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Business Cycle Accounting under Catching Up with the Joneses

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Abstract

Several studies assert that multiple factors are responsible for the recent behavior of the business cycle in Japan. For example, Kobayashi and Inaba (2006, Japan and the World Economy 18, 418–440) apply the business cycle accounting method proposed by Chari et al. (2007, Econometrica 75, 781–836) and conclude that the labor wedge played a significant role in the Japanese economy in the 1980s and 1990s. In this paper, we reconsider this finding using time-series filtering techniques and a “catching up with the Joneses” utility function. We find that the efficiency wedge explains almost all of the recent movements in output in Japan. In addition, because the effects of the labor and capital wedges cancel each other out, they do not appear to significantly affect the business cycle. These results suggest that when employing the business cycle accounting method, researchers should purposively select both the detrending procedure and the utility function that they use.

Keywords: Business cycle accounting, Time-series filtering, Catching up with the Joneses, Japan

JEL Classification: E32, E37, O47

1. Introduction

The Japanese economy has experienced significant fluctuation for several decades, including the bubble economy of the late 1980s, the “lost decade” of the 1990s, the long recovery period in the early 2000s, and the Great Recession of the mid- to late 2000s. To investigate the factors underlying these cycles, Kobayashi and Inaba (2006) and Otsu (2009) apply the business cycle accounting method proposed by Chari et al. (2007) to the Japanese economy. Business cycle accounting is an econometric method used to decompose aggregate macroeconomic variables, e.g., output, labor, and investment, into four wedges: an efficiency wedge, a labor wedge, an investment wedge, and a government consumption wedge. This has proven itself remarkably robust in that Chari et al. (2007) demonstrate that a number of models with different frictions are largely identical to this prototype. In other words, estimating these wedges allows researchers to identify the origin of business cycles. Using this approach, Kobayashi and Inaba (2006) conclude that the labor wedge played a key role in the 1990s business cycle in Japan. This finding is partly consistent with that in Hayashi and Prescott (2002), who investigate the behavior of the Japanese economy, but using a neoclassical growth model.

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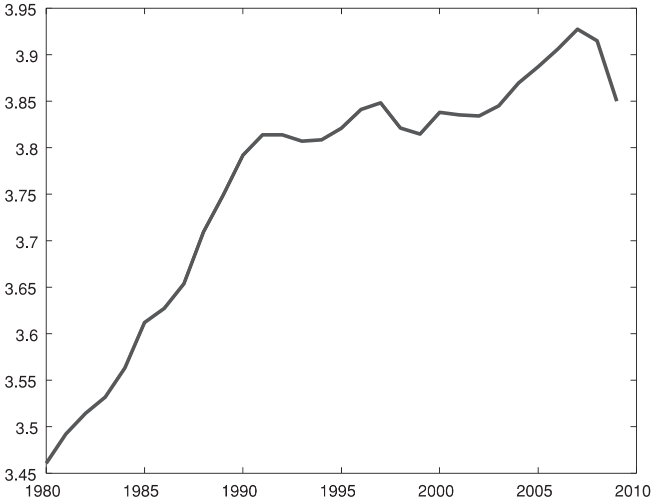
However, there are several points to note when undertaking business cycle accounting. First, it is important to consider the method used to detrend the aggregate variables. For instance, Kobayashi and Inaba (2006), like many earlier studies, employ a constant rate of growth to detrend the variables. Figure 1 plots the natural logarithm of Japan's real per capita GDP.

As shown, the sequence appears to display at least one structural break and fluctuates erratically after 1991. In addition, there is a large negative shock in 2009, which might explain an additional structural break. Consequently, it is inappropriate to assume that the growth rate of the aggregate variables is constant, at least in Japan.

Figure 1: Per capita real GDP in Japan



Second, the choice of functional form can also plausibly account for differences in results. For example, Otsu (2010) employs a small open economy prototype model to conduct business cycle accounting for Hong Kong, Korea, and Thailand. To check the robustness of the results, Otsu (2010) specifies the Greenwood–Hercowitz–Huffman (GHH) utility function from Greenwood et al. (1988). Although the results do not depend on the choice of utility function, the GHH function emphasizes the effects of the efficiency wedge on output. Given that Kobayashi and Inaba (2006) identify the importance of the efficiency wedge in explaining recent business cycles in Japan, it is necessary to reassess their results using other utility functions.

In this paper, we reconsider the business cycle accounting approach conducted by Kobayashi and Inaba (2006) by applying two modifications. The first is to apply other time-series filtering techniques, including the Hodrick–Prescott (HP), Baxter–King (BK), and Christiano–Fitzgerald (CF) filters. This allows us to estimate the wedges without the undue influence of the change in the growth rate. This is a novel contribution in that, whereas Otsu (2009) also applies the HP filter in a business cycle accounting study, we employ the BK and CF filters. The second modification is that we assume external habit formation in the utility function through use of a "catching up with the Joneses" (CUWJ) utility function. The use of this form of utility function is in evidence in many existing studies, especially new Keynesian dynamic stochastic general equilibrium models. Importantly, the CUWJ utility function is a method for addressing the problem of consumption smoothing suggested by many earlier studies. For example, Smets and Wouters (2003) detail a workhorse model of new Keynesian macroeconomics for the study of business cycles that contains the CUWJ utility function. When applying the CUWJ utility to business cycle accounting, the policy function includes consumption in the previous period. As this leads to different equilibrium conditions of the prototype model from those under a log-utility function, we present the condition under which these alternative prototype models are equivalent. Moreover, the difference between those models can also change the accounting procedure. Therefore, we illustrate an alternative accounting procedure that differs slightly from that in Chari et al. (2007).

Our main findings are as follows. First, the efficiency wedge remains the most important factor explaining the business cycle in Japan. We simulate the movement of output, labor, and investment and obtain the same results. Moreover, the CUWJ utility increases the effect of the efficiency wedge relative to that obtained using the log-utility function. As a result, the efficiency wedge in the CUWJ model explains almost all of the observed movements in output. This correspondingly implies that the labor wedge has little explanatory power, as also suggested by Kobayashi and Inaba (2006). Second, the effects of the labor and investment wedges tend to cancel each other out. That is, while these wedges individually have an enormous effect on the business cycle, the net effect is more subtle. Finally, earlier studies generally neglect the government consumption wedge as they consider its effect on output to be only minor, but our estimation shows that we cannot ignore its effect on investment. Consequently, we believe that future studies should report the effect of the government consumption wedge, especially on investment.

The remainder of the paper is structured as follows. Section 2 details the prototype model in Chari et al. (2007), but with a CUWJ utility function, and provides the conditions under which the two models with different assumptions governing marginal utility are equivalent. Section 3 explains the procedure used for business cycle accounting with CUWJ utility. Section 4 discusses the results of alternative simulations using models with log and CUWJ utility functions. Section 5 concludes the paper.

2. The Model

In this section, we present a prototype model for business cycle accounting à la Chari et al. (2007). In this economy, time is discrete and there are four exogenous stochastic variables: the efficiency wedge $A_t(s^t)$, the labor wedge $1-\tau_{lt}(s^t)$, the investment wedge $1/(1+\tau_{xt})$, and the government consumption wedge $g_t(s^t)$. The distinguishing feature of this model from that in Kobayashi and Inaba (2006) is the specification of the utility function. Specifically, we introduce external habit formation into the utility function through use of the CUWJ utility function.

The representative households maximize

$$\sum_{t=0}^{\infty}\sum_{s^t}\beta^t\pi_t(s^t)u\big(c_t(s^t),\bar{c}_{t-1}(s^{t-1}),l_t(s^t)\big), \tag{1}$$

subject to the budget constraint

$$\begin{aligned} c_t(s^t) + [1+\tau_{xt}(s^t)]x_t(s^t) \\ = [1-\tau_{lt}(s^t)]w_t(s^t)l_t(s^t) + r_t(s^t)k_t(s^t) + T_t(s^t), \end{aligned} \tag{2}$$

and the capital transition equation

$$k_{t+1}(s^t) = x_t(s^t) + (1-\delta)k_t(s^{t-1}), \tag{3}$$

where β denotes the subjective discount factor, $u(\cdot,\cdot,\cdot)$ is the instantaneous utility function, $c_t(s^t)$ is per capita consumption, $\bar{c}_t(s^t)$ is the average per capita consumption of all households, $l_t(s^t)$ is per capita labor, $x_t(s^t)$ is per capita investment, $r_t(s^t)$ is the rental rate on capital, $w_t(s^t)$ is the wage rate, $k_t(s^{t-1})$ is the capital stock, and $T_t(s^t)$ is per capita lamp-sum transfer.

Firms maximize

$$A_t(s^t)F\big(k_t(s^t), l_t(s^t)\big) - r_t(s^t)k_t(s^t) - w_t(s^t)l_t(s^t),$$

where $F(\cdot,\cdot)$ is a production technology.

The resource constraint in the economy is

$$c_t(s^t) + x_t(s^t) + g_t(s^t) = y_t(s^t), \tag{4}$$

where $y_t(s^t)$ is per capita output.

We summarize the equilibrium of this economy with the transition law of capital (3) and the resource constraint (4) as

$$-\frac{u_{lt}(s^t)}{u_{ct}(s^t)} = [1 - \tau_{lt}(s^t)]A_t(s^t)F_{lt}(s^t), \tag{5}$$

$$\begin{aligned} &[1 + \tau_{xt}(s^t)]u_{ct}(s^t) \\ &\quad = \beta \sum_{s^{t+1}} \pi_t(s^{t+1}|s^t)\,\{A_{t+1}(s^t)F_{k,t+1}(s^{t+1}) \\ &\quad + \big[1 + \tau_{x,t+1}(s^t)\big](1-\delta)\big\}u_{c,t+1}(s^{t+1}), \end{aligned} \tag{6}$$

$$y_t(s^t) = A_t(s^t)F(k_t(s^t), l_t(s^t)), \tag{7}$$

With the exception of marginal utility, these equations are the same as the model without external habit formation in Chari et al. (2007). If the utility function is separable with respect to consumption and labor, the only difference is the marginal utility of consumption, $u_{ct}(s^t)$. Chari et al. (2007) compare two prototype economies with different marginal utilities of labor and show that these economies are equivalent under a certain condition. Similarly, we can generalize their proposition for two economies with different marginal utilities using Eqs. (8) and (9), even when the utility function is nonseparable with respect to consumption and labor.

Proposition: *If the sequence of wedges for the alternative prototype economy, economy 2, is given by* $A_{2t} = A_{1t}$,

$$1 - \tau_{2l,t} = \big(1 - \tau_{1l,t}\big)\frac{u_{2l,t}/u_{2c,t}}{u_{1l,t}/u_{1c,t}},$$

$\tau_{2x,t}$ *implicitly defined by*

$$\big(1 + \tau_{2x,t}\big)\frac{u_{2c,t}}{u_{2c,t+1}} - \beta\tau_{2x,t+1}(1-\delta) = \big(1 + \tau_{1x,t}\big)\frac{u_{1c,t}}{u_{1c,t+1}} - \beta\tau_{1x,t+1}(1-\delta),$$

and $g_{2t} = g_{1t}$, *then the equilibrium outcomes for the two economies coincide.*

Proof. We first derive the labor wedge. In Eq. (5), $A_{1t}F_{1l,t} = A_{2t}F_{2l,t}$ for economies 1 and 2. Therefore, we have

$$\frac{u_{1l,t}}{u_{1c,t}}\frac{1}{1-\tau_{1l,t}} = \frac{u_{2l,t}}{u_{2c,t}}\frac{1}{1-\tau_{2l,t}}.$$

This provides the condition for the labor wedge.

Next, from Eq. (6), We obtain

$$\beta A_{i,t+1}F_{ik,t+1} = \big(1 + \tau_{ix,t}\big)\frac{u_{ic,t}}{u_{ic,t+1}} - \beta\big(1 + \tau_{ix,t+1}\big)(1-\delta) \quad \text{for } i = 1,2.$$

Given that $\beta A_{1,t+1}F_{1k,t+1} = \beta A_{2,t+1}F_{2k,t+1}$, we have the condition for the labor wedge. Q.E.D.

However, it is important to note that this proposition shows the condition for the equivalence of the two economies, but does not guarantee that the wedges estimated from the two prototype models are the same. For instance, Miyazaki (2009) employs Hansen (1985) and Rogerson (1988)-type preferences whereas Otsu (2009) applies GHH preferences, such that their business cycle accounting results more or less differ from those obtained under log-utility preferences. We present the different results for the estimated wedges using the log utility and CUWJ models in Section 5.

3. The Accounting Procedure

We assume that the production function is $F(k_t, l_t) = k_t^{\alpha} l_t^{1-\alpha}$. We also assume $u(c_t, l_t) = \log c_t + \psi \log(1-l_t)$ in the log preference model and $u(c_t, l_t) = \log(c_t - \zeta \bar{c}_{t-1}) + \psi \log(1-l_t)$ in the CUWJ model. In other words, $\zeta = 0$ is the log preference model and $\zeta > 0$ is the CUWJ model. In the equilibrium, the average of consumption equals equilibrium consumption, i.e., $\bar{c}_t = c_t$. Then, (5)–(7) are rewritten as

$$-\frac{\psi(c_t - \zeta c_{t-1})}{1-l_t} = (1-\tau_{lt})(1-\alpha)\frac{y_t}{l_t}, \tag{8}$$

$$\frac{1+\tau_{xt}}{c_t - \zeta c_{t-1}} = \beta \frac{\alpha y_{t+1}/k_{t+1} + \left(1+\tau_{x,t+1}\right)(1-\delta)}{c_t - \zeta c_{t-1}}, \tag{9}$$

$$y_t = A_t k_t^{\alpha} l_t^{1-\alpha}. \tag{10}$$

For simplicity, we assume all wedges are i.i.d.

Log-linearizing Eqs. (3), (4), and (8)–(10) yields policy functions

$$\tilde{y}_t = y\left(\tilde{k}_t, \tilde{c}_{t-1}, \tilde{s}_t\right), \tilde{l}_t = l\left(\tilde{k}_t, \tilde{c}_{t-1}, \tilde{s}_t\right),$$
$$\tilde{x}_t = x\left(\tilde{k}_t, \tilde{c}_{t-1}, \tilde{s}_t\right), \tilde{c}_t = c\left(\tilde{k}_t, \tilde{c}_{t-1}, \tilde{s}_t\right),$$

where $\tilde{s}_t = (\tilde{A}_t, \tilde{\tau}_{lt}, \tilde{\tau}_{xt}, \tilde{g}_t)'$. The variables denoted with tilde are the differences (in logarithms) from the steady state. For instance, $\tilde{y}_t \equiv \log y_t - \log \bar{y}$ where $\bar{y}$ is the steady state value of y_t.

To estimate the wedges, we apply the following procedure. First, we obtain the government consumption wedge from the data $\tilde{g}_t^d$. We denote the variable with superscript d as the data. Second, we rewrite the policy function as

$$\begin{bmatrix} \tilde{y}_t^d \\ \tilde{l}_t^d \\ \tilde{x}_t^d \end{bmatrix} = P_1 \begin{bmatrix} \tilde{A}_t \\ \tilde{\tau}_{lt} \\ \tilde{\tau}_{xt} \end{bmatrix} + P_2 \begin{bmatrix} \tilde{k}_t \\ \tilde{c}_{t-1} \\ \tilde{g}_t \end{bmatrix},$$

where P_1 and P_2 are the parameter matrices of the policy function. Therefore, we have wedges

$$\begin{bmatrix} \tilde{A}_t \\ \tilde{\tau}_{lt} \\ \tilde{\tau}_{xt} \end{bmatrix} = P_1^{-1} \left(\begin{bmatrix} \tilde{y}_t^d \\ \tilde{l}_t^d \\ \tilde{x}_t^d \end{bmatrix} - P_2 \begin{bmatrix} \tilde{k}_t \\ \tilde{c}_{t-1} \\ \tilde{g}_t \end{bmatrix} \right). \tag{11}$$

At time $t = 1$, we use the data $\tilde{y}_1^d$, $\tilde{l}_1^d$, $\tilde{x}_1^d$, $\tilde{g}_1^d$, $\tilde{c}_0 = \tilde{c}_0^d$, and $\tilde{k}_1 = \tilde{k}_1^d$. For $t > 1$, we calculate the capital stock from the linearized transition law of capital $\tilde{k}_t = \delta \tilde{x}_{t-1}^d + (1-\delta)\tilde{k}_{t-1}$ and consumption from the policy function $\tilde{c}_{t-1} = c(\tilde{k}_{t-1}, \tilde{c}_{t-2}, \tilde{s}_{t-1})$. We then substitute $\tilde{k}_t$ and $\tilde{c}_{t-1}$ into (11) to obtain the wedges and repeat this same procedure. However, this procedure differs somewhat from Chari et al. (2007) in that our prototype model includes an additional predetermined variable, $\tilde{c}_{t-1}$.

4. Data

All variables are annual and obtained from the SNA (National Accounts of Japan) of the Cabinet Office of Japan, the Labor Force Survey of the Statistics Bureau and the Director-General for Policy Planning of Japan, and the Monthly Labor Survey of the Ministry of Health, Labor, and Welfare.

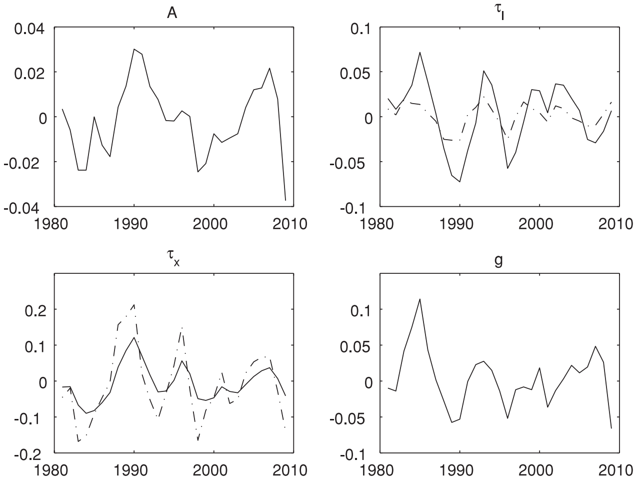
Per capita output y_t is real GDP for the population over 15 years of age N_t. Per capita investment x_t is investment over N_t. The government consumption wedge g_t is real GDP minus the sum of private consumption and private and government investments over N_t. Labor is computed as $l_t = (E_t/N_t)[h_t/(16 \times 30)]$ where E_t is employment and h_t is monthly hours worked. The per capita capital stock at $t = 0$, k_0, is national wealth in 1980 over N_t. All variables are detrended using Hodrick and Prescott's (1980) filter using the smoothing parameter $\lambda = 100$. Although this particular parameter value is widely used, as an alternative, Ravn and Uhlig (2002) recommend $\lambda = 6.25$ for annual data. We check the robustness of this assumption in Section 6.

We set $\alpha = 0.372$, $\beta = 0.98$, and $\delta = 0.0846$ following Kobayashi and Inaba (2006) and $\zeta = 0.595$ following Smets and Wouters (2009). The parameter of labor in the utility function ψ is set so that the steady state level of labor is the value in 1980, $l^{ss} = l_{1980} = 0.227$: $\psi = 2.302$ in the log-utility model; and $\psi = 2.257$ in the CUWJ model. For the steady state level, we employ the 1980 data.

5. Simulation

In this section, we conduct simulations using the log-utility model and the CUWJ model. However, we first illustrate the wedges. Figure 2 depicts the sequence of the estimated wedges from the two models. As shown, the efficiency and government consumption wedges are identical in both models. However, while the labor wedge under CUWJ fluctuates less than under log utility, the investment wedge under CUWJ moves more noticeably. We also note that these wedges do not necessarily move in the same direction.

Figure 2: BCA wedges



Note: The solid lines are the wedges in the usual log-utility model. The broken lines are the wedges in the CUWJ model.

5.1 The Model under Log Utility

Next, we simulate the variables with only a single wedge. Figure 3 demonstrates the series of output with one wedge under log utility. The simulated output with only the efficiency wedge is approximately the same as the actual output. However, there is also a gap between the two series. It is worth noting that the series of output with only the labor and investment wedges indicates that they tend to move to cancel each other out. The gap between data and output with only the efficiency wedge depends on the balance of the effects of the labor and investment wedges. Conversely, the government consumption wedge appears to have little effect on output.

Figure 3: Output with only one wedge

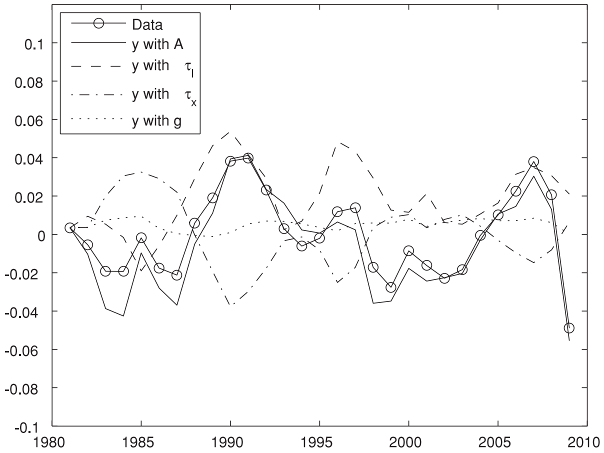
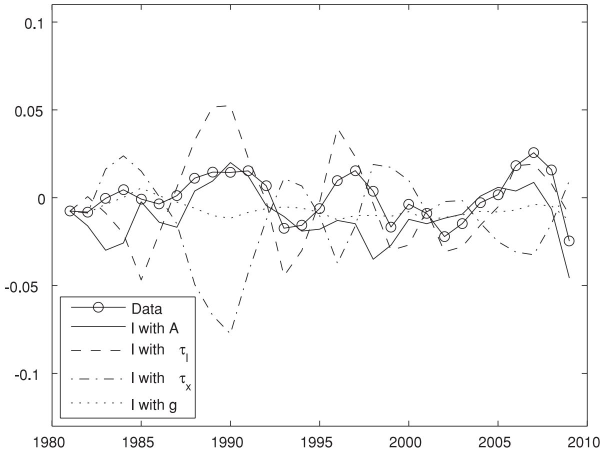


Figure 4 presents the simulation for labor. Note that the sequence with only the efficiency wedge roughly corresponds to the actual data, as does that with only the labor wedge, but this is balanced out by the effect of the investment wedge.

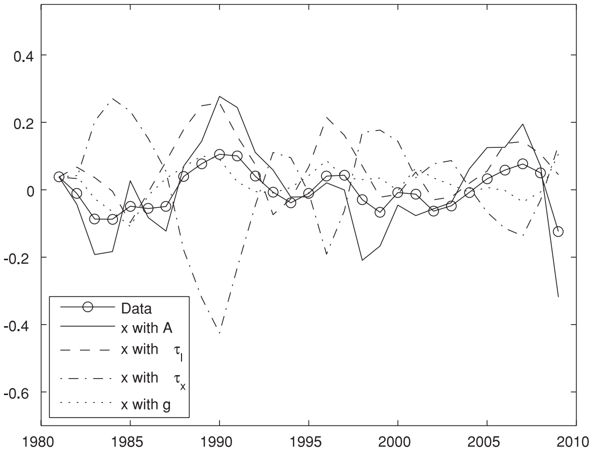
Figure 4: Labor with only one wedge



However, as shown in Figure 5, the efficiency wedge does not successfully recreate the movement of actual investment. In this case, the investment wedge dampens the effect of the efficiency wedge. Interestingly, government consumption affects investment throughout the period.

In this manner, the government consumption wedge reinforces the effect of the efficiency wedge up until 2000, and then moves against it. We have not come across this feature in earlier Japanese studies of business cycle accounting.

Figure 5: Capital with only one wedge



Comparing the result with that of Kobayashi and Inaba (2006), we obtain the following findings. First, as in Kobayashi and Inaba (2006), we argue the efficiency wedge is the most important determining factor in Japan's recent business cycles, particularly in its impact on output. Second, unlike Kobayashi and Inaba (2006), the labor and investment wedges fluctuate inversely such that their net effect on output is negligible.

5.2 The Model under CUWJ

Figure 6 displays the series of output with only one wedge under CUWJ. Surprisingly, output with only the efficiency wedge almost totally coincides with the actual data. Once again, the labor and investment wedges exert an enormous effect on output, but they cancel each other out. The government consumption wedge has no effect.

Figure 6: Output with only one wedge under CUWJ

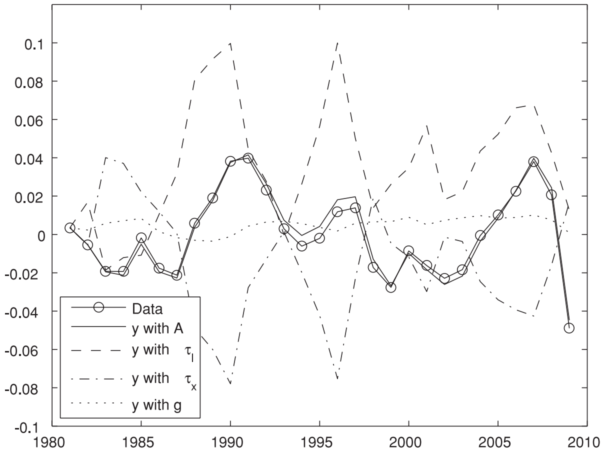


Figure 7 depicts the effect of the other wedges on labor under CUWJ. As shown, the efficiency wedge affects labor by the same magnitude shown in Figure 4. The series with only the labor and investment wedges fluctuates significantly. However, the net effect is similar to that in Figure 4.

Figure 7: Labor with only one wedge under CUWJ

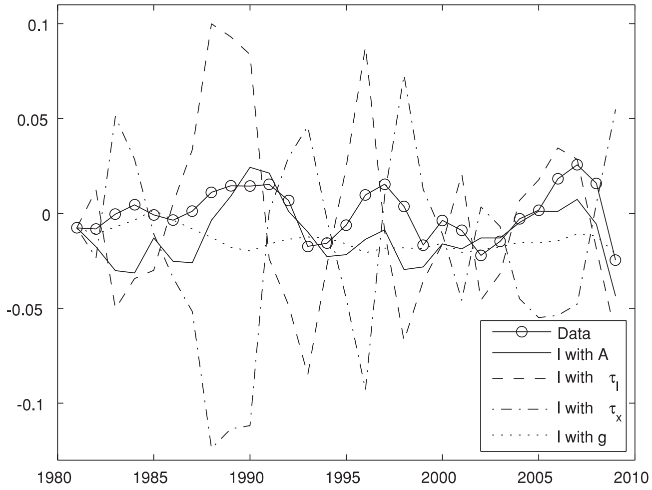
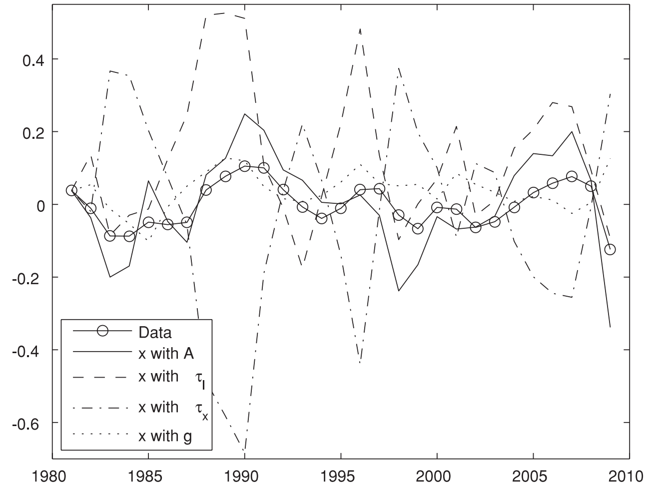


Figure 8 presents the simulation for investment with only one wedge under CUWJ. Even here, the efficiency wedge can not totally explain the actual investment, but the magnitude is the same as in Figure 5. This gap is supplemented by the net effect of the labor and investment wedge.

Figure 8: Capital with only one wedge under CUWJ



In sum, the effect of the efficiency wedge on output under CUWJ is stronger than under log utility, but this does not apply for labor and investment. We also find that the effects of the labor and investment wedges move inversely and tend to cancel each other out. Lastly, the government consumption wedge has no effect on output, but does affect investment to some extent.

6. Robustness

In this section, we check the robustness of the results obtained in the previous section.

6.1 Ravn-Uhlig's λ

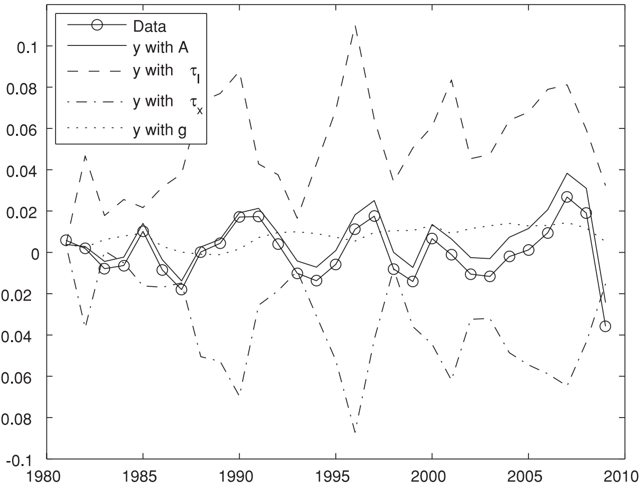
In brief, the HP filter is a method to minimize

$$\min \sum_{t=1}^{T} \{(y_t - g_t)^2 + \lambda[(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2\},$$

with respect to $\{g_t\}$, where y_t is the original time series. Hodrick and Prescott (1997) set the smoothing parameter $\lambda = 100$ for an annual rate. As an alternative, Ravn and Uhlig (2002) propose quite a small value, $\lambda = 6.25$, which we use to reestimate the wedges.

Figure 9 demonstrates the result. Although the effect of the efficiency wedge increases relative to that in Figure 6, it still prevails over time. In addition, the government consumption wedge affects output slightly. As a whole, all the effects are almost identical.

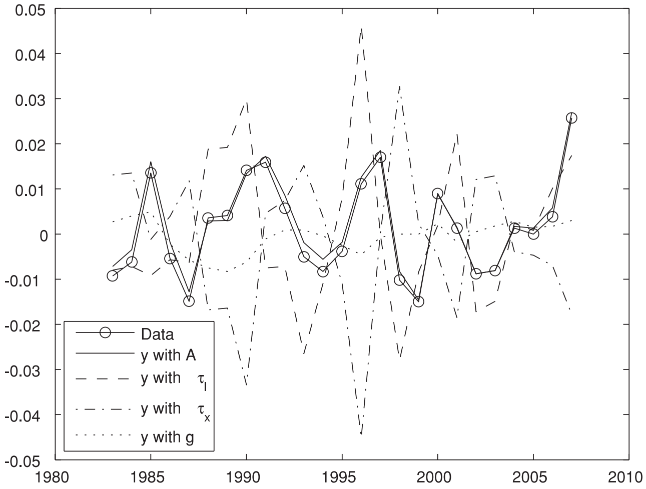
Figure 9: Output with only one wedge under CUWJ and the Ravn–Uhlig annual



6.2 Other Filters

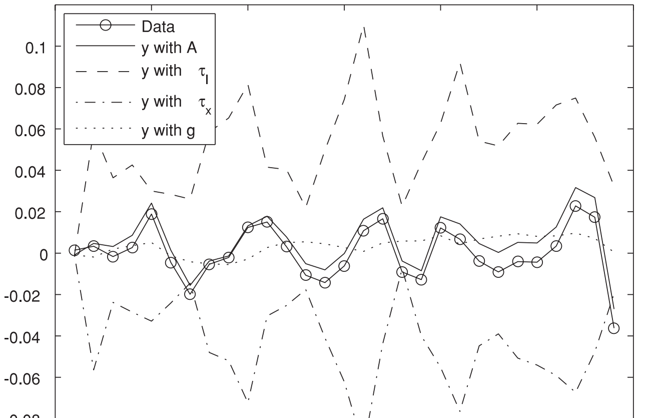
Otsu (2009) also conducts business cycle accounting for the Japanese economy using the HP filter, which is a high-pass filter, that is, it removes only high-frequency components. Alternatively, Baxter and King (1999) propose a band-pass filter, which removes low-frequency components as well. To compare the BP filter with the HP filter at the annual frequency, Baxter and King (1999) set 2–8 years as representing each business cycle and three leads/lags, $B_3(2,8)$. However, as the BP filter requires leads and lags, it necessarily reduces the number of observations. Given that the sample size in this paper is already small, we set $B_2(2,8)$, which means there are two moving average terms. Figure 10 is the result. Compared with the other filtering techniques, the variance of this series is quite small, but the shape of the fluctuation is pretty much the same. Once again, the efficiency wedge plays an important role in the movement of output.

Figure 10: Output with only one wedge under CUWJ and the BK filter



As another alternative, Christiano and Fitzgerald (2003) consider the ideal band-pass filter and propose a random-walk filter, which fortunately does not reduce the number of observations. Figure 11 plots the result using the CF filter. We find that all the series behave quite similarly to those in Figure 9. Furthermore, the efficiency wedge again outperforms the other wedges, but there is a small gap with output over time.

Figure 11: Output with only one wedge under CUWJ and the CF filter

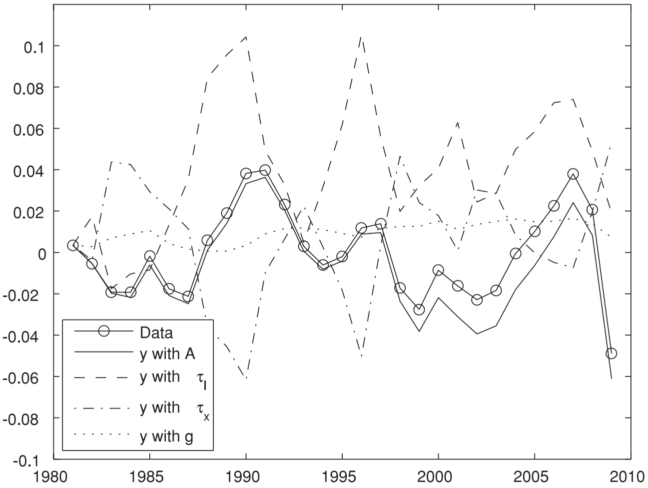


6.3 Arato–Yamada’s Capital Stock

Very recently, Arato and Yamada (2012) reestimated the tangible and intangible capital stock using firm-level data. We now use their data for the initial capital stock to conduct our business cycle accounting.

We depict the simulation results for output with only one wedge under CUWJ and Arato and Yamada’s (2012) capital stock in Figure 9. Although the efficiency wedge remains the most powerful factor in explaining the observed data, there is a gap after about 1993. Given that the data are slightly greater than output with the efficiency wedge, the labor wedge contributes the gap. Hence, our main findings in the previous section do not depend on the choice of capital stock data.

Figure 12: Output with only one wedge under CUWJ and using Arato–Yamada's capital data



7. Concluding Remarks

In this paper, we applied business cycle accounting following Chari et al. (2007) to reassess the Japanese business cycle since 1980. Unlike Kobayashi and Inaba (2006), we employed a nonlinear detrending method, namely, the HP filter, because the aggregate variables for Japan appear to include several structural breaks. We also specified CUWJ utility to address the problem of consumption smoothing.

Technically speaking, we provide two main contributions to the literature. First, we provide the condition under which two prototype models with different utility functions are equivalent. This is a general version of the proposition in Chari et al. (2007). Second, we present an accounting procedure under CUWJ, which requires the computation of consumption in the previous period from the policy function. The results suggest that the effect of the efficiency wedge on output under CUWJ is stronger than under log utility. Moreover, the labor and investment wedges move to cancel each other out, so their net effect on output is negligible. In contrast, while the effect of the government consumption wedge on output is relatively small, it does affect investment to some extent.

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