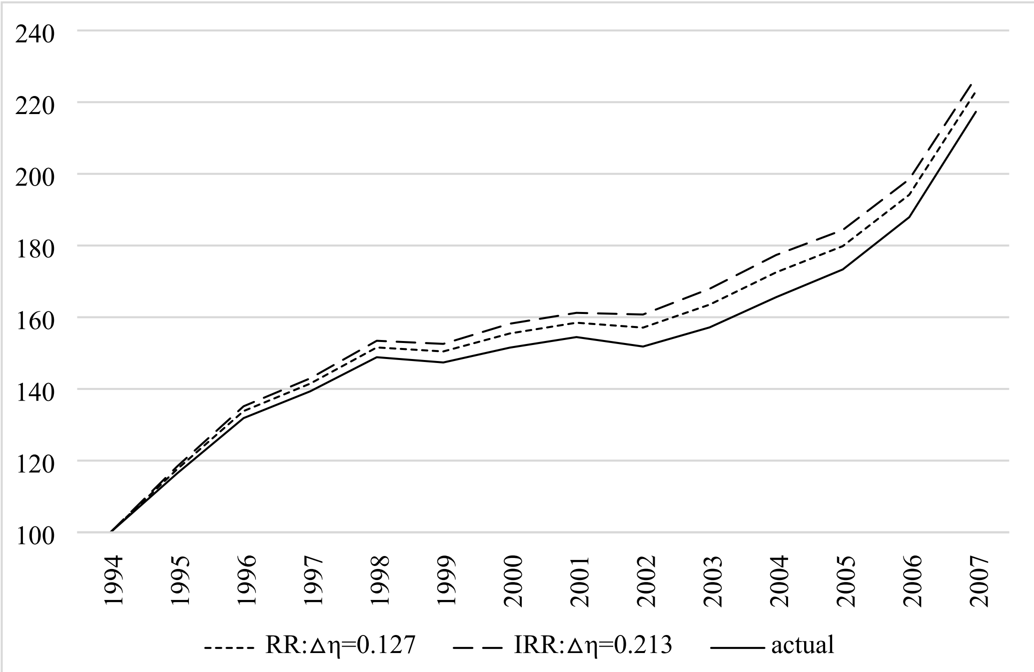

Source: World Development Indicators.

**Figure 3b. Cumulative Labor Productivity Growth in China, 1980–2008 (1980 = 100)**



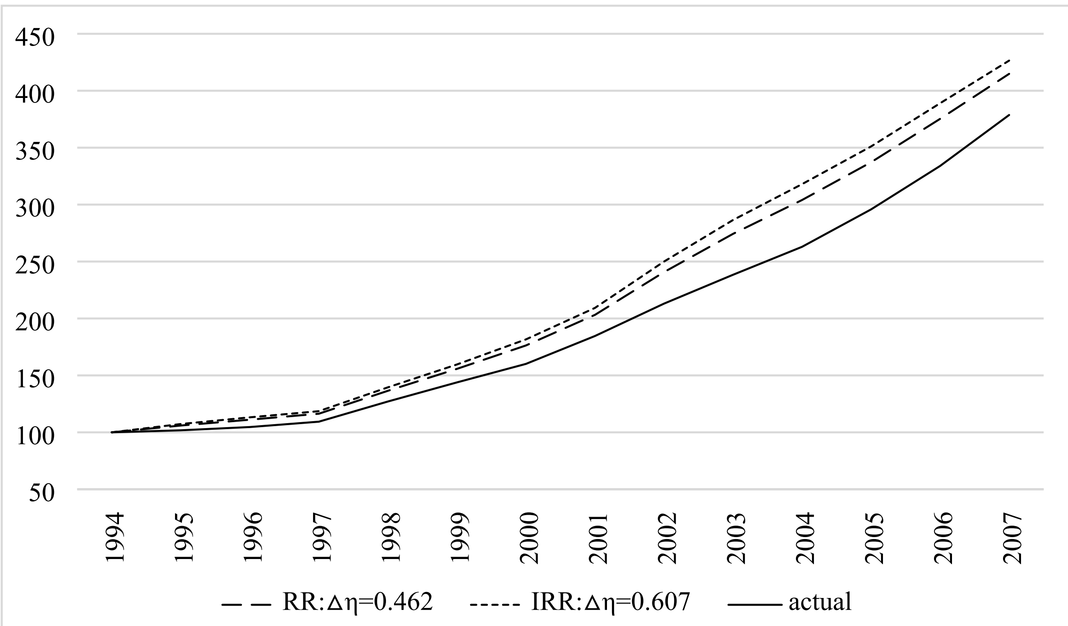

Source: World Development Indicators.

**Figure 4. Cumulative RER Growth in China, 1994–2007 (1994 = 100)**



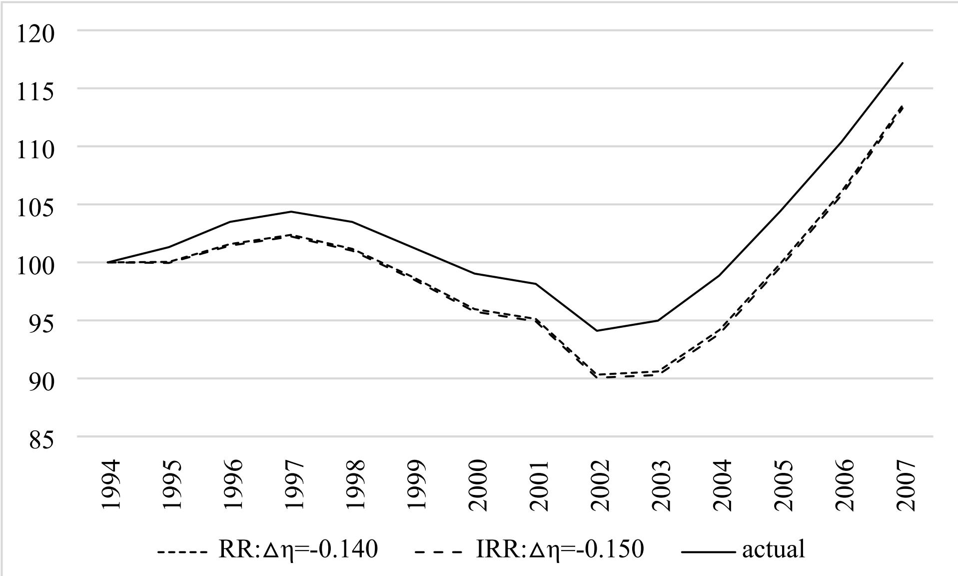

Source: Penn World Table 9.0 and authors' calculation based on the results of Table 3.

**Figure 5. Cumulative Growth of Real Wage in China, 1994–2007 (1994 = 100)**



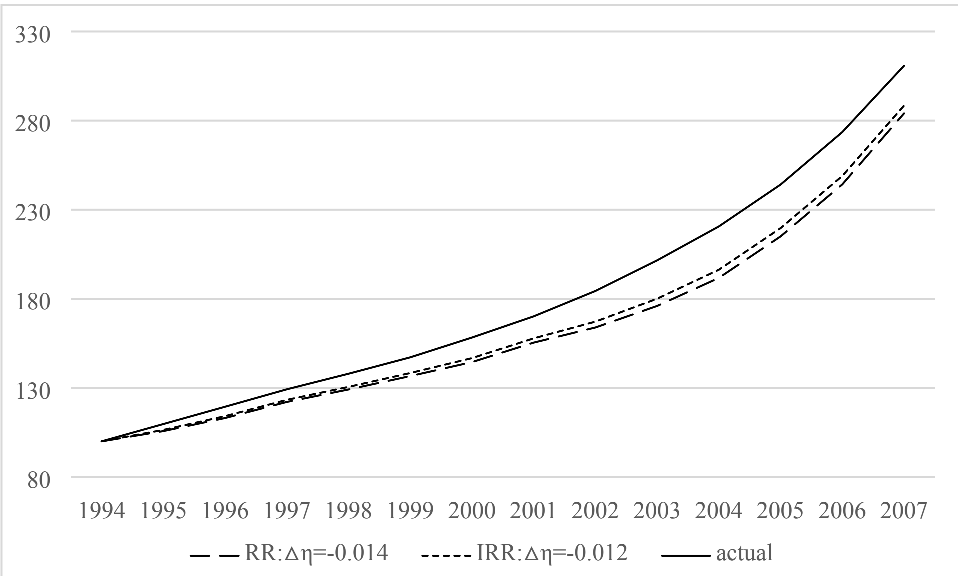

Source: Penn World Table 9.0 and authors' calculation based on the results of Table 5.

**Figure 6. Cumulative Growth of the Industrial Share of Employment in China, 1994–2007 (1994 = 100)**




Source: World Development Indicators and authors' calculation based on the results of Table 6a.

**Figure 7. Cumulative Growth of Real GDP per Capita in China, 1994–2007 (1994 = 100)**




Source: Penn World Table 9.0 and authors' calculation based on the results of Table 7b.

**Appendix**

**Table A1. FERR Suppresses the BS Effect**

| Dep. variable $\ln RER$ | (1) IMF | (2) RR | (3) IRR | (4) LS | (5) JS |
|---|---|---|---|---|---|
| $\ln A_{TS}$ | 0.0653** | 0.0411 | 0.0475 | 0.00637 | 0.00178 |
| | (0.0320) | (0.0338) | (0.0362) | (0.0427) | (0.0361) |
| $\ln A_{TS} \times FERR$ | -0.0363 | -0.196*** | -0.198*** | 0.0393 | 0.0383 |
| | (0.0432) | (0.0592) | (0.0539) | (0.0425) | (0.0387) |
| *FERR* | 0.149*** | 0.131*** | 0.114*** | 0.0466** | 0.0801*** |
| | (0.0194) | (0.0245) | (0.0249) | (0.0219) | (0.0198) |
| *l.govt_GDP* | -0.00210 | -0.00102 | -0.00126 | -0.00251 | -0.00335 |
| | (0.00260) | (0.00282) | (0.00286) | (0.00287) | (0.00269) |
| *l.g_M2* | 8.51e-05** | 0.000104*** | 0.000104*** | -3.28e-05 | -1.13e-05 |
| | (3.53e-05) | (3.77e-05) | (3.82e-05) | (0.000110) | (0.000107) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | -0.534*** | -0.508*** | -0.513*** | -0.620*** | -0.637*** |
| | (0.0453) | (0.0480) | (0.0493) | (0.0489) | (0.0465) |
| Observations | 1,158 | 1,207 | 1,178 | 949 | 1,066 |
| R-squared | 0.918 | 0.908 | 0.908 | 0.912 | 0.917 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent. Observations of *g_M2* below the 5th or above the 95th percentiles are excluded.

**Table A2. Wage Rigidity Enlarges the Gap of BS Effect**

| Dep. variable<br>ln*RER* | (1)<br>IMF | (2)<br>RR | (3)<br>IRR | (4)<br>LS | (5)<br>JS |
|---|---|---|---|---|---|
| $\ln A_{TS}$ | 0.0711** | 0.0445 | 0.0531 | -0.00728 | 0.00215 |
| | (0.0319) | (0.0337) | (0.0362) | (0.0428) | (0.0360) |
| $\ln A_{TS} \times FERR$ | 0.271*** | 0.306* | 0.198 | 0.246*** | 0.285*** |
| | (0.0895) | (0.162) | (0.141) | (0.0942) | (0.0958) |
| $\ln A_{TS} \times FERR \times l.rural$ | -0.605*** | -1.000*** | -0.795*** | -0.368** | -0.428*** |
| | (0.154) | (0.300) | (0.265) | (0.151) | (0.152) |
| *FERR* | 0.147*** | 0.114*** | 0.0993*** | 0.0360 | 0.0670*** |
| | (0.0196) | (0.0249) | (0.0254) | (0.0221) | (0.0202) |
| *l.rural* | 0.402* | 0.0333 | 0.192 | -0.242 | -0.119 |
| | (0.206) | (0.201) | (0.218) | (0.240) | (0.218) |
| *l.govt_GDP* | -0.000826 | -0.000645 | -0.000947 | -0.00300 | -0.00351 |
| | (0.00260) | (0.00281) | (0.00286) | (0.00287) | (0.00269) |
| *l.g_M2* | 8.17e-05** | 0.000102*** | 0.000102*** | -3.83e-05 | 2.48e-06 |
| | (3.50e-05) | (3.76e-05) | (3.81e-05) | (0.000110) | (0.000107) |
| Country FEs | Y | Y | Y | Y | Y |
| Year FEs | Y | Y | Y | Y | Y |
| Constant | -1.419*** | -1.205*** | -1.268*** | -0.999*** | -1.076*** |
| | (0.116) | (0.111) | (0.118) | (0.131) | (0.120) |
| Observations | 1,158 | 1,207 | 1,178 | 949 | 1,066 |
| R-squared | 0.920 | 0.909 | 0.908 | 0.913 | 0.917 |

Note: Standard errors are reported in parentheses. Significance levels: * 10 percent, ** 5 percent, and *** 1 percent. Observations of *g_M2* below the 5th or above the 95th percentiles are excluded.