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Abstract

We evaluate sources of business cycle fluctuations in China after 1978 with business cycle accounting method developed by Chari, Kehoe, and McGrattan (2007). We find that efficiency wedge, which represents institutional change and technology advance, was the main source of economic fluctuations in 1978 - 2006. The amplitude of it fluctuation declined after 1992, which resulted in moderation of business cycle fluctuations. We also find that distortions manifest themselves as taxes on investment, which represents frictions in the capital market, became another economic fluctuation source after 1992, which is different from results of business cycle accounting on US and Japan data. Our results also show that government consumption and net exports played minor roles in generating business cycles. Our results point out several promising directions for future research on China's business cycle.

Keywords: Business cycle fluctuations, Business cycle accounting, Chinese economy

JEL Classification Numbers: E32, E37, O47, O53

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1 Introduction

Since its market reform started at 1978, China's economic performance is outstanding in the past 3 decades. The average annual growth rate of real GDP reached 9.8%, which is higher than that of most countries. However, the high growth is accompanied by wild business cycle fluctuations.

What drives business cycle fluctuations in China? This question interests researchers for its importance in both theoretical side and practical side. Theoretically, identification of business cycle fluctuation sources in China may greatly contribute to our understanding of the mechanism of Chinese economy. Practically, with the knowledge of fluctuation sources, government can adopt corresponding polices to smooth business cycles to raise welfare.

Although there are abundant studies in the literature talking about China's business cycle, most of them stay at the level of descriptive study and summary statistic calculations. Qian (2004), L and Qi (2006), Liu (2006) are some representative studies among others. Unlike them, Zhang and Wan (2005), Xu (2007) employed long-run restriction proposed by Blanchard and Quah in a SVAR framework to decompose business cycle fluctuation sources into supply shock and demand shock, and found most fluctuations in output can be explained by supply shock.

In this paper, we are trying to analysis China's business cycle fluctuations with method proposed by Mulligan (2002) and Chari, Kehoe, and McGrattan (2007a) (CKM hereafter). This method, which was named "business cycle accounting (BCA)" by CKM starts from a standard neoclassical growth model with time-varying wedges of efficiency, investment taxes, labor taxes and government consumption. These four wedges are then measured so that the model replicates the data exactly. Hence, by inspecting the measured wedges, researchers can get to know the relative importance of wedges in generating macro variable fluctuations and identify possible business cycle sources. CKM also show that a large class of quantitative business cycle models are equivalent to the prototype model used in BCA. Hence, measured wedges serve researchers as useful guidelines in model building.

Despite debates about its validity (Christiano and Davis, 2006, Chari et al. 2007b), BCA method was gradually accepted by researchers. It was employed by Chakraborty (2004), Kobayashi and Inaba (2006) to investigate Japan's recessions. Lama (2005) used it to search business cycle sources of Argentina, Brazil and Mexico. Cavalcanti (2004) employed it to account business cycles in Portugal.

For this paper, we conduct a business cycle accounting exercise using data from 1978 – 2006 in China to answer the question about the business cycle sources in China. We find that efficiency wedge was the main source of China's business cycle fluctuations, and it is the easing of the efficiency wedge fluctuation after 1992 that caused the moderation of output fluctuation in the same period. This finding implies that the institutional changes may be the major reason of China's business cycle fluctuations in the early stage of China's reform. We also find that investment wedge, which has little impact on output in US, served as another main source of business cycle fluctuation in the post − 1992 Chinese growth. This is in line with some observations of Chinese economy for this period. It is also shown in our BCA exercise that government consumption and net exports played only a minor role in generating business cycle fluctuations.

The remainder of the paper is organized as follows. Section 2 summarizes some important business cycle stylized facts found in macro series of China. Section 3 describes the benchmark model used in our business cycle accounting exercise. Details of accounting procedures are introduced in section 4. In section 5, we present accounting results. Section 6 concludes.

2 Business Cycle Stylized Facts

Before proceeding to our business cycle accounting procedures, it is useful to outline some important regularities in macroeconomic data of China since the reform began in 1978.

Since 1978, China maintained a high real GDP growth rate averaged 9.8% for almost 30 years. This is a great economic achievement especially when China's huge population is taken into account. However, this rapid growth is accompanied by big ups and downs in the growth rate. Figure 1 shows the real growth GDP growth rate of China since 1978. Real GDP growth rate of US is also plotted in the figure as a comparison. It is only in recent years that the fluctuations in economic growth started to ease gradually.

Ideally, we should inspect quarterly series to summarize stylized facts, and some key variables such as output, consumption and working hours should be included in the analysis. However, lack of data is a common obstacle for empirical research on China. First, there isn't any available quarterly GDP by expenditure data for China, which makes it impossible for us to get accurate quarterly figures of private consumption, government consumption, etc. Second, data of working hours in China is not available, and what makes things even worse is other data related to labor (such as unemployment rate) is highly unreliable. Hence, we rely on annual GDP by expenditure data of China to summarize business cycle facts. Specifically, real series of output, private consumption, government consumption plus net exports (we will call it "government wedge" for short hence force)[1], and investment are employed in our exercise. Data for labor force is not used by us for its low quality.

Figure 2 shows the cyclical behavior of those four series chosen by us that characterize the real Chinese economy. All these series are first logged and then detrended using the HP filter. It is obvious from figure 1 that the business cycle behavior of China since 1978 was changing in the past 29 years. In the late 1970s and in 1980s, cyclical component of private consumption was almost perfectly correlated with fluctuations in output. However, it is hard to identify any correlation between investment and output. As for the government wedge, it would be appropriate to categorize it as countercyclical variable. Things changed in 1990s and early 2000s. Positive correlation between output and private consumption broke up in this period. Meanwhile, co-movements between output and investment increased significantly. Government wedge became a pro-cyclical variable in this period.

Calculated statistics reinforce our impression got in figure 2. Table 1 shows the standard deviations and correlations with output of those four macroeconomic series. In panel A and B of the table, statistics are calculated with data in period of 1978 – 1991 and period of 1992 – 2006, respectively. Statistics in panel C of the table are calculated with all observations from 1978 to 2006.

We choose the beginning of year 1992 as the time point to cut the whole sample period into 2 parts for two reasons: First, political events such as Deng Xiaoping's Southern Tour and the following reform measures marked this year as the start of a new phase of China's reform process. Second, in our former empirical research on China's macro-economy, we found out that it was highly possible that there was a structure change occurred in this year (Xu 2007).

Several features of the statistics in table 1 are worth noting:

Structure change between two sub sample periods is evident. Private consumption, government consumption and investment were pro-cyclical, counter-cyclical and acyclical, respectively, in the first sub sample period (1978-1991). In 1992-2006, private consumption became acyclical, and the other two became pro-cyclical. Hence, as a compromise of two sub sample period, results in panel C of table 1 do not give us an accurate picture of China's business cycle facts.

Volatility of business cycle fluctuations in China declined over time. Standard deviations of cyclical components of output, private consumption and government consumption in 1992-

[1]We use government consumption and net export in total as a single variable in our analysis because it has a exact counterpart in the benchmark model specified in section 3.

2006 were much smaller than those in 1978-1991. This is in line with common opinion that China's economy is getting more and more stable. However, compared with similar statistics computed with US data, China had bigger business cycle fluctuation magnitude. For example, Cooley and Prescott (1995) estimated a 1.72 standard deviation of US GNP in the postwar period. Stock and Watson (1998) got an estimation of 1.66 for US GDP. Both are smaller than the corresponding numbers presented in table 1.

In both sub-sample periods, private consumption, government wedge and investment all lagged output.

In China, fluctuations of private consumption were bigger than that of output, which is not in line with stylized facts got with US data. In US, standard deviation of private consumption fluctuation was roughly 2/3 of that of output.

These are some, but clearly not all, of the business cycle features based on Chinese data. Among all these facts, two main questions emerged: First, what drives business cycles in China? Second, compared with those before 1992, why business cycle fluctuations moderated after 1992?

In the rest of this paper, we will try to answer these two questions within the framework of business cycle accounting.

3 The Benchmark Growth Model

Following CKM, we use a stochastic growth model as benchmark model in our business cycle accounting exercise. In each period, the economy experiences one of finitely many events s_t which we call them shocks. The history of events up through and including period t is denoted by $s^t = (s_0, \cdots, s_t)$. Initial state s^0 is given. In period 0, the probability of any particular history s^t is $\pi_t(s^t)$. In the model, there are four stochastic variables, all of which are functions of history s^t. They are: the efficiency wedge $A_t(s^t)$, the investment wedge $1/[1 + \tau_{xt}(s^t)]$, the labor wedge $1 - \tau_{lt}(s^t)$, and the government wedge $g_t(s^t)$.

The representative consumer chooses per-capital consumption $\tilde{c}_t(s^t)$ and per-capital labor supply $l_t(s^t)$ to maximize expected utility

$$\sum_{t=0}^{\infty} \sum_{s^t} \rho^t \pi_t(s^t) u(\tilde{c}_t(s^t), l_t(s^t)) N_t$$

subject to the budget constraint

$$C_t(s^t) + [1 + \tau_{xt}(s^t)]X_t(s^t) = [1 - \tau_{lt}(s^t)]\omega_t(s^t)L_t(s^t) + r_t(s^t)K_t(s^{t-1}) + T_t(s^t)$$

and the law of motion of capital

$$K_{t+1}(s^t) = (1 - \delta)K_t(s^{t-1}) + X_t(s^t)$$

where $C_t(s^t)$, $X_t(s^t)$, $T_t(s^t)$ and $K_t(s^{t-1})$ denote aggregate consumption, investment, lump-sum transfer and capital stock, respectively. $\tilde{c}_t(s^t)$ denotes the per capita consumption, $\omega_t(s^t)$ the wage rate, $r_t(s^t)$ the rental rate on capital, ρ the discount factor, δ the depreciation rate of capital, and N_t the population with growth rate equal to $1 + g_n$.

The production function is $A_t(s^t)F(K_t(s^{t-1}), Z_tL_t(s^t))$, where Z_t denotes the labor- augmenting technology level with an assumed constant growth rate equal to $1 + g_z$. At the equilibrium, we have the following resource constraint relation

$$C_t(s^t) + X_t(s^t) + G_t(s^t) = Y_t(s^t)$$

where $Y_t(s^t)$ denotes the aggregate output.

To facilitate following analysis, we transform the model into stationary form by defining following detrended variables: $c_t = C_t/(Z_tN_t) = \tilde{c}_t/Z_t$, $x_t = X_t/(Z_tN_t)$, $k_t = K_t/(Z_tN_t)$, $t_t = T_t/(Z_tN_t)$, $g_t = G_t/(Z_tN_t)$, $y_t = Y_t/(Z_tN_t)$, $w_t = \omega_t/Z_t$.

The representative consumer's problem can be rewritten with detrended variables as

$$\max_{c_t, l_t, x_t} \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi_t(s^t) U(c_t(s^t), l_t(s^t))$$

subject to

$$c_t(s^t) + [1 + \tau_{xt}(s^t)]x_t(s^t) = [1 - \tau_{lt}(s^t)]w_t(s^t)l_t(s^t) + r_t(s^t)k_t(s^{t-1}) + t_t(s^t)$$

and

$$(1 + \gamma)k_{t+1}(s^t) = (1 - \delta)k_t(s^{t-1}) + x_t(s^t)$$

where $\beta = \rho(1 + g_n)$, $1 + \gamma = (1 + g_n)(1 + g_z)$and $U(\cdot, \cdot)$ depends on our choice of utility $u(\cdot, \cdot)$.

Firms' problem can be rewritten as

$$\max_{\{k_t(s^t),l_t(s^t)\}} A_t(s^t)F(k_t(s^{t-1}),l_t(s^t)) - r_t(s^t)k_t(s^{t-1}) - w_t(s^t)l_t(s^t)$$

The equilibrium of the model is summarized by the following resource constraint of the economy

$$c_t(s^t) + x_t(s^t) + g_t(s^t) = y_t(s^t) \tag{1}$$

together with

$$y_t(s^t) = A_t(s^t)F(k_t(s^{t-1}), l_t(s^t)) \tag{2}$$

$$-\frac{U_{lt}(s^t)}{U_{ct}(s^t)} = [1 - \tau_{lt}(s^t)]A_t(s^t)F_{lt}(s^t) \tag{3}$$

$$\begin{aligned} &U_{ct}(s^t)(1+\gamma)[1+\tau_{xt}(s^t)] \\ &= \beta \sum_{s^{t+1}} \pi(s^{t+1}|s^t)U_{ct+1}\left\{A_{t+1}(s^{t+1})F_{kt+1}(s^{t+1}) + (1-\delta)[1+\tau_{xt+1}(s^{t+1})]\right\} \end{aligned} \tag{4}$$

where U_{ct}, U_{lt}, F_{kt} and F_{lt} denote the derivatives of the utility function and the production function with respect to their arguments.

CKM show that various frictions in quantitative business cycle models are equivalent to the wedges of the above benchmark growth model: Frictions, such as input-financing friction, that cause input to be used inefficiently are equivalent to a efficiency wedge; sticky-wage or powerful labor unions are equivalent to a labor wedge; financial friction of the type proposed by Carlstrom and Fuerst (1997) is equivalent to a investment wedge; and net exports are equivalent to a government wedge, in an associated benchmark model.

4 Accounting Procedures

The accounting procedure is to conduct experiment that isolates the marginal effect of each wedge as well as combinations of wedges on aggregate variables. First, the four wedges in the benchmark growth model are estimated from the data using equilibrium conditions (1), (2), (3) and (4). Then, the values of measured wedges are fed back into the benchmark model, one at a time and in combinations, to assess their marginal effect on aggregate variables. By construction, all four wedges together account for all of the observed movements in aggregate variables. Hence, the procedure employed here is an accounting procedure in this sense.

4.1 Calibration

To apply the accounting procedure, following standard functional forms and parameter values in the business cycle literature are employed. Preference of the representative consumer are assumed to take the form of $U(c, l) = \log c + \psi \log(1 - l)$. Production function is assumed to have the Cobb-Douglas form of $F(k, l) = k^{\alpha} l^{1-\alpha}$.

We use Bayesian techniques in this empirical exercise to estimate wedges from the data. Although it is possible to estimate all model parameters from data simultaneously, we choose to fix those parameters, which have commonly accepted calibration values, in the estimation.

We choose the capital share $\alpha = 0.65$, the discount factor $\beta = 0.95$, the depreciation rate $\delta = 0.05$, time allocation parameter $\psi = 2.24$, which are commonly used in the quantitative research on Chinese economy. The value of growth rate of effective labor $\gamma = 0.098$ can be got directly from real output series.

4.2 Estimation of Wedges

To estimate the four wedges, the benchmark model is first log-linearized around its steady state and then solved with method proposed by Blanchard and Kahn (1980).

We define vector

$$s_t = [\ \widehat{a}_t \quad \widehat{\tau}_{xt} \quad \widehat{\tau}_{lt} \quad \widehat{g}_t\ ]'$$

where $\widehat{a}_t$ and $\widehat{g}_t$ are log deviations from trend, $\widehat{\tau}_{xt}$ and $\widehat{\tau}_{lt}$ are linear deviations from trend. Clearly, vector s_t can be viewed as the event experienced by the economy. Follow CKM, we assume s_t takes the following vector AR(1) process

$$s_{t+1} = H s_t + \varepsilon_{t+1} \tag{5}$$

where the shock ε_{t+1} is i.i.d. over time and distributed normally with mean zero and covariance matrix V. To ensure our estimate of V is positive semidefinite, we estimate the lower triangular matrix Q where $V = QQ'$.

Because the four wedges are represented as deviations, their steady state values are needed for us to fully characterize the stochastic process for the state. The steady state value of government wedge g can be got directly from the real data. For the efficiency wedge, its steady state value is normalized to 1. Hence, there are 28 parameters (16 in matrix H, 10 in matrix Q and 2 steady state values for investment wedge, τ_x, and labor wedge, τ_l) need to be estimated.

We then use a standard maximum likelihood procedure combined with prior from long-run relationships among different GDP components to estimate those 28 parameters. The realizations of those four wedges are estimated with Kalman smoothing method.[2]

Because there are 4 shocks in our benchmark model, we can use up to 4 observation series to estimate the model with maximum likelihood method. If the number of observation series exceeds 4, measurement errors should be introduced into the model to overcome the problem of singularity encountered in the estimation. However, the existence of measurement errors will make our empirical exercise no longer an accounting procedure.

Due to the data problem stated in the section 2, we choose the four series of real output, real private consumption, real government consumption (plus net export) and real investment as the observation series. Filtered series of those four variables are used as raw data in our estimation.

4.3 Counterfactual Experiments

The final step of our accounting procedure is to conduct counterfactual experiments to isolate the marginal effects of wedges. In these experiments, a subset of the wedges is allowed to fluctuate as they do in the data while the others are set to their steady state values.

In the solution of the model, decision rules for output $y(s_t, k_t)$, consumption $c(s_t, k_t)$, investment $x(s_t, k_t)$ etc can be found. Suppose we want to evaluate the effects of the efficiency wedge, we set $\widehat{a}_t(s_t) = \widehat{a}_t$, $\widehat{\tau}_{xt}(s^t) = \tau_x$, $\widehat{\tau}_{lt}(s^t) = \tau_l$, $g_t(s^t) = g$. These assumed wedges, in addition with the decision rules and capital accumulation law, give us the realized sequences of output, consumption and investment, which are called the efficiency wedge components of output, consumption and investment. Components of other wedges or wedge combinations are got in similar procedures.

5 Accounting for Business Cycles in China

In this section, we describe our results of applying business cycle accounting procedure to China. Before 1978, Chinese economy was characterized as highly central planned economy in which production and resource allocation were carried out according to plan designed by the government. Hence, it will be inappropriate to approximate China before 1978 with a

[2]Please refer to the technical appendix of this paper for details of the estimation procedure.

RBC model, which is used to capture the essences of a market economy. Therefore, our attention of business cycle accounting procedure is restricted to the period of 1978 to 2006, when China was transiting from a planned economy to a market economy.

Although there are only 29 years in our sample period (1978 – 2006), significant changes were witnessed in China during these years. Some of these changes are summarized in business cycle stylized facts stated in section 2 of this paper. Hence, it may be inaccurate to capture the whole sample period with only one set of parameters. As suggested in the section 2, we divide the whole period into 2 sub sample periods, 1978 – 1991 and 1992 – 2006, and estimate parameters for both of them, respectively. Our choice of year 1992 as the cutting point of two sub sample periods may seem arbitrary at the first glance. Hence, to check the robustness of our results, we estimate the model and wedges with data from the whole sample period. It turns out that the results got within two sub sample periods and that got in the whole sample period are roughly the same. So, our results are not sensitive to the choice of the cutting point of two sample periods.

5.1 Properties of Estimated Wedges and Output Components

Now we move to the main part of our empirical exercise – business cycle accounting for Chinese economy.

In figure 3, short-term fluctuation (log-deviation from trend) of four wedges estimated with data from the period 1978 – 1991 are plotted. Short-term fluctuation of output is also plotted in the figure for comparison. Fluctuations of decomposed output components (private consumption component, investment component) associated with every wedge are plotted in figure 4 (figure 5, figure 6)[3]. The four figures of 7 – 10 give us similar results depicted in figures 3 – 6, with sample period replaced by 1992 – 2006. At last, wedges and output components estimated with whole sample period data are shown in figure 11 and figure 12 for comparison. Clearly, patterns of four wedges plotted in figure 11 and those displayed in figure 3 and 7 look roughly similar, so do output components in figure 4, 8 and 12. Those are evidences of the robustness of our business cycle accounting procedure.

By looking at figures, it may take a long time for us to summarize regularities about measured wedges and components. But things will become clearer when some statistics are calculated. Hence, some summary statistics for the two sub sample periods and the whole sample period are developed using HP-filtered data. In table 3, we display the standard

[3]Fluctuations of government consumption were completely caused by government consumption wedge. Therefore, we do not include figures about government consumption here.

deviations of the wedges relative to output as well as correlations of output with each wedge at various leads and lags. Standard deviations and cross correlations of output due to each wedges are displayed in table 4. These wedge statistics can be viewed as analogs of the plots of measured wedges. Similarly, the output statistics can be viewed as analogs of the plots of output due to just one wedge. To make the lead and lag relations among wedges and output clearer, we display Granger causality test results in table 5.

With all those results in hand, we are ready to address some important issues about China's business cycle fluctuations.

5.1.1 Cyclical Behavior of Wedges

Cross correlations of wedges and output components with output are displayed in table 3 and 4. In 1978 – 1991, efficiency wedge was a pro-cyclical variable with correlation with output reaching 0.94. Meanwhile, investment wedge, labor wedge and government wedge were counter-cyclical variables. Output components due to each wedge show a similar pattern.

While pro-cyclical of efficiency wedge remained unchanged, cyclical behavior of other 3 wedges was completely different in the period of 1992 – 2006. Investment wedge and government consumption wedge became pro-cyclical variables, although correlations stood at low level. Labor wedge remained as counter-cyclical, but correlation declined dramatically.

These cyclical patterns suggest that, before 1992, efficiency wedge may be the driving force of output fluctuations, while the other 3 wedges played damping roles in business cycles. After 1992, investment wedge, government consumption wedge, together with efficiency wedge drove China's business cycle fluctuations.

5.1.2 Sources of Output Fluctuations in China

In the cyclical property analysis before, we find clues that efficiency wedge may drive the output fluctuations in the past 29 years. Now, we will approach this issue more deeply. We will try to answer the main question that motivated this paper: what are the sources of China's business fluctuations?

To answer this question, we should first find out the relatively importance of each wedge's contribution to output fluctuation. This can be done by inspecting table 4. In column 2 of this table, standard deviations relative to output of each output component are displayed. It is evident from this table that output fluctuation due to efficiency wedge was much bigger than those caused by other wedges. In the period of 1978 – 1991, given other three wedges kept as constants, output fluctuation due to efficiency wedge was 2.63 times of that observed in real world data. Although this number declined to 1.12 in 1992 – 2006, it was still much bigger than those associated with other three wedges. Given the fact that efficiency wedge was highly correlated with output, it can be viewed as a good candidate for the business cycle fluctuation source.

In 1978 – 1991, in terms of relative standard deviation of output component, labor wedge was the second most important wedge affecting output. However, this wedge was highly negatively correlated with output. This implies that the labor wedge was damping instead of increasing amplitude of business cycle. Hence, it would be inappropriate to categorize it as business cycle fluctuation source. Investment wedge played only a moderate role in output fluctuations in the first sub sample period. Although it overtook labor wedge and became the second biggest factor of output fluctuations, its impact was still much smaller than that of efficiency wedge. As its cyclical behavior is considered (counter-cyclical before 1992 and pro-cyclical afterwards), we believe it was a source of output fluctuation after 1992 but not before. In both sub sample periods and the whole sample period, government wedge played only a minor role in generating output fluctuations, which ruled it out as an important business cycle fluctuation source.

In addition to the analysis on the cyclical behaviors and impacts on output of four measured wedges, Granger causality tests are also conducted by us to inspect the prediction relations among wedges and output. Their results are displayed in table 5. Panel A and B of table 5 shows results got from data in 1978 – 1991 and 1992 – 2006, respectively. In both sub sample periods, efficiency wedge had significant prediction power for output. This reinforced our claim of efficiency wedge as a source of output fluctuations. In the period of 1992 – 2006, Granger test results of investment wedge to output, efficiency wedge and labor wedge became significant, which suggests investment wedge became another significant source of output fluctuation in this period.

To sum up, before 1992, efficiency wedge was the main source of output fluctuations in China, despite the fact that its impact on output was dampened by other 3 wedges. After 1992, efficiency wedge remained as the most important output fluctuation source. But in the same time, investment wedge became another source of output fluctuation which can not be ignored. Labor wedge, despite its big impact on output movements, should be categorized as damper instead of source of output fluctuation. In the whole sample period, government wedge played only a minor role in generating output fluctuations in China.

5.1.3 What Caused the Fluctuation Moderation

We have summarized in section 2 that the business cycle fluctuations in China moderated significantly over the past 29 years. As what displayed in table 1, the standard deviation of output fluctuation after 1992 was only about a half of that before 1991. At the same time, fluctuations in private consumption and government consumption moderated, too. So, here comes the question: What caused this moderation in fluctuations?

In column 2 of table 3, we present the standard deviations of four wedges. Compare numbers in panel B with those in panel A, we can find out that fluctuations of efficiency wedge and labor wedge decreased dramatically over time. However, fluctuations of investment wedge and government consumption wedge increased. Similar changes can be found in table 4, too. Output fluctuation due to efficiency wedge in 1992 – 2006 was only about 40% of that in 1978 – 1991, so was output component associated with labor wedge. For investment wedge and government consumption wedge, their contributions to output fluctuations increased over time. Because we know in the analysis above that labor wedge was a damper to output fluctuation, the ultimate reason of output fluctuation moderation should not attribute to it.

Therefore, it was the easing of efficiency wedge fluctuation that caused the moderation in output fluctuation.

5.1.4 Some Explanations

In the empirical findings presented above, we have seen that the efficiency wedge was the main driving force behind China's business cycles, and the easing of its fluctuation led to the business cycle fluctuation moderation in China in recent years. We have also seen that the investment wedge became another important source of business cycles in China after 1992. Although these empirical findings were got within a simple DSGE model, they can offer us some insights about Chinese economy.

First, we will look at the efficiency wedge. In the literature, the efficiency wedge in our model is usually referred to as "Solow residual", which captures factors other than inputs that have impact on final output. More often than not, we call it the "technology shock" or "institutional factor". Our empirical results point to that the technological advance and institutional change are the main determinants of China's business cycle. This is in line with the observation of Chinese economy.

In 1978, China can be best described as a planned economy with backward technology. However, after 29 years of "reform" and "opening-up", Chinese economy has become more and more market oriented, and the technology gap between China and advanced countries has been narrowed significantly. Through reform, institutional structure in China was changed greatly to liberate productive force. Through opening-up, China attracted huge amount of foreign direct investment which brings in advanced technology. In 1984, 1988 and 1993, we saw acceleration in the reform process promoted by the government. Resource reallocation from low efficient sector to high efficient sector was significant in these years, which led to huge efficiency gain. In the mean time, foreign direct investment in China was also above its long-run trend in these years, which resulted in faster pace of technology advance. Our empirical results provide quantitative evidences to these two observations.

Second, we will take a look at fluctuation moderation after 1992. After 1992, the institutional infrastructure of China became more stable than before. The technology advance also became more stable because of the shrinking technology gap between China and advanced economies. Therefore, a more stable economy is the natural result, given those two factors are the main driving forces of business cycle fluctuations in China. This explains the fluctuation moderation of Chinese economy after year 1992.

Third, we saw that the investment wedge became another main source of business cycle fluctuation after 1992. This is also consistent with our observation. At the early stage of the reform, because of the legacy of traditional planned economy, investment activities were mainly carried out by the government. Hence, frictions involved in investments were big but stable. That why we didn't find them as an important determinant of business cycle in this stage. However, things changed in the 1990s and 2000s. Because bigger and bigger share of investment was done by private sector, fluctuations in investment frictions were amplified in the private sector to generate a bigger impact on the general economy. Therefore, investment wedge was identified as another business cycle fluctuation source in this period.

Here we have presented some explanations about the empirical findings we got. To get a more detailed explanation, more specific models should be employed in the empirical exercise. However, these explanations as well as estimated results above do shed some light on our understanding of China's business cycles.

5.2 Estimated Long-run Changes

Although our focus in this paper is the short-run fluctuations of Chinese economy, some results about long-run changes are got in our empirical procedure as by-products. Because long-run trends of investment wedge and labor wedge were estimated in our maximum likelihood estimation, long-term changes in investment efficiency and distortions in consumption-leisure substitution can be studied.

In table 2, estimated long run trends of investment wedge and labor wedge for both sub sample periods are presented. Average share of government wedge (government consumption plus net export) in total output, which is calculated directly from data, is also included in the table for reference. Our estimation shows, on average, 73.7% of total investment would be converted to capital stock in 1980s. In 1990s and early 2000s, this rate increased to 79.5%. Meanwhile, average labor wedge decreased from 99.5% to 87.9%. These estimate figures can shed light on some hot debates about China.

Recently, there is a hot debate in academic field about China's investment efficiency. On one hand, improving micro data such as rising return on investment suggests the increase of investment efficiency. But on the other hand, inspection on macro data such as ratio of marginal output to capital stock leads to a completely different conclusion. Clearly, our estimation result supports the former one.

In our estimation, we find out that the average value of labor wedge decreased, which means the distortion in consumption and labor substitution increased. Because it was shown in the work of CKM that a labor wedge corresponded to sticky-wage or powerful labor unions, our results points to increasing stickiness in the wage rate, which may be a promising research direction.[4]

5.3 The 1997 – 2000 Deflation and the Subsequent Growth Slowdown

From June 1997 to September 2000, China was hit by a deflation (Cheng 2002). The subsequent growth slowdown lasted even longer. Because it was the first deflation since the reform started at 1978, and only 3 years before, the biggest problem faced by China was severe inflation exceeding 25%, this deflation surprised everyone, and, naturally, gave rise to hot debate on its causes. Here, we are not going to give an extensive review of the proposed reasons of this deflation[5]. Instead, we will report the empirical findings got within our business cycle accounting framework, which may shed light on the analysis of this period.

5.3.1 Analysis of Chinese Data with BCA procedures

Our findings for the period 1992 – 2006, which includes the deflation and the subsequent growth slowdown, are displayed in figures 7 – 10. In sum, we find that efficiency wedge,

[4] In China, the effect of labor unions on production can be ignored, because they are branches of government and usually do not speak for workers.

[5] For those interested, please refer to Cheng (2002) and references within.

investment wedge and labor wedge all played important roles in the deflation and slowdown period.

In figure 7, actual output along with four measured wedges is displayed. Because the government wedge played only a minor role in business cycle fluctuation determination, we focus on other three: the efficiency wedge, investment wedge and labor wedge. It is clearly from figure 7 that the underlying distortions revealed by the three wedges have different patterns. The distortions that manifest themselves as labor and investment wedges became worse between 1997 and 2000. Meanwhile, efficiency wedge remained above its long run trend. However, since 2000, labor wedge and investment wedge started to recover, but efficiency wedge started to worsen.

In figure 8 – 10, we plot the data for output, consumption and investment along with model's predictions for them when the model includes just one wedge. Figure 8 gives us a clear picture of the sources of economic growth slowdown between 1999 and 2004. In the first half of this period (1999 – 2001), labor wedge and investment wedge were the distortions that drove the output below its long-run trend. Efficiency wedge actually drove output the wrong way during this period. However, things were quite different in the second half of the slowdown period. Between 2002 and 2004, Efficiency wedge in addition with investment wedge drove output downward. Meanwhile, labor wedge drove output to the opposite direction. Hence, we should say that the deflation and subsequent economic slowdown in China was caused by bigger frictions in labor and capital markets.

Another finding worth noting in the whole period of 1992 – 2006 is that investment wedge played an important role in generating business cycle fluctuations. Components of output, consumption and investment due to investment wedge alone matched the real world data at a very high level. Investment component associated with investment wedge even leads real world investment for one year, which makes investment wedge a good predictor for the real world investment.

5.3.2 Comparison with the US 1982 Recession

As a comparison, we analyze the US 1982 recession with empirical method presented in this paper. This empirical exercise is carried out for two reasons: First, by comparing the analysis results of this US recession with results got in CKM, we can double check the validity of the empirical method employed by us. Second, the comparison of China's economic growth slowdown in 1999 - 2004 and the US 1982 recession can reveal the differences in business cycle between China and US.

CKM used data on output, labor, investment and the sum of government consumption and net exports to estimate wedges. However, to maintain consistence with our empirical work on Chinese data, we use data on private consumption instead of labor in our estimation. Despite different series used in the estimation, the four measured wedges in our estimation and those got in CKM were roughly similar: the efficiency wedge and the labor wedge played primary roles in the US 1982 recession, and the investment played essentially none.

Those patterns got with US data are quite different from what we get with Chinese data. We find that the efficiency, labor and investment wedges all played significant roles in the business cycle fluctuations. Especially, investment wedge is the main source of fluctuations in consumption and investment. This suggests that the mechanisms which behind business cycles of China and US differs greatly from each other.

6 Concluding Remarks

In this paper, we conduct business cycle accounting on Chinese data of the period 1978 – 2006. We divide the whole sample period into two sub periods of 1978 – 1991 and 1992 – 2006 because of the possible structure change suggested by the data.

Our results show that before 1992, efficiency wedge (includes institutional change and technology advance) and frictions in labor market, in combination, accounted for essentially all of the ups and downs in business cycles. Specifically, efficiency wedge was the main source of output fluctuations in this period, despite its impact on output dampened by labor wedge. Meanwhile, investment wedge (frictions in capital market), government consumption and net exports played only ignorable roles in generating output fluctuations. However, things were quite different after 1992. Although efficiency wedge remained as the most important output fluctuation source in this period, investment wedge became another source of output fluctuation which can not be ignored. Frictions in labor market, despite its big impact on output movements, still served as a damper instead of a source of output fluctuation. Effect of government consumption and net exports on output increased, but still remained insignificant. We have also found that the output fluctuation moderation occurred after 1992 was caused by the moderation of efficiency wedge fluctuations.

Compared with those business cycle accounting exercises on data from US (Chari et al. 2007) and Japan (Kobayashi and Inada, 2006), our results of China before 1992 were roughly similar: efficiency and labor wedges in combination accounted for essentially all business cycle fluctuations while investment wedge played only a minor role. However, we find that investment wedge was an important determinant of China's business cycle after 1992.

Our findings have direct implications for future research on China's business cycle. First, it would be inappropriate to describe China's economic growth since 1978 with a single model. We find that cyclical behavior of measured wedges are quite different before and after 1992, which implies some fundamental changes in the business cycle mechanism. Hence, it is more preferable to model growth process before and after 1992 separately. Second, because the predominant role played by efficiency wedge in business cycles, models with frictions that cause inputs to be used inefficiently are good candidates to analyze Chinese economy. Third, as investment wedge becomes another fluctuation source after 1992, financial frictions are needed in models describing post-1992 Chinese economy. Fourth, because minor role played by government consumption wedge in business cycles, models with emphasis on government consumption or net exports may not be appropriate for modeling Chinese economy.

Appendix: Data

In this appendix, we briefly describe the data source and data construction method used in this paper.

For China, because there is no quarterly data on private consumption, government consumption, we use annual GDP by expenditure data to carry out our business cycle accounting exercise. Annual data on GDP, private consumption, government consumption, gross capital formation and net exports (at current price) is available in "China Statistical Yearbook". Annual real GDP growth is also available there. Annual GDP deflator can be calculated with current price GDP data and real GDP growth. We use GDP deflator to deflate each current price series to get real series.

All annual series for US used in this paper come from St. Luis Fed Economic Database (FRED).

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Figure 1. Real GDP Growth

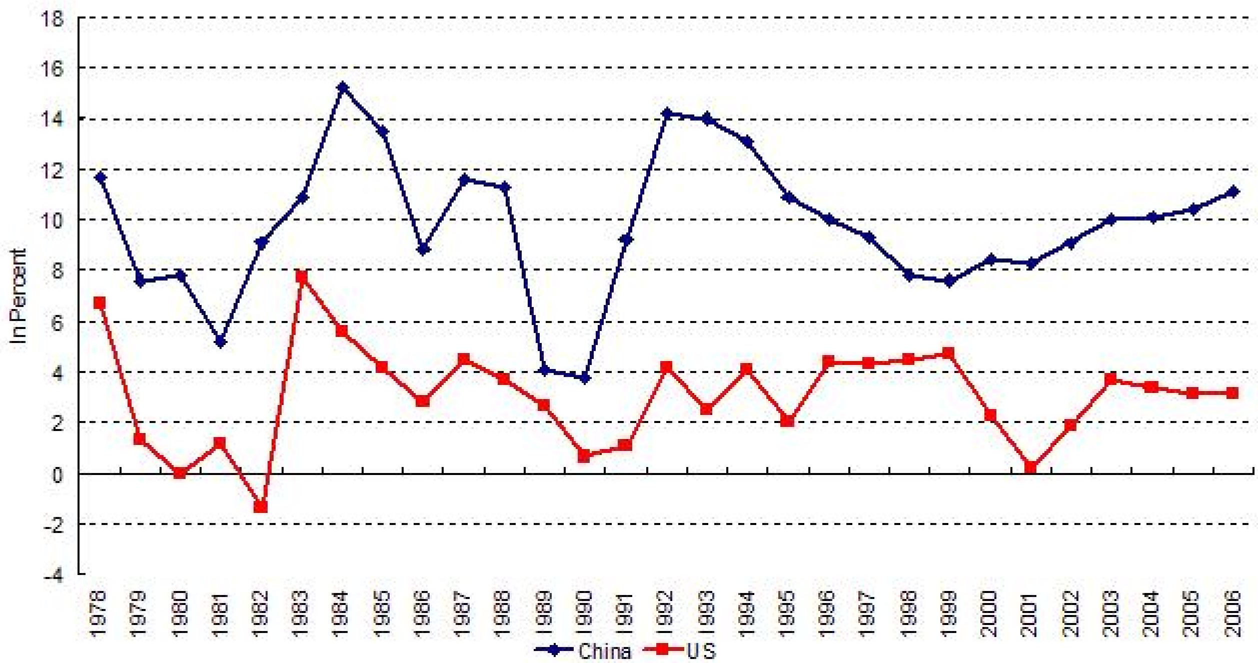

Figure 2. Business Cycle Fluctuations in China

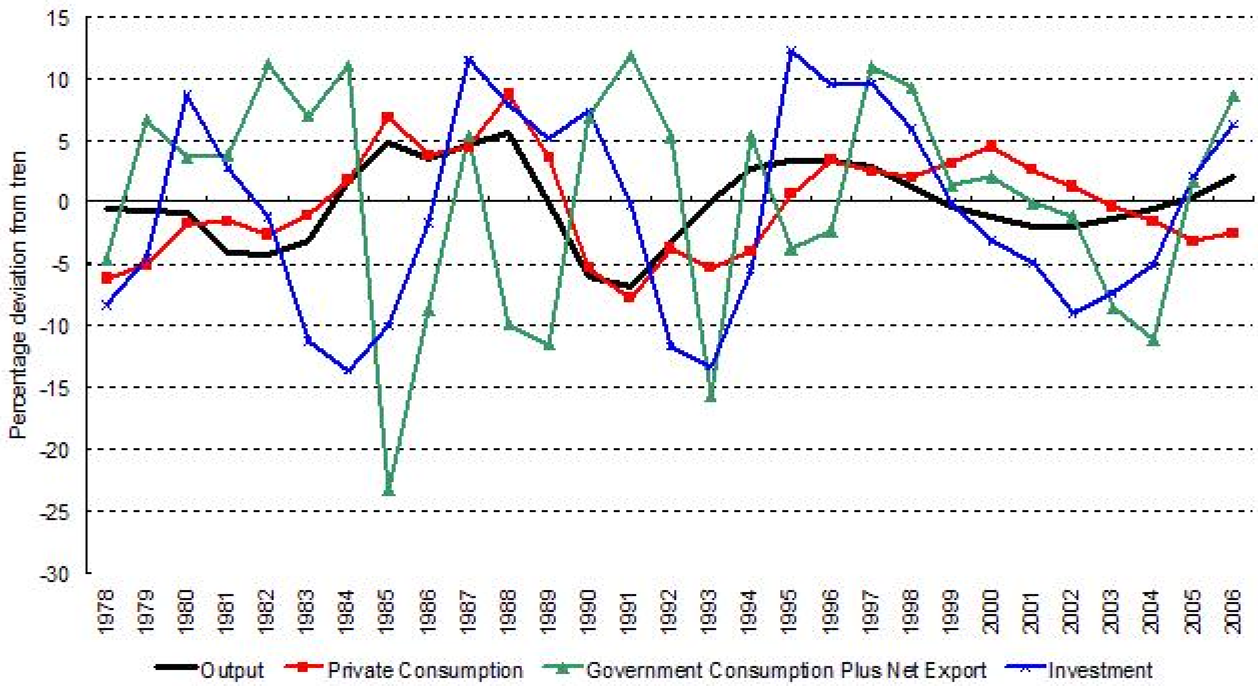

Figure 3. Output and Measured Wedges (1978-1991)

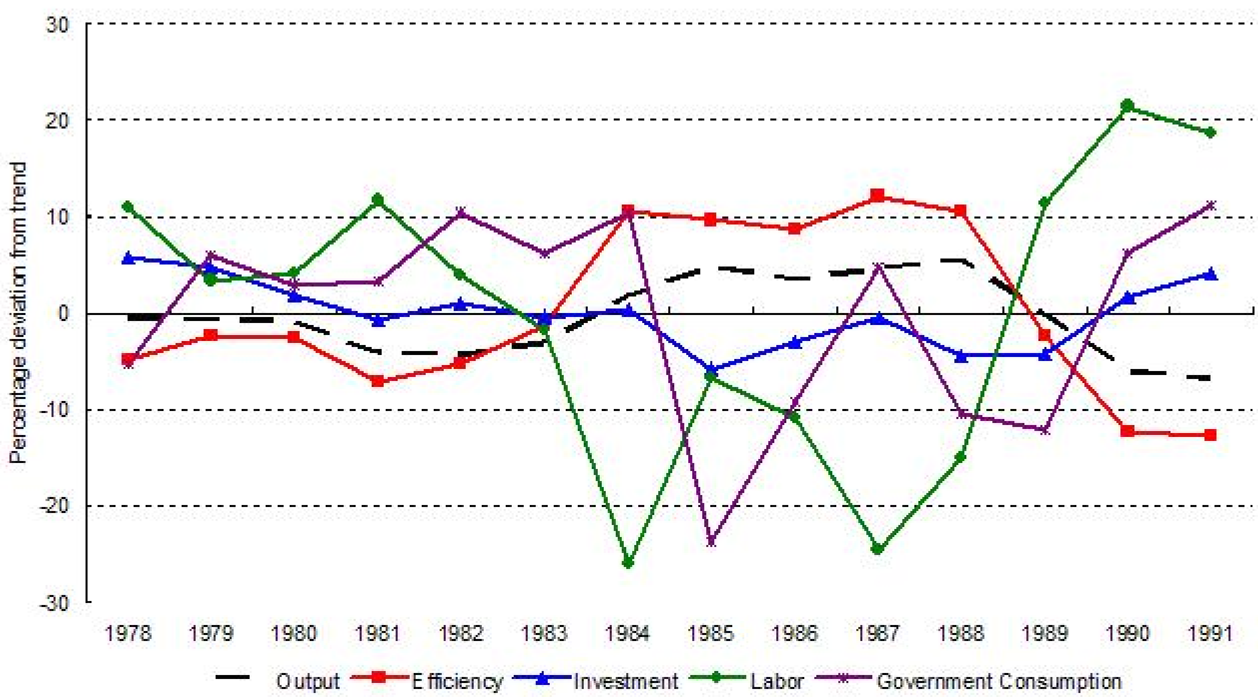

Figure 4. Data and Predictions of Models with Just One Wedge: Output (1978-1991)

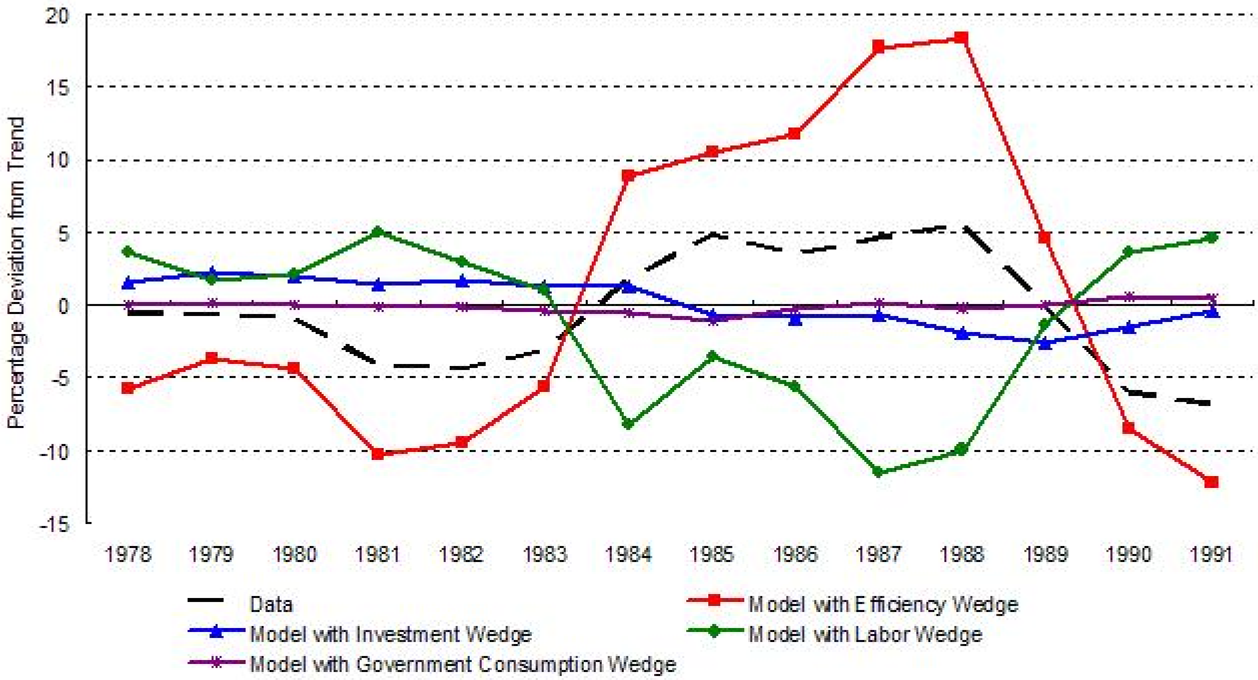

Figure 5. Data and Predictions of Models With Just One Wedge: Consumption (1978-1991)

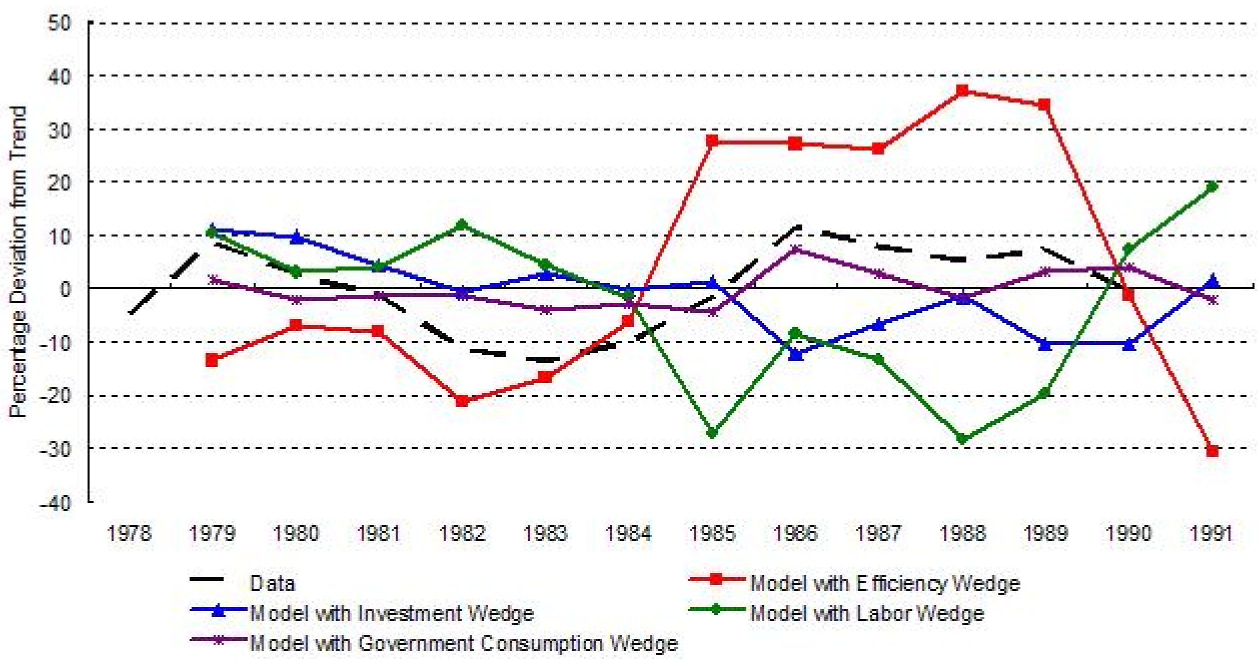

Figure 6. Data and Predictions of Models With Just One Wedge: Investment (1978-1991)

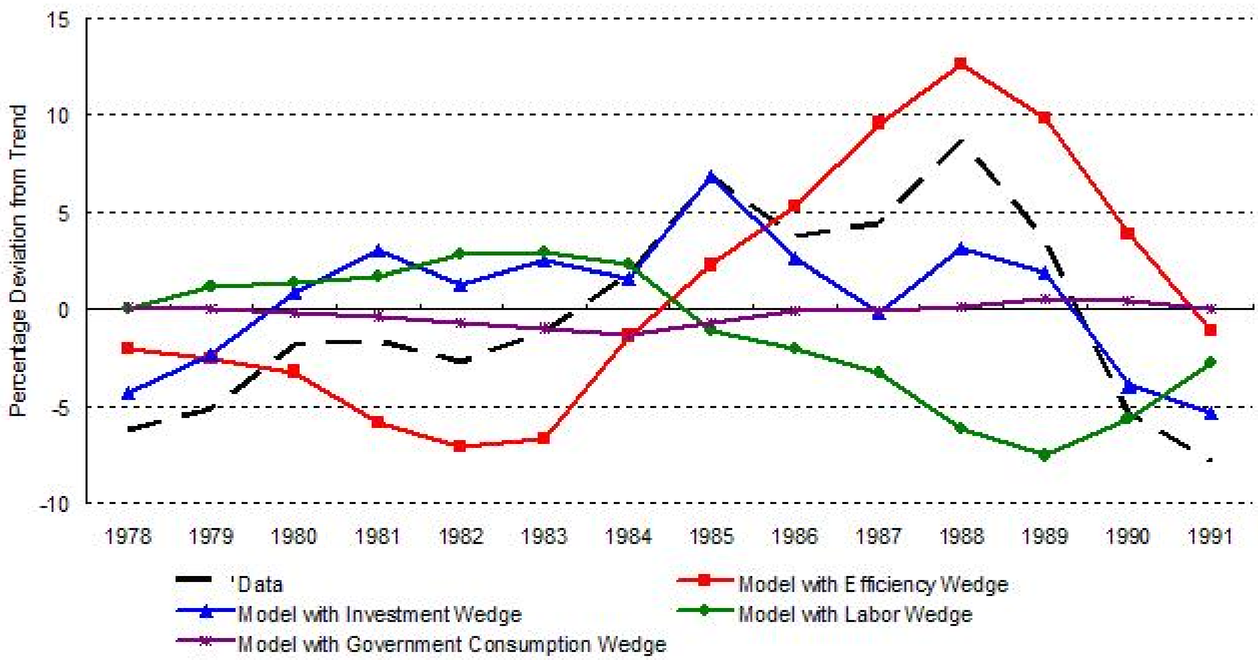

Figure 7. Output and Measured Wedges (1992-2006)

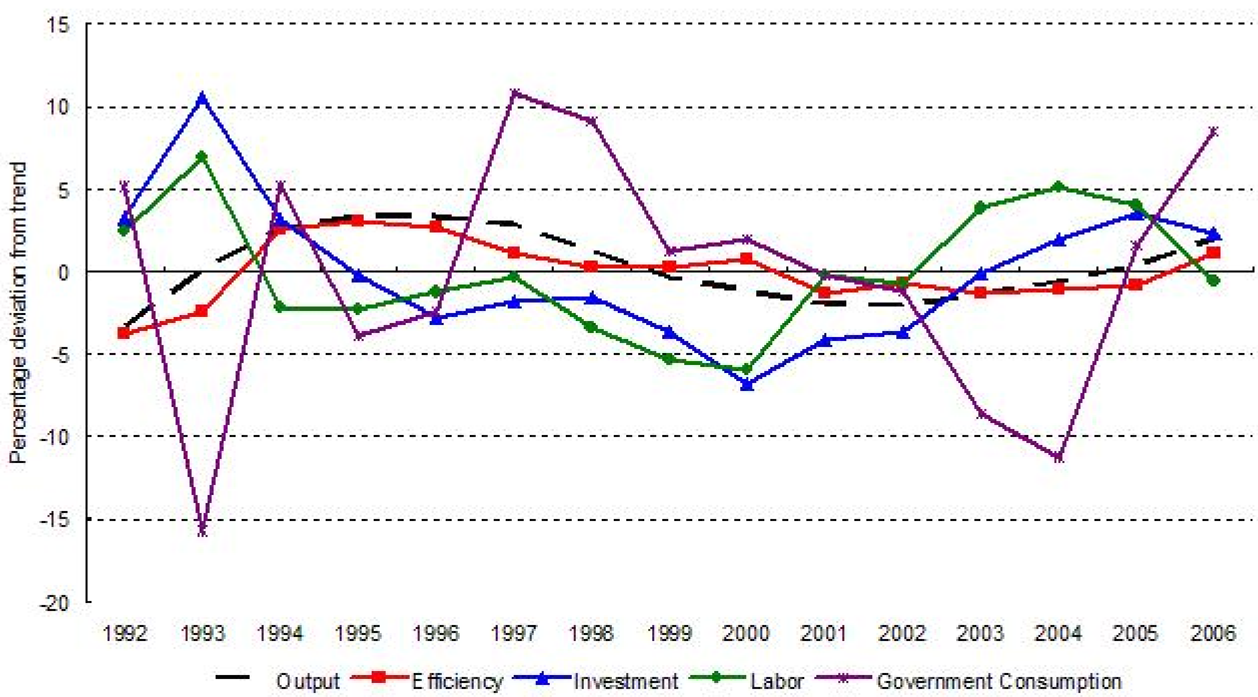

Figure 8. Data and Predictions of Models With Just One Wedge: Output (1992-2006)

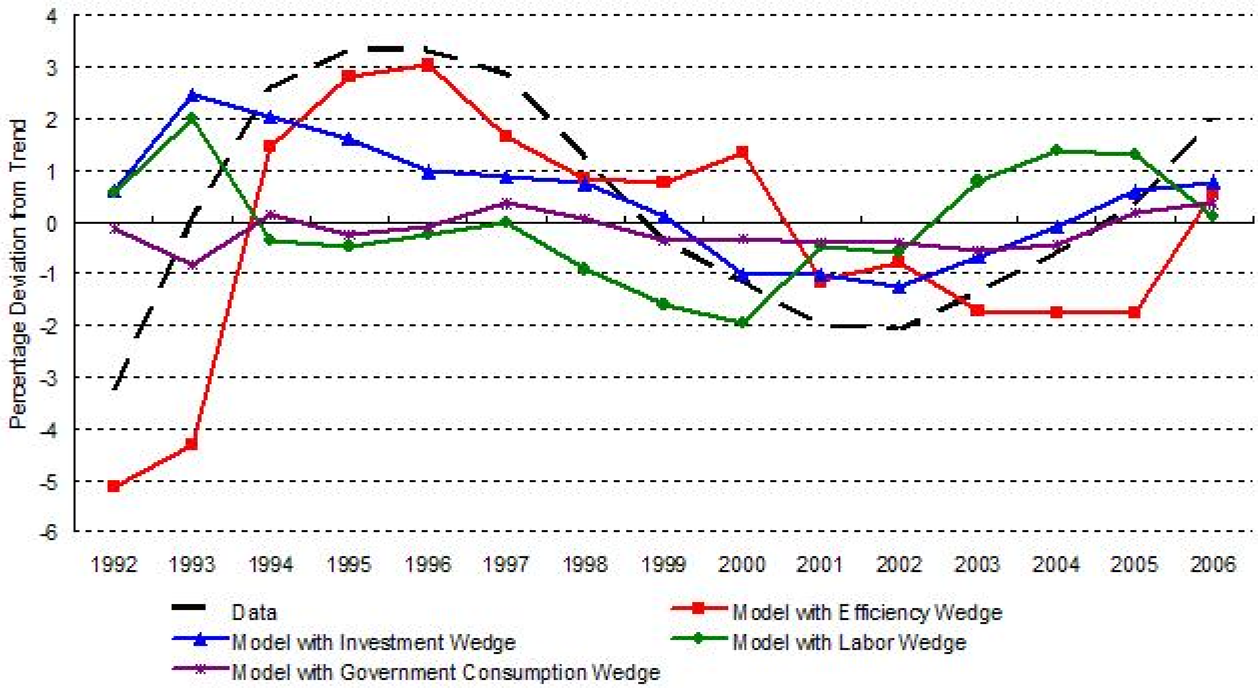

Figure 9. Data and Predictions of Models With Just One Wedge: Consumption (1992-2006)

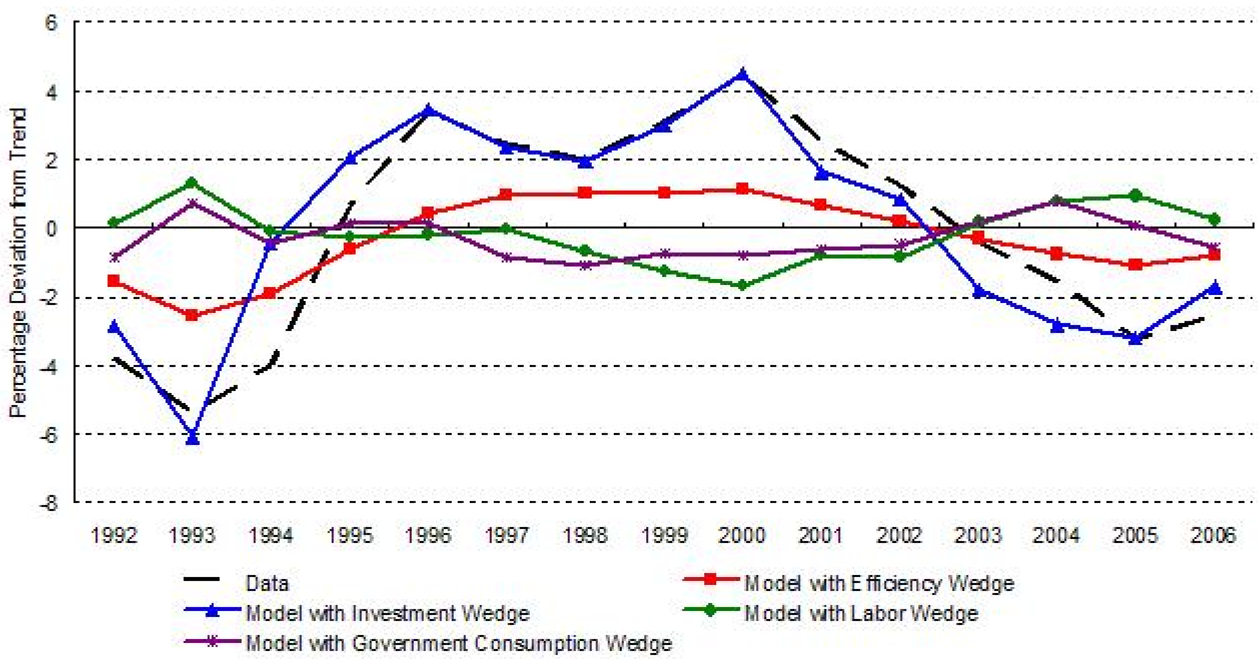

Figure 10. Data and Predictions of Models With Just One Wedge: Investment (1992-2006)

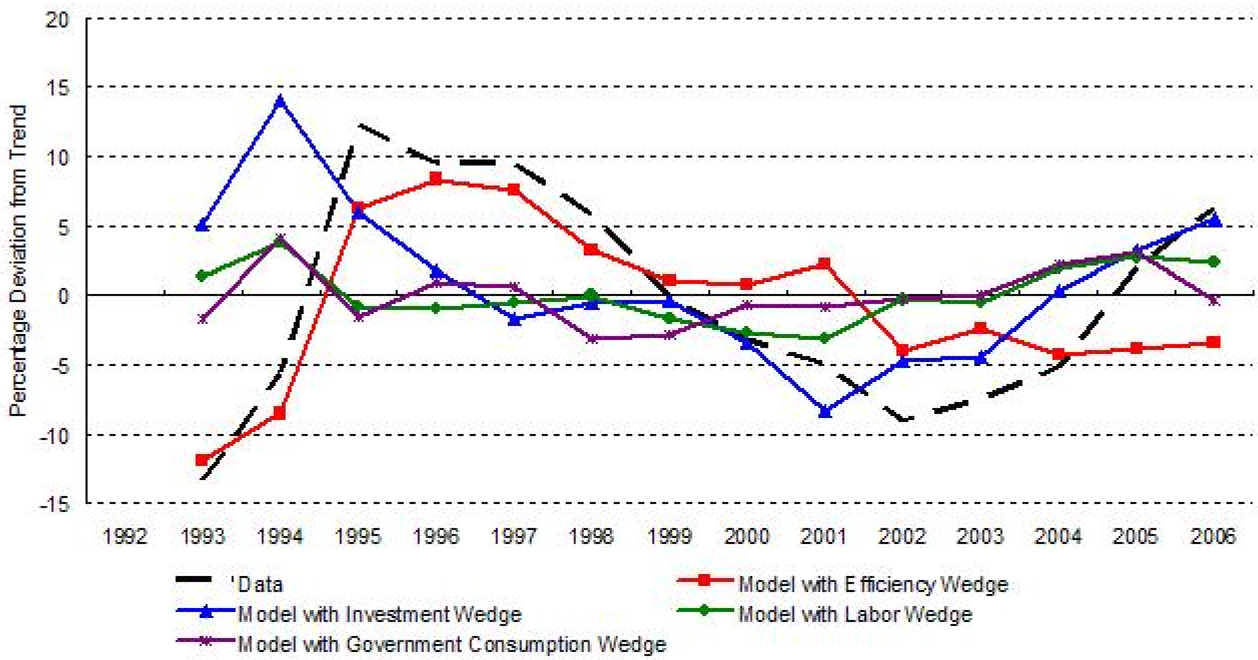

Figure 11. Output and Measured Wedges (1978-2006)

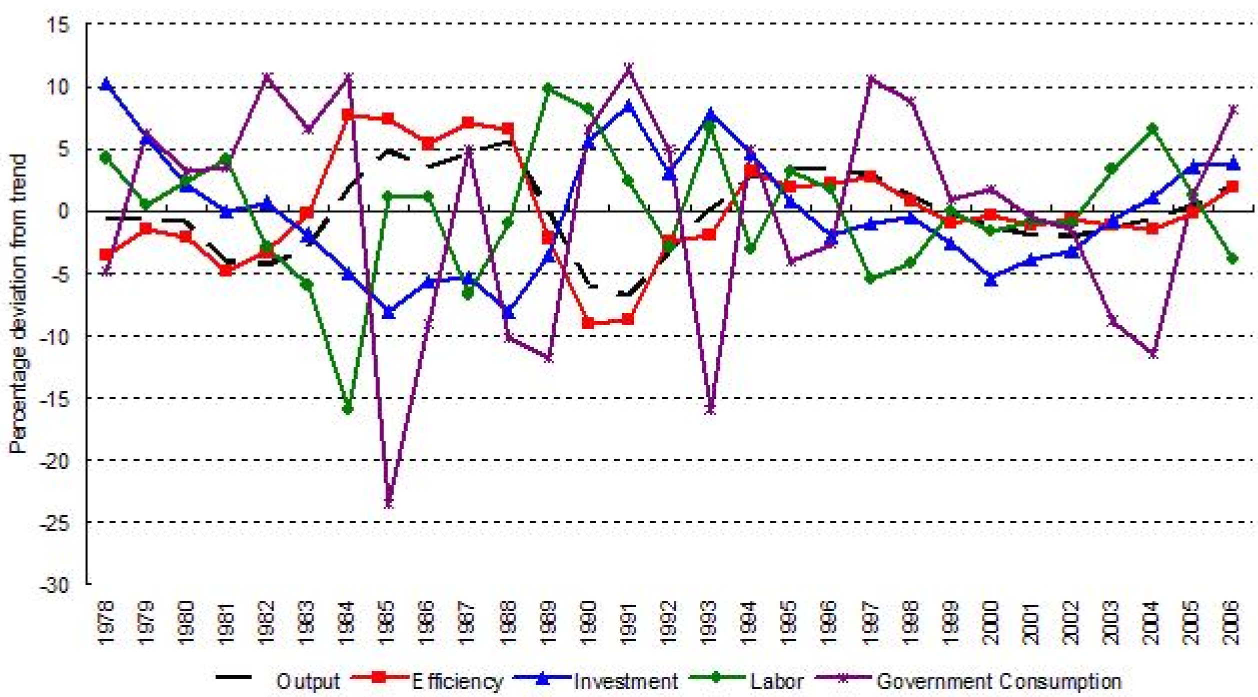

Figure 12. Data and Predictions of Models with Just One Wedge: Output (1978-2006)

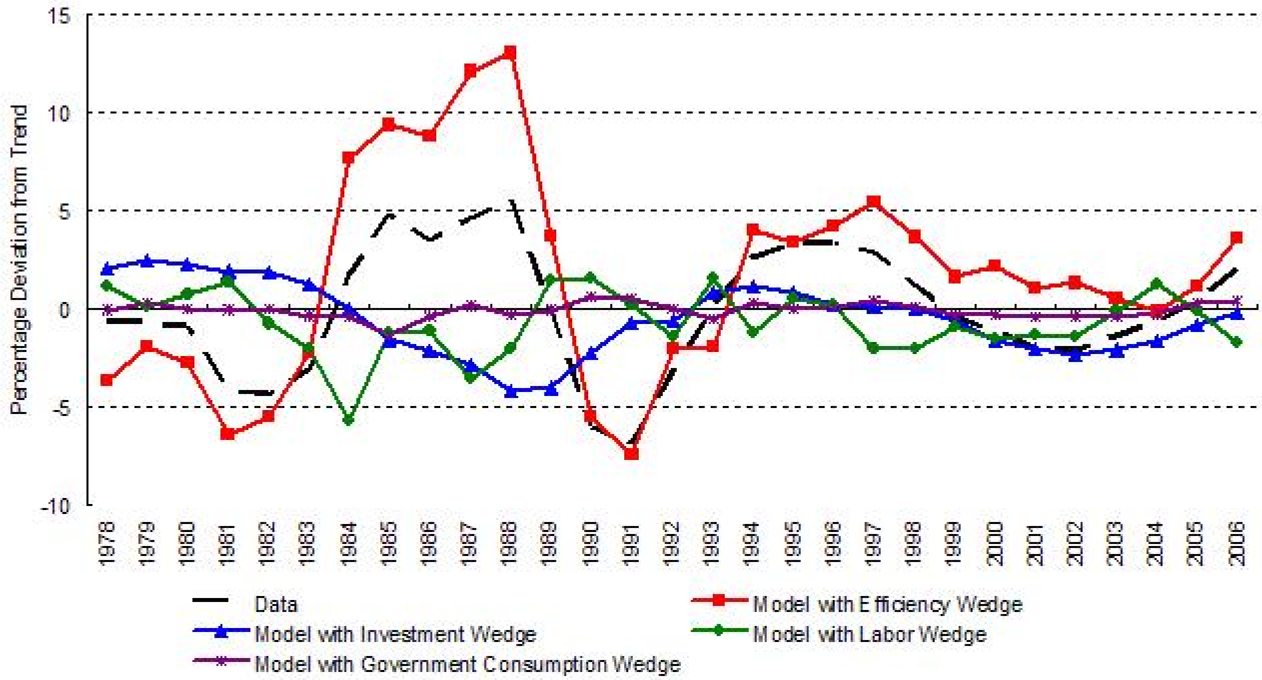

Figure 13. Data and Predictions of Models with Just One Wedge:
US Output (1979-1985)

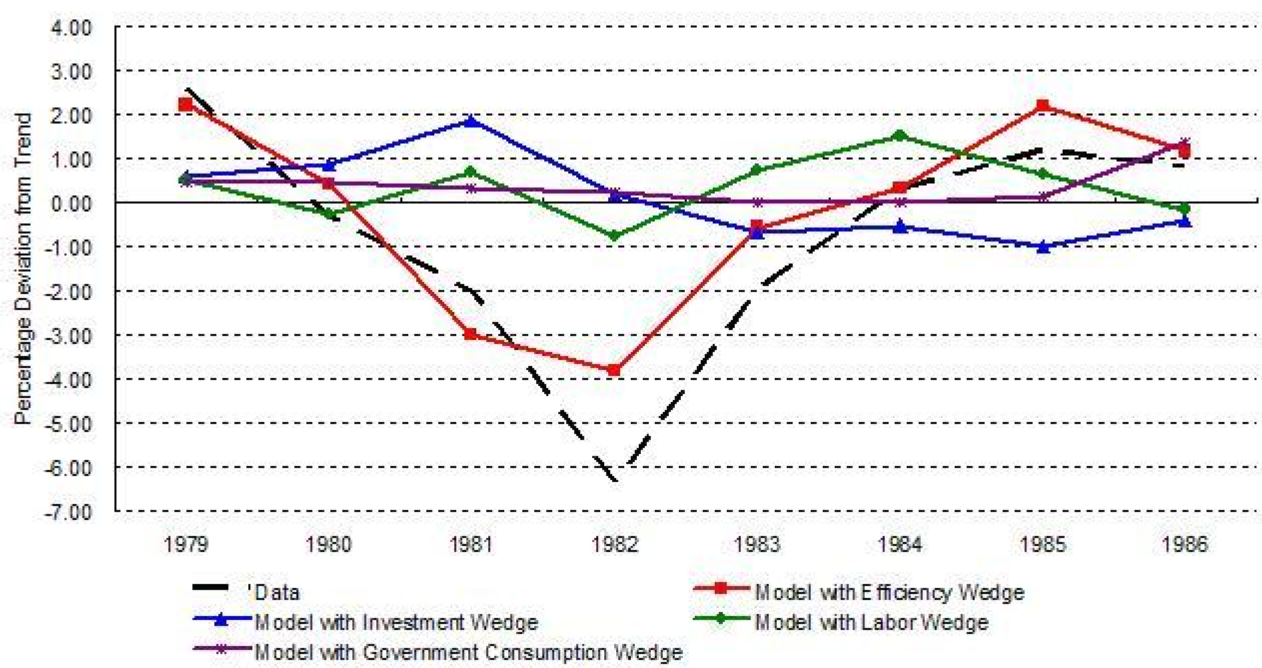

Table 1. Cyclical Behavior of the Chinese Economy: Deviations from Trend of Key Variables [a]

A. 1978-1991						
		Cross Correlation of Output with variable at Lag k=				
variables	SD%	-2	-1	0	1	2
Output	4.09	.09	.71	1.00	.71	.09
Private Consumption	5.11	.07	.49	.85	.74	.11
Government Consumption[b]	10.55	.04	- .14	- .65	- .74	- .15
Investment	8.14	- .65	- .42	.01	.46	.85

B. 1992-2006						
		Cross Correlation of Output with variable at Lag k=				
variables	SD%	-2	-1	0	1	2
Output	2.14	.28	.75	1.00	.75	.28
Private Consumption	3.14	- .83	- .50	.06	.51	.77
Government Consumption[b]	7.59	- .40	- .14	.24	.62	.45
Investment	8.19	- .17	.34	.79	.92	.61

C. 1978-2006						
		Cross Correlation of Output with variable at Lag k=				
variables	SD%	-2	-1	0	1	2
Output	3.20	.17	.72	1.00	.72	.17
Private Consumption	4.13	- .09	.28	.65	.68	.43
Government Consumption[b]	8.98	- .10	- .18	- .39	- .33	.13
Investment	8.02	- .48	- .17	.27	.65	.80

[a] Series are first logged and detrended using the HP filter.
[b] Net export is included.

Table 2. Estimated Long-run Trends of Wedges

	Investment Wedge	Labor Wedge	g/y
1978-1991	0.737	0.995	0.141
1992-2006	0.795	0.879	0.173

Table 3. Properties of the Wedges [a]

A. 1978-1991

Wedges	SD Relative to Output	Cross Correlation of Output with Wedge at Lag k= -2	-1	0	1	2
Efficiency	2.12	.34	.86	.94	.54	- .09
Investment	0.63	- .10	- .21	- .59	- .69	- .11
Labor	3.61	- .40	- .88	- .81	- .31	.19
Government Consumption	2.58	.04	- .14	- .65	- .74	- .15

B. 1992-2006

Wedges	SD Relative to Output	Cross Correlation of Output with Wedge at Lag k= -2	-1	0	1	2
Efficiency	0.90	.00	.44	.85	.78	.25
Investment	1.61	.82	.61	.08	- .39	- .58
Labor	1.56	.59	.27	- .25	- .59	- .57
Government Consumption	3.55	- .40	- .14	.24	.62	.45

C. 1978-2006

Wedges	SD Relative to Output	Cross Correlation of Output with Wedge at Lag k= -2	-1	0	1	2
Efficiency	1.33	.34	.80	.90	.50	- .01
Investment	1.04	- .01	- .26	- .48	- .50	- .29
Labor	1.59	- .33	- .51	- .27	.15	.17
Government Consumption	2.81	- .10	- .18	- .39	- .33	.13

[a] Series are first logged and detrended using the HP filter.

Table 4. Properties of the Output Components [a]

A. 1978-1991

Output components	SD Relative to Output	Cross Correlation of Output with Wedge at Lag k= -2	-1	0	1	2
Efficiency	2.63	.08	.68	.95	.74	.24
Investment	0.39	.17	.04	- .31	- .67	- .73
Labor	1.38	- .15	- .72	- .87	- .58	- .18
Government Consumption	0.10	- .66	- .59	- .56	- .09	.68

B. 1992-2006

Output components	SD Relative to Output	Cross Correlation of Output with Wedge at Lag k= -2	-1	0	1	2
Efficiency	1.12	- .28	.20	.74	.86	.55
Investment	0.52	.73	.88	.65	.28	.07
Labor	0.51	.69	.44	- .07	- .48	- .55
Government Consumption	0.16	- .07	.29	.53	.64	.20

C. 1978-2006

Output components	SD Relative to Output	Cross Correlation of Output with Wedge at Lag k= -2	-1	0	1	2
Efficiency	1.66	.12	.64	.90	.69	.28
Investment	0.57	.21	.03	- .21	- .39	- .45
Labor	0.52	- .28	- .53	- .39	- .02	.06
Government Consumption	0.12	- .35	- .30	- .26	.00	.40

a Series are first logged and detrended using the HP filter.

Table 5. Granger Causality Relations among Wedges [a]

A. 1978-1991

	Output	Efficiency	Investment	Labor	Government
Output	–	.04 *	.05 *	.40	< .01 *
Efficiency	< .01 *	–	< .01 *	.77	< .01 *
Investment	.39	.35	–	.84	.38
Labor	< .01 *	.19	< .01 *	–	< .01 *
Government	.09 *	.27	.17	.87	–

B. 1992-2006

	Output	Efficiency	Investment	Labor	Government
Output	–	.01 *	.04 *	.05 *	.02 *
Efficiency	.05 *	–	.04 *	.32	.15
Investment	< .01 *	< .01 *	–	.09 *	.91
Labor	< .01 *	.07 *	.07 *	–	.93
Government	.14	.22	.81	.87	–

C. 1978-2006

	Output	Efficiency	Investment	Labor	Government
Output	–	.04 *	.30	.27	.10
Efficiency	< .01 *	–	.02 *	.31	< .01 *
Investment	.37	.13	–	.49	.04 *
Labor	.01 *	.08 *	< .01 *	–	< .01 *
Government	.33	.40	.05 *	.36	–

Note: Efficiency, investment, labor and government are short for efficiency wedge, investment wedge, labor wedge and government consumption wedge, respectively.All numbers in the table are p-values. Each number corresponds to the probability of H0: Variable for the corresponding row does NOT Granger cause varable for the corresponding column.
* indicates significance at 10%. a Granger causality tests are conducted with 1 lag.