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Accounting for the economic relationship between Japan and the Asian Tigers[☆]

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ABSTRACT

This paper applies the business cycle accounting method of Chari, Kehoe and McGrattan (2007) to a two-country, two-good model based on Backus, Kehoe and Kydland (1994) to investigate the economic relationship between Japan and the Asian Tigers from 1980Q1 to 2008Q2. We find that the main driver of long-run shifts and short-run fluctuations in output in each economy is domestic production efficiency. Furthermore, the recent increase in the cross-country business cycle correlation between the two can be attributed to an increase in the cross-country correlation of production efficiencies.

1. Introduction

Asia's economic landscape has significantly changed since the 1980s. The deepening economic linkages among Asian countries, which refer to the rapid increase in trade and financial linkages among them, have been widely documented. Because of such growing economic ties, these Asian nations, so-called the Asian Tigers, have become the major economic counterparts of the only advanced country in the region, Japan. This development has stimulated scholarly debate about the changes in the cyclical properties of the Asian economy and the changes in economic impact of the Asian Tigers on Japan.

Theoretical predictions about the role of emerging trade and financial integration in business cycle comovements have been ambiguous, which raises an essential empirical question (e.g., Kose et al., 2012). Empirical studies on the degree of cross-country output synchronization of Asian countries have produced mixed findings.[1] The diverse conclusions appear to stem from differences in econometric methods, country coverage, sample periods, and macroeconomic aggregates.

Our primary focus of this paper is the time-varying effects of Asian Tigers as a unified economic region of Asia, i.e., Korea, Taiwan and Hong Kong, on the Japanese economy.[2] At the same time, thanks to the two-country model employed in this paper, we can examine the opposite effects, i.e., the time-varying effects of Japan on the Asian region. Unlike the previous empirical studies, we apply the business cycle accounting method of Chari et al., (2007) to a two-country, two-good dynamic stochastic general equilibrium (DSGE) model of Backus et al., (1994). We find that domestic efficiency wedges in each economy are the main drivers of both long-term shifts and short-term fluctuations of output, which are consistent with the current literature on international business cycles.

Business cycle accounting views distortions in markets as wedges in equilibrium conditions derived from a general equilibrium model, and computes the wedges using time series data

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[1] The survey of empirical literature on business cycle comovements in Asia appears in Section 3.

[2] Throughout this paper we refer to the Asian Tigers as Korea+Taiwan+Hong Kong and treat them as one country. We omit Singapore, the fourth "Tiger", from our analysis, since crucial data are unavailable, such as Singapore's quarterly total hours worked. Additionally, Singapore's economy is quite small compared to Korea and Taiwan so it does not significantly affect the Asian Tiger's aggregate behavior.

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Table 1
Basic Statistics of Japan and The Asian Tigers in 2008Q2.

	Japan	Tigers
Population (Thousands)	110,473	64,188
Population Growth Rate (1980-2008)	0.75%	1.74%
Output per Capita (1990 PPP $)	6673	6921
Output per Capita Growth Rate (1980-2008)	1.76%	4.41%
Consumption Share of Output	0.501	0.465
Investment Share of Output	0.301	0.285
Government Share of Output	0.162	0.075
Labor Input	0.228	0.261

Table 2
Direction of Trade in 2007.

Japan Exports to			Imports from		
1	U.S.	20.1%	1	China	20.6%
2	China	15.3%	2	U.S.	11.4%
3	*Korea*	*7.6%*	3	Saudi Arabia	5.7%
4	*Taiwan*	*6.3%*	*6*	*Korea*	*4.4%*
5	*Hong Kong*	*5.4%*	*8*	*Taiwan*	*3.2%*
			-	*Hong Kong*	*0.2%*
Asian Tigers					
Exports to			Imports from		
1	China	35.0%	1	China	28.8%
2	U.S.	14.1%	*2*	*Japan*	*15.3%*
3	*Japan*	*6.5%*	3	U.S.	9.0%
4	Singapore	3.2%	4	Singapore	4.0%
5	Germany	3.0%	5	Saudi Arabia	3.5%

of the economy of interest. Then it simulates the model using the computed wedges to investigate their economic impact. This method has been used to analyze output fluctuations in Japan and the Asian Tigers separately by employing the closed-economy or the small open-economy models in the literature.[3] However, our study is the first to extend this method to open-economy business cycle models of two economies that trade intermediate goods and contingent claims with each other. By employing the business cycle accounting method, we compute the time-series paths of economic disturbances for Japan and the Asian Tigers and investigate their impact on the long-term shifts and the short-term business cycle patterns for these economies as well as their correlation. We then link the model prediction to actual historical events that occurred in the two economies.

Our sample period is from 1980Q1 to 2008Q2, which encompasses a strong, deep, and continually growing mutual economic interdependence between Japan and the Asian Tigers. This period corresponds to the emergence of regional cycles within Asia. Hirata et al., (2013) claim the importance of identifying its sources. This period further includes the important economic events such as the 1997-1998 Asian crisis, the Japanese financial crisis in the late 1990s, and the global IT bubble burst in the early 2000s.

The advantage of our approach is three-fold. First, the 28-year data period allows us to investigate the long-term catch-up period of the Asian Tigers and the medium-term cycles of the Japanese economy simultaneously. Second, by employing quarterly production and expenditure data, we can investigate higher frequency short-term fluctuations by detrending the business cycle accounting results with the Hodrick-Prescott (HP) filter. Third, by applying business cycle accounting to an open economy model, we can investigate the effects of the long-term catch-up of the Asian Tigers on the Japanese economy as well as the short-term business cycle comovement of the two economies.

The remainder of the paper is organized as follows. In section 2, we review the data for Japan and the Asian Tigers – Korea, Taiwan and Hong Kong. In section 3, we briefly survey key studies on business cycle synchronization among Asian countries. In section 4, we describe the two-country, two-good business cycle accounting model. In section 5, we describe our quantitative method and present our results. Section 6 concludes the paper.

2. Facts

Table 1 presents basic economic statistics for Japan and the Asian Tigers for 2008Q2.[4] In terms of population, the three Asian Tigers' population combined is roughly two-thirds that of Japan. Nonetheless, the PPP adjusted per capita real output in 2008Q2 is roughly the same.[5] However, the annual per capita output growth rate from 1980Q1 to 2008Q2 for the Tigers is much higher (4.41%) than that of Japan (1.76%).

Table 2 shows the strong international trade linkages of Japan and the Asian Tigers in 2007. For Japan, Korea, Taiwan and Hong Kong are the third, fourth and fifth largest export destinations following China and the U.S. The exports from Japan to the Asian Tigers sum up to 19.3% of Japanese total exports which, is only slightly less than that to China. The Japan's imports from the Tigers comprise 7.8% of its total imports, not a considerable amount, but the Tigers are Japan's third largest source of imports, following China and the U.S. As for the Tigers, 15.3% of its total imports comes from Japan, which is second only to China. Finally, Japan is the third largest export destination for the Tigers following China and the U.S.

Fig. 1(a) presents the log of per capita output of Japan and the Asian Tigers detrended by 0.44% quarterly linear trend, which is the average growth rate of Japanese per capita output. We consider this the universal growth rate along a balanced growth path for the two. For convenience, we normalize both countries by setting the values of each variable at the terminal period to zero. Japan grew faster than the trend during the late 1980s, known as the "bubble economy" period, and its growth slowed considerably during the 1990s, known as the "lost decade". Overall, the Asian Tigers grew much faster than the trend throughout the entire period, and experienced a gradual slowdown in recent years. As we will see later, this long run convergence is driven by both capital accumulation and productivity growth.

The business cycle correlations between Japan and the Asian Tigers appear to have increased over the sample period. Fig. 1(b) presents the HP-filtered fluctuations of output in each country. A structural-break test indicates a break in the business cycle correlation in 1996Q1. The correlation for 1980Q1 to 1995Q4 is -0.23 while that for 1996Q1 to 2008Q2 is 0.73. This fact indicates that business cycle dynamics of the two have been changing and exploring the sources of fluctuations is important. Another interesting fact is that the cross-country consumption correlation from 1996Q1 to 2008Q2 is 0.19. The fact that the cross-country correlation of output is greater than that of consumption represents the well-known "quantity anomaly" in international macroeconomics (Backus et al., 1992), suggesting that some force prevents international consumption risk sharing.

[3] Kobayashi and Inaba (2006) apply the method to Japan and find that disturbances in production efficiency and the labor market are primarily attributable to the "lost decade." Otsu and Pyo (2009) conduct BCA on Japan and Korea separately. Otsu (2010a) applies BCA to a small open-economy model for the Asian crisis and shows that production efficiency and labor market disturbances are drivers of Korea's 1998 output drop.

[4] Labor Input is defined as employment × average weekly hours worked per worker normalized by adult population and maximum hours available per week, which is set at 14 × 7. See Appendix A for details on the data.

[5] We compare per capita output levels using the PPP adjusted GDP data from the Maddison Project data set from the Groningen Growth and Development Centre.

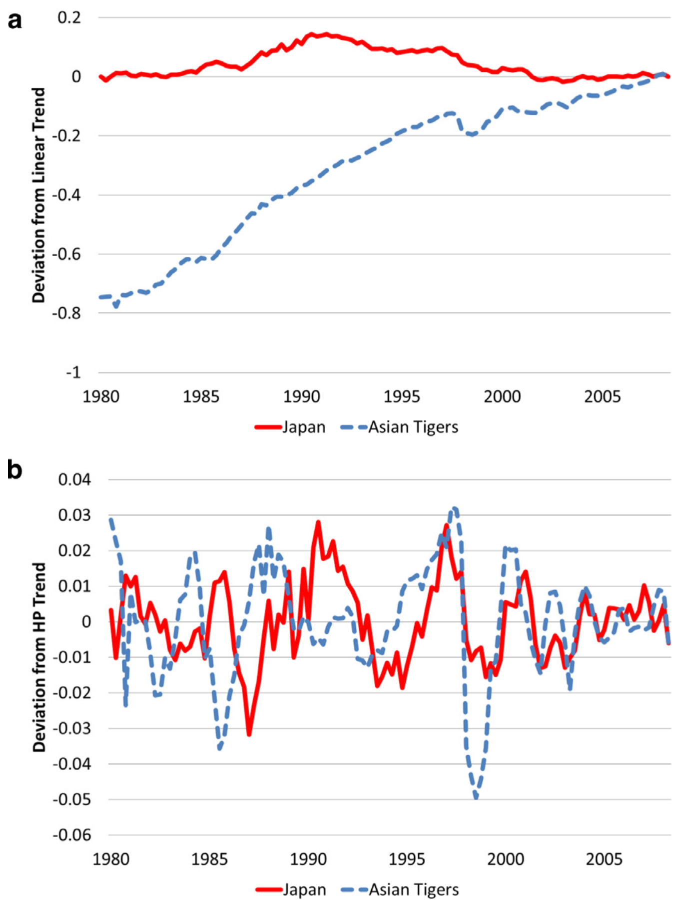

Fig. 1. (a). Linearly Detrended Output. (b). HP Filtered Output.

3. Brief literature review

3.1. Economic interdependence

To understand the dynamics of the economic relationship between Japan and the Asian Tigers, one cannot bypass the fact that such economic linkages have become stronger through the rising volume of trade and financial flows that have reached unprecedented levels since the 1980s (Hirata et al., 2013).[6] Increasing economic interdependence through international trade and finance can lead to changes in the business cycle synchronization between Japan and the Asian Tigers. Some studies focusing on the influence of international trade on business cycle synchronization have found that stronger trade linkages have more positive impacts on synchronization (Shin and Wang, 2004; Weber, 2009); however, some studies have reported the opposite (Abeysinghe and Forbes, 2005).[7] The role of financial integration in the Asian region has garnered much scholarly attention in light of regional integration, but its impact on an empirical level appears to be mixed so far (Kim et al., 2006; Dai, 2014).

The literature provides valuable suggestions for constructing a viable business cycle model for Asian countries. First, as the economic impact of Japan in the Asian region has been a vital and persistent concern over the last three decades, placing Japan as one of the two countries in the model is reasonable. Second, given the strong economic linkages between Japan and the Asian Tigers since the 1980s, a two-country model is preferred over a closed-economy or small open-economy model when examining the business cycle dynamics of this region (see Hirata, 2014).

3.2. Business cycle accounting

As Chari et al., (2007) noted, business cycle accounting is intended to map detailed model economies associated with various frictions and primitive shocks into a simple, perfectly competitive prototype economy associated with various time-varying wedges. Frictions can arise for a variety of reasons, including taxes, transportation costs, and sticky prices and wages. Among four wedges, such as efficiency, labor, investment, and government consumption wedges, Chari et al., (2007) found the quantitative importance of efficiency and labor wedges in explaining the U.S. business cycles.

Previous studies employing business cycle accounting have been applied for closed-economy and small open-economy environments and generally support the findings of Chari et al., (2007) — the essential role of efficiency wedges and labor wedges. Business cycle accounting has been applied to business cycle studies not only in advanced economies (López and García, 2016; Kersting, 2008), but also in developing economies (Lama, 2011; Otsu, 2010a). Moreover, some studies have extended the model to study the causes of financial crises (Cho and Doblas-Madrid, 2013), fiscal multiplier (Gunji and Miyazaki, 2016), and monetary economy (Sustek, 2011; Brinca, 2013).

There are two main reasons why business cycle accounting is suitable for our research objective. First, this method is designed to have time-varying frictions as wedges, i.e., all possible distortions that can affect the first order conditions. The underlying wedges in Japan and the Asian Tigers have likely been time-varying given the fact that both economies have experienced a variety of short-term and long-term changes since the 1980s. Second, to the best of our knowledge, this paper is the first to extend the business cycle accounting method to a large open-economy environment trading multiple goods.[8] In particular, business cycle accounting is suitable for analyzing two economies that share both synchronous movements of macroeconomic aggregates and mutual but asymmetric influences. This paper can answer whether or not the quantitative importance of efficiency wedges and labor wedges is upheld even in explaining international business cycles, in particular business cycle comovements. This paper can, furthermore, answer whether or not international wedges that are not shown in closed-economy business cycle models have quantitatively significant impacts on business cycle comovements.

3.3. The role of China

As suggested in Section 2, China is undoubtedly an important trade partner of Japan and the Asian Tigers in this region, indicating that the profound spillover from China to Asia (and the rest of the world) are not negligible.

The latest studies have supported this view. For example, Fujiwara et al., (2011) showed that China's post-1978 rapid productivity growth significantly benefitted the rest of the world through its terms of trade effect. This may generate uneven effects in Japan and the Asian Tigers depending on the complementarity of goods across these economies. Duval et al., (2014) showed that China's

[6] Employing a dynamic factor model to decompose the business-cycle fluctuations into global, regional, and country-specific factors, Hirata et al., (2013) found that the output's variance shares attributed to Asian regional factors for Japan and the Tigers account for 40-50% from 1985 to 2010 and less than 10% from 1960 and 1984.

[7] Rafiq (2013) demonstrated the importance of using a time-varying model to explore the trade balance dynamics of Asian countries.

[8] Otsu (2010b) applied the business cycle accounting method to the two-country, one-good model of Baxter and Crucini (1995) to examine the Japan-U.S. business cycle correlation.

output synchronization with the rest of Asia has increased, although Asian countries still continue to move to a stronger degree with Japan. Dai (2014) also reported on the growing impact of China on the rest of the Asian countries through international trade.

Despite the growing importance of spillovers from China, we leave it to future research to investigate the effect of adding China to the model. The most important reason for this is the unavailability of a dataset. We use quarterly GDP and its component data between 1980Q1 and 2008Q2, but quarterly GDP data is available only from 2003Q1. Moreover, several data adjustments used to conduct the theory-based empirical analysis explained later also cannot be done due to the unavailability of data (e.g., disaggregated consumption and imputed service flow from durable goods). Note that the annual dataset that previous studies have mostly relied on is not suitable for our analysis since our primary focus is to investigate the effects of the long-term catch-up of the Asian Tigers on the Japanese economy as well as the short-term business cycle comovements between them.

4. Model

The model is based on the Backus et al., (1994) two-country, two-good model. Each economy, Japan and the Asian Tigers, produces specialized intermediate goods. They combine both intermediate goods using aggregation technology and produce a common final good. The households in each country can trade real international state-contingent claims each other.[9] The government imposes distortionary taxes on labor and capital income and intermediate-goods trade.

4.1. Intermediate-goods firms

Intermediate-goods firms combine labor, l_t, and capital, k_t, and produce intermediate goods. We assume that Japan, *JP*, produces good *a*, and the Asian Tigers, *AS*, produce good *b*, so that

$$\begin{aligned} \varpi f_t^{JP}(s^t) &= \varpi a_t^{JP}(s^t) + (1-\varpi) a_t^{AS}(s^t) \\ (1-\varpi) f_t^{AS}(s^t) &= \varpi b_t^{JP}(s^t) + (1-\varpi) b_t^{AS}(s^t) \end{aligned} \tag{1}$$

where ϖ is the population weight of Japan, f_t^i is the per capita production in country *i*, j^i is the intermediate good *j* used in country *i*, and s^t represents the state of the economy.

The detrended profit maximization problem in each country $i = JP, AS$ is

$$\max\ \pi_t^i(s^t) = p_{j,t}^i(s^t) f_t^i(s^t) - w_t^i(s^t) l_t^i(s^t) - r_t^i(s^t) k_t^i(s^t) \tag{2}$$

subject to

$$f_t^i(s^t) = z_t^i(s^t)(k_t^i(s^t))^{\theta^i}(l_t^i(s^t))^{1-\theta^i}. \tag{3}$$

$p_{j,t}^i$ is the price of the intermediate good *j* relative to the price of final goods in the country that *j* is produced, where $j = a$ if $i = JP$ and $j = b$ if $i = AS$. w_t^i and r_t^i are the real wage and return on capital relative to final goods prices in each country. z_t^i represents the productivity of the intermediate-goods firm, which we call *efficiency wedges* following Chari et al., (2007).

4.2. Final-goods firms

Final-goods firms in each country combine intermediate goods both from domestic and foreign markets and produce final goods using an aggregation technology, *h*(*a*, *b*). The detrended profit maximization problems of the final-goods firm in each economy are

$$\begin{aligned} \max\ \hat{\pi}_t^{JP}(s^t) &= h_t^{JP}(s^t) - p_{a,t}^{JP}(s^t) a_t^{JP}(s^t) - p_{b,t}^{JP}(s^t) b_t^{JP}(s^t) \\ \max\ \hat{\pi}_t^{AS}(s^t) &= h_t^{AS}(s^t) - p_{a,t}^{AS}(s^t) a_t^{AS}(s^t) - p_{b,t}^{AS}(s^t) b_t^{AS}(s^t) \end{aligned} \tag{4}$$

subject to

$$h_t^{JP}(a_t^{JP}(s^t), b_t^{JP}(s^t)) = \left(\eta (a_t^{JP}(s^t))^{\frac{\varepsilon-1}{\varepsilon}} + (1-\eta)(b_t^{JP}(s^t))^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}$$
$$h_t^{AS}(a_t^{AS}(s^t), b_t^{AS}(s^t)) = \left((1-\eta)(a_t^{AS}(s^t))^{\frac{\varepsilon-1}{\varepsilon}} + \eta(b_t^{AS}(s^t))^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where parameter η represents home bias and ε is the elasticity of substitution between the intermediate-goods.

4.3. Household

Households in each economy maximizes the life time expected utility obtained from consumption, c_t, and leisure, $1 - l_t$, based on the preference function,

$$\max\ U = \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \varphi(s^t) \left[\Psi^i \ln\ c_t^i(s^t) + (1-\Psi^i) \ln\ (1 - l_t^i(s^t))\right],$$

where $\varphi(s^t)$ is the probability that state s^t occurs, β is the subjective discount factor, and Ψ is the preference weight on consumption.

The household receives labor income, capital income, and return on the state-contingent international claim, d_t^i, and the lump-sum transfer from the government, tr_t^i. The household consumes, invests, and purchases the state-contingent international claim for the next period. We assume that each country imposes distortionary taxes on labor income, $\tau_{l,t}^i$, capital income, $\tau_{k,t}^i$, and international claims transactions, $\tau_{d,t}^i$. Therefore, the budget constraint that each household faces at each period is

$$\begin{aligned} &\left(1 - \tau_{l,t}^i(s^t)\right) w_t^i(s^t) l_t^i(s^t) + \left(1 - \tau_{kt}^i(s^t)\right) r_t^i(s^t) k_t^i(s^{t-1}) \\ &\quad + \pi_t^i(s^t) + \hat{\pi}_t^i(s^t) + tr_t^i(s^t) \\ &= c_t^i(s^t) + x_t^i(s^t) \\ &\quad + \left(1 + \tau_{d,t}^i(s^t)\right) \left(\sum_{s^{t+1}|s^t} Q_t(s^{t+1}|s^t) \frac{d_{t+1}^i(s^{t+1}|s^t)}{P_t^i(s^t)} - \frac{d_t^i(s^t)}{P_t^i(s^t)}\right), \end{aligned} \tag{5}$$

where P_t^i is the final good price in each country. The price of the state-contingent claim for each possible state Q_t is common across countries. Following Chari et al., (2007), we call $\tau_{l,t}^i$ and $\tau_{k,t}^i$ *labor and capital wedges*, respectively. In terms of the distortions on international claims transactions, what matters in equilibrium is the ratio of the distortions so we define *international finance wedges*, $\tau_{d,\,t}$, as

$$\frac{1 + \tau_{d,t}^{JP}(s^t)}{1 + \tau_{d,t}^{AS}(s^t)} = 1 + \tau_{d,t}(s^t).$$

These wedges are necessary for our analysis because without them, the model cannot account for the lack of cross-country consumption risk sharing observed in data[10].

[9] Assuming complete markets implies that the degree of international risk sharing is high, but it is not so in reality. The previous literature (Baxter and Crucini, 1995, Heathcote and Perri, 2002, and Hirata, 2014), however, shows that the extent of international borrowing and lending opportunities has a quantitatively minor impact on the predictions of international business cycle models.

[10] We can consider international financial wedges as time-varying transaction fees in the international financial market, which play a role of disturbances in the international risk sharing condition. This wedge can reflect government regulations such as taxes or capital control.

Capital stock is accumulated following the capital law of motion:

$$\Gamma^i k_{t+1}^i\left(s^t\right) = x_t^i\left(s^t\right) + \left(1-\delta^i\right)k_t^i\left(s^{t-1}\right) - \Phi\left(\frac{x_t^i\left(s^t\right)}{k_t^i\left(s^{t-1}\right)}\right)k_t^i\left(s^{t-1}\right), \tag{6}$$

where Γ^i is the growth trend of technology and population. We assume a standard quadratic capital adjustment cost function

$$\Phi\left(\frac{x_t^i\left(s^t\right)}{k_t^i\left(s^{t-1}\right)}\right) = \frac{\phi^i}{2}\left(\frac{x_t^i\left(s^t\right)}{k_t^i\left(s^{t-1}\right)} - \Omega^i\right)^2,$$

where $\Omega^i = \Gamma^i - (1-\delta^i)$ so that the adjustment cost is zero in the steady state.

4.4. International transactions

The accumulation of international claims must be balanced with the trade of intermediate goods. Therefore, the capital accounts in each country is defined as:

$$\begin{aligned}&\varpi \sum_{s_t^{t+1}|s^t}\left[Q_t\left(s^{t+1}|s^t\right)\frac{d_{t+1}^{JP}\left(s^{t+1}|s^t\right)}{P_t^{JP}\left(s^t\right)} - \frac{d_t^{JP}\left(s^t\right)}{P_t^{JP}\left(s^t\right)}\right]\\ &\quad = (1-\varpi)p_{a,t}^{JP}a_t^{AS}\left(s^t\right) - \varpi\, p_{b,t}^{JP}b_t^{JP}\left(s^t\right)\end{aligned}$$

$$\begin{aligned}&(1-\varpi)\sum_{s_t^{t+1}|s^t}\left[Q_t\left(s^{t+1}|s^t\right)\frac{d_{t+1}^{AS}\left(s^{t+1}|s^t\right)}{P_t^{AS}\left(s^t\right)} - \frac{d_t^{AS}\left(s^t\right)}{P_t^{AS}\left(s^t\right)}\right]\\ &\quad = \omega p_{b,t}^{AS}b_t^{JP}\left(s^t\right) - (1-\varpi)p_{a,t}^{AS}a_t^{AS}\left(s^t\right).\end{aligned}$$

These guarantee that the sum of capital accounts across countries is zero.

The trade balance in each country is defined as

$$\begin{aligned}&\varpi\, tb_t^{JP}\left(s^t\right) = (1-\varpi)p_{a,t}^{JP}a_t^{AS}\left(s^t\right) - \varpi\, p_{b,t}^{JP}b_t^{JP}\left(s^t\right) + \varpi\,\rho_t^{JP}\left(s^t\right)\\ &(1-\varpi)tb_t^{AS}\left(s^t\right)\\ &\quad = \varpi\, p_{b,t}^{AS}b_t^{JP}\left(s^t\right) - (1-\varpi)p_{a,t}^{AS}a_t^{AS}\left(s^t\right) + (1-\varpi)\rho_t^{AS}\left(s^t\right),\end{aligned} \tag{7}$$

where ρ_t^i represents exogenous surpluses in the trade balance, which we call *international resource wedges*. These wedges are crucial to match the trade balance to data in the business cycle accounting procedure. Unfortunately we cannot separately observe ρ^{JP} and ρ^{AS} for the entire period due to data unavailability. For simplicity, we assume $\rho_t^{JP}(s^t) = \rho_t^{AS}(s^t) = \rho_t(s^t)$.[11]

The terms of trade tot_t is defined as the price of Japanese intermediate goods relative to that of the Asian Tigers' intermediate goods:

$$tot_t = \frac{p_{a,t}^{JP}}{p_{b,t}^{JP}} = \frac{p_{a,t}^{AS}}{p_{b,t}^{AS}}. \tag{8}$$

The price of Japanese final goods relative to Asian Tigers' final goods, P_t, is defined as

$$P_t = \frac{P_t^{JP}}{P_t^{AS}} = \frac{p_{a,t}^{AS}}{p_{a,t}^{JP}} = \frac{p_{b,t}^{AS}}{p_{b,t}^{JP}}. \tag{9}$$

Finally, the following international resource constraint can be derived from (7) and (9):

$$\varpi\, tb_t^{JP}\left(s^t\right) + (1-\varpi)\frac{tb_t^{AS}\left(s^t\right)}{P_t\left(s^t\right)} = \left(\varpi + \frac{1-\varpi}{P_t\left(s^t\right)}\right)\rho_t\left(s^t\right). \tag{10}$$

[11] The natural interpretation of the international resource wedges is an exogenous demand shock from the rest of the world including the U.S., EU and China.

4.5. Domestic absorption and national accounts

The government collects labor and capital income taxes as well as tariffs in order to finance exogenous government expenditures, g_t^i, and rebates the remaining through a lump-sum transfer, tr_t^i. Therefore the government budget constraint is

$$\begin{aligned}&\tau_{l,t}^{JP}\left(s^t\right)w_t^{JP}\left(s^t\right)l_t^{JP}\left(s^t\right) + \tau_{k,t}^{JP}\left(s^t\right)r_t^{JP}\left(s^t\right)k_t^{JP}\left(s^{t-1}\right)\\ &\quad + \tau_{m,t}^{JP}\left(s^t\right)p_{b,t}^{JP}\left(s^t\right)b_t^{JP}\left(s^t\right)\\ &= tr_t^{JP}\left(s^t\right) + g_t^{JP}\left(s^t\right),\\ &\quad \tau_{l,t}^{AS}\left(s^t\right)w_t^{AS}\left(s^t\right)l_t^{AS}\left(s^t\right) + \tau_{k,t}^{AS}\left(s^t\right)r_t^{AS}\left(s^t\right)k_t^{AS}\left(s^{t-1}\right)\\ &\quad + \tau_{m,t}^{AS}\left(s^t\right)p_{a,t}^{AS}\left(s^t\right)a_t^{AS}\left(s^t\right)\\ &= tr_t^{AS}\left(s^t\right) + g_t^{AS}\left(s^t\right).\end{aligned} \tag{11}$$

Combining the household budget constraint (5), intermediate-goods firm profit (2), final-goods firm profit (4), government budget constraint (11) and the intermediate-good resource constraint (1), we can derive the domestic resource constraint:

$$h_t^i\left(a_t^i\left(s^t\right), b_t^i\left(s^t\right)\right) = c_t^i\left(s^t\right) + x_t^i\left(s^t\right) + g_t^i\left(s^t\right). \tag{12}$$

Furthermore, we define the income-expenditure identity in this model as

$$y_t^i\left(s^t\right) = c_t^i\left(s^t\right) + x_t^i\left(s^t\right) + g_t^i\left(s^t\right) + tb_t^i\left(s^t\right), \tag{13}$$

where income components are the before-tax labor and capital income, tariffs on imported intermediate goods, which correspond to indirect business taxes, and trade wedges, which represent income from exogenous surpluses in the trade balance.

4.6. Wedges

In this model, we have 10 exogenous variables: the government wedges, g^i, labor wedges, τ_l^i, capital wedges, τ_k^i, efficiency wedges, z^i, international finance wedges, τ_d, and international resource wedges, ρ. For convenience, we define

$$s_t = \left\{g_t^{JP}, g_t^{AS}, \tau_{l,t}^{JP}, \tau_{l,t}^{AS}, \tau_{k,t}^{JP}, \tau_{k,t}^{AS}, z_t^{JP}, z_t^{AS}, \tau_{d,t}, \rho_t\right\}$$

and $\widetilde{s_t} = \ln\, s_t - \ln\, \bar{s}$ where the upper bar corresponds to the steady state level.

We assume that the wedges follow the stochastic process

$$\widetilde{s_t} = \Lambda\widetilde{s_{t-1}} + \varepsilon_t, \varepsilon \sim N(0, V). \tag{14}$$

where

$$\varepsilon_t = \left\{\varepsilon_{g,t}^{JP}, \varepsilon_{g,t}^{AS}, \varepsilon_{l,t}^{JP}, \varepsilon_{l,t}^{AS}, \varepsilon_{k,t}^{JP}, \varepsilon_{k,t}^{AS}, \varepsilon_{z,t}^{JP}, \varepsilon_{z,t}^{AS}, \varepsilon_{d,t}, \varepsilon_{\rho,t}\right\}.$$

The wedges are defined by the income-expenditure identity (13), the labor first order condition

$$\frac{\Psi}{1-\Psi}\frac{c_t^i\left(s^t\right)}{1-l_t^i\left(s^t\right)} = \left(1-\tau_{l,t}^i\left(s^t\right)\right)p_{j,t}^i\left(s^t\right)(1-\theta)\frac{f_t^i\left(s^t\right)}{l_t^i\left(s^t\right)},$$

the capital Euler equation

$$\begin{aligned}&\left(1+\Phi_t'^i\left(s^t\right)\right)\frac{\Gamma}{c_t^i\left(s^t\right)}\\ &\quad = \beta E_t\left[\frac{1}{c_{t+1}^i\left(s^{t+1}\right)}\left(\begin{array}{l}\left(1-\tau_{k,t+1}^i\left(s^{t+1}\right)\right)p_{j,t+1}^i\left(s^{t+1}\right)\theta\frac{f_{t+1}^i\left(s^{t+1}\right)}{k_{t+1}^i\left(s^{t+1}\right)}\\ +\left(1+\Phi_{t+1}'^i\left(s^{t+1}\right)\right)\times\\ \left(1-\delta+\Phi_{t+1}'^i\left(s^{t+1}\right)\frac{x_{t+1}^i\left(s^{t+1}\right)}{k_{t+1}^i\left(s^{t+1}\right)} - \Phi_{t+1}^i\left(s^{t+1}\right)\right)\end{array}\right)\right],\end{aligned}$$

the intermediate goods production function (3), the international first order condition

$$P_t\left(s^t\right) = \frac{\Psi^{JP}}{\Psi^{AS}}\frac{c_t^{AS}\left(s^t\right)}{c_t^{JP}\left(s^t\right)}\left(1+\tau_{d,t}\left(s^t\right)\right),$$

and the international resource constraint (10).

Table 3
Parameters.

	Description	Japan	Tigers
θ	Capital Share	0.385	0.389
δ	Depreciation	0.022	0.012
Γ	Growth Trend	1.006	1.015
β	Discount Factor	0.992	0.997
Ψ	Preference Weight	0.232	0.272
ϕ	Adjustment Cost	34.45	37.06
ε	Goods Elasticity	1.5	1.5
η	Home Bias	0.906	0.902
ϖ	Population Weight	0.663	0.337

4.7. Equilibrium

The competitive equilibrium is a set of quantities $\{k^i, y^i, c^i, x^i, l^i, tb^i, a^i, b^i, f^i, h^i, tr^i\}$, prices $\{w^i, r^i, q^i, p^i_a, p^i_b, tot, P\}$ and wedges $\{g^i, \tau^i_l, \tau^i_k, z^i, \tau_d, \rho\}$ such that, (i) the households in both countries respectively optimize by taking $\{w^i, r^i, P^i, tr^i, \tau^i_l, \tau^i_k, Q\}$ as given; (ii) the final-goods and intermediate-goods firms in both countries respectively optimize by taking $\{w^i, r^i, p^i_a, p^i_b, z^i\}$ as given, (iii) the government budget constraints (11) hold, (iv) the income-expenditure identities (13) hold, (v) the intermediate goods resource constraints (1) hold, (vi) the international resource constraint (10) holds, and (vii) the wedges follow the stochastic process (14). A full set of the equilibrium conditions is in available upon request.

5. Quantitative analysis

5.1. Parameter values

To conduct a quantitative analysis, we need to obtain the model's parameter values of the model. We obtain the parameters that determine the steady state of the detrended model by calibration and we obtain the parameters that characterize the stochastic process of the wedges by structural estimation.

Table 3 lists the calibrated parameter values. We calibrate these parameters to match the Japanese data assuming that the parameters of Asian Tigers are symmetric to those of Japan.[12] The income share of capital θ is defined as the average of

$$\theta_t = \frac{(capital\ income)_t + (imputed\ service\ from\ durables)_t}{GDP_t + (imputed\ service\ from\ durables)_t},$$

over the entire period; the definition of capital income and the imputed service from durables follows Cooley and Prescott (1995). The depreciation rate δ is calculated as the average of

$$\delta_t = \frac{X_t}{K_t} + 1 - \frac{K_{t+1}}{K_t},$$

over the entire sample period where X_t and K_t are non-detrended real investment and capital stock, respectively. All other parameters are calibrated to match the data average over the 1980Q1-2008Q2 period. The subjective discount factor β is calibrated to match the capital output ratio using the steady state capital Euler equation

$$\beta = \frac{\Gamma}{(1-\tau_k)\theta\left(1-\frac{tb}{y}\right)\frac{y}{k} + 1 - \delta},$$

[12] We have conducted a sensitivity analysis using country specific parameters and find that the business cycle accounting results are not sensitive to this assumption. However, we prefer common parameters as they guarantee symmetric steady states and balanced growth.

Table 4
Estimated parameters.

$$\Lambda = \begin{bmatrix} 0.86 & -0.01 & 0.03 & -0.04 & -0.01 & 0.01 & -0.05 & 0.06 & 0.02 & -0.01 \\ 0.06 & 0.80 & 0.04 & 0.11 & 0.02 & 0.01 & -0.04 & 0.03 & -0.02 & 0.01 \\ 0.00 & 0.04 & 0.86 & -0.01 & -0.01 & 0.00 & -0.07 & 0.02 & -0.03 & 0.01 \\ 0.01 & 0.02 & -0.05 & 0.72 & 0.07 & -0.02 & -0.06 & 0.01 & 0.02 & 0.04 \\ 0.00 & -0.07 & 0.03 & 0.06 & 0.90 & 0.00 & -0.06 & -0.02 & 0.02 & 0.00 \\ -0.03 & -0.09 & 0.01 & 0.01 & -0.01 & 0.85 & 0.02 & -0.02 & 0.03 & 0.02 \\ -0.09 & 0.02 & -0.10 & 0.02 & -0.04 & -0.01 & 0.76 & 0.02 & 0.02 & 0.00 \\ -0.07 & 0.05 & 0.02 & 0.02 & -0.02 & 0.01 & 0.06 & 0.90 & -0.08 & 0.01 \\ -0.02 & 0.04 & -0.08 & 0.06 & 0.11 & 0.02 & 0.05 & -0.05 & 0.80 & 0.02 \\ 0.02 & 0.03 & -0.01 & 0.13 & -0.03 & 0.01 & -0.09 & -0.09 & 0.17 & 0.96 \end{bmatrix}$$

$$V = 1e-3 \times \begin{bmatrix} 0.07 & 0.00 & 0.03 & -0.01 & 0.00 & -0.01 & -0.05 & 0.00 & 0.04 & 0.00 \\ 0.00 & 0.15 & 0.05 & 0.00 & 0.00 & 0.00 & -0.05 & 0.01 & 0.00 & -0.11 \\ 0.03 & 0.05 & 1.45 & 0.00 & 0.05 & 0.15 & -0.31 & -0.02 & -0.19 & 0.13 \\ -0.01 & 0.00 & 0.00 & 0.09 & -0.01 & 0.02 & 0.07 & 0.02 & -0.04 & 0.04 \\ 0.00 & 0.00 & 0.05 & -0.01 & 0.29 & -0.06 & -0.10 & -0.01 & 0.01 & 0.10 \\ -0.01 & 0.00 & 0.15 & 0.02 & -0.06 & 0.85 & 0.27 & -0.03 & -0.07 & 0.05 \\ -0.05 & -0.05 & -0.31 & 0.07 & -0.10 & 0.27 & 24.92 & -0.01 & 0.00 & -0.99 \\ 0.00 & 0.01 & -0.02 & 0.02 & -0.01 & -0.03 & -0.01 & 0.27 & 0.06 & -0.15 \\ 0.04 & 0.00 & -0.19 & -0.04 & 0.01 & -0.07 & 0.00 & 0.06 & 1.57 & 0.41 \\ 0.00 & -0.11 & 0.13 & 0.04 & 0.10 & 0.05 & -0.99 & -0.15 & 0.41 & 10.16 \end{bmatrix}$$

where we assume that the steady state capital wedge τ_k is equal to zero.[13] The preference parameter Ψ is calibrated to match the consumption share of output and the total hours worked per available hours using the steady state labor first order condition

$$\frac{1-\Psi}{\Psi} = (1-\tau_l)(1-\theta)\frac{y}{c}\frac{1-l}{l},$$

where we assume that the steady state labor wedge τ_l is set at zero. The elasticity of substitution ε is set at 1.5 following Backus et al., (1994).[14] The adjustment cost parameter is set so that the marginal Tobin's q is equal to one in the steady state following Christiano and Davis (2006):

$$\frac{\partial q}{\partial x}x = \phi\frac{x}{k} = 1.$$

The home bias parameter η is calibrated to match the ratio of bilateral exports to output (see Appendix B). The weight of country size ϖ is calculated directly from the population share of Japan.

The estimated parameters characterizing the stochastic process of wedges are listed in Table 4. Since the wedges in this model are not directly observable in the data, we estimate the stochastic process by the Bayesian maximum likelihood estimation using Dynare. Specifically, we estimate the lag matrix Λ and the error term variance and covariance matrix V in (14). The data we use for the estimation is the linearly detrended output, consumption, investment, government expenditures and non-detrended total hours worked.[15]

5.2. Computing the wedges

The wedges in our model is computed in the following steps.

[13] The term $(1-\frac{tb}{y})y$ is equivalent to $p^i_j f^i$ because $y^i_t = h^i_t + tb^i_t = p^i_{j,t} f^i_t + \rho_t$, and by assumption $tb = \rho$ in the steady state. We have conducted a sensitivity analysis assuming $\tau_k = 0.2$ and find that the business cycle accounting results are not sensitive to this assumption.

[14] Unfortunately, we do not have empirical evidence for this parameter. Therefore, we conduct a sensitivity analysis shown in Appendix D.

[15] The initial guess for Λ is a diagonal matrix with 0.8 as the diagonal terms and zero otherwise and the prior distributions are assumed to be normal with 0.2 standard deviaiton. The initial guess for the diagonal terms of V is an inverted gamma distribution with 0.1 standard deviation. The off-diagonal terms are obtained by estimating the correlation coefficients among the error terms assuming a normal prior distribution with zero mean and 0.3 standard distribution. We use the posterior mode obtained from the Monte-Carlo based optimization routine in Dynare as the estimates for Λ and V.

1. Solve the model for linear decision rules

$$\left\{\widetilde{y_t^i}, \widetilde{c_t^i}, \widetilde{l_t^i}, \widetilde{x_t^i}\right\} = DR\left(\widetilde{k_t^i}, \widetilde{g_t^i}, \tau_{l,t}^i, \tau_{k,t}^i, z_t^i, \tau_{d,t}, \widetilde{\rho_t}\right). \tag{15}$$

2. Compute $\widetilde{k_{t+1}^i}$ from a linearized version of the capital law of motion (6):

$$\Gamma \overline{k^i}\widetilde{k_{t+1}^i} = \overline{x^i}\widetilde{x_t^i} + (1-\delta)\overline{k^i}\widetilde{k_t^i}$$

given the data of $\widetilde{x_t^i}$ and the initial capital $\widetilde{k_1^i}$. For initial capital, we use the log deviation of capital stock in 1980Q1 from that in 2008Q2, which gives −0.19 for Japan and −1.29 for the Asian Tigers.

3. Compute $\{\widetilde{g_t^i}, \tau_{l,t}^i, \tau_{k,t}^i, z_t^i, \tau_{d,t}, \widetilde{\rho_t}\}$ from (15) given the computed $\widetilde{k_t^i}$ and the data of $\{\widetilde{y_t^i}, \widetilde{c_t^i}, \widetilde{l_t^i}, \widetilde{x_t^i}, \widetilde{g_t^i}\}$.

Fig. 2(a) shows the computed wedges for Japan. The government wedges grow slightly faster than the annual 1.76% growth trend as the government expenditure to output ratio increases over time. Labor wedges rise throughout the period. Gunji and Miyazaki (2011) show that the social security burden on workers has steadily increased due to the growing population aging. Braun et al. (2009) show that shrinking family size generates an income effect that discourages the head of the household to work.[16] Both of these effects manifest as labor wedges. Capital wedges fell dramatically during the 1980s, which suggests that the capital markets were favorable to invest during the late-1980s "bubble economy". After remaining somewhat stable during the "lost decade" of the 1990s, capital wedges fluctuated during and after the IT bubble in the early 2000s and then gradually declined through the mid-2000s. Efficiency wedges declined during the early 1980s, grew during the "bubble economy," and declined in the "lost decade" and beyond.

Fig. 2(b) shows the wedges for the Asian Tigers. Government wedges increase much faster than the trend. However, since output grows even faster, the government expenditure to output ratio rather declines. Labor wedges also grow throughout the entire sample period with a sudden jump up during the Asian crisis in the late 1990s. Capital wedges for the Tigers fluctuate erratically until the 2000s. They significantly decline from the late 1980s to the mid-1990s corresponding to the Asian Tiger's capital-market deregulation period (Kawai, 1999). The efficiency wedges rapidly grow until the Asian financial crisis and then flatten out afterwards.

Fig. 2(c) presents international wedges. Overall, the international finance wedges gradually decline and then return to the steady state level. This could be the result of a reduction in the restrictions on Japan's foreign exchange transactions, i.e., a reduction in foreign exchange transaction costs, in 1980, which soon occurred in Taiwan and Korea.[17] There are some notable disturbances to this otherwise smooth trend. One is the bump in 1986 corresponding to the Plaza agreement that led to the yen's appreciation; the other is the bump during the Asian financial crisis corresponding to the sudden depreciation of the Korean won in the late 1990s. The international resource wedges grow rapidly during the early 1980s

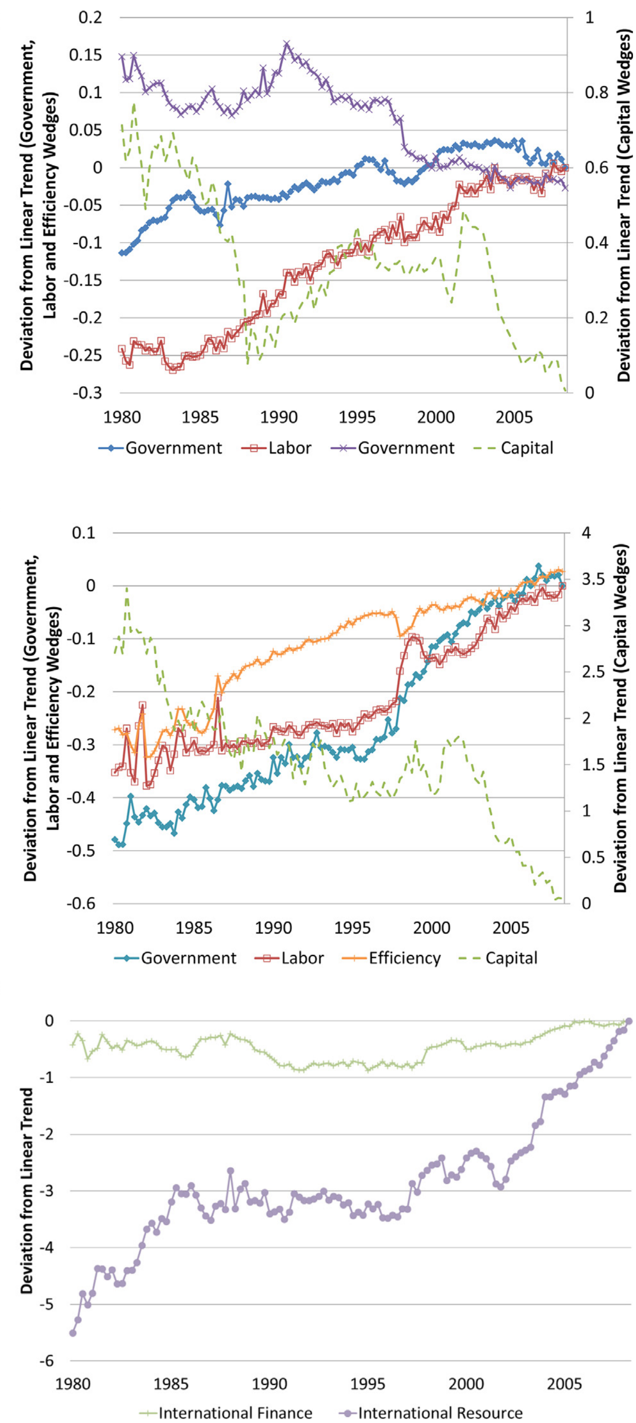

Fig. 2. (a). Japanese Wedges. (b). Asian Wedges. (c). International Wedges.

as shown in Fig. 2(c), reflecting the increase in exports from Japan and the Asian Tigers between each other and to the rest of the world. Reasons for this growth is the decline of the oil price during the early 1980s following the oil shocks in the 1970s and the emergence of the U.S. twin deficits problem. The further rise in the international resource wedges after 1995 reflects the so-called global imbalance where the U.S. accumulated trade deficits to the rest of the world. These shocks are common to both Japan and the Asian Tigers.

Next, we assess the short-run properties of the computed wedges. Table 5 presents the HP-filtered contemporaneous correlation between each wedge and output in each economy. For both

[16] In Braun et al. (2009), the head of the household bases his/her labor-leisure choice on the consumption of the whole family. When the family size shrinks, the head of the household has to support less family members, which increases the preference weight for leisure over consumption in the household preference function. The shift in the preference weight is observationally equivalent to changes in labor wedges.

[17] Japan introduced the New Foreign Exchange Law in 1980 to liberalize foreign exchange transaction. Taiwan deregulated foreign exchange controls on capital movements in 1987. Korea revised the Foreign Exchange Management Act in 1991 to encourage capital inflow. Hong Kong, on the other hand, had very little restrictions to foreign exchange throughout our sample period. See Bekaert and Harvey (2000).

Table 5
Correlation of Wedges with Output: HP-filtered.

Wedges	Output	
	Japan	*Tigers*
Government (JP)	−0.06	0.37
Labor (JP)	0.30	0.04
Investment (JP)	−0.32	−0.19
Efficiency (JP)	0.80	0.12
Government (AS)	0.00	−0.31
Labor (AS)	−0.16	−0.39
Investment (AS)	−0.01	−0.55
Efficiency (AS)	−0.12	0.68
Intl. Finance	−0.52	0.04
Intl. Resource	0.20	−0.13

Table 6
Cross-Country Correlation of Domestic Wedges: HP-filtered.

Wedges	80Q1-95Q4	96Q1-08Q2	80Q1-08Q2
Government	−0.15	−0.07	−0.12
Labor	−0.01	−0.40	−0.18
Investment	−0.02	0.38	0.14
Efficiency	−0.37	0.54	−0.11
Output	−0.24	0.68	0.18

Japan and the Asian Tigers, domestic efficiency wedges are most highly correlated with output. In addition, the domestic capital wedges have a strong negative correlation with output.[18] Table 6 presents the cross-country correlation of domestic wedges. The cross-country correlation of efficiency wedges increase dramatically after 1996. Therefore, they are very likely responsible for the recent increase in cross-country output correlation. To better understanding the impacts of each wedge, we now simulate the model.

5.3. Business cycle accounting

In this section, we present the business cycle accounting results. Each computed wedge is fed into the model one by one. The reactions of output in each economy are in comparison with the data. First, we discuss the main results, which correspond to the linearly detrended data shown in Fig. 1a. Next, we analyze the high frequency features of our results using HP-filtered results, which correspond to those in Fig. 1b.

5.3.1. Linearly detrended data

Fig. 3(a) presents the endogenous fluctuations of output in Japan in response to each wedge. In the "bubble economy" of the late 1980s, Japan's output grew faster than the trend. Our results show that Japanese efficiency wedges were the main contributors to this unusual growth spurt. The rise in intermediate-goods production efficiency reduces the production cost of the final-goods firm, which leads to a rise in total factor productivity. In Japan's "lost decade" of the 1990s, output fell approximately 15% relative to trend. The main drivers of the decline in output during this period are deterioration in efficiency and labor wedges. This result is consistent with the finding of Kobayashi and Inaba (2006). An important result of our study is that the rapid growth of Asian efficiency wedges after 1985 contributed to output growth in Japan.[19] In addition, the drop in Asian efficiency wedges during the Asian crisis led to a 0.2% drop in Japanese output over the 1997Q3-1998Q1 period.

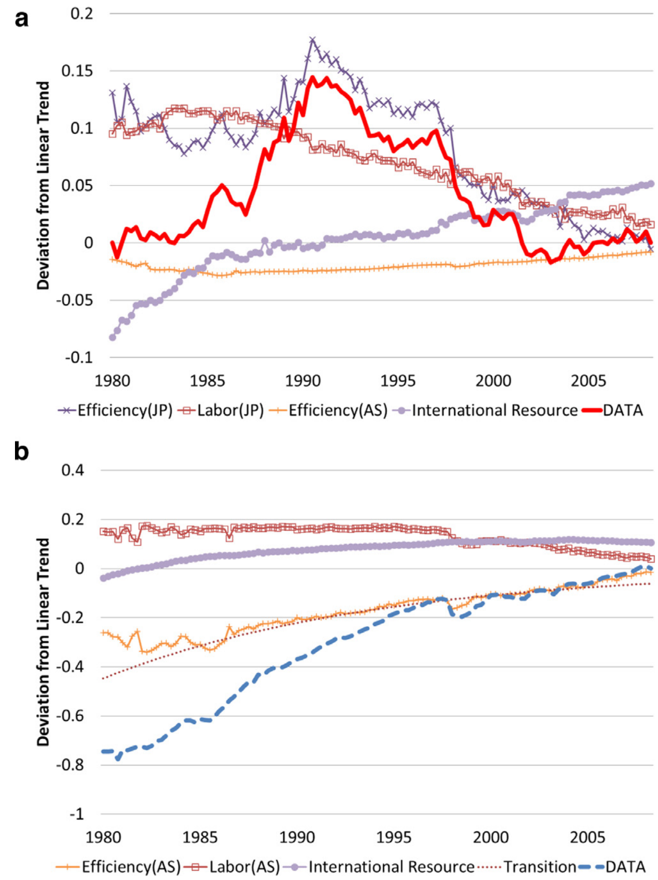

Fig. 3. (a). Japanese Simulated Output. (b). Asian Tigers' Simulated Output.

Fig. 3(b) presents the results of our analysis for the Asian Tigers. Output growth was extremely rapid for the Asian Tigers from 1980 until the Asian crisis in 1998. Clearly, capital stock accumulation was one of the key drivers of this rapid output growth. A simulation with no wedges labeled as "transition" can account for roughly half of the output growth over the entire sample period. The rapid growth in efficiency wedges also played an important role in this growth. The sudden output drop in 1998 can mainly be attributed to deterioration in efficiency and labor wedges for the Asian Tigers, which is consistent with Otsu's (2010a) findings. Finally, we found that international resource wedges significantly contribute to the growth in Asian Tigers.

The Asian Tigers' efficiency wedges impacted Japanese output primarily due to the endogenous terms of trade effect. Fig. 4 shows how efficiency wedges in each country affects the terms of trade where a rise in the index represents an improvement in Japanese terms of trade. The rapid growth in the efficiency wedges of the Asian Tigers reduces the prices of Asian intermediate goods and prompts an improvement in Japanese terms of trade. On the other hand, the gradual decline in Japanese efficiency wedges during the "lost decade" leads to a deterioration in the Asian Tigers' terms of trade, although the effect on their output is small. This finding is consistent with that of Abeysinghe and Forbes (2005) who report that Asia was minimally affected by Japan's economic slowdown after the 1990s.

We also assess the endogenous response of total factor productivity to each wedge. Fig. 5(a) shows that the Japan's total factor productivity does not decline as fast as efficiency wedges, because international resource wedges prevent them from falling. Fig. 5(b) shows that the Asian Tigers' total factor productivity grows faster than efficiency wedges especially in the 2000s. International

[18] Since a rise in capital wedges operates as an increase in capital income tax, they are expected to be countercyclical if they greatly impact business cycles.

[19] The growth in Asian efficiency wedges led to a Japanese output growth of 2.1% (or 0.1% per year) over the 1985Q4-2008Q2 period.

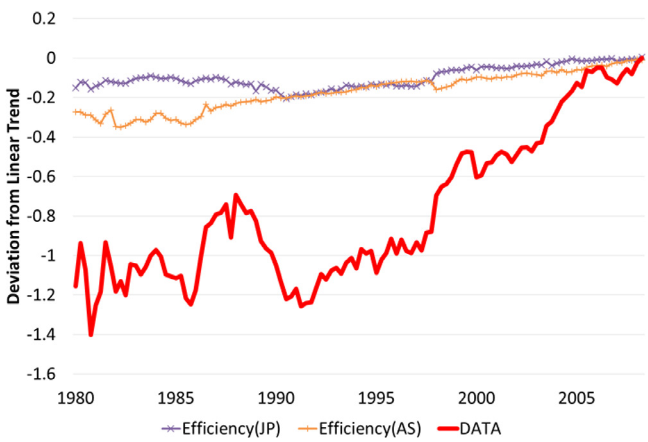

Fig. 4. Simulated Terms of Trade.

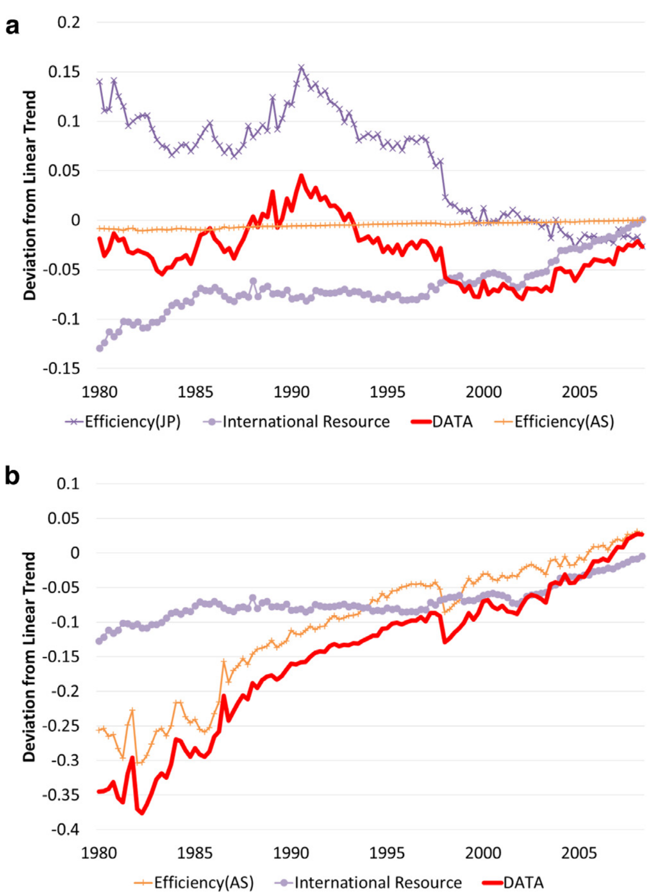

Fig. 5. (a). Simulated Japanese Total Factor Productivity. (b). Simulated Asian Tigers' Total Factor Productivity.

resource wedges appear to contribute significantly to total factor productivity growth. We show in Appendix C how international resource wedges theoretically affect total factor productivity.

5.3.2. HP-filtered data

Next, we assess the short-run features of the model by detrending the results with the HP filter. Following Otsu (2010b), we decompose the data variance into contributions of each wedge (see Table 7). The contribution index for fluctuations is defined as

$$CI^f = \frac{cov(v_{data}, v_{wedge})}{var(v_{data})},$$

Table 7
Contribution Index for fluctuations: HP-filtered.

Wedges	Output		Consumption	
	Japan	*Tigers*	*Japan*	*Tigers*
Government (JP)	0.00	0.00	0.02	−0.00
Labor (JP)	−0.11	0.00	−0.02	−0.02
Capital (JP)	0.16	0.03	0.16	0.07
Efficiency (JP)	0.79	0.00	1.19	0.03
Government (AS)	0.00	−0.03	0.01	0.05
Labor (AS)	0.01	0.26	0.00	0.42
Capital (AS)	0.00	0.16	0.00	−0.02
Efficiency (AS)	0.00	0.64	0.01	0.50
Intl. Finance	0.10	−0.02	−0.30	0.09
Intl. Resource	0.06	−0.02	−0.08	−0.12

Table 8
Contribution Index for Output Correlation: HP-filtered.

Wedges	80Q1-95Q4	96Q1-08Q2	80Q1-08Q2
Government (JP&AS)	0.01	0.00	0.01
Labor (JP&AS)	0.02	−0.09	−0.03
Capital (JP&AS)	0.09	0.12	0.11
Efficiency (JP&AS)	−0.31	0.37	−0.01
International	0.09	0.05	0.07
DATA	−0.24	0.68	0.18

where v_{wedge} represents the fluctuations (HP-filtered log deviation) of variable v in response to a particular wedge and v_{data} represents fluctuations of data. In terms of output, Japanese efficiency and capital wedges account for 79% and 16% of domestic output fluctuation respectively. For the Asian Tigers, domestic efficiency and labor wedges account for 64% and 16% of the output fluctuation, respectively. Therefore, domestic wedges, particularly the efficiency wedges, for both economies, drive output fluctuation.[20]

In terms of consumption, Japanese efficiency wedges alone explain more than the actual domestic consumption fluctuations. For the Asian Tigers, domestic efficiency and labor wedges account for 50% and 42% of the consumption fluctuation, respectively. Overall, foreign wedges contribute minimally to the consumption fluctuations of each economy. Therefore, consumption risk sharing across the two economies is weak. This finding is consistent with those of studies noted in Section 3.

We also investigate the sources of the recent increase in cross-country output correlation by decomposing the cross-country correlation coefficient (see Table 8). We define the contribution index for cross-country correlation of selected wedges as

$$CI^c = \frac{cov\left(v^{JP}_{wedge}, v^{AS}_{wedge}\right)}{std\left(v^{JP}_{data}\right)std\left(v^{AS}_{data}\right)},$$

We focus on the contributions of the cross-country pairs of domestic wedges on the output correlation. For example, the first row presents the correlation index computed for a simulation with Japan's and the Asian Tigers' government wedges.[21] The results show that the Japanese and Asian efficiency wedges account for the increase in output correlation from −0.24 to 0.68 across the two sub-periods (1980Q1-1995Q4 and 1996Q1-2008Q2). The most recent increase in the cross-country output correlation is essentially driven by the increase in the correlation of efficiency wedges

[20] We conducted a robustness check and found that these results hold for alternative parameter values for ε and η. See Appendix D for the results.

[21] Unlike the contribution index for fluctuation, the contribution index for fluctuation for each wedge does not add up to one due to the covariance terms.

for Japan and the Asian Tigers as expected from the observation in Table 5.[22]

6. Conclusion

In this paper, we constructed a two-country, two-good model to investigate the macroeconomic relationship between Japan and the Asian Tigers. We found that domestic production efficiency is the main driver of both the long-term shifts and the short-term fluctuations of output in each economy. We also found that consumption risk-sharing has been weak between the two economies. Furthermore, the most recent increase in business cycle synchronization is mainly due to the increase in the cross-country correlation of efficiency wedges.

There are a number of interesting research questions for future studies. First, we documented the cross-country correlation of efficiency wedges in explaining the cross-country correlation between Japan and the Tigers; future studies could analyze the main sources of fluctuations in efficiency wedges in each economy and why their cross-country correlation has increased. Second, given the fact that it is of considerable interest from a policy perspective to understand the drivers that can change the degree of synchronization (Obstfeld and Rogoff, 2002), it is worth applying similar methods as those used in this paper particularly to countries in the Eurozone. As the emergence of Euro-area regional cycles has been widely observed (e.g., Hirata et al., 2013; Shin and Wang, 2005), we need to have a better understanding of the factors that explain this emergence. Third, it would be very useful to consider the role of third-country effects from the U.S. As the main interest of this paper is the economic relationship between Japan and the Asian Tigers, we have not discussed the third-country effects of the U.S., which is undoubtedly an important trade partner for both economies. For example, some papers discussing whether Asian economies are decoupled from or recoupled to developed countries, including Japan (e.g., Kose et al., 2012; Kim et al., 2011), have suggested both possibilities, indicating that the impact of the third-country effect is indefinite. Since it is beyond the scope of this paper, we have left it for future research to investigate the effect of adding the U.S. to the model.

Appendix A. Data

The data consist of seasonally adjusted quarterly data between 1980Q1 and 2008Q2. GDP data are from Economic and Social Research Institute (ESRI), National Accounts for Japan, Korea National Statistical Office Statistical Database for Korea, Directorate General of Budget, Accounting and Statistics, National Accounts for Taiwan. Private corporate capital stock data are from ESRI's Quarterly Estimates of Gross Capital Stock of Private Enterprises for Japan, Pyo (2003) for Korea, and TEDC Taiwan Economic Statistical Databank System and Directorate General of Budget, Accounting and Statistics, National Wealth Statistics for Taiwan. In addition, Nikkei NEEDS-Financial QUEST, TEDC, and CEIC database are used for completing the data series.

Several data adjustment was used to conduct a theory-based empirical analysis. Consumption is defined as the sum of consumption on non-durables, services, and imputed service flow from durable goods. Investment data are comprised of gross fixed capital formation, public investment, and expenditures on durables. Government expenditure is defined as government consumption. Exports and imports are defined as exports of goods and services and imports of goods and services, respectively. Capital stock is defined as the sum of private corporate capital stock, government capital stock and consumer durables. Labor is defined as the product of average hours worked per worker and the total number of workers.

The service flow from consumer durables is imputed following Cooley and Prescott (1995). The economic return from a productive asset is its marginal product net of its depreciation. Since the household can choose to hold any asset, the economic return from consumer durables should be equal to that from productive assets due to arbitrage. Therefore, the service flow from consumer durables S_d can be defined as the sum of the return plus depreciation:

$$S_d = (R + \delta_d)D,$$

where

$$R = \theta \frac{y}{k} - \delta_k.$$

In order to aggregate the Asian Tigers, we have first constructed data sets for output, consumption, investment, government expenditures and capital stock in constant prices in national currencies. Then we convert output for each country into PPP adjusted 1990 US dollars using the output estimates by the Maddison Project of the Groningen Growth and Development Centre. In specific, we take the ratio of the annual Maddison output estimates for 2007 to the sum of quarterly national output estimates for 2007 and use this ratio to convert national estimates into PPP adjusted 1990 US dollars. We convert consumption, investment, government purchases and capital stock in each country into PPP adjusted 1990 US dollars by computing their ratios to output in national currencies and multiply that with PPP adjusted output. Finally, we sum the PPP adjusted expenditure components for the three economies. We also aggregate population and total hours worked in order to construct the aggregate data set of the Asian Tigers.

Appendix B. Calibrating the home bias parameter

Assuming balanced trade across Japan and the Asian Tigers in the steady state leads to

$$\begin{aligned}(1-\varpi)p_a^{JP}a^{AS} &= \omega p_b^{JP}b^{JP},\\ tb^{JP} = tb^{AS} &= \rho.\end{aligned}$$

Define the common export share to domestic absorption in the symmetric steady state as φ. That is,

$$\varphi = \frac{ex^{JP}}{h^{JP}} = \frac{(1-\varpi)p_a^{JP}a^{AS}}{p_a^{JP}\left(\omega a^{JP}+(1-\varpi)a^{AS}\right)},$$
$$\varphi = \frac{ex^{AS}}{h^{AS}} = \frac{\omega p_b^{AS}b^{JP}}{p_b^{AS}\left(\omega b^{JP}+(1-\varpi)b^{AS}\right)}.$$

Therefore,

$$\frac{a^{JP}}{a^{AS}} = \frac{1-\varphi}{\varphi}\frac{1-\varpi}{\varpi}, \quad \frac{b^{JP}}{b^{AS}} = \frac{\varphi}{1-\varphi}\frac{1-\varpi}{\varpi}. \tag{B1}$$

Assuming that the steady state international price wedge τ_m is equal to zero, we get

$$p_a^{JP} = \eta\left(\frac{h^{JP}}{a^{JP}}\right)^{\frac{1}{\varepsilon}}, \ p_b^{JP} = (1-\eta)\left(\frac{h^{JP}}{b^{JP}}\right)^{\frac{1}{\varepsilon}},$$

$$p_a^{AS} = (1-\eta)\left(\frac{h^{AS}}{a^{AS}}\right)^{\frac{1}{\varepsilon}}, \ p_b^{AS} = \eta\left(\frac{h^{AS}}{b^{AS}}\right)^{\frac{1}{\varepsilon}}. \tag{B2}$$

Combining (B1) and (B2) we get,

$$tot = \frac{p_a^{JP}}{p_b^{JP}} = \frac{\eta}{1-\eta}\left(\frac{b^{JP}}{a^{JP}}\right)^{\frac{1}{\varepsilon}} = \frac{p_a^{AS}}{p_b^{AS}} = \frac{1-\eta}{\eta}\left(\frac{b^{AS}}{a^{AS}}\right)^{\frac{1}{\varepsilon}}.$$

[22] We conducted a robustness check by splitting the sample period into 1980Q1-1995Q4 and 1996Q1-2008Q2, separately calibrate and estimate parameters for each period, simulate the model for each period and HP filter the data and simulation results for each period. The results are similar to the benchmark results.

Table A1
Contribution Index for fluctuations: HP-filtered (Sensitivity Analysis).

Wedges	*Japan* Benchmark	$\eta = 0.744$	$\varepsilon = 0.75$	*Tigers* Benchmark	$\eta = 0.744$	$\varepsilon = 0.75$
Government (JP)	0.00	0.00	0.00	0.00	0.00	0.00
Labor (JP)	-0.11	−0.10	−0.05	0.00	0.00	0.00
Capital (JP)	0.16	0.28	0.14	0.03	0.02	0.01
Efficiency (JP)	0.79	0.77	1.00	0.00	0.00	0.00
Government (AS)	0.00	0.00	0.00	-0.03	−0.02	−0.03
Labor (AS)	0.01	0.00	0.01	0.26	0.24	0.23
Capital (AS)	0.00	0.00	0.08	0.16	0.14	0.24
Efficiency (AS)	0.00	-0.02	-0.02	0.64	0.69	0.69
Intl. Finance	0.10	0.00	-0.34	−0.02	−0.03	−0.07
Intl. Resource	0.07	0.11	0.19	−0.02	−0.03	−0.06

Therefore, we can compute η from φ given ε:

$$\frac{\eta}{1-\eta} = \left(\frac{1-\varphi}{\varphi}\right)^{\frac{1}{\varepsilon}} \text{ or } \eta = \frac{1}{1+\left(\frac{\varphi}{1-\varphi}\right)^{\frac{1}{\varepsilon}}}.$$

Finally, since $h = y - tb$, the home bias parameter can be calibrated to the export to output ratio and trade balance to output ratio:

$$\varphi = \frac{ex}{h} = \frac{ex/y}{\left(1-\frac{tb}{y}\right)}.$$

Appendix C. Efficiency wedges and total factor productivity

Define TFP as

$$A_t^i = \frac{y_t^i}{\left(k_t^i\right)^{\theta}\left(l_t^i\right)^{1-\theta}}.$$

Given (12) and (13)

$$y_t^i = h_t^i + tb_t^i.$$

Given the zero profit condition for the final-goods firm (4), the intermediate goods resource constraint (1), and the definition of the trade balance (7)

$$y_t^{JP} = p_{a,t}^{JP}a_t^{JP} + p_{b,t}^{JP}b_t^{JP} + \tfrac{1-\varpi}{\varpi}\,p_{a,t}^{JP}a_t^{AS} - p_{b,t}^{JP}b_t^{JP} + \rho_t$$
$$= p_{a,t}^{JP}f_t^{JP} + \rho_t,$$
$$y_t^{AS} = p_{b,t}^{AS}f_t^{AS} + \rho_t.$$

Therefore,

$$A_t^{JP} = p_{a,t}^{JP}z_t^{JP} + \zeta_t^{JP},$$
$$A_t^{AS} = p_{b,t}^{AS}z_t^{AS} + \zeta_t^{AS},$$

where

$$\zeta_t^i = \frac{\rho_t}{\left(k_t^i\right)^{\theta}\left(l_t^i\right)^{1-\theta}}.$$

Thus, total factor productivity will be affected by changes in the international resource wedge.

Appendix D. Sensitivity analysis

In this section, we check the robustness of our results to changes in parameter values for ε and η. First, instead of the home bias parameter we consider a lower home bias parameter $\eta = 0.905$ that is calibrated to match the Japanese export towards Asian tigers to output ratio 0.032, we consider $\eta = 0.744$ which corresponds to the Japanese total export to output ratio of 0.164. Next, we consider a case with lower elasticity of substitution where $\varepsilon = 0.75$ rather than $\varepsilon = 1.5$ which was borrowed from Backus et al., (1994).

Table A1 below summarizes the sensitivity analysis results for the HP-filtered Japanese and Asian output simulation. Reducing the home bias parameter has little effect on the contribution index for output fluctuations except that the importance of capital wedges increased for Japan. Reducing the elasticity of substitution increases the contribution of efficiency wedges especially in Japan. This is because an increase in domestic production efficiency leads to an increase in demand for not only domestic goods but also foreign goods as the goods become more complementary.

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