A Comparative Estimation of Financial Frictions in Japan and Korea

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We apply the Business Cycle Accounting method a la Chari, Kehoe, and McGrattan (2007) to the Japanese and the Korean economy and quantitatively analyze the effects of financial frictions during the recent recessions. First, we compute exogenous distortions in the financial, government purchases, labor, and production markets. The preliminary results show that the sudden drop in production efficiency (TFP) was the main reason of the Korean recession while the increase in labor market distortions was the main reason of the Japanese slump. Next, we orthogonalize the innovations to the distortions and quantify the maximum spill-over effects of financial frictions on output fluctuations in both countries following Christiano and Davis (2006). Our results imply that financial frictions may have been important in explaining the recessions in both countries through their effects on TFP and labor market distortions.

Keywords: Business cycle accounting, TFP, Financial frictions

JEL Classification: E12, E32

I. Introduction

The role played by financial frictions during large business cycle episodes has been among one of the main interests of researchers. In this paper, we use the business cycle accounting method introduced by

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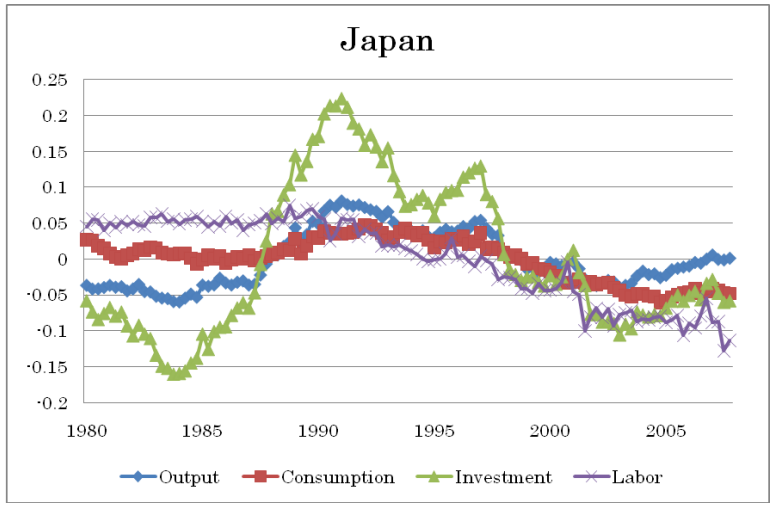
Chari, Kehoe, and McGrattan (2007) in order to quantify the effects of financial frictions during the Japanese boom and recession during the 1980s and the 1990s and the 1998 Korean financial crisis. An influential work by Hayashi and Prescott (2002) shows with a deterministic closed economy model that the decline in total factor productivity (TFP) and working hours were the main causes of the Japanese lost decade. Otsu (2008a) shows with a stochastic small open economy model that TFP is important in accounting for the sudden recession and rapid recovery in Korean output. Lee and Pyo (2007) has shown that during the pre-crisis period of 1990-1997, the service sector of the Korean economy, which includes the financial service sector, had experienced a negative growth (-4.01%) of technical efficiency while making a positive growth of technical progress (5.40%) with TFP growth (1.02%) and output growth (10.92%). These studies imply that if financial frictions caused or aggravated these recessions, they should have done so by affecting TFP or labor market conditions. We find that financial frictions may have been important in accounting for the recent business cycle fluctuations in Japan and Korea through their spill-over effects on production efficiency and labor market distortions.

Financial frictions can take several different forms. Bernanke, Gertler, and Gilchrist (1999) models financial frictions as monitoring costs. Carlstrom and Fuerst (1997) models them as agency costs. Alternatively, financial frictions can simply be modeled as adjustment cost on capital. In this paper, we do control for adjustment costs following business cycle analysis literature, but do not intend to reveal the identity of financial frictions because assuming a single source will limit the role of financial frictions. Instead, we estimate the upper-bound of the effect that financial frictions have on business cycle fluctuations in Japan and Korea.[1]

Japan and Korea recently went through dramatic economic downturns over the past two decades. Figure 1 shows the time paths of linearly detrended output, consumption, investment and labor input in both countries.[2] We set the data period to 1980-2007 for Japan in order to incorporate both the bubble economy and the lost decade whereas we

[1] The paper also does not evaluate the influences of monetary policies dealing with financial turbulence during the crisis episodes in both countries, which is a possible future extension.

[2] Output, consumption and investment are detrended with the growth trend in total factor productivity while labor input is demeaned since in theory it is a stationary variable.



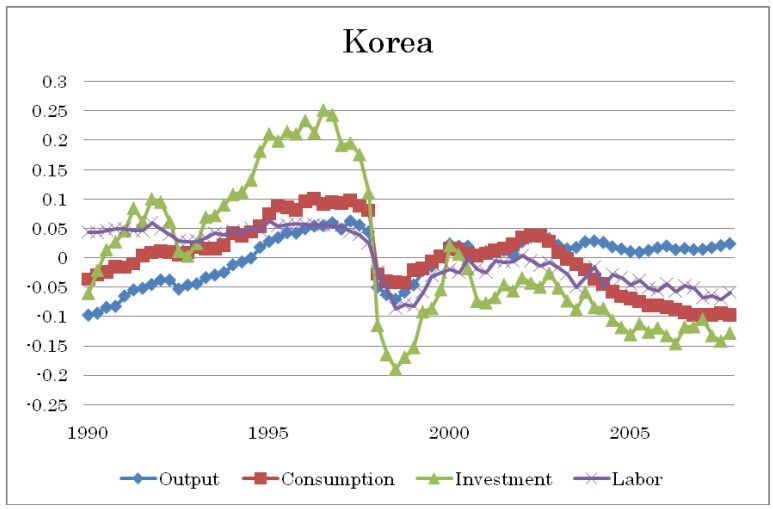


FIGURE 1
BUSINESS CYCLES

set it to 1990-2007 for Korea in order to focus on the financial crisis episode in late 1997. In Japan the rapid economic boom over the period of 1985-1990 was followed by a recession that lasted for a decade. Consumption and investment fluctuated along with output.

Labor remained relatively stationary during the boom but constantly declined during the recession. On the other hand, Korea faced an economic crisis in the end of 1997 and has recovered rapidly to its trend level by the beginning of 2000. Consumption, investment and labor all fell dramatically during the crisis and recovered as output did. In this paper we use the business cycle accounting method based on a dynamic stochastic general equilibrium model and quantify the effects of financial frictions in order to reinvestigate the sources of business cycle fluctuations during these episodes.

The model consists of a representative household, firm and government. The firm produces a final good from capital and labor using a constant-returns-to-scale production technology, which is affected by exogenous changes in TFP. The infinitely-lived representative household's utility depends on consumption and leisure. The household owns capital stock and labor endowment and decides how much to consume, invest and work. The government imposes distortionary labor income and investment taxes on the household. It spends on government purchases and rebates the remaining to the household *via* lump-sum transfer. Government purchases, labor income and investment taxes and TFP are taken as exogenous. The values of these exogenous variables are computed as wedges in equilibrium conditions. Thus, they need not be modeled as government expenditure, taxes and TFP. Therefore, we call the exogenous variables resource wedges, labor wedges, investment wedges and efficiency wedges.

The business cycle accounting method is useful to diagnose recessions. The seminal literature, Chari, Kehoe, and McGrattan (2007), focuses on the U.S. economy and analyzes the Great Depression and the 1982 recession. They find that efficiency and labor wedges were important in both cases. Kersting (2008) studies the U.K. economy and shows that labor wedges are important in accounting for both the recession in early 1980s and subsequent recovery. Kobayashi and Inaba (2006) apply a deterministic version of the method to Japan during the Great Depression and in the 1990s and show that efficiency and labor wedges are important in accounting for the episodes. Otsu (2008b) confirms that their result holds in a stochastic setting. Otsu (2007) applies the method to a small open economy model and shows that efficiency wedges are important in accounting for the sudden recessions in East Asia during the late 1990s. These studies show that distortions in the investment market are not important in accounting for output fluctuations of these episodes.

We apply the business cycle accounting method to the Japanese and Korean economies and find that investment wedges are not the main factor in accounting for output fluctuations in both economies. This is surprising since investment wedges capture the distortions in capital markets where the financial sector is believed to have played a role in the boom and bust in both countries. Nonetheless, the result does not immediately imply that financial factors had nothing to do with the recessions. Christiano and Davis (2006) point out that the business cycle accounting method fails to correctly capture the effects of financial frictions on business cycles. That is, although the estimated investment market distortions cannot explain much of the U.S. output drop during the Great Depression, innovations to this distortion can cause fluctuation in distortions in other markets. They claim that financial frictions should be considered as orthogonalized innovations to investment market distortions and that in order to evaluate their impacts on the economy the spill-over effects from them onto other distortions must be considered.[3] We use a simple orthogonality condition to identify financial frictions and compute the impact of them on output fluctuation. Our results show that the impacts of financial frictions on output through labor and efficiency wedges may have been significant during the recent business cycle in Japan and Korea.

The remaining sections are organized as follows. In Section 2, we describe the model. In Section 3, we discuss the quantitative method of business cycle accounting. In Section 4 we present the quantitative results. In Section 5, we identify financial frictions and compute their quantitative impact on output fluctuation. Section 6 concludes the paper.

II. The Model

A. Household's Problem

The lifetime utility for the representative household depends on consumption C_t and labor L_t:

$$\max U = E_0 \sum_{t=0}^{\infty} \beta^t u(C_t,\ L_t) \tag{1}$$

[3] Lee and Pyo (2007) identifies technical efficiency separately from technological progress where technical efficiency can be affected by the financial market conditions. They are implicitly eliciting the spill-over effect of financial frictions onto efficiency wedges whereas we also consider the spill-over to labor wedges.

where β $(0<\beta<1)$ is the subjective discount rate. Consumption in our model corresponds to household expenditure on nondurables, service and flow services imputed from the stock of durable goods. Labor is computed as

$$L_t = h_t * E_t$$

where h_t is the index of average weekly hours worked per worker and E_t is the number of workers employed. The index h_t is computed as the average weekly hours worked per worker divided by 14*7 hours[4] and is a number between zero and one. For the periodical preference function, $u(\cdot)$, we assume Cobb-Douglas preferences

$$u(C_t,\ L_t) = \psi \log\ C_t + (1-\psi)\log(\bar{L}_t - L_t)$$

which are commonly used in the macroeconomic literature.[5] The maximum amount of labor L_t is equal to the population size since the maximum value of the index of average hours worked is one and the maximum number of workers employed is equal to the population.

The representative agent maximizes the lifetime utility (1) subject to the budget constraint

$$(1-\tau_t^l)W_tL_t + r_tK_t + T_t = C_t + (1+\tau_t^x)X_t + \Phi\left(\frac{X_t}{K_t}\right)K_t$$

and the capital law of motion

$$K_{t+1} = X_t + (1-\delta)K_t \tag{2}$$

where K_t is the capital stock, X_t is investment, W_t is the real wage, r_t

[4] We assume that the maximum hours the household can allocate to work is 14 hours per day. The remaining 10 hours include time allocated to sleeping, eating and so on which is inevitable.

[5] This is a special case of a general form

$$u = \frac{(C_t^{\psi}(\bar{L}_t - L_t)^{1-\psi})^{1-\sigma}}{1-\sigma}$$

with $\sigma = 1$. Otsu (2007) applies the business cycle accounting method to a small open economy using GHH preferences

$$u = \frac{(C_t - \chi_t L_t^{\upsilon})^{1-\sigma}}{1-\sigma}\ .$$

is the real capital rental rate, τ_t^l and τ_t^x are gross labor income and investment tax rates, T_t is the government transfer and δ is the depreciation rate of capital stock. Investment in our model includes gross fixed capital formation and household expenditures on durable goods while capital stock includes residential capital, nonresidential capital and the stock of durable goods. The function $\Phi(X_t/K_t)$ represents the capital adjustment cost, which we assume to be quadratic

$$\Phi\left(\frac{X_t}{K_t}\right)=\frac{\phi}{2}\left(\frac{X_t}{K_t}-d\right)^2$$

where $d=(1+n)(1+\gamma)-(1-\delta)$ assures that the adjustment cost is equal to zero in the steady state.

B. Firm

The firm produces a single storable good with a Cobb-Douglas production function,

$$Y_t=z_t K_t^{\theta}(\Gamma_t L_t)^{1-\theta} \tag{3}$$

where Y_t is output, z_t is TFP, θ is the income share of capital and Γ_t is the labor augmented technical progress. In our model, output corresponds to GDP plus the flow service imputed from the stock of durable goods. We assume that the labor augmenting technical progress grows at a constant rate γ such that $\Gamma_t=(1+\gamma)\Gamma_{t+1}$. The firm maximizes its profit defined by the value of production net of costs of hiring labor and renting capital stock from the household. That is,

$$\max \Pi_t=Y_t-W_t L_t-r_t K_t.$$

C. Government

The government collects distortionary taxes, spends on exogenous government purchases G_t and rebates the remaining to the household using lump-sum transfer. Thus, the government budget constraint is

$$T_t+G_t=\tau_t^l W_t L_t+\tau_t^x X_t$$

Note that the transfer can be negative in which case the government

collects lump-sum taxes from the household.

D. Detrending

The variables in the model are growing due to growth in population N_t and labor augmenting technical progress Γ_t. In this section, we describe how we detrend these variables and define a stationary equilibrium.

For simplicity, assume a constant rate of population growth

$$N_t = (1+n)\, N_{t+1} \tag{4}$$

Then we define a detrended variable as a variable divided by $N_t \Gamma_t$ and denote them in small case letters. According to the neoclassical growth theory, along the balanced growth path, all variables except for labor[6] should be growing at the same rate as $(1+n)(1+\gamma)$. Thus, detrending these variables with $N_t \Gamma_t$ induces stationarity.

The household's problem reduces to

$$\max U = E_0 \sum_{t=0}^{\infty} \beta^t [\psi \log c_t + (1-\psi) \log (1-l_t)]$$

$$\text{subject to } (1-\tau_t^l) w_t l_t + r_t k_t + \tau_t = c_t + (1+\tau_t^x) x_t + \Phi\left(\frac{x_t}{k_t}\right) k_t$$

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

The firm's problem is

$$max\, \pi_t = y_t - w_t l_t - r_t k_t$$

Where

$$y_t = z_t k_t^{\theta} l_t^{1-\theta}. \tag{5}$$

Finally, the government budget constraint is

[6] Along the balanced growth path, labor grows at the rate of population. Thus, labor per adult population l_t is a stationary variable. This does not mean that we are detrending variables with different rates. In the utility function, had we added Γ_t to the leisure term, it will have absolutely no effect on the equilibrium outcome because of the nature of log functions. All equations hold after detrending all variables.

$$\tau_t + g_t = \tau_t^l w_t l_t + \tau_t^x x_t . \tag{6}$$

Notice that real wages are detrended but the real rate of return on capital is not. Along the balanced growth path, the marginal product of labor grows because output per capita grows but labor per capita is stationary. On the other hand, the marginal product of capital is stationary since both output and capital grow at the same rate.[7] Therefore, detrending output leads to detrending real wages but not the real rate of return on capital.

E. Competitive Equilibrium

The competitive equilibrium is, $\{c_t, l_t, k_{t+1}, y_t, x_t, \tau_t, w_t, r_t, g_t, \tau_t^l, \tau_t^x, z_t\}_{t=0}^{\infty}$ such that;

a. households optimize given $\{\tau_t, w_t, r_t, \tau_t^l, \tau_t^x\}$ and k_0,
b. firm optimizes given $\{w_t, r_t, z_t\}$,
c. markets clear and the government budget constraint (6) holds,
d. the resource constraint holds:

$$y_t = c_t + x_t + g_t + \Phi\left(\frac{x_t}{k_t}\right) k_t , \tag{7}$$

e. exogenous variables follow the stochastic process

$$s_t = P_{0(4\times1)} + P_{(4\times4)} s_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0_{(4\times1)}, Q_{(4\times4)}) \tag{8}$$

where $s_t = (\log g_t, \tau_t^l, \tau_t^x, \log z_t)'$ and $\varepsilon_t = (\varepsilon_t^g, \varepsilon_t^l, \varepsilon_t^x, \varepsilon_t^z)'$.

The household and firm optimality leads to the capital Euler equation

$$(1+n)(1+\gamma) U_{ct}\left(1 + \tau_t^x + \Phi'\left(\frac{x_t}{k_t}\right)\right)$$

$$= \beta E_t\left[U_{ct+1}\left(\theta \frac{y_{t+1}}{k_{t+1}} + (1-\delta)\left(1 + \tau_{t+1}^x \Phi'\left(\frac{x_{t+1}}{k_{t+1}}\right)\right) - \Phi\left(\frac{x_{t+1}}{k_{t+1}}\right) + \Phi'\left(\frac{x_{t+1}}{k_{t+1}}\right)\frac{x_{t+1}}{k_{t+1}}\right)\right] \tag{9}$$

and the labor first order condition

[7] This is consistent with the Kaldor growth facts such that real wages grow as the economy grows whereas the real rate of return on capital does not.

$$\frac{1-\Psi}{\Psi}=(1-\tau_t^l)\frac{y_t}{l_t}\frac{1-l_t}{c_t}. \tag{10}$$

III. Quantitative Analysis

In order to carry out the quantitative analysis, first we obtain the values of the parameters. Next, we quantitatively solve for linear decision rules of endogenous variables. Then we back out wedges using the linear decision rules. Finally, we compute the reactions of endogenous variables to changes in each type of wedges.

A. Parameters

In this section we describe how we obtain the parameter values. The parameter values for both Japan and Korea are listed in table 1. Since we use quarterly data for our analysis, the parameter value also reflect quarterly level (*e.g.*, growth rates and discount rates).

The income share of capital θ is computed directly from data using the definition

$$\theta=\frac{\text{capital income}+\text{flow income from consumer durables}}{GNP+\text{flow income from consumer durables}}.$$

We use the capital income share of GDP from Young (1995) and Hayashi and Prescott (2002), for Korea and Japan respectively. Flow income from consumer durables are computed from the stock value of durable goods. Population growth rate n is computed directly from (4) using data of the population of people older than fifteen years old.

The growth rate of labor augmenting technical progress is computed from the trend growth rate of Solow residuals estimated with ordinary least squares. The log of Solow residuals are defined as

$$log\,SR_t=log\,\Gamma_t^{1-\theta}+log\,z_t=log\,\Gamma_0+(1-\theta)\,t\,log\,(1+\gamma)+ln\,z_t \tag{11}$$

from (3) and is directly computable using data of output, capital and labor. Thus, we can estimate γ from a regression of Solow residuals on a linear trend t and a constant:

$$log\,SR_t=a+bt+u_t. \tag{12}$$

TABLE 1
PARAMETER VALUES

	Japan	Korea
θ	0.388	0.328
n	0.002	0.003
γ	0.0035	0.0084
δ	0.022	0.011
β	0.987	0.995
Ψ	0.228	0.251

That is, from (11) and (12) $\gamma \approx log(1+\gamma) = b/1-\theta$.

Other structural parameters are obtained using calibration. Calibration is a technique to compute parameter values from data using steady state equations. For simplicity, we assume that the steady states of investment, labor and efficiency wedges are zero. The depreciation rate δ is computed directly from (2), as the average over the data period.[8] Then from (9), the discount factor β is computed as

$$\beta = \frac{(1+n)(1+\gamma)}{\theta \frac{y}{k} + 1 - \delta}$$

where we assume that investment taxes are zero in the steady state. Also, from (10), the utility parameter Ψ is computed as

$$\frac{1-\Psi}{\Psi} = \frac{y}{l}\frac{1-l}{c}.$$

Since investment wedges are not directly observable we define it as a latent variable and estimate the whole shock process using Bayesian estimation. We use quarterly data of output, consumption, labor and

[8] We use benchmark data for capital stock and interpolate them with investment data in order to find the depreciation rate for fixed assets. The Japanese capital stock data is from Hayashi and Prescott (2002) while the capital stock data for Korea is from Pyo, Rhee, and Ha (2007). In both datasets, durable goods stock is not included so we add them by interpolating benchmark data with durable goods expenditure data.

investment in order to estimate the model with four shocks.

B. Wedges

Given all parameters values, the model can be solved quantitatively following the solution method à la Uhlig (1999) to solve for linear decision rules. Having obtained the decision rules, the values of $\{\hat{g}_t,\ \hat{\tau}_t^l,\ \hat{\tau}_t^x,\ \hat{z}_t\}$ can be computed from the linear decision rules

$$(\hat{y}_t,\ \hat{c}_t,\ \hat{l}_t,\ \hat{x}_t,\ \hat{k}_{t+1})' = DR_{5\times5}(\hat{k}_t,\ \hat{g}_t,\ \hat{\tau}_t^l,\ \hat{\tau}_t^x,\ \hat{z}_t)'$$

and data of $\{\hat{y}_t, \hat{c}_t, \hat{l}_t, \hat{x}_t\}$, where DR is a matrix containing the corresponding linear decision rule coefficients and the hat on the variables indicate deviations of variables from their steady state values. In specific, the procedure is as follows:

a. Assume $\hat{k}_0 = 0$.

b. Given $\hat{k}_0$, compute $\{\hat{g},\ \hat{\tau}^l,\ \hat{\tau}^x,\ \hat{z}\}_0$ from $\{\hat{y}, \hat{c}, \hat{l}, \hat{x}\}'_0 = DR_{4\times5}\{\hat{k}, \hat{g}, \hat{\tau}^l, \hat{\tau}^x, \hat{z}\}'_0$

c. Given $\{\hat{g},\ \hat{\tau}^l,\ \hat{\tau}^x, \hat{z}\}_0$, obtain k_1 from $k_1 = DR_{1\times5}\{\hat{k}, \hat{g},\ \hat{\tau}^l,\ \hat{\tau}^x, \hat{z}\}'_0$

d. Given $\hat{k}_1$, compute $\{\hat{g},\ \hat{\tau}^l,\ \hat{\tau}^x, \hat{z}\}_1$ from $\{\hat{y}, \hat{c}, \hat{l}, \hat{x}\}_1' = DR_{4\times5}\{\hat{k}, \hat{g}, \hat{\tau}^l, \hat{\tau}^x, \hat{z}\}'_1$ and so on.

Chari, Kehoe, and McGrattan (2007) maps alternative settings into the above-mentioned framework showing that distortionary shocks need not be modeled as taxes. Since the exogenous shocks s_t are computed as above, any alternative exogenous variable that shows up in the aggregate production function (5), the resource constraint (7), the capital Euler equation (9) and the labor first order condition (10) will serve the same purpose.[9] Therefore, we refer to them as resource, labor, investment and efficiency wedges.

The computed wedges are shown in Figure 2. Resource wedges are defined in the resource constraint as the difference between output and the sum of consumption and investment. In the data, this includes

[9] Inaba and Nutahara (2008) show that the alternative shocks must also satisfy certain stochastic properties to be mapped into wedges in the original model.

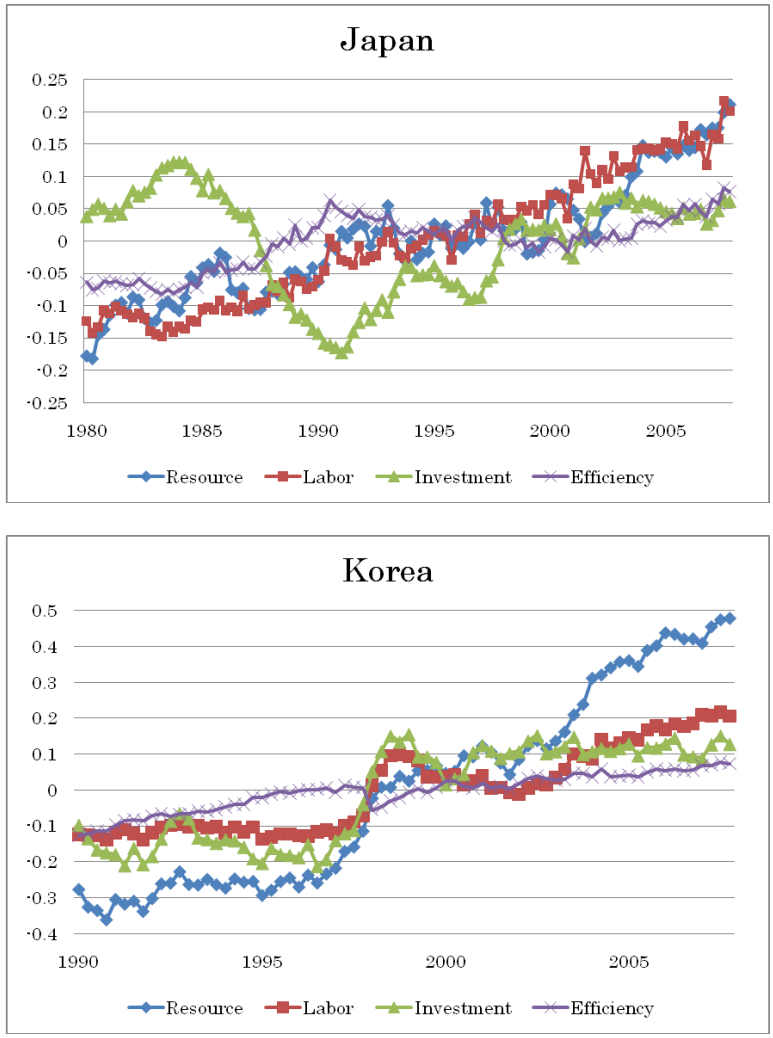
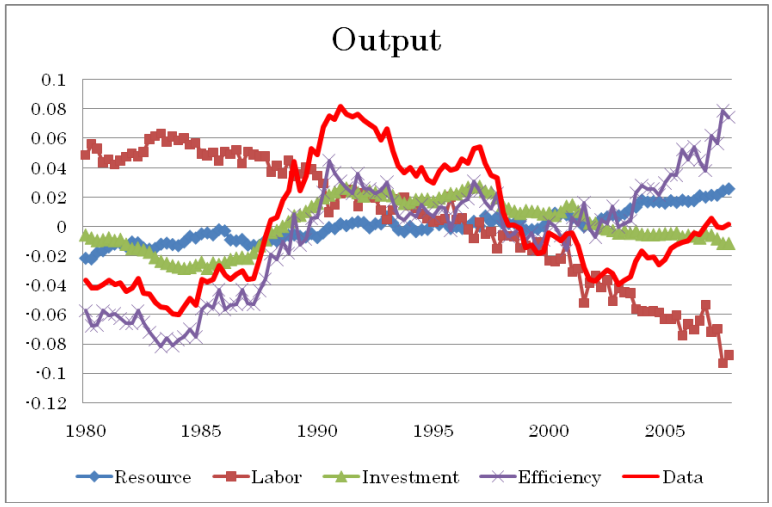
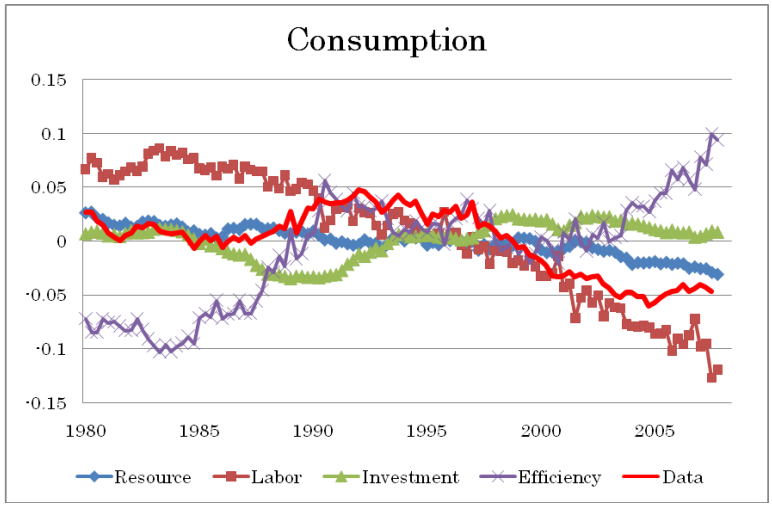


FIGURE 2
WEDGES

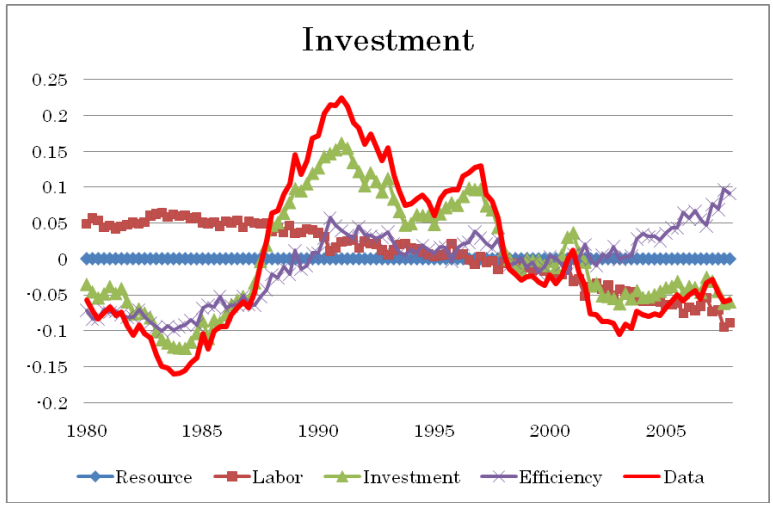
government purchases, changes in inventories and trade balance. In Japan, resource wedges has been increasing during the bubble period reflecting the trade surplus while it settled down during the recession. Recently it has started to increase again. In Korea, resource wedges increased dramatically during the crisis reflecting the sudden reversal





(Figure 3a Continued)

of trade balance. An increase in resource wedges causes a negative income effect which discourages consumption and encourages working. Labor wedges are defined in the labor first order condition as the wedge between the marginal rate of substitution of leisure for consumption and the marginal product of labor. In Japan, labor wedges have been constantly rising. In Korea, labor wedges increase dramatically during



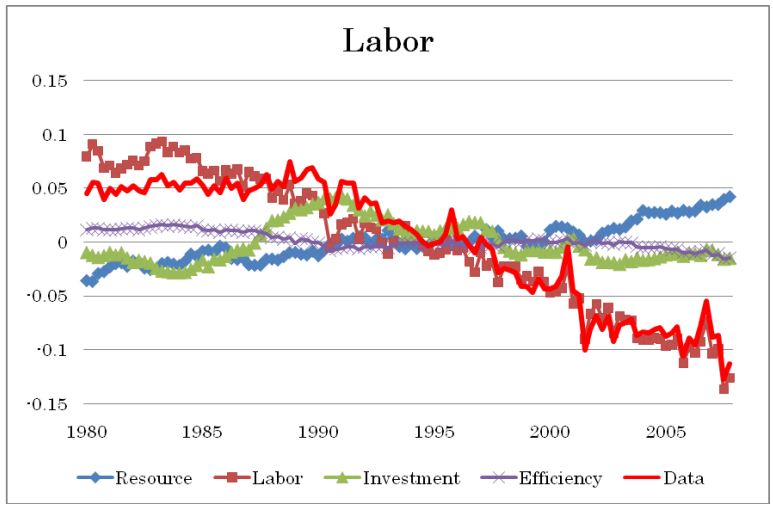
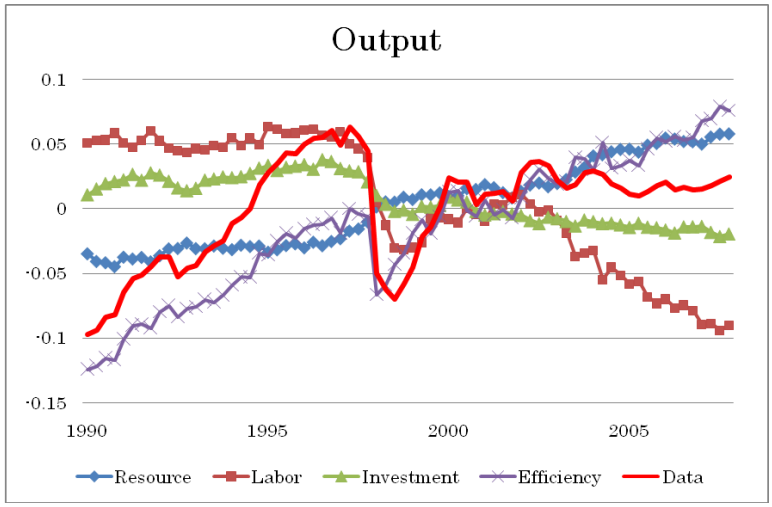
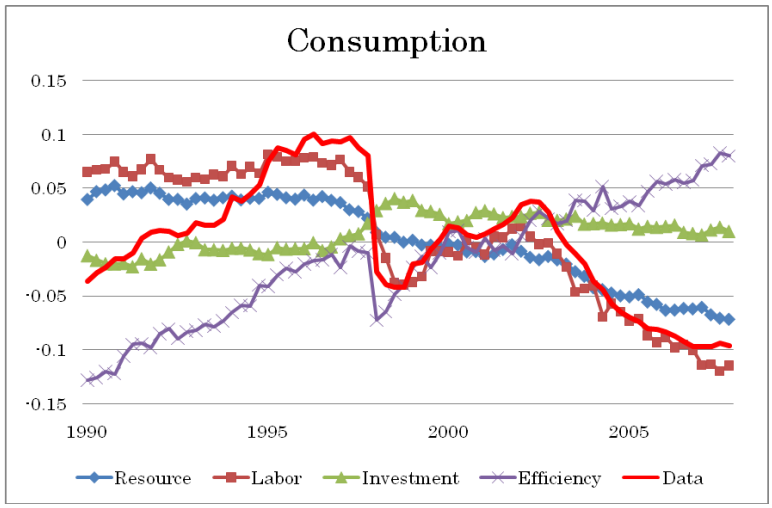


FIGURE 3a
SIMULATION RESULTS (JAPAN)

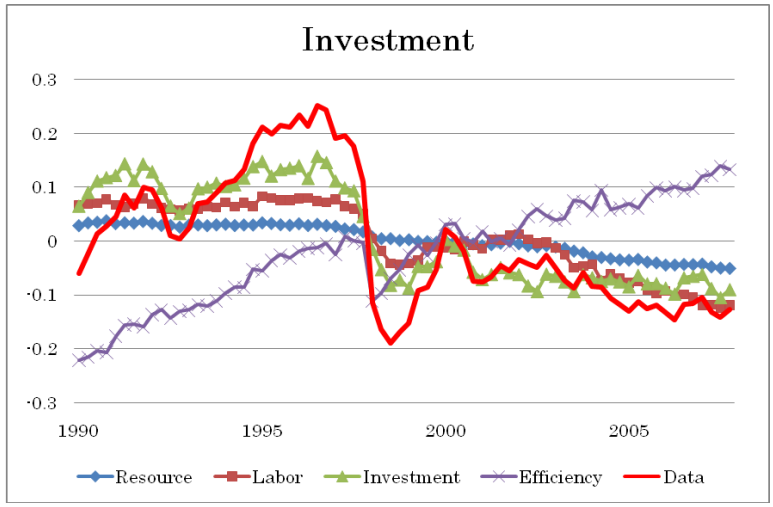
the crisis. An increase in labor wedges decreases the effective wage the household faces, which discourages working. Investment wedges are defined in the capital Euler equation as a wedge between the intertemporal marginal rate of substitution and the net return on capital. In Japan, investment wedges fall rapidly during the bubble era and increases





(Figure 3b Continued)

during the recession. In Korea, investment wedges jump up during the crisis. An increase in investment wedges increases the effective price of investment relative to consumption, which discourages investment. Efficiency wedges are defined in the production function as TFP, also known as the Solow residual. In Japan, efficiency wedges increase constantly during the bubble era and starts to fall during the recession.



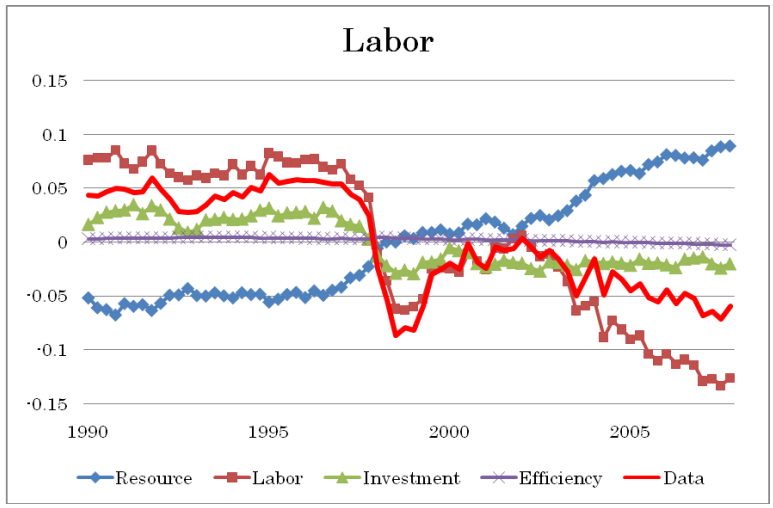


FIGURE 3b
SIMULATION RESULTS (KOREA)

In Korea, efficiency wedges fall sharply during the crisis. A fall in efficiency wedges leads to contraction in output, consumption, investment and labor through real business cycle effects.

TABLE 2
BREAK DOWN OF OUTPUT CHANGE (%)

	Data	Resource	Labor	Investment	Efficiency
Japan (1985-1990)	10.0	0.1	-2.6	4.6	8.0
Japan (1991-2000)	-8.3	0.6	-4.1	-1.5	-3.4
Korea (1997-1998)	-11.3	2.2	-6.7	-2.5	-4.4
Korea (97Q4-98Q1)	-9.4	1.2	-3.5	-1.1	-6.1

C. Results

Figure 3 shows the results of simulations feeding one shock into the model at a time. That is, for example, the line referred to as resource plots the simulation result of the model with $s_t=(\hat{g}_t, 0, 0, 0)'$. Results for each variable for each simulation are reported for both countries.

In Japan, the decline in output during the lost decade is mostly accounted for by labor and efficiency wedges. Although investment wedges also accounts for part of the output drop, the amount is small. Resource wedges cannot account for the output drop at all. In the second row of Table 2, we break down the effects of each wedge on the annual detrended output drop from the 1991 level to the 2000 level. This shows that labor and efficiency wedges together can account for a 7.5% decline in output, where detrended output actually fell 8.3% in data. This result is consistent with the finding of Kobayashi and Inaba (2006) and Otsu (2008b) that labor wedges are important in accounting for the lost decade. For consumption, although labor and efficiency wedges seem to be accounting for the decline during the recession, it is not clear which wedge is important in other periods. For investment, investment and efficiency wedges are important in accounting for both the increase during the bubble period and the decline during the recession. Labor wedges are important in accounting for the constant decline in labor.

In Korea, the sudden drop in output is mainly accounted for by labor and efficiency wedges.[10] Investment wedges also have depressing

[10] The result that labor wedges are important in accounting for the recession is contrary to the finding of Otsu (2007) that labor wedges do not have depressing effects. The reason is because Otsu (2007) assumes a preference function with no income effect on labor, which is common in the small open economy literature. With Cobb-Douglas preferences, labor wedges do have depressing effects.

effects but not as much as labor and efficiency wedges. The rise in resource wedges during the crisis captures the reversal of trade balance, which increases output through negative income effects on labor. This is consistent with the finding of Chari, Kehoe, and McGrattan (2005) which shows that sudden stops of capital inflows cause income effects that leads to a boom rather than a recession. In the third row of Table 2, we break down the effects of each wedge on the annual detrended output drop from the 1997 level to the 1998 level. This shows that labor and efficiency wedges account for a decline in annual output by 6.7% and 4.4%, respectively, where detrended output actually fell by 11.3%. The forth row of Table 2 focuses on the final quarter of 1997 and the first quarter of 1998. Labor and efficiency wedges account for declines by 3.5% and 6.1%, respectively, where output actually fell by 9.4%. Thus, efficiency wedges account for the immediate drop in output. For consumption, both efficiency and labor wedges are important. For investment, labor, investment and efficiency wedges are important. Finally, labor wedges alone can account for most of the fluctuation in labor.

Overall, the results show that labor and efficiency wedges are the major sources of both recessions. On the other hand, investment wedges, which represent distortions in the investment market, do not account for much of the output drops in both recessions. This is surprising since both recessions were accompanied by financial crises. However, this result does not mean that financial factors are not important. In the following section, we will argue that this does not necessarily contradict to a common perception that financial frictions are sources of the recessions in Japan and Korea.

IV. Estimates of Financial Frictions

Several studies show that financial frictions can be mapped into investment wedges. Chari, Kehoe, and McGrattan (2007) show that financial frictions caused by monitoring cost a la Bernanke, Gertler, and Gilchrist (1999) can be mapped into investment wedges. Inaba and Nutahara (2008) show that a similar mapping can be made from a Carlstrom and Fuerst (1997) type of financial friction model with agency cost into a prototype model with investment wedges. The result that investment wedges are not important in accounting for the recessions seems to reject financial frictions as their major sources. However, as Christiano and Davis (2006) point out, the fact that

TABLE 3a
CORRELATION OF ERRORS (JAPAN)

	Resource	Labor	Investment	Efficiency
Resource	1	0.45	-0.06	0.38
Labor		1	-0.07	0.82
Investment			1	-0.25
Efficiency				1

TABLE 3b
CORRELATION OF ERRORS (KOREA)

	Resource	Labor	Investment	Efficiency
Resource	1	0.53	0.52	-0.02
Labor		1	0.44	0.17
Investment			1	-0.17
Efficiency				1

investment wedges cannot account for recessions does not necessarily mean that financial frictions are not important.

Table 3 shows the correlations between the innovations in the shocks process. In both countries, investment wedge errors are negatively correlated to efficiency wedge errors. In Korea, investment wedge errors are positively correlated to labor wedge errors. Therefore, there is a chance that although investment wedges are not important in accounting for the recessions, innovations to investment wedges may be important in accounting for the decline in efficiency wedges in both countries and the increase in labor wedges in Korea. Following Christiano and Davis (2006), we assume fundamental economic shocks $e_t=\{e_t^g, e_t^l, e_t^x, e_t^z\}$ such that,

$$\varepsilon_t = Ce_t \text{ where } Ee_t e'_t = I \text{ and } CC' = Q.$$

In other words, the matrix

$$C=\begin{pmatrix} c_{11} & \cdots & c_{14} \\ \vdots & \ddots & \vdots \\ c_{41} & \cdots & c_{44} \end{pmatrix}$$

orthogonalizes errors in the shock process into fundamental economic shocks. Once orthogonalized, the shocks e_t can be interpreted as fundamental economic shocks called resource shocks, labor frictions, financial frictions and technology shocks. Then, the correlation between error terms of investment wedges and efficiency/labor wedges can be decomposed as follows:

$$corr(\varepsilon_t^x, \varepsilon_t^z) = \frac{cov(\varepsilon_t^x, \varepsilon_t^z)}{std(\varepsilon_t^x)\,std(\varepsilon_t^z)} = \frac{c_{31}c_{41} + c_{32}c_{42} + c_{33}c_{43} + c_{34}c_{44}}{std(\varepsilon_t^x)\,std(\varepsilon_t^z)}$$

$$corr(\varepsilon_t^x, \varepsilon_t^l) = \frac{cov(\varepsilon_t^x, \varepsilon_t^l)}{std(\varepsilon_t^x)\,std(\varepsilon_t^l)} = \frac{c_{31}c_{21} + c_{32}c_{22} + c_{33}c_{23} + c_{34}c_{24}}{std(\varepsilon_t^x)\,std(\varepsilon_t^l)}$$

Negative correlations between investment wedge errors and efficiency wedge errors can be caused by any of the four terms in the denominator. If c_{43} is largely negative, there is a spill-over effect from financial frictions on efficiency wedges shocks and vice versa. In a similar fashion, positive correlations between investment wedge errors and labor wedge errors can come any of the four terms in the denominator. Unfortunately, as there are infinite potential matrices C that results in Q, there is no definitive way to identify the matrix C. For simplicity, we assume $c_{31}, c_{32}, c_{34} = 0$ to identify e_t^x such that $corr(\varepsilon_t^x, \varepsilon_t^z)$, $corr(\varepsilon_t^x, \varepsilon_t^l)$ match the business cycle accounting results. Since this result depends on our identification strategy, it tends to overestimate the effect of financial frictions. Thus we consider this result as an upper-bound of the effect of financial frictions.

Figure 4 presents the implied fluctuations in wedges feeding only the identified e_t^x into the shock process (8). In Japan, financial frictions have large effects on efficiency wedges during the bubble period more than during the recession. Efficiency wedges increase by 8.8% during the 1985-1990 period and decrease by 4.6% during the 1991-2000 period where the model predicts a 5.6% increase (63% relative to data) and a 1.6% decrease (34% relative to data), respectively. Since labor wedge errors and investment wedge errors have a slightly negative correlation, financial frictions cannot account for the recession through their effects on labor wedges. In Korea, financial frictions can account for a significant portion of fluctuations in labor and efficiency wedges. Efficiency wedges decrease by 4.4% and labor wedges increase by 16.1% during the 1997-1998 period where the model predicts a 0.9% decrease in efficiency wedges (20% of data) and a 5.3% increase in

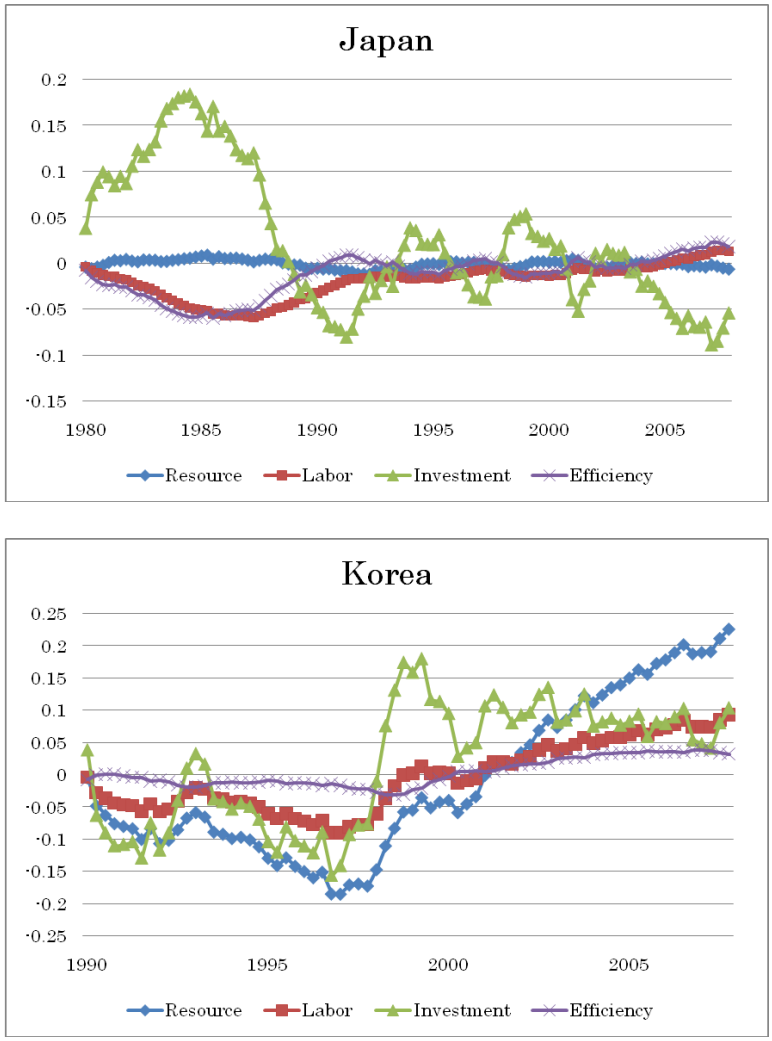


FIGURE 4
EFFECTS OF FINANCIAL FRICTIONS (WEDGES)

labor wedges (33% relative to data), respectively. The statistics are summarized in Table 4.

Figure 5 presents the simulation results feeding the wedges computed in Figure 4 into the model. Financial frictions can account for a large portion of output fluctuations in both countries. In Japan, financial

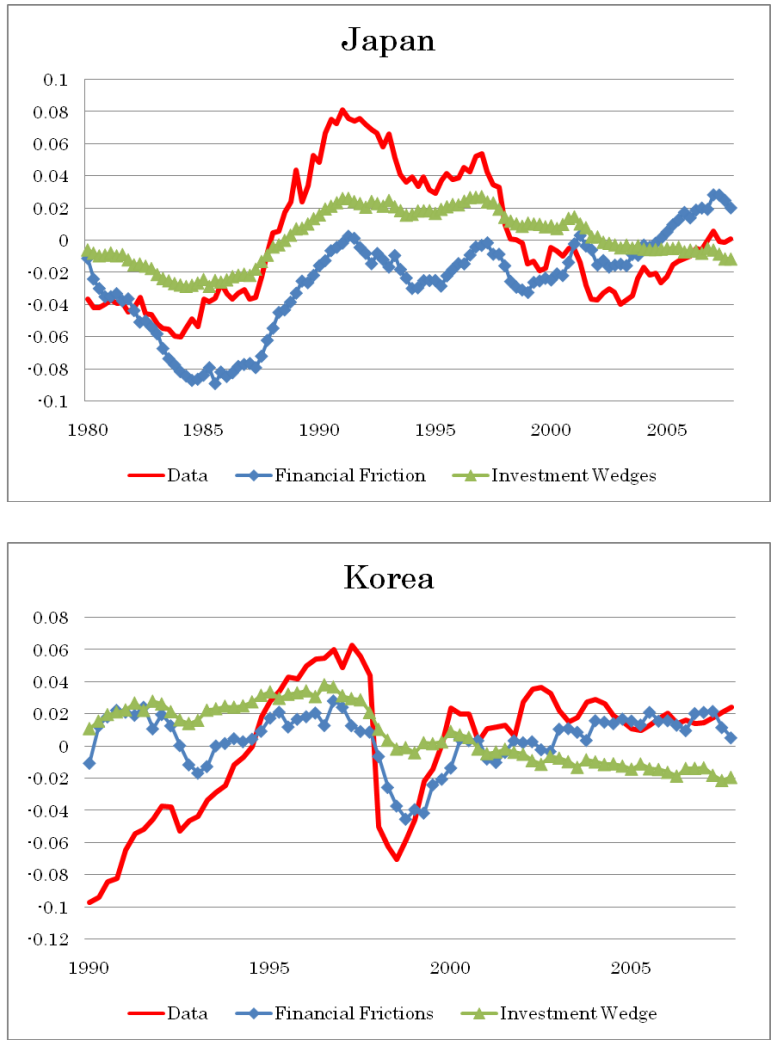


FIGURE 5
EFFECTS OF FINANCIAL FRICTIONS (OUTPUT)

frictions alone can account for a 6.8% increase in output during the 1985-1990 period (67% relative to data) and a 1.8% drop of output during the 1991-2000 (21% relative to data) period. During the 1985-1990 period, the difference between the model with financial frictions and the model with investment wedges (a 4.6% increase in output) are

TABLE 4
CHANGES IN WEDGES (%)

	z		τ^l	
	Data	Model	Data	Model
Japan (1985-1990)	8.8	5.6	7.4	2.5
Japan (1991-2000)	-4.7	-1.6	8.8	0.6
Korea (1997-1998)	-4.4	-0.9	16.1	5.3
Korea (97Q4-98Q1)	-6.2	-0.4	8.4	2.4

TABLE 5
CHANGES IN OUTPUT (%)

	Data	Model (e_t^x)	Model (ε_t^x)
Japan (1985-1990)	10.0	6.8	4.6
Japan (1991-2000)	-8.3	-1.8	-1.5
Korea (1997-1998)	-11.3	-4.2	-2.5
Korea (97Q4-98Q1)	-9.4	-1.5	-1.1

quite large. However, during the 1991-2000 period the difference is less prominent (1.5% in the former and 1.8% in the latter). Therefore the reduction in financial frictions in Japan during the bubble period, which can be attributed to drastic financial deregulation, seems to have been important in accounting for the output growth. However, during the recession in the 1990s, the effect of labor wedges which cannot be accounted for by financial frictions seems to be strong. This is consistent with the finding of Hayashi and Prescott (2002) that the reduction in legal working hours in the 1990s is important in accounting for the lost decade in Japan. This policy shock will appear as a shock to labor wedges which can be considered orthogonal to investment wedges. In Korea, financial frictions alone can account for a 4.2% drop in output during the 1997-1998 period (38% relative to data). Since the model with investment wedges alone can account for only a 2.5% decrease, the spill-over effect is large. The statistics are summarized in Table 5.

Overall, our results show that although investment wedges seem to be less important in accounting for the recent business cycle patterns of Japan and Korea than labor and efficiency wedges, financial frictions, which are the orthogonalized shocks in the investment market, have

significant impacts on the fluctuation of output due to the spill-over effects.

V. Conclusion

In this paper, using the business cycle accounting method, we find that investment wedges are not important in accounting for the recent business cycle fluctuation in Japan and Korea. We show that although investment wedges are not important, financial frictions may have had a significant impact on output fluctuation through their spill-over effects on efficiency and labor wedges. The magnitude of this spill-over effect cannot be directly estimated with the current data used for business cycle accounting. In order to identify financial frictions and their spill-over effect, we either need a detailed model or additional data.

An example of a model that has detailed assumptions on the spill-over effect is a financial crisis model with finance searching as in Otsu and Saito (2008). Under this setting, firms face exogenous financial frictions which affect the availability of funds. Firms can allocate labor into finance searching, which will reduce the cost of lending funds for investment. The shift of labor from production to financial search will appear as a decline in efficiency wedges. Therefore, financial frictions cause recessions through affecting efficiency wedges, which is consistent with our business cycle accounting result. Also, a model assuming working capital on labor, a la Christiano and Eichenbaum (1992), can explain the link between financial frictions and labor market distortions. When the firm must borrow in the financial market in order to pay for wage bills, an increase in borrowing cost due to financial frictions will create labor market distortions by affecting the effective wage.

However, there is no guarantee that these identifications are correct. In order to choose the right model for identification, additional information that show the significance of these channels is needed. For instance, for the first model, data on labor allocated to financial search is needed. For the second model, data on the fraction of the wage bills that must be paid in advance is needed. To the best of our knowledge, these types of data do not exist. Further study should be done on the identification in order to deepen our understanding of the importance of financial frictions on business cycles.

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