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Exploring the Sources of Growth and Slowdowns for Growth Successes

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Japan, South Korea, and Taiwan experienced unprecedented high growth after World War II but failed to sustain the high growth after the 1990s. Why did these growth successes fail to sustain their high growth? This study shows that the dynamics of total factor productivity growth has been crucial in driving the overall output dynamics. Moreover, the long-term stagnation was exacerbated by labor market frictions and sometimes prolonged by capital market frictions.

Keywords: sources of growth and slowdown, neoclassical, Japan, South Korea, Taiwan
JEL classification: E1, E2, O4, O5

1 Introduction

Japan, South Korea, and Taiwan are three important cases for studying growth as they all experienced extremely high growth rates after the Second World War. The annual growth rate was above 3% for Japan and above 6% for South Korea and Taiwan up to the 1990s. However, all of these economies experienced slowdowns in growth to some extent afterwards. Were these slowdowns the outcomes of these countries reaching a state of diminishing returns after years of rapid factor accumulation, or were the

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slowdowns because of declines in their processes of efficiency improvement? Which mechanisms have been critical in driving the output dynamics? We quantitatively address these interesting issues of growth and stagnation in this paper.

Our analysis begins by defining the period of high growth and the period of slowdown for these economies, and then a technique for identifying the causes of business cycles is adopted to identify the critical mechanism driving the rapid growth and the slowdown. It turns out that the dynamics of TFP critically drives the dynamics of output growth, especially in the later period of the rapid growth and then the slowdown. Moreover, the slowdowns were also exacerbated due to labor market frictions and prolonged by capital market frictions, especially in the cases of Japan and Taiwan.

We first define the period of rapid growth (the high growth regime/the early period) and the slowdown (the slow growth regime/the late period) using the econometric technique introduced by Bai and Perron (1998, 2003) and Liu, Wu, and Zidek (1997). The results suggest that the growth rate of each economy had several structural breaks and the first demarcation indicating a fall in the growth rate occurred in the 1990s: 1992 for Japan, 1993 for Taiwan, and 1996 for South Korea. Hence, hereafter, we define the periods before these break years as the periods of rapid growth and the periods after these break years as the periods of slowdowns.[1] Of particular note, the growth rate in Japan fell abruptly from above 3% to about 1% and resulted in the notable Lost 20 years in Japan, whereas the growth rates in Taiwan and South Korea only fell gradually. Finally, the growth of these economies was no longer significant — i.e., the growth rates for each of them fell below 3% in the late 2000s.

We then uncover the mechanisms driving the long-term growth as well as the recent slowdowns using business cycle accounting (Chakraborty, 2009; Chari, Kehoe, and McGrattan, 2002, 2007; Cole and Ohanian, 1999, 2002; Ho, 2011; Kobayashi and Inaba, 2006; Lu, 2012a; Otsu, 2010a,b; Otsu and Pyo, 2009). The great advantage of this approach is that it reveals the causes of the growth/slowdown dynamics because its analysis relies on a general equilibrium model (which clearly shows the causes and effects) instead of on a production function (which only reveals the contributions of various inputs in production). Accordingly, we separate out the sources of the

[1] Hereafter, we discuss the development of each country based on the sequence in which the slowdowns took place: Japan, Taiwan, and South Korea.

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growth/slowdowns from (1) the transition dynamics to a steady state, (2) efficiency improvements, or (3) those mechanisms that may be associated with policy effects–resembling frictions in the capital market, labor market, or excess demand from government and the rest of the world–that induce factor accumulation.

Our work differs from previous studies in that we adopt structural break tests to identify the period of growth and slowdown and then explore the causes of the growth and slowdown. Moreover, we include post-2010 data in the analysis. Finally, most past works have focused on the recession periods (except for Chakraborty (2009) and Otsu (2010b) who studied the growth since 1980) and none of them include Taiwan (except for Ho (2011) who studied the recession in 2001) in the study. Accordingly, we provide a rigorously defined period of growth and stagnation and a comprehensive view of the causes of growth and slowdown for these three economies.

From this new perspective, we provide model-based evidence to support the view that TFP growth induced capital growth after the mid-1980s, and TFP was the critical driver of the observed unprecedented long-term growth. Factor accumulation at most plays a role in contributing to growth only in the early stages of development. This result reconciles different views in the literature regarding the sources of growth for South Korea and Taiwan.[2]

We then turn to explore the causes of the slowdowns and find that the slowdown in TFP growth is responsible for all the major declines, and the factor market frictions play a secondary role in prolonging the slowdown. For Japan, the Lost decades beginning in the 1990s were exacerbated by labor market frictions in addition to the dramatic slowdown in TFP growth. Then, although the labor market friction generated the momentum for recovery during the 2000s, the capital market frictions prolonged the Japanese stagnation in the 2000s. For Taiwan, in addition to the slowdown in TFP

[2]The causes of these growth successes have been widely discussed in the literature yet remain unclear. There were debates in the 1990s regarding whether the source of their growth was factor accumulation or efficiency improvement as measured by total factor productivity (TFP) growth. The view that factor accumulation was critical was first advocated in Young (1994) and then supported by Kim and Lau (1994) and Krugman (1994), among others. On the other hand, other quantitative works found a much bigger role for TFP growth (or some sort of efficiency improvements or technological advances) in accounting for the growth of these two countries (see Hsieh (1999, 2002), Harberger (1996) and Klenow and Rodriguez-Clare (1997b)). Various later discussions in the literature support this direction in the literature, e.g., Easterly and Levine (2001), and Rodrigo (2000), among others.

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growth, the factor market frictions — either labor market frictions or capital market frictions, one by one played a secondary role in the gradual decline in growth since the 1990s. For South Korea, in addition to the slowdown in TFP growth, labor market frictions further exacerbated the slowdown. Of particular note, the negative impact of labor market frictions was often existed way before the stagnation began. This hidden syndrome regarding the labor market did not reveal itself until the growth momentum generated by the TFP weakened. These results are consistent with Kobayashi and Inaba (2006) and Lu (2012a) with regard to the development patterns before the 2000s.

We also look into what causes the growth dynamics of factors of production, i.e., capital and labor, and discuss their impacts on output growth. We conclude that TFP crucially drives the dynamics of capital accumulation, especially toward the later stages. Accordingly, we quantitatively show that TFP growth affects output growth through two channels: one is an indirect effect on output growth through inducing capital growth, while the other is a direct effect on output in the form of efficiency improvements. As our approach takes into account this indirect effect on output growth, we conclude that TFP is crucial to the growth after the mid-1980s. This result differs from the general view about sources of growth for these countries based on growth accounting (e.g., Young (1995, 1998)). We argue that as the decomposition of growth accounting treats this indirect channel for TFP to affect output growth as a contribution of capital growth, earlier works based on growth accounting tend to underestimate the impact of TFP growth on output growth. Moreover, we find that the labor input growth comes primarily from an increase in the working-age population. Accordingly, when focusing on the growth of output per capita instead of the growth of output, the growth from labor growth is insignificant.

Therefore, our results support the view that improvements in production efficiency drove the sustainable rapid growth of these economies. As the TFP growth rate slowed down, the output growth rate fell. Then, the slowdown was exacerbated as new frictions arose in the factor markets. Therefore, the slowdown was not directly attributable to reaching a state of diminishing returns to certain factors of production, and the period of rapid growth was not solely the outcome of factor accumulation.

The remainder of this paper is organized as follows. Section 2 discusses the methodology including the basic setup of the benchmark model, defines wedges, and outlines the procedures based on the methodology of business

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cycle accounting. Section 3 discusses the data and the parameters used and assumptions made. Section 4 discusses the results. Section 5 presents concluding remarks.

2 Methodology

We apply the structural break test by Bai and Perron (1998, 2003) (hereafter the BP test) and then adopt the modified Schwarz criterion proposed by Liu, Wu, and Zidek (1997) (hereafter the LWZ criterion) to identify the periods of growth and stagnation. This structural break test allows us to identify the number of breaks as well as the breakpoints without specifying the number of breaks before the test. Based on the determined break date, we closely follow the diagnostic approach used by Lu (2012a) to identify the causes of growth and slowdowns. This diagnostic approach, which is also referred to as business cycle accounting (see Cole and Ohanian (1999, 2002) and Chari, Kehoe, and McGrattan (2002, 2007)), is a model-based measurement of the frictions that drive booms and busts. Following the practices described in this literature, we define a one-sector Ramsey-Cass-Koopmans model with deterministic and discrete-time growth features for our wedge computation (Section 2.1). Then we describe the procedure for implementing this approach (Section 2.2).

2.1 A benchmark model

This benchmark model is a one-sector deterministic growth model with perfect foresight.[3] The model consists of an infinitely-lived representative

[3]We adopt the benchmark model setting, i.e., a closed economy economic environment, for conducting business cycle accounting. Although in reality these economies are small open economies, our choice of model may not be an issue for the following three reasons. First, our study seeks to provide a preliminary diagnosis for a future model setup, and thus choosing a benchmark model is adequate for the preliminary purpose. Second, this paper is not the first paper to adopt a closed-economy framework to study small open economies. Kobayashi and Inaba (2006), Chakraborty (2009), Otsu and Pyo (2009) and Lu (2012a) also adopted business cycle accounting under a closed-economy framework to study small open economies, i.e., Hong Kong, Japan, Singapore, South Korea and Taiwan. Third, our study overlaps with that of Otsu (2010a) for South Korea during 1990–2003, which adopted business cycle accounting within a small open-economy context. Both studies result in similar outcomes: the labor wedges and TFP account for the output fall during 1997–1998.

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household and its utility,[4] and it is described by

$$\sum_{t=0}^{\infty} \beta^t N_t \left\{ \log (c_t) + \phi \log (1 - l_t) \right\}$$

where N_t is the size of the working-age population that grows at the rate n_{t+1} from date t to $t+1$, i.e., $N_{t+1} = (1 + n_{t+1}) N_t$; c_t is consumption per head and C_t is aggregate consumption.; l_t is labor hours per head and L_t is total labor hours. Moreover, the parameter β is the discount factor, and ϕ is the time allocation parameter used to add leisure to the utility function. The budget constraint of each household head at each date is

$$c_t + i_t = w_t l_t + r_t k,$$

where i_t is investment per head, w_t is the wage rate, r_t is the return on capital, and k_t is the capital stock per head, which evolves following the law of motion

$$(1 + n_{t+1})\, k_{t+1} = (1 - \delta) k_t + i_t.$$

The production technology is characterized by

$$Y_t = K_t^{\theta} \left(x_t L_t \right)^{1-\theta}, \tag{1}$$

where Y_t is aggregate output, which is the sum of all the output per head (y_t), and the parameter θ is the capital share. x_t characterizes the progress of labor-augmenting production technology that grows at the rate g with the initial technological level beginning at x_0 at date 0 (which is a scalar). On the balanced-growth path, y_t, c_t, i_t, k_t grow at the rate g. We detrend each of these variables and define the variable with a tilde ($\sim$) as the variable for detrended per working-age person.

Then, Eqs. (2)–(6) characterize this economy as follows:

$$\tilde{y}_t = \tilde{k}_t^{\theta} \left(x_0 l_t \right)^{1-\theta}, \tag{2}$$

$$\frac{(1-\theta)}{\tilde{c}_t} \frac{\tilde{y}_t}{l_t} = \frac{\varphi}{(1 - l_t)}, \tag{3}$$

$$\frac{(1+g)}{\tilde{c}_t} \frac{\tilde{c}_{t+1}}{\beta} = 1 + \theta \frac{\tilde{y}_{t+1}}{\tilde{k}_{t+1}} - \delta, \tag{4}$$

[4] We also examine how the model's results change when we allow for a different form of utility function and the results turn out to be similar. See Technical Appendix C.3.

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$$\tilde{c}_t + \tilde{i}_t = \tilde{y}_t, \tag{5}$$

$$(1+g)\,(1+n_{t+1})\,\tilde{k}_{t+1} = (1-\delta)\tilde{k}_t + i_t. \tag{6}$$

This system of equations characterizes how an economy evolves over time on the path on which y grows at the rate g annually. However, when data are plugged into this system of equations, one soon finds that the economy does not behave as the model predicts. Then a gauge is inserted into each equation to measure the extent to which the model's prediction deviates from reality. In keeping with Lu's procedure (2012a), we designate the gauges/wedges for Eqs. (2)–(5) as TFP, labor wedge, capital wedge and income wedge, respectively, as follows:

$$\text{TFP}\,(z_t) : z_t \equiv \frac{\tilde{y}_t}{\tilde{k}_t^{\theta}\,(x_0 l_t)^{1-\theta}},$$

$$\text{labor wedge}\left(1-\tau_{l,t}\right) : (1-\theta)\frac{\tilde{y}_t}{l_t}\left(1-\tau_{l,t}\right) \equiv \frac{\varphi \tilde{c}_t}{(1-l_t)},$$

$$\text{capital wedge}\left(1-\tau_{k,t+1}\right) : \theta\frac{\tilde{y}_{t+1}}{\tilde{k}_{t+1}}\left(1-\tau_{k,t+1}\right) \equiv \frac{(1+g)}{\tilde{c}_t}\frac{\tilde{c}_{t+1}}{\beta} - 1 + \delta,$$

$$\text{income wedge}\left(\tilde{y}_t \cdot \text{gap}_t^{y}\right) : \left(\tilde{y}_t \cdot \text{gap}_t^{y}\right) \equiv \tilde{y}_t - \tilde{c}_t - \tilde{i}_t.$$

One can regard TFP as an efficiency scalar. The growth of TFP reflects the capture of any mechanism that generates the effect of an efficiency improvement and quality improvement in terms of inputs. Moreover, the labor wedge captures the exogenous forces that affect the tradeoff between the marginal product of labor and the marginal rate of substitution between labor and consumption. It turns out that a larger labor wedge implies the creation of motivations that induce a household to work harder. Next, the capital wedge captures the exogenous forces that affect the tradeoff between intertemporal consumption and returns on savings. Larger capital wedges imply a stronger tendency to save more for tomorrow's consumption. Finally, the income wedge is the difference between output and the sum of domestic demand by the household, i.e., private consumption and investment; this difference captures the changes in additional demand from sources other than domestic households, i.e., the government and the rest of the world.

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2.2 The procedure

Given the measured wedges, we then explore how each wedge affects the periods of growth and slowdown by feeding the wedges into the model in 16 different combinations. Of particular note, when all the wedges are included, the time path predicted by the model matches the data. Moreover, because our focus is on the growth dynamics, the model with an added wedge that creates a slope change matching the slope change in the data is regarded as the main driver of the growth and slowdown.

To explore the contribution of each wedge to output growth, we add wedges to the model one at a time. This step isolates the contribution of each wedge.[5] Moreover, once we identify the single wedge crucial to each period's development, all of the crucial wedges are then added in chronological order to reexamine the effect of each wedge over time. These ways of demonstrating the results portray how the importance of each wedge changes over time. Similarly, we perform the same exercise with regard to capital and total labor hours to study the possible causes of the growth and slowdown for both capital and labor.

3 Data and Parameterization

The collection of data (see Section 3.1), the principles for parameterization (see Section 3.2), and the key assumptions (see Section 3.3) for implementing business cycle accounting all closely match the practices used in Lu (2012a).

3.1 The data

The period studied in this paper is 1970–2017. In terms of data sources, the data for Japan are gathered from two major sources. The data for working-age population, labor hours, and employment are obtained from Penn World Table 9.1. Furthermore, the data on GDP, the GDP deflator, indirect tax, private consumption, and gross fixed capital formation are downloaded from World Development Indicators (WDI) (please refer to the Appendix for the details on data sources).

[5] For a case that is more complex or when the key driver is not obvious, we confirm the results by exploring the cases without one wedge only, which reveals the significance of a single wedge in driving the actual dynamics.

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Most of the data collected for Taiwan and South Korea are from the same sources as in Lu (2012a), but there are some exceptions. For South Korea, the data for working-age population are obtained from WDI. The data on GDP, the GDP deflator, indirect tax, private consumption, and gross fixed capital formation used in this paper are all obtained from a single data source, namely, the Bank of Korea's Economic Statistics System (ECOS). Moreover, the data on labor hours are downloaded from the Total Economy Database. For Taiwan, the data for the GDP deflator, indirect tax, and private consumption are obtained from the Taiwan Economic Data Center. This new data set also preserves the data characteristics for South Korea and Taiwan described in Lu (2012a) in that, from the perspective of growth accounting, factor accumulation is the major source of their growth, although it encompasses more years.[6]

3.2 Parameterization

In this study, we need data smoothing for the structural break tests. We therefore adopt the Hodrick-Prescott filter for data smoothing and set the smoothing parameter at 100 to obtain the trend of the output growth rate for each country. Then, we adopt these smoothed time series to conduct the structural break tests to identify the periods of growth and stagnation.

Next, when conducting the BP test to detect different periods of economic growth for each country, we perform BP tests of 1 to M globally-determined breaks on the series of growth rates for each country's output. When conducting the BP tests, we set the maximum permitted number of breaks at $M = 5$, a trimming percentage $\varepsilon = 0.15$, and a significance level $\alpha = 0.05$. Afterwards, we conduct the double maximum tests by calculating the UDmax and WDmax statistics to specify whether at least one break exists. After we specify the existence of breaks, we estimate the number of breaks and their dates for each country's output using the LWZ criterion.[7]

[6]For South Korea, more output growth comes from capital accumulation (i.e., 44%) than from TFP growth (i.e., 41%). For Taiwan, more output growth comes from TFP (i.e., 45%) than from the growth of the capital stock (i.e., 40%). However, in a comparison based solely on the effect of TFP growth versus the growth of capital and labor (i.e., factor accumulation) for South Korea and Taiwan, it is shown that in South Korea, 59% of growth comes from factor accumulation and 41% from TFP. In Taiwan, 55% comes from factor accumulation and 45% from TFP.

[7]We also provide alternative results for the breakpoints based on the sequential procedure

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Based on these results for the breakpoints, we compute the growth rate of each period and identify the periods of growth and stagnation.

Now we discuss the parameters used when implementing business cycle accounting. As in Lu (2012a), we choose standard parameter values for the discount factor β and set it equal to 0.95. Moreover, we assume that the balanced-growth rate (g) equals 2%, the time allocation parameter (ϕ) equals 2.3, the capital share θ equals 1/3, and the efficiency scalar (x_0) of the labor-augmenting production technology equals 60.[8] We calibrate the country-specific depreciation rate (δ) (i.e., 5.45% for Japan, 4.20% for South Korea and 8.14% for Taiwan) such that given the level of the initial capital stock (i.e., in 1970) and the time series for aggregate investments, the result of the capital-to-output ratio in 2017 matches that of 2017 in the data. Moreover, we allow each country to have its own population growth rate (n) at different dates.

Finally, we make all the same assumptions as in Lu (2012a), except that the final year is 2017 instead of 2006. Therefore, we focus only on the results from 1970 to 2016 because the terminal values of wedges are subject to these assumptions. Moreover, the final conditions are slightly changed. The population growth rate after 2017 remains constant at -0.67% for Japan, 0.02% for South Korea, and 0.44% for Taiwan, which are the growth rates of the working-age population in 2017. Finally, all the wedges are constant at the value for $t = 2017$ after the year 2017 except for TFP, which grows at a constant rate of 2% over the 2017 value.

4 The Results: Assessing the Contributions to Growth

We re-examine the inconclusive debate in the 1990s regarding whether the East Asian growth miracles are due to extensive factor accumulation or the growth of total factor productivity (TFP). Moreover, we examine why these

of the BP test and the Schwartz criterion in Technical Appendix A. For Japan, the result of the sequential procedure for the BP test shows that 1992 and 2011 are the turning points of the output growth rate for Japan. For Korea, the results of the sequential procedure also indicate that 1996 and 2007 are the breakpoints of the output growth rate for South Korea. For Taiwan, the result of the sequential procedure of the BP test shows that the slow economic growth started in the 1990s.

[8] We also examine the cases that allow each country to have its country-specific parameters and different detrending values and the results remain similar. See Technical Appendices C.2 and C.4 for the details.

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Table 1: Periods of output growth and slowdown and the related output growth rates

	1970–2017	1970–1992	1992–2011	2011–2017	
Japan	2.34%	3.37%	1.11%	2.46%	
	1970–2017	1970–1993	1993–2000	2000–2010	2010–2017
Taiwan	4.59%	6.02%	4.94%	3.05%	1.71%
	1970–2017	1970–1996	1996–2007	2007–2017	
South Korea	5.06%	6.48%	4.00%	2.54%	

growth successes also experienced a growth slowdown, either in the form of an abrupt fall in the 1990s for Japan or the gradual decline since the 1990s for Taiwan and South Korea. Accordingly, we first define the period of growth and slowdown (Section 4.1), before measuring the wedges (Section 4.2), and we then explore the impacts of the wedges on output growth (Section 4.3.1) and on the growth of the capital and labor inputs (Section 4.3.2).

4.1 Define the period of growth and stagnation

We apply the BP test to identify the existence of the turning points before adopting the LWZ criterion to identify the period of growth and stagnation and find that the turning points for these economies are around the early 1990s.[9] The results are shown in Table 1.

For Japan, 1992 is the demarcation for growth and stagnation. The results suggest that there are two breakpoints, and thus there are three development periods. Moreover, as the growth rates of GDP per capita are 3.37% before 1992 and 1.43% afterwards, we define the periods before 1992 as the periods of growth and the periods after 1992 as the periods of stagnation. Moreover, we regard the period after 2011 as the period of recovery after the Lost 20 years.

For Taiwan, the structural break test suggests that there are three break dates: 1993, 2000, and 2010. Therefore, there are four development periods: 1970–1993, 1993–2000, 2000–2010, and 2010–2017. We compute

[9]The tables that summarize the results of the BP test and the adoption of the LWZ information criterion are presented in Technical Appendix A.

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the growth rate for these four periods and find that the growth rates are 6.02%, 4.94%, 3.05%, and 1.71%, respectively. As these growth rates have fallen gradually since 1993, we take the breakpoint at 1993 as the demarcation for the rapid growth regime and the slowdown regime.

Finally, for South Korea, the structural break test suggests that there are two break dates: 1996 and 2007. Therefore, there are three development periods: 1970–1996, 1996–2007, and 2007–2017. We also compute the growth rate for these three periods and find that the growth rates are 6.48%, 4.00%, and 2.54%, respectively. Similar to Taiwan, as the growth rate has fallen gradually since 1996, we take 1996 as the demarcation for the growth and slowdown.

4.2 Measuring the wedges

Before implementing the counterfactual simulations to explore the main drivers of the growth and slowdown, we measure the wedges for these economies. Figure 1 shows the results. We contrast the results for our wedges with those of the U.S. such that each value has a basis for comparison. Of particular note, the wedges discussed here are the results that assume that there is no technological growth such that the discussion related to TFP can be comparable with the literature on growth accounting and development accounting.

The TFP for these economies shows the patterns of growth and slowdown. To explore the patterns of TFP growth, we also conduct the BP test to explore whether or not there is any break in TFP growth and apply the LWZ criterion to detect the turning points of TFP growth, if any break exists. It turns out that the TFP growth slows down in the early 1990s for all the economies. However, the break points for TFP growth differ from the break points for output growth. For example, for Japan, the TFP growth experienced a fall from 1.67% (during 1979–1993) to 0.87% (during 1993–2017). For Taiwan, after 1993, the trend of TFP growth gradually declined from 3.37% (for 1993–2000) to only 1.64% (for 2009–2017). For South Korea, the TFP growth rate had its first demarcation, indicating a fall from 4.59% (1982–1993) to 2.98% (1993–2011) in 1993, and then a further fall to only 0.67% (2011–2017) with the demarcation in 2011 (see Table 2). Comparing these demarcations for TFP growth with the demarcations for output growth, we find that the patterns of the TFP slowdown are similar to the patterns of the output slowdown. The fall for Japan was abr-

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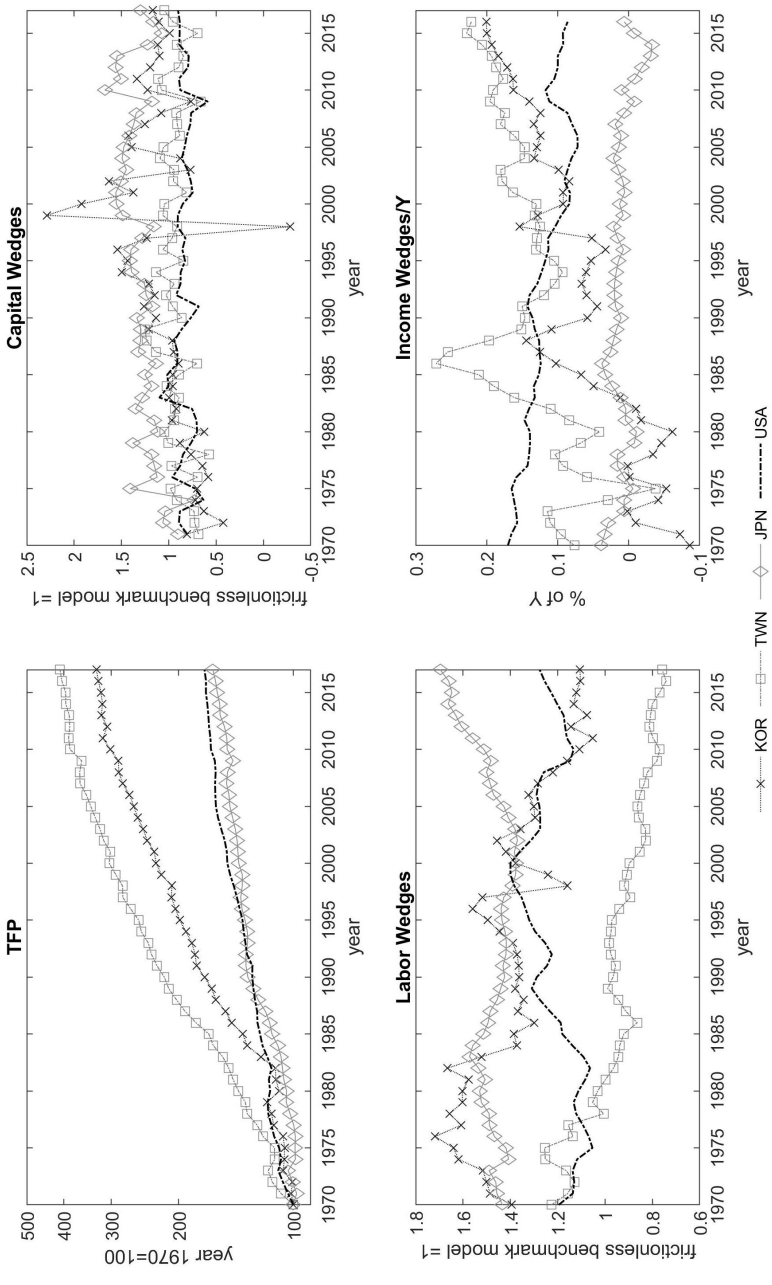


Figure 1: Wedges for Korea, Taiwan and Japan versus those for the U.S. (terminal condition $\gamma = 0$)

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Table 2: Periods of TFP growth and slowdown and the related TFP growth rates

	1970–2017	1970–1979	1979–1993	1993–2017		
Japan	1.03%	0.47%	1.67%	0.87%		
	1970–2017	1970–1982	1982–1993	1993–2000	2000–2009	2009–2017
Taiwan	3.00%	3.25%	4.42%	3.37%	1.85%	1.64%
	1970–2017	1970–1982	1982–1993	1993–2011	2011–2017	
South Korea	2.53%	0.90%	4.59%	2.98%	0.67%	

upt in the 1990s, whereas the falls for Taiwan and South Korea were gradual in the 1990s and then fell further in the 2000s.

These changes in TFP growth may be the outcome of various factors. The dramatic structural transformation from agriculture to non-agriculture right after WWII accounts for some of the TFP growth, especially for Taiwan and South Korea (see Lu (2012b)). Moreover, eradicating misallocations (see Hsieh and Klenow (2009)), cost reductions (see Harberger (1996)), human capital accumulation (see Mankiw, Romer, and Weil (1992)), and research and development (Romer, 1990) are all possible explanations for some of the TFP growth. Yet, as these economies developed, some sources of TFP growth became trivial, e.g., the extent to which misallocations or cost reductions were eradicated, and so it is not surprising that the TFP growth rate fell.

Moreover, in the cases where the TFP growth came from technological diffusion via trade and foreign investment, especially for Taiwan and South Korea, these technology followers acquired knowledge from the frontiers which rapidly raised their production efficiency, which was reflected by the high TFP growth. However, as these economies' technologies approached the frontiers in the later stages of development — so that what they could learn from the frontiers became limited, and innovation takes time — it is also not that surprising that the TFP growth rate fell to about 1%. In the case of Japan, as its level of technology was closer to the frontier than that for Taiwan and South Korea, the TFP growth rate was 0.47% during 1970–1979 and then rose only slightly to 1.67% during 1979–1993. The TFP growth rate then fell further to 0.87% during 1993-2017 which may have been due to the fact that the long depression prevented Japan from

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investing in R&D so that it lowered its TFP growth. This suspicion coincided with the fact that the ratio of R&D expenditure to GDP for Japan fell from 27.85% to 24.16% between 1993 and 2000, before rising slightly to 25.09% by 2007 and then remaining above 26% up to the present time.[10] For Taiwan, the TFP growth rate fell to 1.64% during 2009–2017. Finally, for South Korea, the TFP growth rate fell to 0.67% during 2011–2017.

Next, we discuss the patterns for all other wedges. For capital wedges, we find that the overall trend suggests that the wedges increased and then decreased in general. The decrease happened in Taiwan the earliest, and then in South Korea followed by Japan. These results imply that the improvements in the capital market frictions faced limitations toward the later stages of development. Of particular note, for South Korea, the capital wedges experienced dramatic fluctuations during 1997–2000. That outcome may indicate that the 1997 Asian Financial crisis impacted the economy through the mechanisms resembling capital wedges and the shocks were over after 2000.

For labor wedges, we find that Japan's labor wedges reveal a different pattern from those for Taiwan and South Korea. For Taiwan and South Korea, the labor wedges have fallen steadily. This fact indicates that in these economies, the incentives provided for households to work hard have been declining over time. By contrast, Japan's labor wedges rose in the 1970s and early 1980s and then fell in the late 1980s, then remained low in the 1990s and increased again after the 2000s. We further explore why there are rises and falls for Japan's labor wedges. The first rise in labor wedges may be due to the fact that when income becomes higher, the households are supposed to have a tendency to work less. However, in Japan, the number of hours worked in each year remained above 2,000 until the early 1990s. The second rise in labor wedges in the 2000s may reflect the fact that the working-age population has been shrinking since 1995 and that the unemployment rate fell from 5.40% in 2002 to 2.80% in 2017, while the total employment has increased from 64.6 million in 2002 to 67.5 million in 2017. Accordingly, despite the decline in the hours per worker, Japan's annual total working hours per population of working age have risen from 1,384 (in 2002) to 1,562 (in 2017).[11]

[10] Data Source: World Development Indicators, downloaded Nov 12, 2019.

[11] There are exceptions around the 2008–2012 period: unemployment temporarily rose during 2008–2009 and total employment temporarily fell during 2008–2012; working hours

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Finally, income wedges have fluctuated within a band for these economies, and the pattern is similar to the pattern for the net exports-to-GDP ratio. This is due to the fact that the government expenditure-to-GDP ratio has been kept within a narrow band in these economies, that is, 11%–19% for Japan, 13%–19% for Taiwan, and 9%–16% for South Korea. The size of the band is smallest in the case of Japan as its net export-to-output ratio has remained stable, fluctuating within a small range, i.e., between −5% and 5%.

4.3 Exploring the causes of growth and stagnation

Once the wedges are measured, we first feed only one wedge at a time into the model so as to separately explore the role of each wedge in the growth in output in excess of 2%. As noted earlier, the focus should be on the slope of each curve, and the wedge that generates a curve with a slope closest to the data emerges as the most crucial factor in driving the dynamics of the growth and slowdown. All the series are indexed relative to 1970 as 100. We first explore the sources of growth and slowdown for output (Section 4.3.1), and then explore the causes of the capital and labor dynamics (Section 4.3.2).[12]

4.3.1 Output

We first explore the causes of the rapid growth, and then look into the causes of the slowdown in output growth.

Overall, TFP growth is important in sustaining the output growth and then when the TFP growth slows down, the output growth is vulnerable to other shocks. For Japan, although the earliest period of development can be explained by the model with capital wedges, the slowdown of TFP growth is the main cause of the slowdown since the 1990s. For Taiwan and South Korea, TFP had been important in sustaining the growth and then the TFP growth slowdown together with factor market frictions have subsequently accounted for the slowdown.[13]

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per worker temporarily rose from 2010 to 2012, and working hours per working-age population temporarily fell from 2008 to 2009.

[12] Although adding wedges in different sequences may affect the size of the contribution of each wedge, our main conclusion remains the same when we allow different sequences of adding in wedges. The related results are discussed in Technical Appendix C.5.

[13] Please refer to Technical Appendix E for the detailed table about the contribution of

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To be specific, for the period of rapid growth, capital wedges and then TFP are the key drivers sustaining the high growth up to the 1990s. Figure 2 shows the results for output simulated with various combinations of wedges to explore the key wedges contributing to the output dynamics.[14] As can be seen, during the period of rapid growth, the model with frictions represented by capital wedges generates a trajectory replicating the growth trend in the earlier stage of development, and then the TFP growth becomes the critical driver in the later stage of development. We therefore conclude that for the growth period, the model with capital wedges can only explain the early development and then TFP kicks in to play the key role driving the dynamics of output for all countries.

For the period of the slowdown, the slowdown of TFP growth is the primary cause of the slowdown of output growth. Since Japan's output growth fell dramatically in the early 1990s, whereas that for South Korea and Taiwan fell gradually from the 1990s onward, we zoom into the periods of the slowdown in Figure 3. From the perspective of the counterfactual simulations, the model with TFP replicates these major patterns. However, the slowdown was exacerbated due to either the labor wedges or the capital wedges.[15]

To be specific, the stagnation in Japan starting from 1992 was mainly caused by the slowdown in TFP growth and to a lesser extent by factor market frictions. From the counterfactual simulation, we find that such a transition is mainly caused by TFP. In addition to the TFP effect, labor market frictions manifested in the form of falling labor wedges exacerbated the stagnation, especially before the early 2000s. Afterward, the labor market frictions were mitigated, and were reflected by rising labor wedges, which generated the momentum for recovery. However, capital market frictions manifested in the form of falling capital wedges generated another negative impact on growth such as that which prolonged the Japanese stagnation.

Of particular note, the negative impact of labor market frictions on growth began in 1983 but this issue was not revealed until the early 1990s. By contrast, although the Japanese, economy started to stagnate in 1992,

each wedge to output growth.

[14] Please refer to Technical Appendix B for the simulation results with other combinations of wedges. The results confirm the findings above.

[15] Since the secondary driver of the slowdown is not that obvious, we also provide the plots for the model with three wedges, i.e., the model in the absence of one wedge, in Technical Appendix B and thereby confirm the results.

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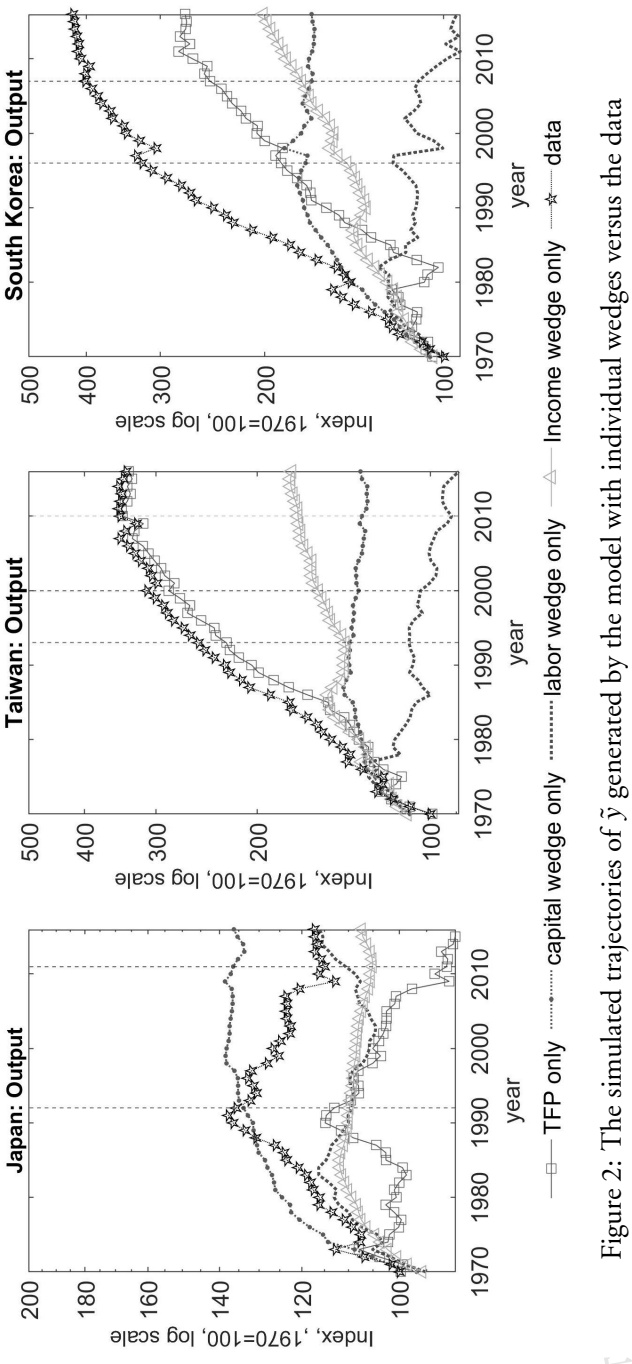


Figure 2: The simulated trajectories of $\tilde{y}$ generated by the model with individual wedges versus the data

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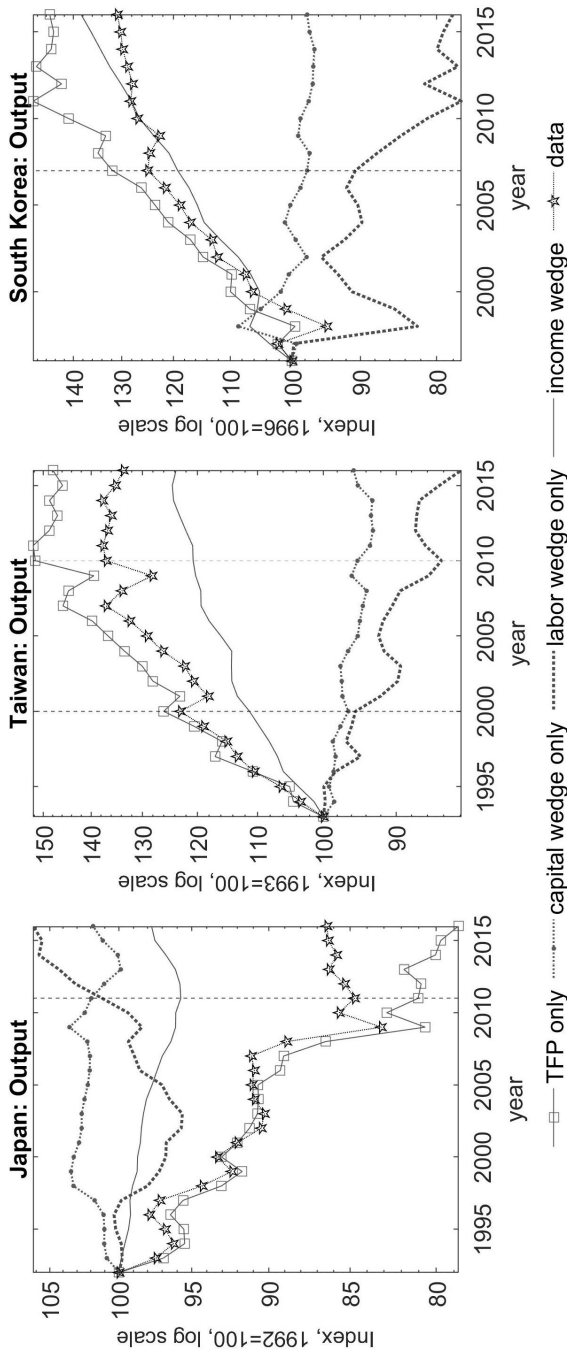


Figure 3: The simulated trajectories of $\tilde{y}$ generated by the model versus the data, slowdown regime

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capital market frictions that manifest themselves in the form of capital wedges maintained the growth momentum until the early 2000s. The negative growth impact of these two wedges together with the slow growth of TFP were the key factors driving the Lost 20 years in Japan.

The slowdown in TFP growth also drove Taiwan's slowdown, which came about in three stages, with the growth of per capita GDP being 6.02% before 1993. Then the fall began. The growth rate fell to 4.94% during 1993–2000, to 3.05% during 2000–2010 and then fell further to 1.71% during 2010–2017. Although the model with TFP replicated most of the trend, when focusing on the periods after 2000, we find that only the model with labor wedges generated a long-term output decline from 2000 onward. Accordingly, in addition to the TFP effect, the further slowdown from 2000 onward was also driven by labor market frictions that manifested themselves as falling labor wedges. Moreover, although the labor market frictions were mitigated and from time to time generated some sort of a recovery from 2000 onward, the model with capital wedges that generated a falling time path approximated the model with labor wedges that generated a rising time path. Thus, for Taiwan, the factor market frictions — either labor market frictions or capital market frictions — one after the other played a secondary role in exacerbating the stagnation.

Similar to the Japanese case, the negative impact of labor market frictions on economic growth existed as early as the late 1970s in Taiwan. However, as the TFP growth rate was high, this previously hidden syndrome manifested itself as an issue after the 2000s. Similarly, the negative impact of capital market frictions manifested itself in the form of falling capital market wedges, having also been since 1987 a hidden syndrome, but having then revealed itself as an issue again after the 2000s when the TFP growth rate slowed down.

Finally, in the case of South Korea, the slowdown came in two stages. Although output fell gradually from 1996 onward, the growth of output fell to below 3% after the 2008 Subprime Crisis. When comparing the output growth implied by one wedge, we find that only the model with labor wedges generates a slowdown in output growth even though the model with capital wedges generates an increase in output growth. Thus, we conclude that the second stage of the slowdown was also caused by the labor market frictions that manifest themselves as falling labor wedges. Similar to Taiwan, the negative impact of labor market frictions was also mostly hidden from the late 1980s to the early 1990s and then again in the late 1990s. This hidden

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syndrome was revealed on one occasion during the 1997 Asian Financial Crisis and then the effect revealed itself again from 2008 onward.

Therefore, we conclude that the TFP dynamics is important in accounting for the growth and stagnation of these economies.[16] Moreover, the negative impact of labor wedges on growth is trivial when TFP growth is the dominant driver of output growth. However, the positive impact of labor wedges on the recovery is salient, especially for Japan. Moreover, although capital wedges positively contribute to growth in the early stages for all these economies, capital wedges are not the key factor driving the later stage growth and stagnation dynamics. Therefore, the slowdowns were not solely due to either reaching a state of diminishing returns or caused by a decline in production efficiency. Other labor market-related factors were also responsible for the slowdowns in general.

4.3.2 Capital and Labor

Next, the impacts of wedges on capital and labor accumulation are examined in a search for evidence to reconcile the findings of Young (1994, 1995), Hsieh (1999, 2002), Klenow and Rodriguez-Clare (1997a,b), and Lu (2012a).

We confirm the view that there are two channels for TFP to contribute to growth. The first is that TFP not only directly increases output but also increases capital inputs, and thus indirectly increases output. Figure 4 shows the results from models that sequentially added capital wedges, TFP, and labor wedges. As is shown for South Korea and Taiwan, capital wedges contributed to most of the dynamics of capital accumulation before 1985. Afterward, TFP was crucial in driving the dynamics of capital evolution. This result provides quantitative support for the view in Klenow and Rodriguez-Clare (1997a) that a growth accounting approach underestimates the role of TFP in contributing to growth because this approach cannot capture the contribution of TFP to capital accumulation and ignores the fact that some (actually a lot) of the capital growth is attributed to TFP growth.

[16] Our counterfactual exercise shows that if the TFP growth rates after 1993 remain the same as for the earlier periods, the growth rate of output per capita can be marked up by 1.29 percentage points, 2.57 percentage points, and 2.62 percentage points for Japan, Taiwan, and South Korea, respectively. Please refer to Technical Appendix D for a detailed discussion with the simulation results.

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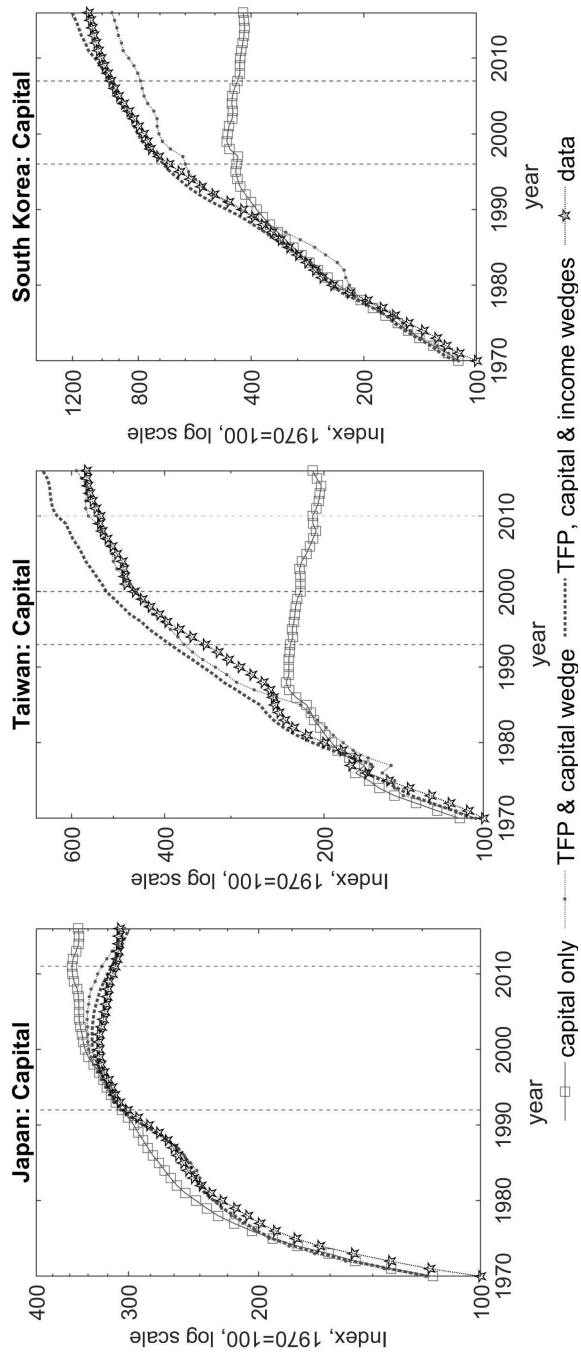


Figure 4: The simulated trajectories of $\tilde{k}$ generated by the model that sequentially adds in capital, TFP, income wedges, and then labor wedges versus the data and the trajectory from the model without exogenous changes

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The indirect channel for TFP to affect capital accumulation was also revealed in the Japanese Lost 20 years. Although capital wedges by themselves are good at capturing the dynamics of capital, the fall in capital from the late 2000s to the 2010s can be explained by the TFP effect. This outcome also suggests that TFP not only affects output directly but also indirectly by inducing the changes in capital.

On the other hand, Figure 5 shows how different wedges and the growth of the working-age population affect the total labor hours worked. We find that for all these economies, the growth dynamics of the labor inputs comes mainly from population growth. If the growth in the working-age population is excluded, total labor hours have barely increased since 1970. Moreover, when the increase in the working-age population is taken into account, most of the labor input growth in the data has been captured. Finally, labor wedges mostly drive the decline in total labor hours in the late 2000s except in the case of Japan. Therefore, although population growth contributes to output growth, our simulation results show that there is little room for any policy to be effective in South Korea and Taiwan in boosting the growth in labor input except for those policies that boost the growth of the working-age population. Therefore, when we focus on output per capita instead of mere output, the contribution of labor growth is mostly nullified. Of particular note, the Japanese labor growth after 2000 differs from the labor growth trend captured by the growth of working-age population. This pattern is reflected in the improvement in labor market conditions that manifests itself as rising labor wedges (recall the discussion in Section 4.2).

5 Concluding Remarks

We have adopted a neoclassical approach in the business cycle accounting literature to identify the critical drivers of the economic growth and slowdown for Japan, Taiwan, and South Korea. For the period of rapid growth, capital market frictions resembling capital wedges are the main drivers of the earlier growth and the TFP growth is then critical in driving the growth. For the period of the slowdown, the slowdown in TFP growth in addition to labor market frictions resembling labor wedges results in the slowdown in the 1990s. Then, in Japan, the capital wedges prolong the stagnation, whereas in South Korea and Taiwan it is the labor wedges that exacerbate the slowdowns in the 2000s.

Thus, we find that TFP is a critical factor driving the major output dyna-

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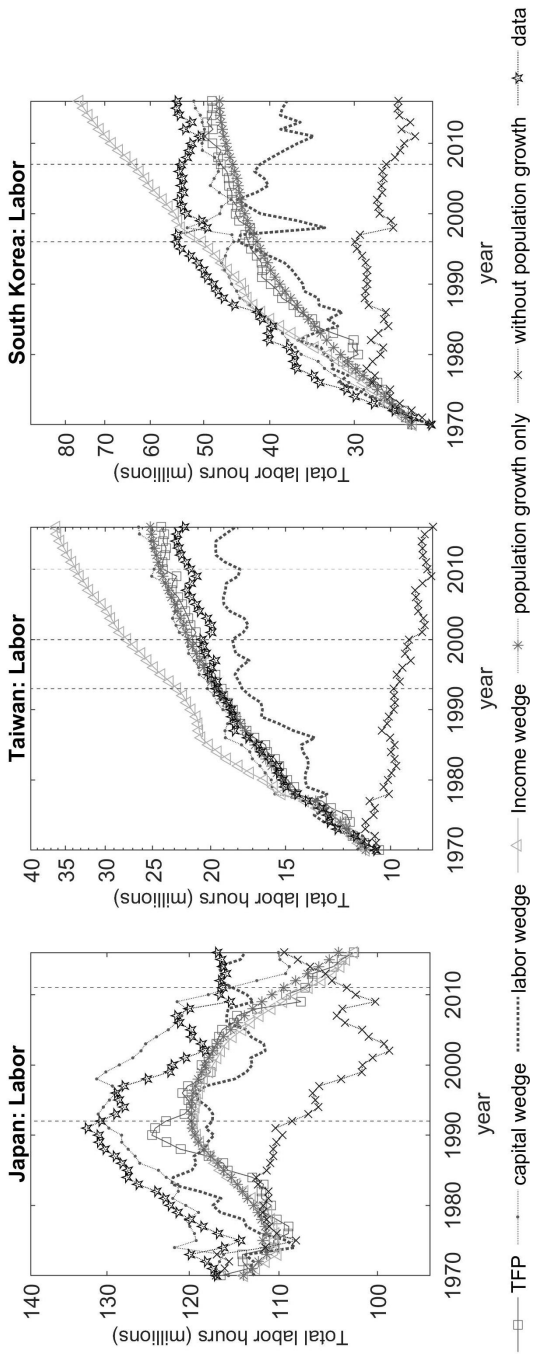


Figure 5: ($L * N * 3600$) The simulation paths generated by adding one wedge at a time versus those from the model with no exogenous changes (pure growth from population growth), no population growth (population fixed at the 1970 level), and data

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mics. During the high growth period, TFP growth plays a critical role in the sustainable growth from the mid-1980s to the mid-1990s. Although various factors such as structural transformation, eradicating misallocations, cost reductions, human capital accumulation, and research and development each contribute to TFP growth, some factors become trivial as the economies develop. What is known so far is that human capital accumulation in the form of education quantified by Barro and Lee (2013) cannot explain TFP growth after the 1980s (see Lu (2012a)). However, during the slow growth period, whether the decline in the TFP growth rate is due to these economies now being closer to the technological frontiers — such that what they can learn from the frontiers becomes limited, and innovation takes time — is an interesting question for detailed future research.

Moreover, frictions resembling capital wedges, which can be generated by capital market-related policy reforms, account for the growth dynamics before the mid-1980s, the earlier stages of the rapid growth. This result implies that policies related to capital market reforms can have some sort of effect in contributing to the rapid growth observed in these economies. According to Lu (2013), improvements in financial efficiency can account for more than 58% of the capital wedge changes for South Korea and Taiwan, and the improvements in financial efficiency positively contribute to long-term growth. Therefore, the quantitative result is that this paper supports the view in King and Levine (1993a,b), Beck, Levine, and Loayza (2000), Levine, Loayza, and Beck (2000), among others, that financial development positively contributes to growth. On the other hand, frictions resembling capital wedges also prolong the slowdown period, especially in the cases of Japan and Taiwan. The extent to which these capital wedge-related shocks linked to foreign debt change is another interesting question for future research.

Finally, frictions resembling labor wedges are found to have exacerbated the slowdowns in the later stages. This result suggests that the reasons for the slowdowns were not because these economies had reached a stage of diminishing returns after so many years of rapid factor accumulation, but rather that labor market frictions had a large negative impact on growth. However, it then needs to be asked what types of labor market frictions arose in these economies so that they generated such a huge negative impact on the growth dynamics. We will also leave this interesting topic for future research.

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Appendix: Data Sources

Table A1 lists the data sources and rules used for constructing the data set. One can find a cross-reference of the abbreviation in the relevant cell on the right of the table to obtain the data sources and how a variable is constructed whenever relevant. For instance, to obtain the data source for Taiwan's labor hours, find the cell under the column labeled Taiwan and in the row labeled Labor hours. The cell states TED, which is the Total Economy Database, as listed in the notes on the right of the table.

Table A1: Table of data sources

Variables	South Korea	Taiwan	Japan
Y (GDP-Indirect tax)			
GDP	ECOS	NS	WDI
Indirect tax	ECOS	TEDC	WDI
C			
Private consumption	ECOS	TEDC	WDI
I			
Gross fixed capital formation	ECOS	NS	WDI
K_0			
Capital stock	EST1	EST1	EST1
Residential buildings	ECOS	NS	SBJ
Nonresidential buildings	ECOS	NS	SBJ
Other construction	ECOS	NS	SBJ
Transportation equipment	ECOS	NS	SBJ
Machinery equipment	ECOS	NS	SBJ
L (EST2)			
Labor hours	TED	TED	TED
N			
Population ages 15–64 (by age group)	WDI	TEDC	WDI
EMP			
Employment	TED	TED	TED
GDP deflator	ECOS	TEDC	WDI

Notes on the notations and related sources:
EST1: Self-computed; adopted the perpetual inventory approach using country-

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specific depreciation rates.
EST2: labor hours divided by 3600 (as in Lu (2012a)). ECOS: Economic Statistics System, Bank of Korea (http://ecos.bok.or.kr/).
NS: National Statistics, Republic of China (http://eng.stat.gov.tw/mp.asp?mp=5).
PWT: Penn World Table 9.1 (http://pwt.econ.upenn.edu/).
SBJ: Statistics Bureau of Japan (https://www.stat.go.jp/english/index.html).
TED: Total Economy Database, Groningen Growth and Development Centre (http://www.ggdc.net/).
TEDC: Taiwan Economic Data Center (http://www.aremos.org.tw/tedcold/tedc2.htm).
WDI: World Development Indicators (http://data.worldbank.org/indicator).

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經濟快速成長與趨緩成因之探究

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日本、韓國和台灣在二次世界大戰後雖都歷經前所未有的高成長, 其幅度卻在1990年代後陸續變小。爲什麼這些經濟快速成長的成功案例無法繼續維持高成長? 本研究指出, 產出的快速增長與趨緩主要受到總要素生產力變化的影響: 總要素生產力快速增長使產出高成長, 但其成長速率趨緩時產出的成長也跟著變慢。另外, 在成長趨緩時期, 多由勞動市場存在均衡下的既有耗損加深趨緩的程度, 但是當勞動市場存在均衡下的既有耗損對產出趨緩沒有作用時, 資本市場存在均衡下的既有耗損又造成趨緩, 使趨緩一直延續, 以致成長停滯的問題更嚴重。

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