Revisiting the Growth of Hong Kong, Singapore, South Korea, and Taiwan, 1978-2006

From the Perspective of a Neoclassical Model

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Abstract

This paper studies the sources of growth for the East Asian Newly-Industrializing Countries (NICs) – Hong Kong, Singapore, South Korea and Taiwan (1978 – 2006) – using a diagnostic procedure, similar to Business Cycle Accounting, which has recently been developed in the business cycle literature. This diagnostic procedure provides a complete characterization of agents' interactions within these NICs from a neoclassical perspective and sheds light on why these NICs quickly accumulated capital and labor, and experienced rapid growth. The growth dynamics show that total factor productivity (TFP) improvement is crucial to the capital boom and output growth in Taiwan and South Korea. Moreover, the country-specific, time-varying capital market conditions induce the growth of output in Singapore and Hong Kong, and the capital and labor boom in all of the NICs. Therefore, the long-term growth is mainly attributable to the combined effect of productivity improvement and changes in capital market conditions.

Keywords: Sources of Growth, East Asian NICs, Neoclassical, Productivity

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1. Introduction

The focal point of this paper is its use of a neoclassical diagnostic procedure to study the rapid growth of the East Asian Newly-Industrializing Countries (NICs) – Hong Kong (HKG), Singapore, (SGP), South Korea (KOR), and Taiwan (TWN) from 1978 to 2006. The procedure is an extension of the previous focus that is solely on the production process (i.e., Growth Accounting) to one involving interactions among the agents in the economy. Through the lens of the neoclassical model, I show the major channel through which these NICs have rapidly accumulated capital and labor, and the critical momentum that has been driving the spectacular growth trend.

The issue – as to why the East Asian NICs grew rapidly after WWII – was discussed in the literature from the perspective of Growth Accounting (e.g., Young 1994, 1995, 1998; Hsieh 1999). Most scholars now believe in Young's result[1] that factor accumulation – the labor and capital boom – was an important explanation for the sources of growth of the East Asian NICs, while still keeping in mind Hsieh's reminder[2] that technology may have played a bigger role than Young suggested.

However, Growth Accounting is not sufficient in accounting for these growth miracles. It only focuses on the production side and shows the percentage contribution from factor inputs, i.e., labor and capital, and from total factor productivity. Consequently, the old methodology

[1] Young (1995), in his paper "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience," adopted growth accounting and carefully analyzed the growth patterns of output productivity and factor accumulation for these NICs. He found that both the labor and capital inputs (except for Hong Kong) grew rapidly. As a result, the high economic growth in these NICs did not result from abnormally high total factor productivity but from a "rising participation rate, intersectoral transfers of labour, improving levels of education, and expanding investment rates." (p.645)

[2] Hsieh (1999), in his paper "Productivity Growth and Factor Prices in East Asia" suggested the use of factor prices rather than quantities for growth accounting exercises because prices can be easily observed. The most striking finding in the paper is that the dual estimate by Hsieh resulted in completely different inferences for the growth in Singapore: the primal estimate resulted in negative TFP growth (as shown in Young 1995), whereas the dual estimate resulted in positive TFP growth (as shown in Hsieh 1999). Moreover, the annual growth rates of TFP were higher under the dual than under the primal estimates. He emphasized that he is not saying factor accumulation was not important in accounting for the sources of growth in these NICs. Instead, he proposed that "technology may have played a much larger role in the economic transformation of Singapore than the primal estimates would have one believe. " (p.138)

ignores the interaction among agents and provides no explanation as to why there is a capital and labor boom. As Young suggested[3] (1995), to better understand the sources of the growth, resorting to the Neoclassical growth theory which focuses on the quantitative framework can explain why these NICs grew faster than the rest of the economies.

Before constructing any detailed neoclassical model to explain the long-term growth in these NICs, I propose to adopt a neoclassical diagnostic procedure, which is similar to Business Cycle Accounting, to preliminarily identify the mechanism which is quantitatively important in accounting for the growth of these NICs. This procedure is developed based on the neoclassical growth model logic. By construction, it preliminarily manifests the types of time-varying wedges (i.e., TFP, labor wedges and investment wedges, representing productivity, labor and capital market conditions, respectively) that are critical in determining the trend and level of output, labor and capital.

Business Cycle Accounting, which has been developed in the recent business cycle literature, has been adopted to identify the most relevant friction leading to the Great Depression of 1929-1939 (Cole and Ohanian, 1999, 2002; Chari, Kehoe and McGrattan 2002, 2007). In addition to literally demonstrating what types of frictions are quantitatively important in accounting for the Great Depression, Chari et al. (2007) demonstrated that "many models are equivalent to a prototype growth model with time-varying wedges that resemble productivity, labor and investment taxes and government consumption." (p. 781) Therefore, in the business cycle literature, Business Cycle Accounting preliminarily identifies the friction that is quantitatively important and guides researchers in building a sophisticated and relevant model to account for the business cycle.

[3] Young (1995) concluded, "Neo-classical growth theory, with its emphasis on level changes in income and its well-articulated quantitative framework, can explain most of the difference between the performance of the NICs and that of other post-war economies." (p. 675)

I apply a procedure similar to Business Cycle Accounting to diagnose the long-term growth of these East Asian NICs. The application is motivated by the fact that long-term growth and business cycles share a common focus on level changes and the dynamics of economic transition. The neoclassical diagnostic procedure enables me to identify the critical momentum driving the growth and provides guidance on how to construct a sophisticated model with a relevant mechanism explaining the growth. Therefore, the new procedure can serve as an intermediate step to move from the observation of Growth Accounting to Neoclassical-type quantitative analysis. To the extent that output growth is being driven by more capital and labor, as suggested by Young (1995) and Hsieh (1999), my analysis is the next step in helping researchers to understand why the East Asian NICs rapidly accumulated so much capital and labor.

This new procedure has at least three advantages when studying long-term growth. First, it is also an accounting approach which takes into account agents' interactions and studies the economy as a whole. Thus it improves Growth Accounting in the sense that it extends the focus from production to the general equilibrium of a simplified economy. Second, the procedure allows researchers to differentiate the growth attribute to changes in capital and labor market conditions or TFP improvement and explains why there is more capital and labor. Finally, the procedure provides a guideline for constructing a detailed model with relevant features to quantitatively study the sources of East Asian growth.

In applying this procedure, I first document those deviations in the capital and labor markets – i.e., the investment wedge and labor wedge, and the TFP using the Solow procedure – relative to a benchmark model. Second, these time-varying wedges are fed into the model one at a time to demonstrate the marginal contribution of TFP improvement, as well as the impact of the changes in capital and labor market conditions on the growth of capital, labor and output in these

NICs. Finally, I identify the wedge creating the largest marginal contribution in forming the realized trajectory, and that particular wedge is the critical source of growth.

The preliminary diagnostic results show that the role of TFP improvement is more important than what is literally shown by Growth Accounting. TFP improvement contributes to growth from two channels[4]: it directly enters the production process and indirectly triggers more capital accumulation and thus more output. Therefore, I quantitatively support the idea that TFP improvement has more of an influence on growth than Growth Accounting would suggest. Similarly, since investment wedges induce more labor and a higher output level, the changes in capital market conditions (represented by investment wedges) play a larger role than that suggested by Growth Accounting. The combined effects of changes in capital market conditions and TFP improvement result in these growth miracles.

To be specific, I find that the growth patterns differ among these NICs. The TFP improvement is crucial in determining the capital and output level attained today by South Korea and Taiwan. The impact of TFP on capital accumulation and output growth is more influential in Taiwan than in South Korea. For Hong Kong, TFP is crucial in explaining the trend (rapid growth in the 1980s and a slowing down in the late 1990s) for both output and capital. Despite the fact that the impact of TFP on growth can not be ignored, investment and labor wedges together already account for the output and capital level attained today by Hong Kong. For Singapore, TFP demonstrates only a trivial contribution in accounting for its long-term trend. Therefore, my result supports Young's finding that TFP improvement is not important in accounting for the growth in Singapore. Finally, changes in factor market (i.e., capital and labor market) conditions drive the labor choice dynamics for all the NICs. In particular, the changes in capital market conditions enhanced the observed labor boom.

[4] This phenomenon can be easily observed from the cases of South Korea and Taiwan.

The remainder of this paper is organized as follows. First, I briefly describe how to use the neoclassical diagnostic procedure in the long-run growth context. Second, I describe the parameters chosen, the benchmark model used for the diagnosis, and the measured wedges. Next, I conduct a simulation controlling the presence of different combinations of wedges and analyze the marginal effect of different wedges on the growth of these East Asian NICs. Finally, I present the concluding remarks in the last section.

2. Neoclassical Diagnostic Procedure for Long-term Growth

In the literature on the U.S. Great Depression, Cole and Ohanian (1999, 2002), and Chari, Kehoe and McGrattan (2002, 2007) suggested the adoption of a neoclassical diagnostic procedure, namely, Business Cycle Accounting, to diagnose the causes of economic downturns. Since long-term growth and business cycle studies share a common focus in terms of changes in output level and transitional dynamics, I adopt a similar procedure to diagnose the causes of economic booms.

I closely follow the procedure suggested by Cole and Ohanian (2002). The accounting procedure begins with the equilibrium conditions of an economy under a Ramsey-Cass-Koopmans type of deterministic, discrete-time growth model. The model can be augmented with assorted shocks, which cause the economy to deviate away from its balanced growth path.

The model is composed of an infinitively-lived representative family with a log utility function and Cobb-Douglas production technology. Therefore, after detrending all the variables, the economy without shocks can be characterized by six equations[5] as follows:

$$\widetilde{Y}_t = \widetilde{k}_t^{\theta}(x_0 h_t)^{1-\theta} \tag{1}$$

$$\widetilde{C}_t = \frac{\widetilde{w}_t}{(1-h_t)\phi} \tag{2}$$

$$\{(1+\gamma)\frac{\widetilde{C}_{t+1}}{\widetilde{C}_t \cdot \beta}\} = 1 + r_{t+1} - \delta \tag{3}$$

[5] The detailed setup for the neoclassical growth model representing the undistorted economy is shown in Appendix 1.

$$\widetilde{Y}_t = \widetilde{C}_t + (1+v)(1+\gamma)\widetilde{k}_{t+1} - (1-\delta)\widetilde{k}_t \quad (4)$$

$$r_t = \theta \frac{Y_t}{\widetilde{k}_t} \quad (5)$$

$$\widetilde{w}_t = (1-\theta)\frac{\widetilde{Y}_t}{h_t} \quad (6)$$

The above system of equations (1-6) defines the general equilibrium of the simplified economic system.

However, although the equality of these equations holds under a simplified economic system, the equality does not necessarily hold in reality. When the data are plugged into these equations, and the right- and left-hand sides of the equations are not equal to each other, the differences are defined as "wedges". These wedges gauge the discrepancy between the two sides of the equations.

I follow Chari et al. (2002, 2007) and refer to the wedges[6] for equation (1) as productivity (Z/TFP). Moreover, the wedges for equation (2) are referred to as labor wedges (τ_{lt}), and the wedges for equation (3) are referred to as investment (Euler Equation) wedges (τ_{kt}). While Chari et al. regard these time-varying labor and investment wedges as labor taxes and investment taxes, under the context of long-term growth, I interpret these wedges as country-specific labor and capital market conditions. Finally, the wedges for equation (4) are referred to as income wedges.

Within the context of the business cycle, these wedges are the types of frictions that drive the business cycle. Therefore, under Chari et al.'s application, their focus is on the magnitude of these wedges (deviations) and they investigate how these wedges drive the economy away from its balanced growth path, which results in the observed business cycle.

Likewise, within the context of long-term growth, I interpret the labor wedge as an indicator of the labor market conditions, and the investment wedge as an indicator of the capital

[6] The detailed discussion regarding the wedges is in Appendix 2.

market condition. For example, I interpret the declining labor (investment) wedge series as representing an improvement in labor (capital) market conditions over time. Similarly, a rising TFP implies an improvement in the production technology. Therefore, under my application, I focus on the trend of these wedges and investigate how these time-varying wedge series drive the economy to transit from a low steady state to a high steady state. If the country-specific market condition changes dramatically and have a long-term effect on economic performance, large and trending wedges, resembling permanent shocks, will be observed. In this case, the wedges reflect the size of the impact on growth from productivity improvements (Z), labor market conditions (the labor wedge) or the capital market conditions (the investment wedge).

These wedges are defined as follows[7]:

$$productivity\ (TFP): Z_t = \frac{\widetilde{Y}_t}{\widetilde{k}_t^{\theta}(x_0 h_t)^{1-\theta}}$$

$$labor\ wedges(wedges\ in\ labor\ market) :: \frac{\widetilde{C}_t}{\widetilde{w}_t}\frac{\phi}{1-h_t} \equiv (1-\tau_{lt})$$

$$investment\ wedges(wedges\ in\ capital\ market): \{(1+\gamma)\frac{\widetilde{C}_{t+1}}{\widetilde{C}_t \cdot \beta} - 1 + \delta\} \equiv r_{t+1} \cdot (1-\tau_{k,t+1})$$

$$income\ wedges: gap_t^y = \widetilde{Y}_t - \widetilde{C}_t - (1+v)(1+\gamma)\widetilde{k}_{t+1} + (1-\delta)\widetilde{k}_t$$

Ideally, introducing all the wedges above will well mimic the trajectory of economic transition since I endogenize factor prices in the model.

3. The Procedure for Implementing the Neoclassical Diagnostic Procedure

To implement the neoclassical diagnostic procedure in relation to the sources of long-term growth, I need to determine all the parameters and the wedges and then begin the neoclassical

[7] My Euler equation wedge is slightly different from that of Chari et al. (2002, 2007). I define the capital wedge as capital income tax rather than investment tax.

diagnosis. I describe the parameters and the benchmark model I use in Section 3.1, the wedges in Section 3.2, and then explain the diagnostic procedure in Section 3.3.

3.1 Parameters and the benchmark model

The main purpose in diagnosing the long-run growth is to show why these NICs grew faster than the rest of the world. Consequently, I apply the standard parameter values for the following parameters[8]: the population growth rate (ν=2%), the technological improvement rate (γ=2%), the labor share (θ=1/3), the discount factor (β=0.95), and the depreciation rate (δ = 5%). I choose a time allocation parameter of 2 (φ=2) so that the share of time a household spends on work is around 0.31. Finally, I choose an efficiency scalar for labor in production technology of 200 (x_0=200) so that the output at the steady state is rounded up to 100.

Given these parameters, a frictionless benchmark model can be derived (with zero labor, investment and income wedges and with TFP equal to one forever) to generate the trajectories representing the economy which grows at 4% each year. I assume this benchmark model represent the simplified economy of the world. Any economy that grows at a rate faster or slower than 4% can attribute such growth to changes in labor wedges, investment wedges, productivity and income wedges. The changes in these wedges reflect the evolution of the country-specific market conditions and can be used to explain why some countries grow rapidly and some grow slowly. Finally, I assume that all these NICs attain their steady states by 2006. From 2007 onward, the economy remains on the steady state with the same country-specific wedges as in 2006 forever.

[8] I assume that the balanced growth rate of the economy equals the average world growth rate (g=2%). Similarly, the average working age population (15-64) in the world grows at a rate of 1.9408%. Therefore, I adopt 0.02 as the population growth (ν =2%) in the model.

3.2 The wedges

Each NIC has different country-specific TFP improvement, capital and labor market conditions (represented by TFP, investment wedges and labor wedges). Compared with the benchmark economy, the spectacular growths (faster than the benchmark economy) of these NICs are mainly attributable to changes in these wedges, namely, labor wedges, investment wedges, productivity and income wedges, all of which are country-specific characteristics.

In this section, I describe these wedges, namely, labor wedges (labor market conditions), investment wedges (capital market conditions), and productivity (TFP) for four cases: HKG, SGP, KOR, and TWN[9]. These wedges capture how the East Asian NICs deviate from the benchmark balanced growth path. I show these wedges and compare them across these NICs.

Figure 1 depicts the productivity (TFP/Z) characteristic. As can be seen, TWN and KOR experienced the greatest productivity improvement. For HKG, productivity improved before 1988, and remained above 1.25 until 1995. By 2006, the TFP equaled 1.138. Finally, for SGP, productivity did not significantly differ over the period from 1978 and 2006 and fluctuated between 1.17 and 1.36 during the period being studied.

Figure 2 focuses on the investment wedges. As can be seen, the frictions in the capital market negatively impacted[10] the agents' decisions regarding saving and investment in the earlier periods. In addition, one interesting phenomenon that can be observed is the impact of the East Asian Currency Crisis in 1997 on these NICs. The corresponding investment wedges reveal a large amount of friction (positive wedges) in the capital market, whereas the magnitude for TWN is small. This may due to the fact that the impact of the East Asian Currency Crisis on Taiwan is minor, whereas the impact on South Korea is significant. In other words, the diagnostic

[9] The income wedge plays a small role in determining the equilibrium paths. For simplicity, I do not discuss how income wedges affect the growth of these NICs. (For Singapore, the income wedge is more volatile than in the cases of the other NICs and plays a slightly larger role in determining the growth trajectory. However, adding the income wedge does not affect my conclusion. Therefore, I only discuss TFP, as well as the labor and investment wedges.

[10] This is implied by the positive investment wedges.

procedure successfully captures major capital market friction such as a financial crisis and is reflected as investment wedges with the right sign.

Figure 3 shows the labor wedges. As can be seen, HKG and SGP follow a similar pattern which has been declining over time. On the contrary, KOR and TWN follow another pattern which has been increasing over time, but by a smaller amount than in the cases of HKG and SGP. The two different patterns may arise due to the fact that HKG and SGP are city states. Therefore, the labor migration patterns in Hong Kong and Singapore differ from those in South Korea and Taiwan.

3.3 The Diagnostic Procedure

The diagnostic procedure starts by assuming that the agents in the economy have perfect foresight. Then, I simulate the transition trajectories for output, capital and labor adding in the wedge series one at a time. I begin with the model with no change in wedges and by fixing all the wedges at their level in 1978 up to the end of the simulation[11]. Then, I sequentially add in the series of labor wedges, investment wedges, TFP, and then income wedges one at a time to show the marginal contribution of each wedge series to output, capital and labor. Finally, by default of the model, introducing all the wedges in the model will result in the trajectories being the same as the data would show.

By including one series of wedges at a time, I can visualize the marginal effect of each wedge in terms of contributing to the output growth, capital and labor boom. The logic behind this application is as follows. The investment and labor wedges represent the capital and labor market conditions, whereas TFP represents productivity. When considering the inclusion of a

[11] For all the scenarios, the wedge values assumed in 2006 are the wedges for the economy after 2006. That is, the wedges do not change from 2006 onward for all the scenarios.

particular wedge in the model[12], it is implied that I take that country-specific market condition into account. Please note that the country-specific condition can be an inferior market condition (i.e., a restriction), a frictionless market condition, a superior market condition, or a transition from a restricted economy to one with less friction.

Therefore, the diagnostic procedure involves a process of decomposition. To begin with, I predict the transition path based on a **"Model without changes in wedges (the wedges are fixed at their value in 1978)".** This counter-factual scenario assumes that the capital and labor market conditions remain the same from 1978 onwards. The trajectories for this case represent the country's initial state and the economic performance without there being any changes in the capital and labor market conditions, nor productivity. When I simulate the trajectories by adding one wedge at a time, the differences between the "Model without changes in wedges" and the data will be decomposed into the marginal contribution of labor wedges, investment wedges, TFP and income wedges.

For the decomposition, I first investigate the **"Model with changes in labor wedges only".** This case shows how the changes in the labor market conditions from 1978 to 2006 contribute to the growth in these NICs. The differences between the trajectories generated by the "Model with changes in labor wedges only" and by the "Model without changes in wedges" represent the marginal contribution of labor wedges (changes in labor market conditions) on the growth of output, capital and the labor boom. Second, I show the trajectories generated by the **"Model with changes in investment and labor wedges"**. This case shows what the growth trajectories would have looked like when the capital and labor market are allowed to evolve as was the actual case during the period of study. Therefore, the marginal contribution of investment wedges is the difference between the trajectories generated by the "Model with

[12] Since the model presented is for detrended per capita variables, the simulated data should show no growth at all if the economy is initially at the steady state, remains on the balanced growth path and grows by 4% annually given my parameters. (The population growth rate and the growth rate of technological advance are 2%, respectively.)

changes in labor wedges only" and those by the "Model with changes in investment and labor wedges". Third, I generate the trajectories under the **"Model with changes in TFP, investment and labor wedges"**. The differences between the trajectories predicted by this scenario and those predicted by the "Model with investment and labor wedges" are the marginal contribution attributable to TFP improvement. Finally, I show the paths generated for the "Model with all wedges". The paths coincide with the data, i.e., "Data", by default. The differences between the trajectories of the data and those generated by the "Model with TFP, investment and labor wedges" represent the marginal contribution of income wedges.

4. The diagnostic results

In this section, I identify the momentum driving the growth in the East Asian NICs using the model and procedure set up in Section 3. By controlling the presence of different wedges under different scenarios, the simulation results identify the marginal contribution of these time-varying wedges in the capital and labor markets and TFP on output growth, as well as the dynamics of capital and labor accumulation.

In this section, I will answer two questions. First, from the neoclassical perspective, what are the major forces that drive the output to grow? (Which wedge leads to the largest marginal contribution?) Second, what are the country-specific characteristics (e.g., labor wedge, investment wedge and TFP) that drive the mass accumulation of capital and labor and then contribute to the growth in these NICs?

For each scenario, I show four cases: HKG, SGP, KOR and TWN, which use labor hours as the labor input. For each case, I sequentially include one series of wedges at a time so as to demonstrate the marginal contribution of labor wedges, investment wedges, TFP and income wedges on the dynamics of output, capital and labor accumulation.

In all the figures (Figure 4 to Figure 6), the results for Hong Kong (HKG) are in the upper left panel; the results for Singapore (SGP) are in the upper right panel; the results for South Korea (KOR) are in the lower left panel; and the results for Taiwan (TWN) are in the lower right panel.

4.1 Decomposition for output growth: Identifying the major contributors to output growth

Figure 4 shows the trajectories for output predicted by models with different combinations of wedges. As can be seen, for HKG, the marginal contribution of the investment wedge is substantial, since the trajectory predicted by the “Model with changes in investment and labor wedges” significantly raises the trajectory predicted by the “Model with changes in labor wedges only”. However, the “Model with changes in investment and labor wedges” does not capture the rapid growth from the mid-1980s to the mid-1990s, nor does it capture the slow down since the mid-1990s. Therefore, investment wedges and TFP improvement are the two major forces driving the output growth in Hong Kong. Finally, the trajectory predicted by the “Model with changes in labor wedges only” falls below that predicted by the “Model without changes in wedges”. This implies that the labor market conditions in Hong Kong are not favorable to growth from the 1970s to the 1990s.

For SGP, the marginal contribution of the investment wedge is substantial as well, since the trajectory predicted by the “Model with changes in investment and labor wedges” significantly raises the trajectory predicted by the “Model with changes in labor wedges only”. Moreover, the path generated by the “Model with changes in investment and labor wedges” moves by following a similar trend to “Data” up to the 1990s. Therefore, the changes in capital and labor market conditions (represented by investment wedges and labor wedges) are the two major forces driving the growth in Singapore. Finally, TFP has a small marginal contribution to growth since the path predicted by the “Model with changes in investment and labor wedges” and by the “Model with changes in TFP, investment and labor wedges” follows the same trend with relatively small differences.

For KOR, the marginal contribution from the TFP improvement is significant since the trajectory predicted by the “Model with changes in TFP, investment and labor wedges” significantly raises the trajectory predicted by the “Model with changes in investment and labor wedges”. Without TFP improvement but with all other wedges, the output level in South Korea could have been 65% of what it realized in 2006. However, the equilibrium path with its upward trend generated by the “Model with changes in investment and labor wedges” suggests that, without TFP, KOR could have continued to grow from 1978 to 2001 (with a few exceptions[13]), but would not have grown that fast. Finally, the figure shows that the path predicted by the “Model with changes in labor wedges only” was slightly higher than “Data” during 1980-1982 and then began to fall below the path predicted by the “Model without changes in wedges”. This may imply that, during its early development period, the changes in labor market conditions positively contributed to the output growth in South Korea. Nevertheless, the changes in labor market conditions have not favored growth since 1983.

For TWN, the marginal contribution of an improvement in TFP is enormous since the trajectory predicted by the “Model with changes in TFP, investment and labor wedges” significantly raises the trajectory predicted by the “Model with changes in investment and labor wedges”. Without an improvement in TFP but with all other wedges, the output level in Taiwan could have been 54% of what it realized in 2006. Finally, the equilibrium predicted by the “Model with changes in investment and labor wedges” shows that Taiwan would have stopped growing since the 1980s if there had been no changes in TFP. Moreover, if changes in the capital

[13] The years that are exceptions are 1979, 1983-1984, 1988, 1990 and 1998.

and labor markets had been the only economic conditions allowed to change in Taiwan, Taiwan's output would have reverted back to an output level lower than that of the 1980s.

To sum up, TFP improvement is important in accounting for the output dynamics in Hong Kong, South Korea and Taiwan. It is also crucial in determining the output level attained today by South Korea and Taiwan but not by Hong Kong. Finally, for Singapore, the changes in capital and labor market conditions are the major forces driving the growth in Singapore.

4.2 Decomposition of the capital boom: Identifying the major contributors to the capital boom

When there is more capital input, the economy will give rise to more output. Therefore, in this section, I would like to address what wedges drive the excess capital accumulation in these NICs. Are investment wedges the only wedges that play a significant role in triggering the rapid capital accumulation?

Figure 5 shows the trajectories for capital accumulation predicted by models with different combination of wedges. As can be seen, for all these NICs, in terms of the marginal contribution of wedges to the capital boom, the role played by changes in labor market conditions is trivial[14]. In addition, the role played by changes in capital market conditions together with TFP improvement is influential[15], except for Singapore.

From the above analysis, I find the contribution of TFP to growth is greater than what Growth Accounting suggests, for Growth Accounting can only show what percentage of output growth results from a TFP improvement. The neoclassical diagnostic procedure, however, shows more than that. Through the lens of the neoclassical model, the transition dynamics reveals that TFP improvement also induces more capital accumulation and thus more output. In other words,

[14] This is because the difference between the trajectory predicted by the "Model without changes in wedges" and that by the "Model with changes in labor wedges only" is either small or has a negative impact on the capital boom.

[15] This is because the difference between the trajectory predicted by the "Model with changes in labor wedges only" and that by the "Model with changes in TFP, investment and labor wedges" is significant and the latter is generated by a path much closer to "Data".

the impact of TFP on growth is twofold. First, TFP directly enters the production process and results in more output. Second, TFP indirectly induces more capital accumulation through the dynamics of the agents' desire to accumulate more capital and thus more output. The latter is the new insight regarding growth from the neoclassical perspective. Therefore, based on the capital accumulation dynamics, I find that TFP is also behind the scenes driving the capital boom, especially in South Korea and Taiwan.

4.3 Decomposition of the labor boom: Identifying the major contributors to the labor boom

When there is more labor input, the economy will result in more output. Therefore, in this section, I would like to address the wedges that drive the labor boom in these NICs. Are labor wedges the only wedges that play a significant role in triggering the labor boom?

Figure 6 shows the trajectories for labor choice predicted by models with different combinations of wedges. As can be seen, for all the NICs, the marginal contribution of TFP to the labor boom is minor since the difference between the trajectory predicted by the "Model with changes in TFP, investment and labor wedges" and that by the "Model with changes in investment and labor wedges" is relatively trivial[16]. This implies that TFP improvement has a relatively small effect in inducing agents to devote more labor hours to work in these NICs. Moreover, the evolutionary pattern of labor choices over time is mainly driven by labor wedges. Finally, investment wedges also play some role in inducing more labor.

In addition, for HKG, KOR and TWN, the "Model without changes in wedges" results in a trajectory that is higher than that predicted by the "Model with changes in labor wedges only," but lower than that predicted by the "Model with changes in investment and labor wedges" for some years. This implies that the labor market conditions in Hong Kong, South Korea and

[16] This is because the difference between the trajectory predicted by the "Model with changes in investment and labor wedges" and that predicted by the "Model with changes in TFP, investment and labor wedges" is either small or has a negative impact on the labor boom.

Taiwan do not favor the growth performance during certain periods of time, and the evolution of capital market conditions has been an important factor enhancing the labor boom during these periods, e.g., Hong Kong from 1979 to 1993, South Korea since 1983, and Taiwan from 1981 to 1991.

Therefore, the effects of TFP improvement on labor choices are obscure. The labor market equilibrium is mainly affected by factor market wedges (i.e., investment and labor wedges), and, in particular, labor wedges determine the trend of labor choice. Finally, since the labor wedges do not favor the growth performance during certain periods of time, the changes in capital market conditions (i.e., investment wedges) are also important in accounting for the dynamic of labor choices.

5. Conclusion

In this paper, in attempting to answer the question regarding the sources of growth for the East Asian NICs, I introduce a neoclassical diagnostic procedure, similar to Business Cycle Accounting (e.g., Cole and Ohanian, 1999; Chari, Kehoe and McGrattan, 2002, 2007), to identify the major sources of growth. Compared with the traditional Growth Accounting used in the literature (which focuses on inputs and outputs in production), the new method identifies the sources of growth by analyzing the dynamics of the economy, which takes into account agents' and firms' decisions in equilibrium in addition to the production function. Thus, the neoclassical diagnostic procedure allows researchers not only to show why these economies grew fast, but also shows why there is a labor and capital boom.

The diagnostic approach sheds new light on understanding the spectacular growth in the East Asian NICs from at least three perspectives. First, it studies growth from the perspective of the economy as a whole rather than only focusing on the production process. Therefore, it enables researchers to take into account the agents' interaction when analyzing sources of growth and reveals more insights than Growth Accounting. Second, by means of identifying the marginal contribution of all the wedges to growth, the new procedure reveals why the output grew so rapidly in these NICs, and it also shows the forces behind the scenes that are driving the capital and labor boom. Finally, the procedure provides guidelines for constructing a model to quantitatively analyze the sources of the East Asian growth.

In other words, the neoclassical diagnostic procedure is also a decomposition methodology. It provides deeper implications than Growth Accounting as it extends the focus to the whole economy rather than solely concentrating on the production process. Moreover, the new approach quantitatively shows what type of friction/changes are needed for detailed model construction so to generate a growth model suitable for studying the growth dynamics in these NICs. Therefore, the neoclassical diagnostic approach serves as an intermediate procedure which decomposes the sources of growth and guides researchers in model construction.

The results of the preliminary diagnosis show that productivity improvement is a crucial momentum driving the long-term growth in South Korea and Taiwan. Without productivity improvement, the output level today in these NICs would have been much lower; these NICs can grow for a certain time, but at a lower rate. For Hong Kong, the improvement in TFP is crucial in capturing its rapid growth in the 1980s and its slow down in the late 1990s. Finally, for Singapore, changes in the capital and labor market conditions are the most important forces driving its long-term growth. This finding is consistent with Young's that the improvement in TFP does not account for the growth in Singapore.

I also investigated the origin of the labor and capital boom in these NICs. Through the neoclassical analysis, I found that the TFP improvement also induces more capital accumulation, especially in South Korea and Taiwan. Therefore, the contribution of TFP to growth is greater than the Growth Accounting would suggest. On the other hand, the evolution of the capital market conditions also accounts for the labor boom in these NICs. Therefore, the contribution of the changes in capital market conditions is greater than Growth Accounting would suggest as it plays a role in accounting for the labor choice dynamics.

To sum up, the improvement in TFP is crucial in explaining the output growth as well as the rapid capital accumulation in South Korea and Taiwan. For Hong Kong, the combined effect of the TFP improvement and the change in capital market conditions co-determines the trend and level of the output growth and capital accumulation. For Singapore, the evolution of the capital market conditions is important in accounting for the output growth and the capital accumulation there. Finally, for all the NICs, changes in labor market conditions determine the trend of labor choice and the changes in capital market conditions enhance the labor boom.

As the diagnostic procedure is preliminary, the results of this paper can guide researchers constructing related models to explicitly study the cause of the spectacular growth in these NICs. A few puzzles remain for this preliminary diagnosis. For example, what are the causes of the evolution of the capital and labor market conditions? What are the forces driving the TFP improvement? It can be promising to construct a model with a mechanism incorporating TFP as well as allowing changes in capital market conditions. A multi-sector model (which can endogenize the TFP improvement through labor migration from a low to a high productivity sector) with a mechanism (which generate changes in capital market conditions, e.g., financial development/liberalization in the 1980s) may shed light on the origin of the growth. Finally, it will be interesting to study the source of the unexplained growth rate (4%) assumed in the diagnostic procedure and to provide some theoretical explanation for it.

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_____ CSD, Census and Statistics Department, The Government of the Hong Kong Special Administrative Region http://www.censtatd.gov.hk/hong_kong_statistics/index.jsp

____ DGBAS, Directorate-General of Budget, Accounting and Statistics Executive Yuan, Republic of China, http://eng.stat.gov.tw/mp.asp?mp=5

_____ DataStream

_____ ECOS, Economic Statistics System, Bank of Korea, http://ecos.bok.or.kr/

_____ IFS, IMF International Financial Statistics

_____ KNOS, Korea National Statistical Office, http://www.nso.go.kr/eng2006/

_____ LABORSTA, International Labor Organization, http://laborsta.ilo.org/

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____ World Development Indicators

Appendix 1: The Model for Neoclassical Diagnoses

In this section, I describe the model used for the neoclassical diagnostic procedure.

A1.1 The Economy

The economy of the model is composed of a representative family, and producers in an environment characterized by perfect foresight. Individuals may face shocks but the shocks only last for one period.

A1.1.1 The Representative Family

I adopt a special form of the CES utility function for the family in this economy. Agents value leisure. There is one unit of labor available each period. In addition, they are infinitely lived. Hence, the preferences are as follows:

$$\text{Max } \left\{ u(C) = \sum_{t=0}^{\infty} \beta^t \{\log(C_t) + \phi \log(1 - \hat{h}_t)\} \right\}$$

where C is the family's consumption, and $\hat{h}$ is the total labor the family provides. The discount factor is represented by β.

Finally, the population grows deterministically at the rate ν, and thus population n at t can be expressed as follows: $n_t = (1+\nu)^t$

A1.1.2 Production Sector

Firms in this economy adopt labor-augmented Cobb-Douglas production technology. For a single firm, $y_t = k_t^{\theta}(x_t l_t)^{1-\theta}$, $x_t = (1+\gamma)^t x_0$, where y is output, k is the capital input, and l is the labor input. In addition, θ is the capital share and γ is the growth rate of the labor-augmented technology. Based on the property of the Cobb-Douglas production function, the production technology for the whole sector can be expressed as in equation (1) below:

$$Y_t = K_t^{\theta}(x_t \hat{L}_t)^{1-\theta} \tag{A.1}$$

In equation (1), Y is the aggregate output, K is the aggregate capital input, and L is the aggregate labor input.

A 1.2 The Equilibrium

A competitive equilibrium is derived as follows (from A to D):

A) Given that the population grows deterministically at the rate ν, and $n_t = (1+v)^t$, I divide all the variables by $n_t = (1+v)^t$ in order to get rid of the growth effect from the population.

B) Given the labor-augmented technology which grows at the rate γ, I detrend all the variables by $(1+\gamma)^t$.

C) The stationary version of the model as a competitive equilibrium is presented below after defining the detrended per capita variables as follows:

$$\tilde{k}_t = \frac{k_t}{(1+v)^t(1+\gamma)^t}; \qquad \tilde{K}_t = \frac{K_t}{(1+v)^t(1+\gamma)^t}$$

$$h_t = \frac{\hat{h}_t}{(1+v)^t}; \qquad L_t = \frac{\hat{L}_t}{(1+v)^t}$$

$$\tilde{Y}_t = \frac{Y_t}{(1+v)^t(1+\gamma)^t}; \qquad \tilde{C}_t = \frac{C_t}{(1+v)^t(1+\gamma)^t}$$

$$\tilde{I}_t = \frac{I_t}{(1+v)^t(1+\gamma)^t}; \qquad \tilde{w}_t = \frac{w_t}{(1+\gamma)^t}$$

D) To obtain the competitive equilibrium, I take the following steps (from a to f) :

a) Given $\{w_t, r_t\}_{t=0}^{\infty}$, K and L solve the firm's problem:

$$\underset{K_t, L_t}{Max}\left\{Z_t K_t^{\theta}(x_t L_t)^{1-\theta} - w_t L_t - r_t K_t\right\}$$

$$\Rightarrow \frac{\partial Y}{\partial K_t} \equiv r_t = \theta \cdot Z_t K_t^{\theta-1}(x_t L_t)^{1-\theta} = \theta \frac{Y_t}{K_t}$$

$$\frac{\partial Y}{\partial L_t} \equiv w_t = (1-\theta) Z_t K^{\theta} x_t^{1-\theta}(L_t)^{-\theta} = (1-\theta)\frac{Y_t}{L_t}$$

b) The representative family maximizes utility given $\{w_t, r_t\}_{t=0}^{\infty}$

$$\underset{h_t, k_{t+1}}{Max}\left\{u(C) = \sum_{t=0}^{\infty} \beta^t \{\log(C_t) + \phi \log(1-h_t)\}\right\}$$
$$s.t. \quad C_t + I_t \le w_t h_t + r_t k_t$$
$$I_t = K_{t+1} - (1-\delta)K_t$$
$$F.O.C.: \quad \frac{\partial \bullet}{\partial h_t} : \frac{w_t}{C_t} = \frac{\phi}{1-h_t}$$
$$\frac{\partial \bullet}{\partial \tilde{k}_{t+1}} : \frac{C_{t+1}}{C_t} = \beta \cdot (1 + r_{t+1} - \delta)$$

c) The market clearance conditions are: $K_t = k_t$, $L_t = h_t$

There are two factor-markets in this economy, namely, the capital market and labor market. Therefore, I set two market clearing conditions in equilibrium. The capital market clears at price r_t, the labor market clears at wage w_t and the resource constraint is satisfied.

d) Resource Constraint

$$C_t + I_t \le Z_t K_t^{\theta} (x_t L_t)^{1-\theta}$$

e) Law of Motion

$$(1+v)(1+\gamma)\tilde{K}_{t+1} = \tilde{I}_t + (1-\delta)\tilde{K}_t$$
$$x_t = (1+\gamma)^t$$

f) The System of Equations

Therefore, a competitive equilibrium for an undistorted system consists of a sequence of quantities $\{h_t, k_t, Y_t, C_t\}_{t=0}^{\infty}$, and a sequence of prices $\{w_t, r_t\}_{t=0}^{\infty}$, such that the representative family and firm optimize their production and markets clear.

The system of equations (equations A.2 to A.7) that characterize the equilibrium in terms of the detrended variables is as follows:

$$\tilde{Y}_t = \tilde{k}_t^{\theta} (x_0 h_t)^{1-\theta} \tag{A.2}$$

$$\tilde{C}_t = \frac{\tilde{w}_t}{(1-h_t)\phi} \tag{A.3}$$

$$\{(1+\gamma)\frac{\widetilde{C}_{t+1}}{\widetilde{C}_t \cdot \beta}\} = 1 + r_{t+1} - \delta \tag{A.4}$$

$$\widetilde{Y}_t = \widetilde{C}_t + (1+v)(1+\gamma)\widetilde{k}_{t+1} - (1-\delta)\widetilde{k}_t \tag{A.5}$$

$$r_t = \theta \frac{Y_t}{\widetilde{k}_t} \tag{A.6}$$

$$\widetilde{w}_t = (1-\theta)\frac{\widetilde{Y}_t}{h_t} \tag{A.7}$$

The system of equations (A.2-A.7) has 6 equations and 6 unknowns. The system expresses the steady state conditions of the economy along the balanced growth path.

Appendix 2: Interpretations of the wedges

The above system of equations (A.2-A.7) is the general equilibrium of the simplified economic system. If all variables remain the same for an economy (if there is any trend, one can detrend the variables and make the trend stationary), we say the economy is at the steady state and this trajectory is referred to as the balanced growth path. However, the economy does not always stay on this path. From the perspective of business cycle analysis, if there are shocks, the economy will deviate away from its balanced growth path and we will observe booms and busts. From the perspective of long-term growth, if the market conditions are better than those of the rest of the world or have been improving over time, or if the economy has more rapid TFP improvement than the rest of the world, the economy will grow at a faster rate and then depart from the balanced growth path of the rest of the world.

A2.1 Interpretation of the wedges in the context of the business cycle

In the context of the business cycle, Chari et al. define wedges (taxes or gaps) to gauge the right- and left-hand side of each equation (A.2 – A.5). These wedges then quantify the extent to which an economy deviates away from the balanced growth path and they represent the sources of shocks that drive business cycles. They characterize these "wedges" as productivity

(Z) for equation (A.2), labor wages or labor taxes (τ_{lt}) for equation (A.3), investment wedges or capital taxes (τ_{kt}) for equation (A.4), and government consumption wedges for equation (A.5).

These wedges reflect the sizes of the shocks to productivity, the labor market, the capital market and domestic resources that cause the economy to deviate from the balanced growth path. The economy faces a positive shock to productivity if Z is greater than one, whereas it faces a positive shock to the labor and capital markets when taxes (τ_{lt} and τ_{kt}) are negative. By construction, introducing all the wedges above will account for the observed dynamics of the business cycle.

A2.2 Interpretation of the wedges in the context of long-term growth

Within the context of long-term growth, I interpret the labor wedge as an indicator of the labor market conditions and the investment wedge as an indicator of the capital market conditions. For example, I interpret the declining labor (investment) wedge series as improving the labor (capital) market conditions over time. Similarly, a rising TFP implies that the production technology has been improving.

To implement this diagnostic approach to study economic development rather than the business cycle, I regard Z as total factor productivity (TFP). I interpret labor wedges (τ_{lt}) as an indicator of labor market conditions that drive the economy away from the balanced growth path for the rest of the world (either higher or lower). As the diagnostic approach is preliminary, higher labor participation over time is regarded as negative labor wedges in this exercise. Similarly, I interpret investment wedges (τ_{kt}) as the capital market conditions. Therefore, all the frictions in the capital market, e.g., financial repression which impedes saving and investment activities, are counted as positive investment wedges. Ideally, introducing all the wedges above will well mimic the trajectory of the economic transition since I endogenize factor prices in the model.

Appendix 3: Data Treatment

In this section, I briefly describe the data used in the analysis:

For all the NICs, as to the output (Y), I chose GDP as my base value for output since the economic shocks generally impact an economy according to geographical regions, rather than being based on national boundaries. In addition, the output I used in the analysis that follows excludes the net indirect tax (equivalent to National Income plus depreciation) since taxes are not payments for factor inputs. Thus, for real per capita output I used GDP minus indirect tax divided by working age population. For per capita consumption, I used private consumption divided by working age population.

For the capital stock, I used the perpetual inventory technique for the sub-category of fixed capital formation and adopt the sub-category depreciation rate assumed in Young (1998): "1.3% for residential structure, 2.8% for non-residential structure, 3.4% for other construction, 18.3% for transportation equipment, and 14.0% for machinery." (p.30) To estimate the initial capital stock, I followed the equation $I_t = (\delta + \gamma)K_{t-1}$. To avoid random bias, I took the average of the gross fixed capital formation in real terms for the first three years for which data were available. The underlying assumption is that different capital stocks grow at the same rate as GDP in the initial years and are representative of the investment prior to the time series[17]. I chose three years rather than five years for the average so as to minimize the use of data and allow longer periods of deprecation for the initial stock before 1978. I also included "net foreign investment" – Gross National Saving minus Gross Domestic Fixed Capital Formation in

[17] This method is used in Harberger (1978).

accumulating the capital stock. The depreciation rate I used for this time series is 5% since this portion of capital is "international investment" and would depreciate at a rate similar to capital in the rest of the world.

For the labor input, I used labor hours as the labor input in the model. In addition to the absolute number of labor hours, an increase in the quality of human capital may mark up the "effective" labor input. In the diagnosis, such an effect is viewed as a tax subsidy in the labor market (negative labor wedges). Another issue that one may encounter when talking about labor input concerns intersectoral transfers of labor. The preliminary diagnosis will view that as a productivity improvement.

The data for Hong Kong were taken from the Census and Statistics Department (CSD), Hong Kong, International Labor Statistics (ILO), and the World Development Indicators (WDI). There are some self-estimated proxies for the data for HKG: indirect tax, fixed capital formation for transportation goods, and labor hours.

The data for indirect tax begins in 1980. To extend the series to 1978, I assumed that the indirect tax rate was 4.04%[18] of GDP from 1978 to 1979. I also calculated the domestic fixed capital formation of transportation for HKG. I requested the subcategories of fixed capital formation from CSD and the data they provided only included the data for four subcategories: residential buildings, non-residential buildings, other construction, machinery and equipment. I also obtained the data for domestic fixed capital formation from WDI. I took the difference between domestic fixed capital formation and the sum of the four categories mentioned above as the domestic fixed capital formation for transportation equipment.

For the hours worked in the case of Hong Kong, I adopted the series from 1985 to 2006 based on the data from CSD. To extend the series to as early as 1978, I referred to the database

[18] This is the average ratio of indirect tax to GDP from 1980 to 2006.

from the ILO. The ILO provides data for the hours worked per week in Hong Kong from 1978 to 2006 for Manufacturing, Construction, Transport, Storage and Communications. I took the average of these three series from the ILO. Next, I also obtained the series from CSD for the period from 1985 to 2006. I calculated the ratio between the series from CSD and those from the ILO and found that the ratio had been increasing over time. Therefore, I assumed that the ratio from 1978 to 1985 had been increasing over time from one by 1 percentage point each year[19]. Thus, the series was extended.

The data for Singapore are taken from DataStream, the ILO, and SingStat Time Series (STS). I estimated the indirect tax for Singapore before 1980. Since the data for indirect tax begin in 1980, to extend the series to 1978, I assumed the indirect tax rate is 7.77%[20] of GDP from 1978 to 1979.

As to the data for South Korea, they were taken from the Korea National Statistical Bureau (KNOS), the Bank of Korea, the ILO and International Financial Statistics (IFS) of the International Monetary Fund (IMF).

Finally, the data for Taiwan were taken from DataStream, and National Statistics, Republic of China (Taiwan), and provided by the Directorate-General of Budget, Accounting and Statistics (DGBAS). The data for the working age population were obtained from the Taiwan Statistical Data Book, published by the Council for Economic Planning and Development (CEPD) of the Executive Yuan.

[19] Based on this rate of increase, by 1984, the ratio was 1.06, which was the same as the ratio in 1985. It is not awkward to have a similar ratio: the ratio in 1992 and 1993 was equal to 1.20, while the ratio in 2002 and 2003 was equal to 1.38.

[20] This is the average ratio of indirect tax to GDP from 1980 to 2006.

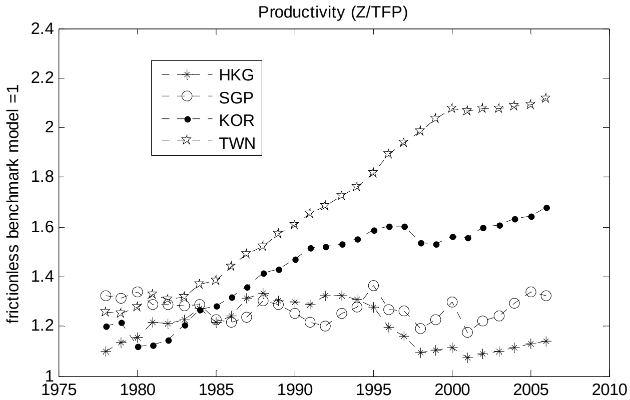

Figure 1: TFP for HKG, SGP, KOR and TWN

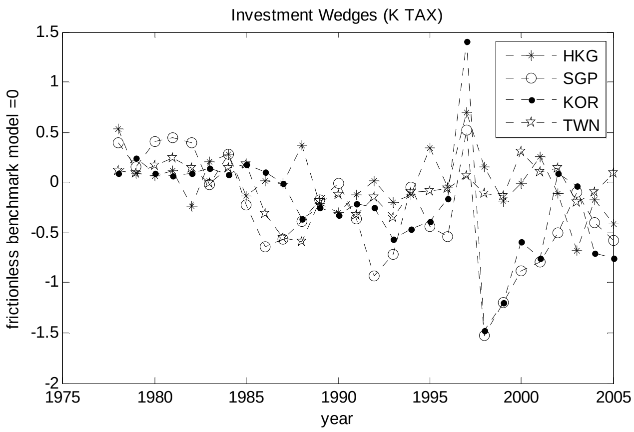

Figure 2: Investment wedges for HKG, SGP, KOR and TWN

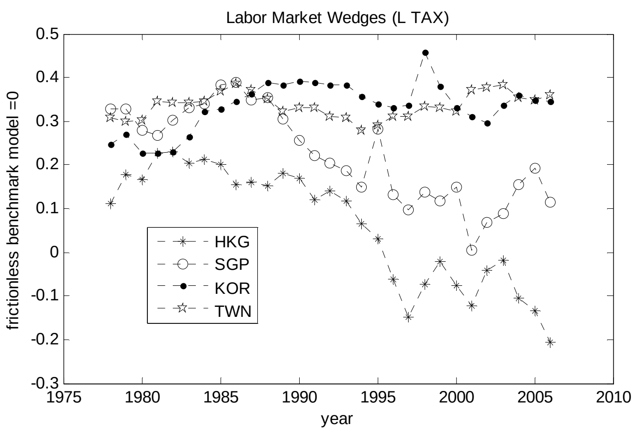

Figure 3: Labor wedges for HKG, SGP, KOR and TWN

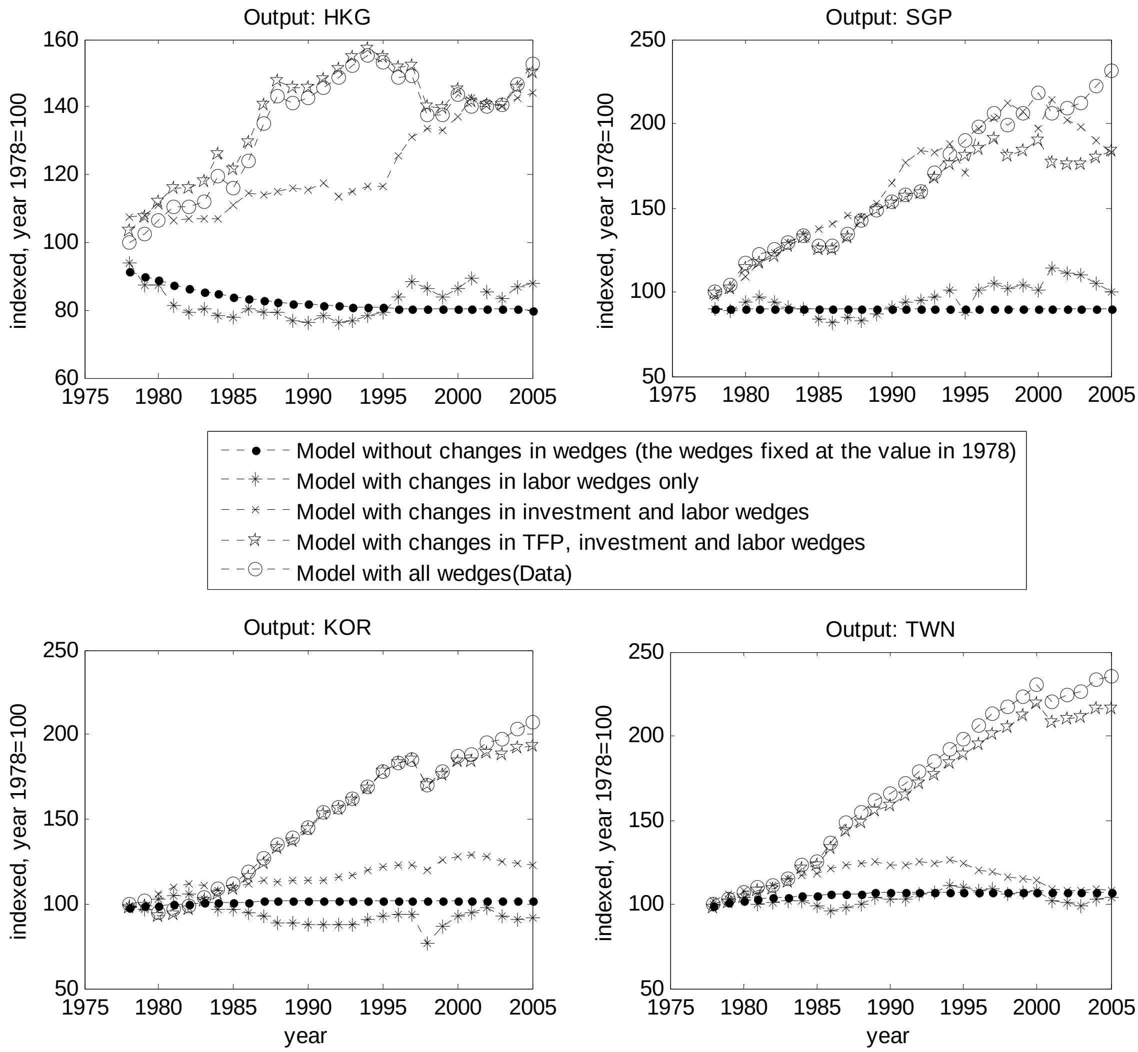

Figure 4: Trajectories for Output: Data and predictions of model for all the NICs

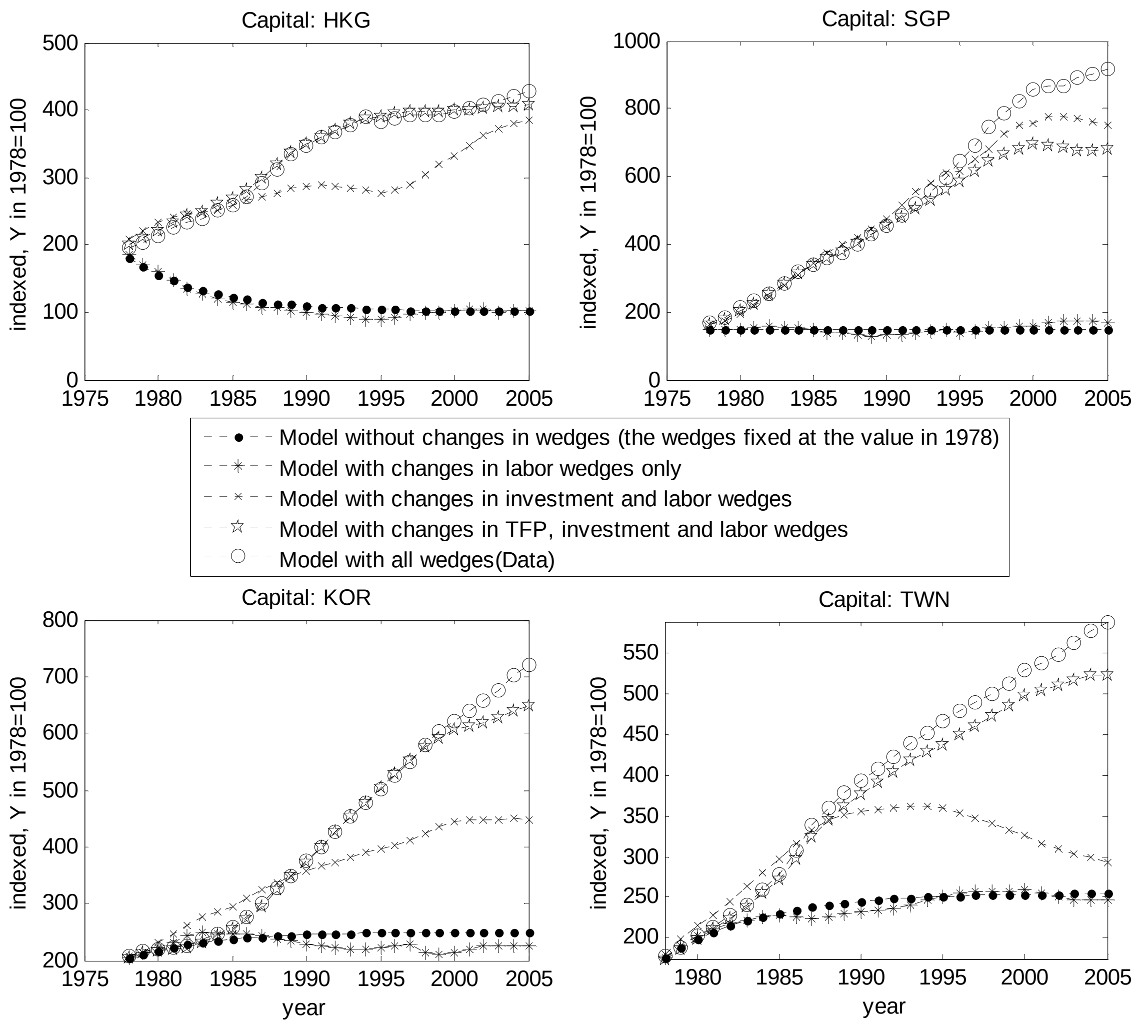

Figure 5: Trajectories for capital: Data and predictions of model for all the NICs

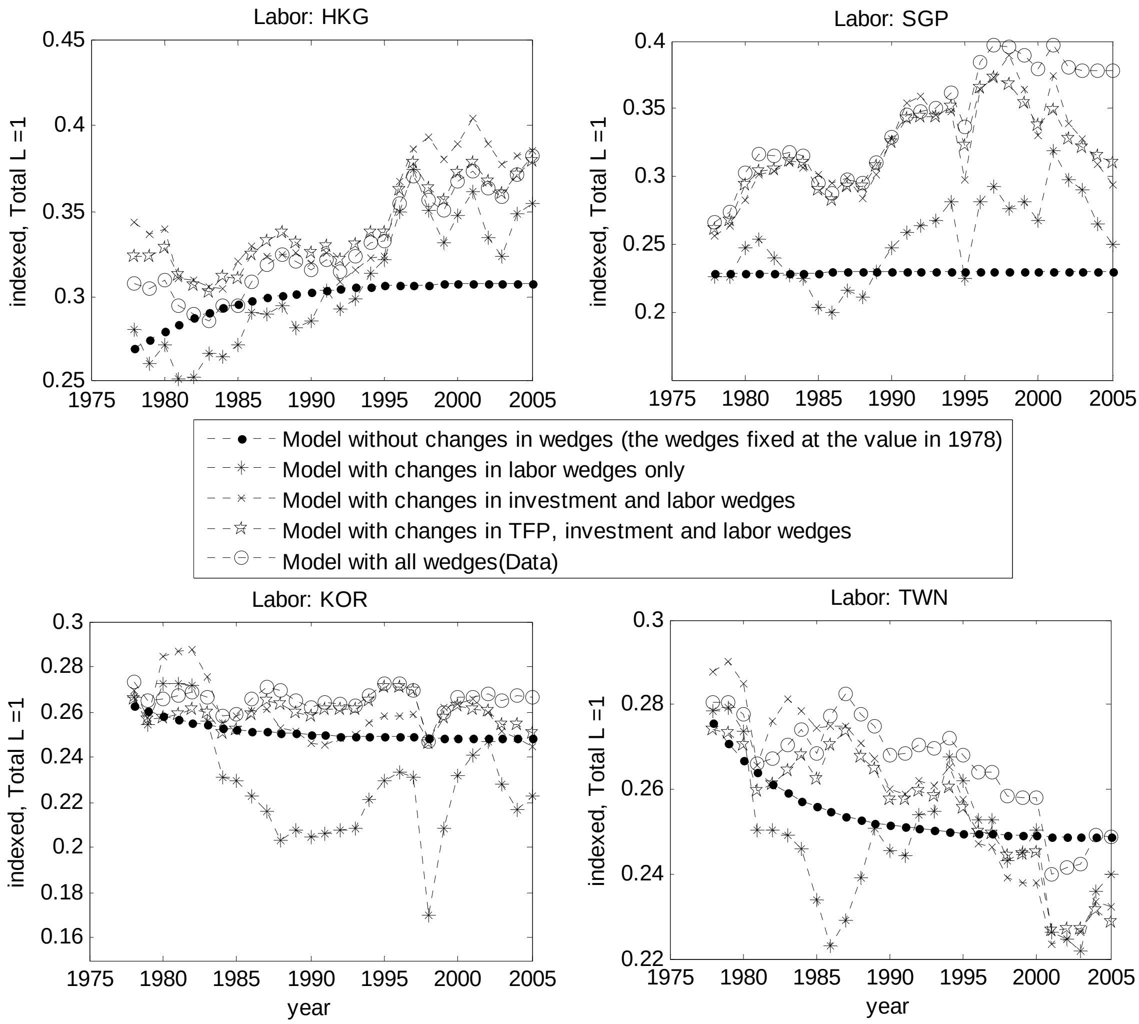

Figure 6: Trajectories for Labor: Data and predictions of model for all the NICs