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Asian Financial Linkage: Macro-Finance Dissonance*

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Abstract

How are Asian financial markets interlinked and how are they linked to markets in developed countries? What is the main driver of fluctuations in Asian financial markets as well as real economic activities? In order to answer these questions, we estimate the spillover index proposed by Diebold and Yilmaz (2009) and gauge the degree of interactions in both financial markets and real economic activities among Asian economies. We first show that the degree of the international spillover in stock markets is like cookie-cutter products, namely, uniform, irrespective of the groups of countries, such as G3, NIEs and ASEAN4. This suggests the importance of the globally common shock in stock markets. We, then, discuss the macro-finance dissonance. In stock and bond markets, the US has been the main driver of fluctuations. Regarding real economic activities, China has emerged as an important source of fluctuations.

JEL codes: C58; E44; G12

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1 Introduction

More attention is now paid to the financial and economic activities in emerging economies than in the past. The collapse and recovery in the global economy caused by the recent financial crisis induced a heated discussion on *de-coupling* or *re-coupling* of financial markets and real economic activities between developed countries and emerging economies. The former view is as follows: even though the financial and economic recovery in developed countries are sluggish, the high growth in emerging economies will sustain globally high economic and financial growth. On the other hand, however, a number of reports claim that there exists no such thing as de-coupling and simultaneous contractions around the world is indeed a sign of re-coupling.

Which of the two stories, namely de-coupling or re-coupling, is more compelling? This is an interesting question, the answer to which should be important not only in understanding the *status quo* but also to have prospects for future developments. In this paper, we particularly focus on Asian economies and their interactions with developed countries. As reported by Obstfeld, Shambaugh, and Taylor (2009), these countries have so far experienced less severe contractions.[1] Some also point out the importance of China as an important player to determine the global financial and economic developments. Against this background, we try to answer following questions. How are Asian financial markets interlinked and how are they linked to markets in developed countries? What is the main driver of fluctuations in Asian financial markets as well as real economic activities?

We estimate the spillover index proposed by Diebold and Yilmaz (2009) and gauge the degree of interactions in financial markets as well as real economic activities among Asian economies. We first show that the degree of the international spillover in stock markets is like *cookie-cutter products*, namely, uniform, irrespective of the groups of countries, such as G3, NIEs and ASEAN. This suggests the importance of the globally common shock in stock markets. We, then, discuss the *macro-finance dissonance*. In stock and bond markets, the US has been the main driver of fluctuations. Regarding real economic activities, China has emerged as an important source of fluctuations. Finally, we also report that inflation expectations seem to be a key driver of country specific developments in nominal bond yields.

Understanding the international interactions in both financial and real economic activities is a long-standing agenda. There exist a number of related studies to our

[1] Obstfeld, Shambaugh, and Taylor (2009) stress the importance of the foreign reserve accumulation after the Asian financial crisis.

paper on this issue. Kose, Otrok and Whiteman (2003, 2008), Gregory and Head (1999), Lumsdaine and Prasad (2003) and Del-Negro and Otrok (2008) investigate global co-movements in output and consumptions. King, Sentana, and Wadhwani (1994), Forbes and Rigobon (2002) and Diebold and Yilmaz (2009) study the degree of interactions in stock markets, and Al Awad and Goodwin (1998), Dungey, Martin, and Pagan (2000) and Diebold, Li, and Yue (2008) inquire into that in bond markets. So far as we know, however, no studies have yet focused on the interactions of Asian economies. There have been previous studies dealing with financial markets and real economic activities, but only separately. Our paper compares the characteristics between financial markets and real economic activities.[2] Also, we focus on the developments in international interactions during the recent financial crisis, which has not been yet fully scrutinized.

The remainder of this paper is structured as follows. Section 2 demonstrates the methodology used in this paper. In Section 3, we show the data and compare them to the theoretical prediction obtained from a simple dynamic stochastic general equilibrium model. Section 4 shows how the linkage among Asian financial markets has been evolving and what is the sources of fluctuations. In addition, we also discuss the macro-finance dissonance and the background behind this result. Finally, Section 5 concludes.

2 Methodology

We evaluate the degree of financial and economic interactions among Asian economies by computing the spillover index proposed by Diebold and Yilmaz (2009). The spillover index evaluates how the forecast error in one country is affected by the shocks occurred in other countries. It is a measures to evaluate the degree of global interdependence and clarifies the origin country of fluctuations.

We first estimate the reduced form VAR (p) model:

$$\mathbf{z_t} = \mathbf{A_1 z_{t-1}} + \ldots + \mathbf{A_p z_{t-p}} + \mathbf{u_t}, \tag{1}$$

where $\mathbf{z_t}$ denotes a $N \times 1$ vector of targeted variables, namely log difference of the stock price, difference of bond yields, or difference of industrial production from its trend for country n. $\mathbf{A}$ denotes a $N \times N$ parameter matrix. $\mathbf{u_t}$ denotes a $N \times 1$

[2]Even regarding developments in financial markets, previous studies focuses on either stock or bond markets.

vector of reduced form shocks, whose variance-covariance matrix is defined as

$$\mathrm{E}\left(\mathbf{u_t}\mathbf{u_t}^{\mathrm{T}}\right) = \mathbf{\Omega}.$$

We use the daily data for stock prices and bond yields, and the monthly data for industrial production.[3] p is set to 5 (days) for the stock price and bond yields, and 1 (month) for industrial production.

We, then, re-write (1) into the moving average representation:

$$\begin{aligned}
\mathbf{z_t} &= \left(\mathbf{I} - \mathbf{A}_1 L - \ldots - \mathbf{A}_p L^p\right)^{-1} \mathbf{u_t} \\
&= \left(\mathbf{I} - \mathbf{A}_1 L - \ldots - \mathbf{A}_p L^p\right)^{-1} \mathbf{B}\boldsymbol{\epsilon_t} \\
&= \mathbf{C}(L)\,\boldsymbol{\epsilon_t},
\end{aligned}$$

where

$$\mathbf{C}(L) = \mathbf{C}_0 + \mathbf{C}_1 L + \ldots + \mathbf{C}_\infty L^\infty.$$

[4]$\boldsymbol{\epsilon_t}$ denotes a $N \times 1$ vector of idiosyncratic (country specific) shocks, whose variance-covariance matrix is made to be the identity matrix. $\mathbf{B}$ is a $N \times N$ lower triangular matrix computed by the Choleski decomposition on

$$\mathbf{B}\mathbf{B}^{\mathrm{T}} = \mathbf{\Omega}.$$

In the vector, $\mathbf{z_t}$, the countries (markets) are ordered according to the market closing time. No significant differences are, however, observed in different orderings.

For our intuitive understanding of the computation of the spillover index, let us explain how to compute the spillover index for a 1-step-ahead forecasts when $N = 2$ and $p = 1$. A 1-step-ahead forecasting error vector under this assumption is expressed as

$$\begin{aligned}
\mathbf{e_{t+1}} &= \mathbf{z_{t+1}} - \mathrm{E}_t \mathbf{z_{t+1}} \\
&= \mathbf{C_0}\boldsymbol{\epsilon_{t+1}} \\
&= \begin{bmatrix} c_{0,11} & c_{0,12} \\ c_{0,21} & c_{0,22} \end{bmatrix} \begin{bmatrix} \epsilon_{1,t+1} \\ \epsilon_{1,t+2} \end{bmatrix}.
\end{aligned}$$

[3]This is simply due to the data availability.

[4]$C_0 \ldots C_\infty$ can be computed recursively. See, for example, Hamilton (1994).

$\mathbf{e_{t+1}}$ has a variance-covariance matrix:

$$\mathrm{E}\left(\mathbf{u_t}\mathbf{u_t^{\mathrm{T}}}\right) = \mathbf{C_0}\mathbf{C_0^{\mathrm{T}}}.$$

With $\mathbf{z_t} = (z_{1,t}, z_{2,t})^{\mathrm{T}}$ at hand, the spillover index, for example, shows what fraction of the 1-step-ahead error variance in forecasting z_1 is attributable to the shock to z_1 or z_2. There exist two types of spillovers, namely effects from shocks to $z_{1,t}$ on the forecast error variance of $z_{2,t}$ and *vice versa*. Hence, the total spillover in this model is defined as $c_{0,12}^2 + c_{0,21}^2$, while the total forecast error variation is

$$c_{0,11}^2 + c_{0,12}^2 + c_{0,21}^2 + c_{0,22}^2 = \mathrm{trace}\left(\mathbf{C_0}\mathbf{C_0^{\mathrm{T}}}\right).$$

As a result, we can derive the global spillover index, S, as

$$S = \frac{c_{0,12}^2 + c_{0,21}^2}{\mathrm{trace}\left(\mathbf{C_0}\mathbf{C_0^{\mathrm{T}}}\right)} \times 100.$$

For the fully general case of a p^{th}-order N-variable VAR, using H-step-ahead forecasts, we have

$$S = \frac{\sum_{h=0}^{H-1} \sum_{i,j=1(i \neq j)}^{N} c_{h,ij}^2}{\sum_{h=0}^{H-1} \mathrm{trace}\left(\mathbf{C_h}\mathbf{C_h^{\mathrm{T}}}\right)} \times 100. \tag{2}$$

Similarly, the country j's specific spillover index, where j is is either China, Japan or the US in this paper, is defined as

$$S = \frac{\sum_{h=0}^{H-1} \sum_{i=1(i \neq j)}^{N} c_{h,ij}^2}{\sum_{h=0}^{H-1} \mathrm{trace}\left(\mathbf{C_h}\mathbf{C_h^{\mathrm{T}}}\right)} \times 100. \tag{3}$$

The forecast horizon, H, is set to 10 (days) for stock prices and bond yields, and 6 (months) for industrial production. Since we are interested in the intertemporal evolution of the global spillover, we estimate (1) for the past 200 days for stock prices and bond yields, and for the past 40 months for industrial production.[5]

3 Data and Theoretical Prediction

In this section, we describe the details of the data used in this paper. We also evaluate them through the lens of a simple two-country dynamic stochastic general

[5]For daily returns, we follow Diebold and Yilmaz (2009), which estimate the model for past 200 observations rolling samples. Since we have only 126 samples for industrial productions, we arbitrarily set the rolling sample for the past 40 months.

Table 1: Stock Price Index

Markets	Index
Taiwan	Taiwan Capitalization Weighted Stock
Japan	Nikkei 225
Korea	Korean Composite Stock Price
Phillippines	PSE Composite
China	SSE Composite
Hong Kong	Hang Seng
Singapore	MSCI Singapore
Indonesia	JSX Composite
Malaysia	FTSE Bursa Malaysia KLCI
Thailand	SET
Euro	Euro Stoxx 50
the US	S&P 500

equilibrium model.

3.1 Data

Stock prices are downloaded from the Bloomberg from May 21, 1992 to August 31, 2010. The indices used in this paper are summarized in Table 2. Regarding Singapore, since the representative index, SGX, is not available for a long time series, we instead use the MSCI Singapore index. Figure 1 displays these series, where the order is that in the estimated VARs as in following Figure 2 and 3.

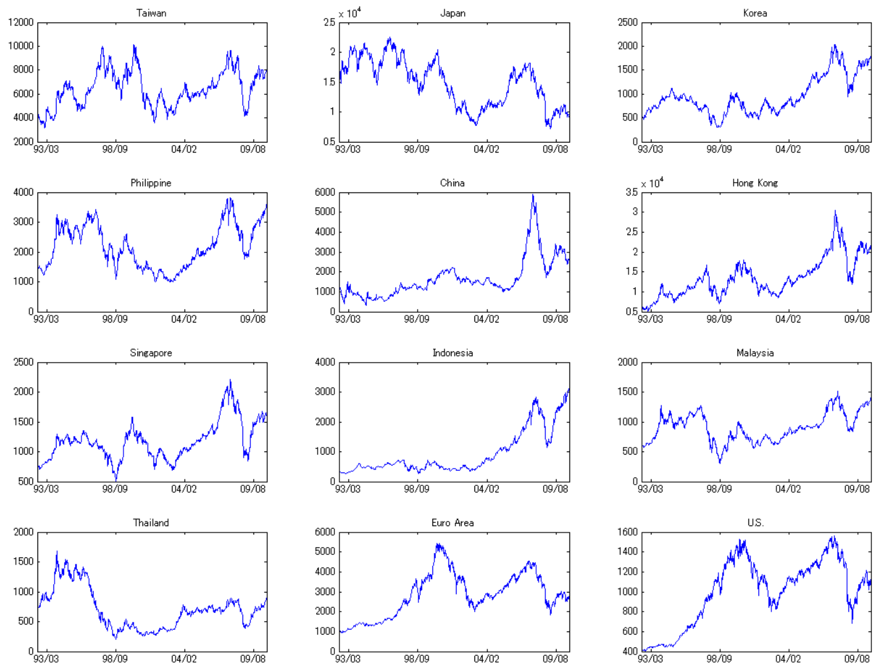
Bond yields for Taiwan, Korea, Hong Kong and Singapore are downloaded from the Data Stream. Others are taken from the Bloomberg. Since the data availability of bond yields is limited, we estimate the model for the period from July 21, 2005 to August 31, 2010. Figure 2 shows the time series of bond yields.

Industrial productions are taken from official releases.[6] The estimated period is from January 1995 to June 2010. Since the seasonally adjusted series are not available for some countries, we compute them for Philippines, Malaysia, and Thailand by X12-ARIMA, and for Indonesia by TRAMO with two dummy series for outliers.[7] Regarding China, only annual growth rates are available. In order to obtain seasonally adjusted series, we first assume industrial productions throughout 1994 is unity. We, then, estimate the seasonally adjusted series by X12-ARIMA with Chinese new year dummies. Since our focus is on fluctuations in business cycle frequencies, we

[6] The data for Hong Kong is available only for quarterly frequency.

[7] The first dummy series put unity on January 1999, January 2000, December 2001, and December 2002. The second dummy series put unity on November 2002 and October 2004.

Figure 1: Stock Price



de-trend the series by the HP (Hodrick and Prescott, 1997) filter. Developments in monthly industrial productions are demonstrated in Figure 3.

3.2 Theoretical Prediction

In order to compare the data in Figure 1 to 3 with theoretical prediction, we use a simple two-county dynamic stochastic equilibrium model based on Backus, Kehoe, and Kydland (1992).[8] The model is very simple and lacks many realistic aspects in the international financial markets, such as nominal rigidities or incomplete financial markets.[9] Nonetheless, a theoretical prediction from such a simple model can be a reference for the data evaluation.

There exist two symmetric country. In a simple model based on Backus, Kehoe, and Kydland (1992), we have no distortion and the equilibrium is efficient. As a

[8] Backus, Kehoe, and Kydland (1992) is the most simple model in international business cycle analysis. See Backus, Kehoe, and Kydland (1994) for the case when the terms of trade matter, Baxter and Crucini (1995), Kollmann (1996) or Kehoe and Perri (2002) for the case when the international financial markets are incomplete, and Stockman and Tesar (1995) for the case with non tradable goods.

[9] Yet, fully specified dynamic stochastic general equilibrium model for open economies, that are estimated and can explain the data well, have not yet been materialized.

Figure 2: Bond Yields

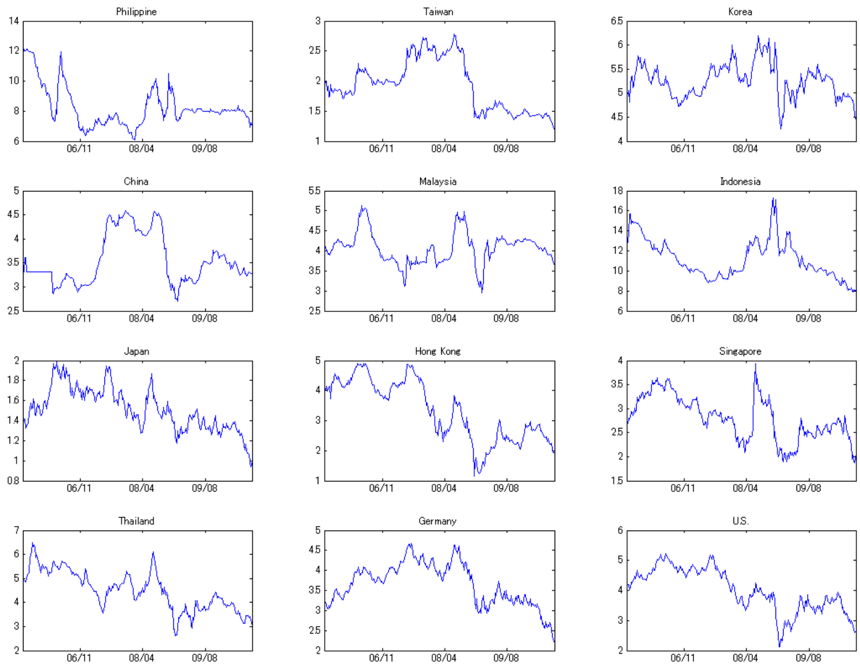
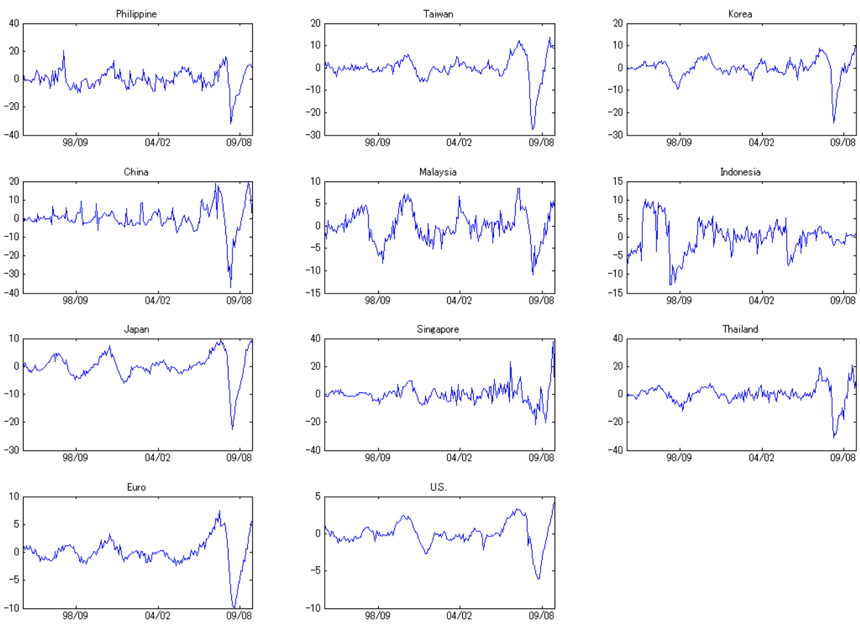


Figure 3: Industrial Productions



result, thanks to the Second Fundamental Theorem of Welfare Economics, we can derive the equilibrium conditions in a competitive equilibrium by the planner's problem. The global social planner maximizes the sum of the welfare in both countries with an appropriate Negishi (1960) weight:[10]

$$\sum_{t=0}^{\infty} \beta^t \left[u \left(c_t, h_t \right) + u \left(c_t^*, h_t^* \right) \right], \tag{4}$$

subject to the resource constraint:

$$c_t + i_t + c_t^* + i_t^* = f \left(\bar{z}_t, z_t, h_t, k_t \right) + f \left(\bar{z}_t, z_t^*, h_t^*, k_t^* \right) \tag{5}$$

and the law of motion for capital:

$$k_{t+1} = (1 - \delta) k_t + \left(1 - \phi \left(\frac{i_t}{i_{t-1}} \right) \right) i_t, \tag{6}$$

$$k_{t+1}^* = (1 - \delta) k_t^* + \left(1 - \phi \left(\frac{i_t^*}{i_{t-1}^*} \right) \right) i_t^*. \tag{7}$$

c_t and h_t denote consumption and labor supply. i_t and k_t denote investment and capital stock. β and δ denote the subjective discount factor and the depreciation rate. z_t and z_t^* denote the domestic and foreign technology shocks, while $\bar{z}_t$ denotes the globally common technology shock. $u(\cdot)$ denotes utility function, $f(\cdot)$ denotes production function and $\phi(\cdot)$ denotes adjustment cost function. The superscript $*$ denotes foreign variables. Appendix A shows the derivation of equilibrium conditions from the planner's problem in (4) to (7).

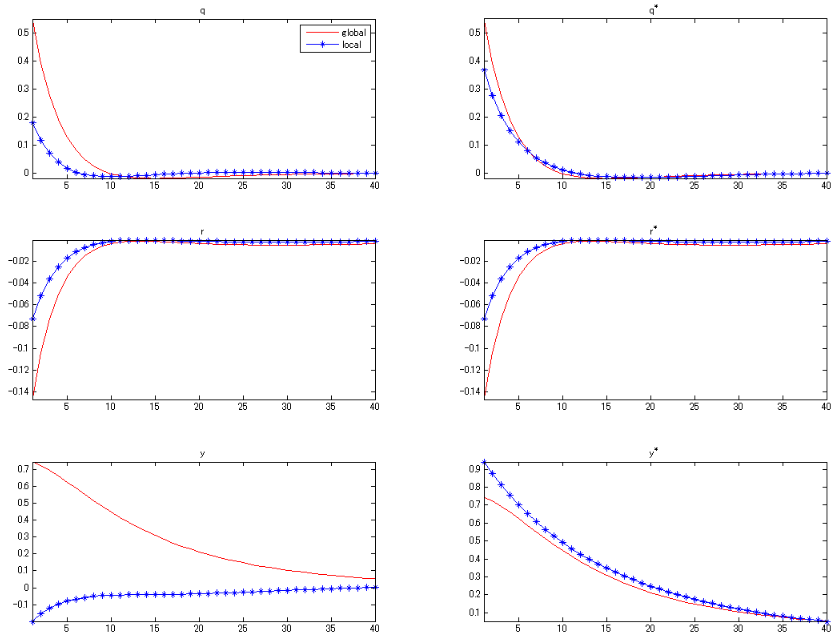
Figure 4 presents impulse responses to both the globally common and the foreign technology shocks. Naturally, under the assumption of symmetric two countries, responses to the globally common shock are identical in both countries.

Regarding the local shock occurred only in the foreign country, arbitrage in international financial markets results in the same real interest rates across the globe, as shown in the middle panels. (8) in Appendix A also derives this condition analytically.[11] The foreign stock price is more increased to the foreign technology shock than the domestic stock price. In both countries, the value of capital rises as the marginal productivity of capital increases. In the foreign country, this is a direct reaction to the foreign shock. On the other hand, in the domestic country,

[10] Here, it is 1:1 thanks to the assumption about the symmetric two countries.

[11] The expected real interest rates should also be the same in this model even if the market is incomplete and the agents can only trade bonds.

Figure 4: Impulse Responses

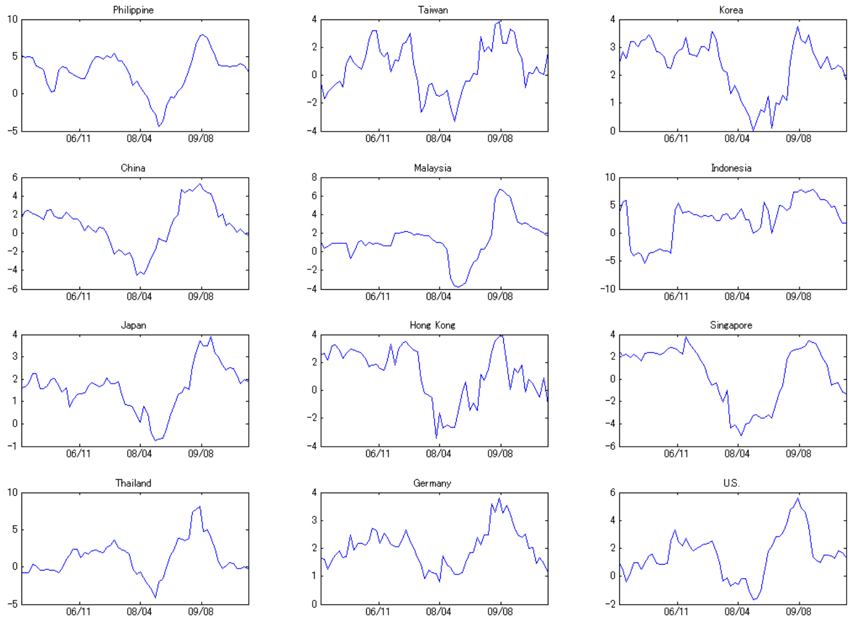


this stems from the capital outflows to more productive country. As a result of this capital flow, a local technology shock positively spillovers to the foreign stock price. The investment adjustment costs, however, hinder the domestic stock price fully catch up with the foreign stock price. On the other hand, outputs in both countries move in different directions. Under the perfect risk sharing implied by the complete financial market, the more productive the country becomes, the more goods should be produced in that country. Consequently, both labor input and output increase in the foreign country while they decrease in the domestic country.

For a reference to the analysis with the spillover index in the next section, we also estimate the country j's specific spillover index in (3) for the simulated data. We find that the country j's specific spillover index for stock prices moves always in line with that for industrial productions. Any significant deviations of these two series are hardly observed.[12]

[12]Note that real interest rates are always equated. Therefore, we cannot compute the spillover index for real interest rates.

Figure 5: Real Interest Rates



3.3 Data vs Theoretical Prediction

According to the model, real bond yields should be equated around the world. If idiosyncratic country shocks are important, stock prices and industrial productions should be less correlated among countries than real bond yields.[13]

Figure 5 displays monthly real bond yields, that is nominal bond yields minus *ex post* CPI inflation rates. Real bond yields in each country display more or less similar dynamics. This supports the theoretical prediction to some extent. The level differences should be attributable to the differences in risk premium.[14] Especially, in G3 countires, the levels and fluctuations are quite similar. This implies highly integrated financial markets among developed countries. On the other hand, overall, nominal bond yields are less correlated than real bond yields. Inflation expectations and risk premium stemming also from inflationary risks seem to be an important idiosyncratic factor to characterize the developments in nominal bond yields.

Regarding stock prices and industrial productions, the degree of co-movement

[13] Although we show the predictions from a very simple IRBC (International Real Business Cycle) model, results will not change even if we use the more complicated NOEM (New Open Economy Macroeconomics) models, namely a model with nominal rigidities and many more frictions, as long as (almost) complete risk sharing is assumed.

[14] Note that according to the standard theory in international finance, exchange rate is passively determined by such as the uncovered interest rate parity condition.

becomes higher around the recent financial crisis. This should be due to the globally common factors. According to Figures 1 to 4, however, there still remain significant idiosyncratic fluctuations especially except for the period of crisis. In addition, the dates of peaks and troughs do not coincide among economies. These implies that a specific shock to some economy may play a critical role in the dynamics of financial variables in other economies. Only with the eye-ball checking on the raw data, it is difficult to grasp the influences from idiosyncratic shocks or the sources of fluctuations. In the next section, we formally examine these points by computing the spillover index.

4 Results

We show the global spillover index in (2) for checking the evolution of global interdependence, and the country j's specific spillover index in (3) for understanding the sources of the fluctuations, where country j is either Japan, China or the US. We also investigate the interactions within different groups of countries. The spillover index for the groups of countries, namely, G3 (Euro area, Japan and the US),[15] NIEs (Hong-Kong, Korea, Singapore, Taiwan), ASEAN4 (Indonesia, Malaysia, Phillipines, Thailand), ASIA (NIEs, ASEAN4, China), and ALL (G3, ASIA), are computed respectively.

4.1 Stock Price

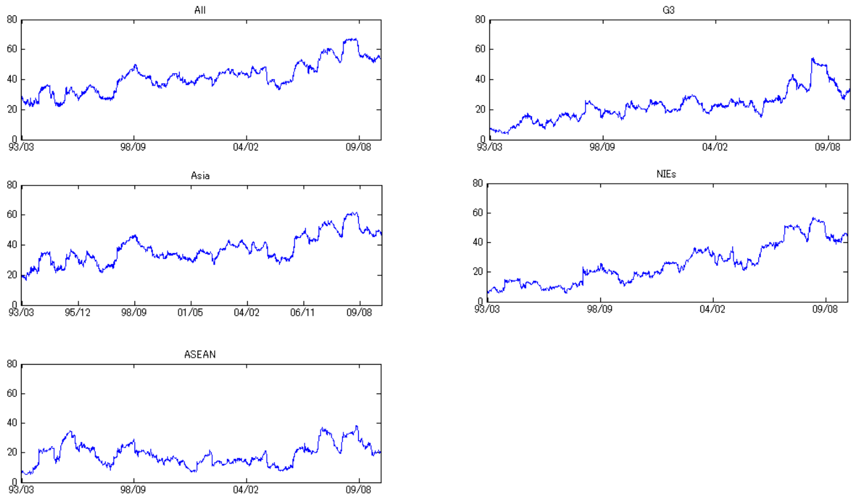
Figure 6 shows the global spillover index in stock markets. As illustrated in the top-left panel, the interdependence in stock markets is on an increasing trend. This finding is consistent with that in Diebold and Yilmaz (2009). According to Diebold and Yilmaz (2009), this implies the gradually developing financial integration.

The index tends to become higher during the financial crisis, such as the Asian financial crisis around 1998 and the current global financial crisis after 2008. The higher interdependence during the crisis seems to be associate with the *international finance multiplier* and the *ambiguity aversion*. Regarding the former, Devereux and Yetman (2010) reports that since banks now operate globally, a local financial crisis can spillover through the balance sheet adjustments of globally active banks.[16] As for the latter, Caballero and Kurlat (2009) argue that investor cannot grasp sizes

[15] For bond yields, we use German bonds instead of the Euro index.

[16] For the amplification of a negative shock through the balance sheet adjustment, see, for example, Brunnermeier (2009) and Shin (2010).

Figure 6: Spillover Index (Stock Price)



and transmission mechanisms of shocks in facing such an unprecedented event as the recent financial crisis, which is associated with complicated securitized products. Global investors, then, have become excessively avert to risks and ambiguity. According to Caballero and Kurlat (2009), this creates the world-wide collapse in both financial and economic activities.

The most striking finding in Figure 6 is that the sizes and the developments of the spillover index are almost identical irrespective of regions. This implies that the stock market interdependence is not a local but a global phenomenon.[17]

Figure 7 displays the country j's specific spillover index, where country j is either China, Japan or the US. A number of reports stress an increasing influence of the China on other Asian stock markets. The Chinese influence has been, however, stable and not large so far. Concerning the developments in the stock markets in Asian economies, the US still remains to be the major source of the co-movements. The dynamic factor analysis in Appendix B confirms this US dominance and also demonstrates that Chinese stock price fluctuates independently from other markets

4.2 Bond Yield

Figure 8 presents the global spillover index in bond markets. Similarly to the case with stock markets, the index is on an increasing trend. Overall, the index, is,

[17]According to the dynamic factor analysis in Appendix B, the global factor is indeed an important driver of the stock price fluctuations.

Figure 7: Influences from China, Japan and the US (Stock Price)

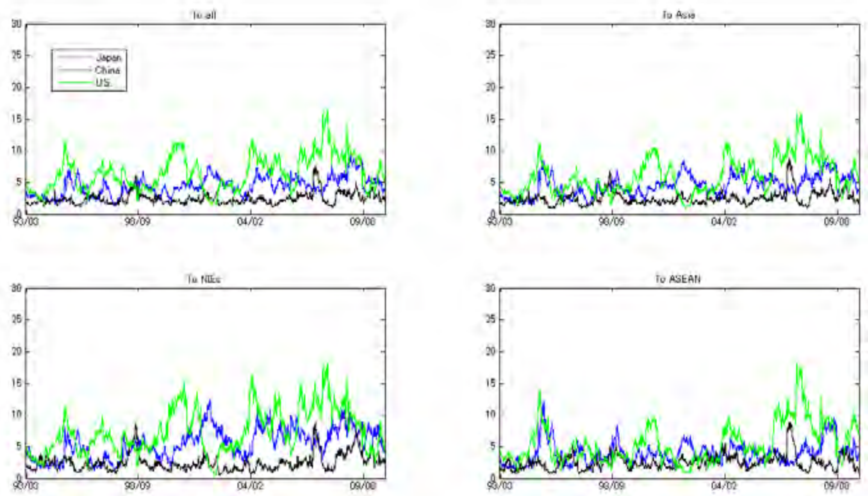


Figure 8: Spillover Index (Bond Yield)

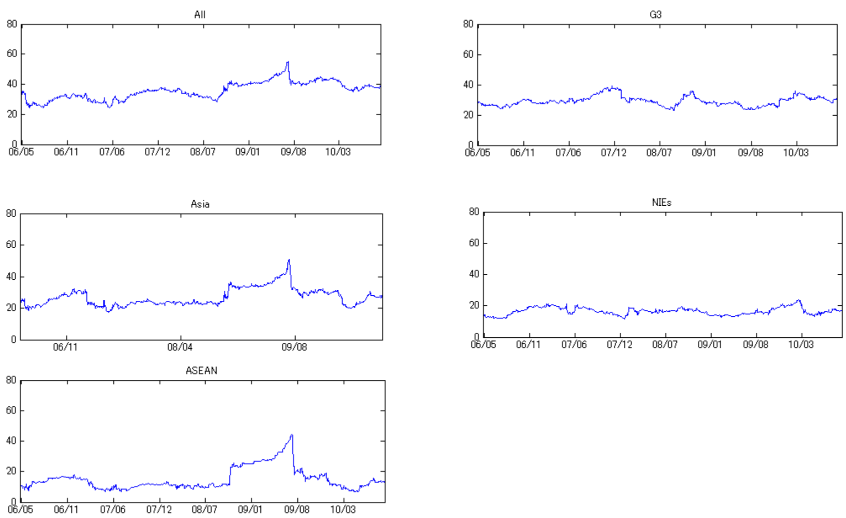
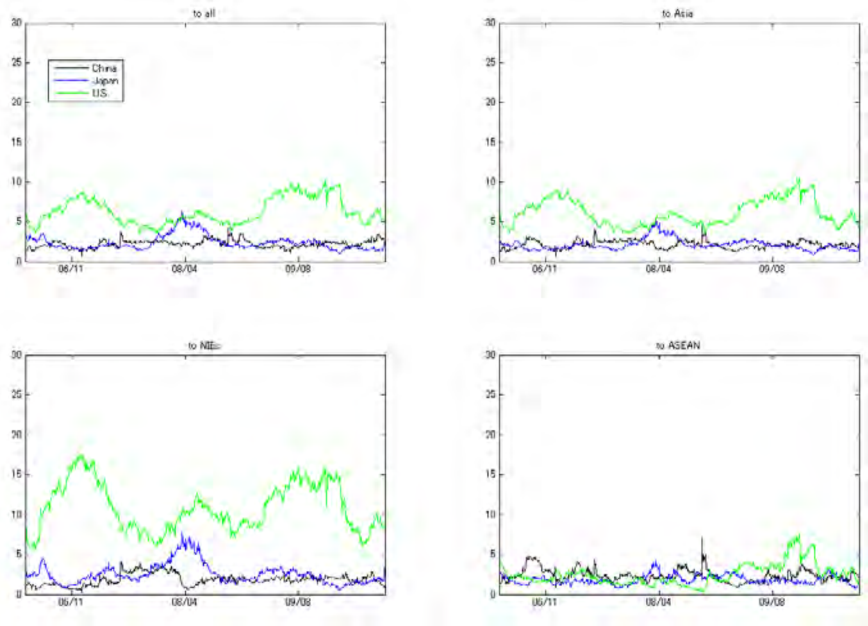


Figure 9: Influences from China, Japan and the US (Bond Yield)



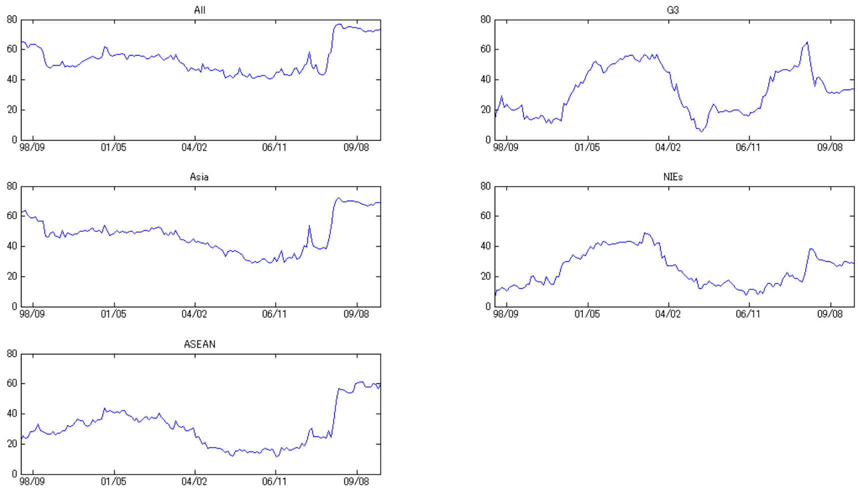
however, smaller in bond than stock markets. In addition, the developments of the spillover index are quite different among regions. Figure 2 and 4 show that the developments of nominal bond yields are different among economies, while those in real bond yields are similar. These facts altogether imply that the idiosyncratic movements in inflation expectation or risk premiums stemming from inflationary risks are very important driver of nominal bond yields among Asian economies.

Figure 9 displays the country j's specific spillover index. Similarly to Figure 7, we observe large impacts from the US and hardly find any significant increase in Chinese influences. Also, Figure 9 suggests that the developments in bond yields in ASEAN4 countries are unique and independent from other markets.

4.3 Real Economic Activity

We investigate the global inter-relations in real economic activities to understand the background behind the financial market integration. Figure 10 shows the global spillover index in industrial productions. Although no clear trend is monitored in the spillover index, it is very high around the recent global financial crisis. As is the case with the stock price, the index becomes very high during the crisis. This again gives some empirical supports for the stories proposed by Caballero

Figure 10: Spillover Index (Output)



and Kurlat (2009) and Devereux and Yetman (2010). Overall, index shows similar developments irrespective of country groups. Among them, the developments are very similar between G3 and NIEs. This fact demonstrates the possibility that the outputs in these countries are driven by a common shock. Also, this suggests that a very high interdependence in ALL, ASIA and ASEAN4 stems from other sources than the common shock among G3 and NIEs economies. We will investigate this point below.

Figure 11 displays the country specific spillover index. Quite contrary to the cases with financial variables, impacts from China are the largest on average and recently increase massively. For the robustness check, instead of using the HP-filtered series, we examine the monthly growth rate of industrial production as $\mathbf{z_t}$ in (1).[18] Figure 12 illustrates the country j's specific spillover with monthly growth rates. We obtain almost identical results. While influences from the US are not impressive, China emerges as the most important driver of real economic activities among Asian economies. This finding is puzzling, considering the results from a simulated data from a theoretical model in the previous section: The specific spillovers should show similar dynamics between stock prices and industrial productions. Below, we will discuss this macro-finance dissonance in the sources of fluctuations.

[18]Constant terms are included to avoid biases in the estimated parameters.

Figure 11: Influences from China, Japan and the US (Output)

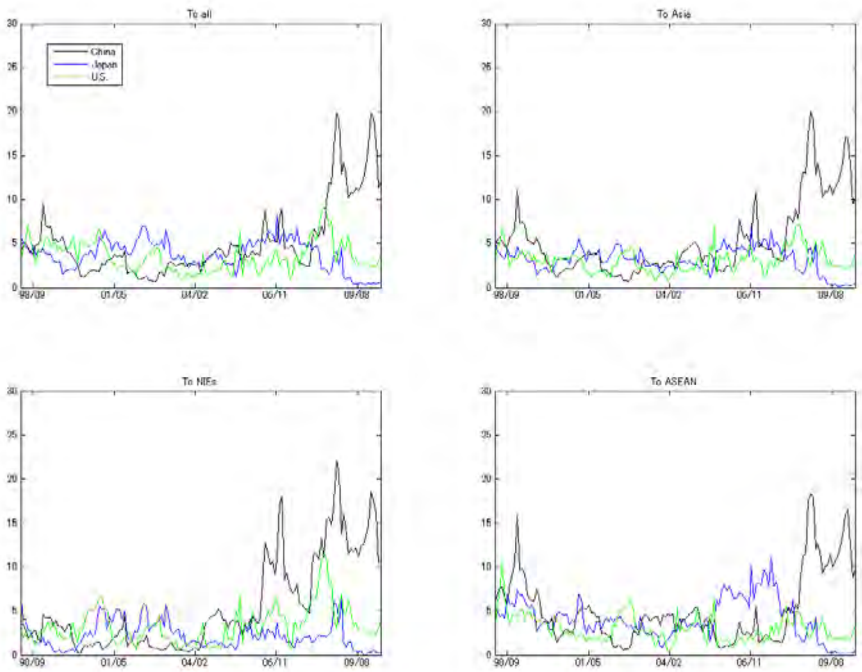
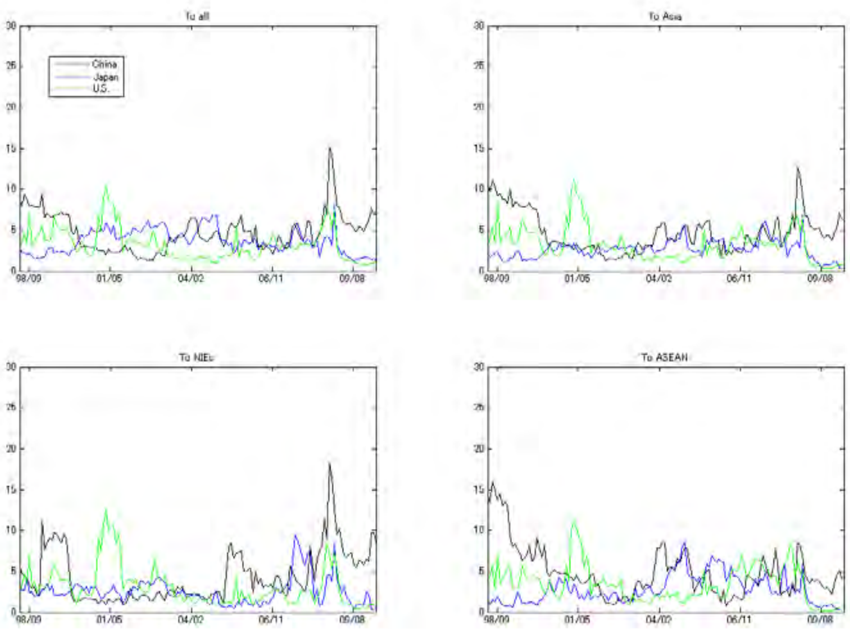


Figure 12: Influences from China, Japan and the US: Monthly Growth (Output)



4.4 Macro-Finance Dissonance

Stock prices and industrial productions tend to co-move, especially around the recent financial crisis. The analysis in this section, however, shows that the sources of fluctuations are different. The major driving force in the financial variables is a shock specific to the US markets, while that in industrial productions is a specific shock to China. A very high global spillovers in the stock prices may have little to do with the real economic activities. We also show that the theoretical model cannot reproduce this dissonance: stock prices are mainly driven by a shock to the home country, while outputs are by a shock to the foreign country.

What is the reason behind this dissonance? We do not have any concrete answer. The global equity traders (or global investment banks) and their increasing role in the international financial markets may be the key to understand this dissonance. The interactions between their position adjustments and time-varying risk-appetite can be an important driver of dynamics in global stock markets, at least, at the business cycle frequencies.[19] Regarding real economic activities, as reported by Kose and Yi (2001), the vertical integration seems to be a *missing link* in business cycle co-movements among Asian economies lead by China.

5 Conclusion

In this paper, we examine the questions such as: How are Asian financial markets interlinked and how are they linked to markets in developed countries?; What is the main driver of fluctuations in Asian financial markets as well as real economic activities? We show that (1) the degree of the international spillover in stock markets is uniform irrespective of the groups of countries; (2) the US has been the main driver of fluctuations, while China emerges as an important source of fluctuations in real economic activities; (3) inflation expectations seems to be a key driver of country specific developments in nominal bond yields.

Although we have shown the possibility of the differences in the sources of fluctuations in macroeconomic and financial activities, there could exist a missing link not investigated in this paper. China's macroeconomic performance may have some correlation with the US specific shocks to both stock prices and bond yields. Since we estimate the models separately for each financial market and real economic activities, we have not tested this hypothesis in this paper. The more detailed microe-

[19] For details on this issue, see, for example, Shin (2010). In macroeconomic context, the model by Ventura (2002) seems to be useful for the analysis on this issue.

conomic based analysis, including the point mentioned above, on the macro-finance dissonance, is left for our future research.

References

Al Awad, Mouawiya, and Barry K. Goodwin (1998). "Dynamic Linkages among Real Interest Rates in International Capital Markets." *Journal of International Money and Finance*, 17(6), 881–907.

Backus, David K., Patrick J. Kehoe, and Finn E. Kydland (1994). "Dynamics of the Trade Balance and the Terms of Trade: The J-Curve?." *American Economic Review*, 84(1), 84–103.

Backus, David, K., Patrick J. Kehoe, and Finn E Kydland (1992). "International Real Business Cycles." *Journal of Political Economy*, 100(4), 745–75.

Baxter, Marianne, and Mario J Crucini (1995). "Business Cycles and the Asset Structure of Foreign Trade." *International Economic Review*, 36(4), 821–54.

Brunnermeier, Markus K. (2009). "Deciphering the Liquidity and Credit Crunch 2007-2008." *Journal of Economic Perspectives*, 23(1), 77–100.

Caballero, Ricardo, and Pablo Kurlat (2009). "The "Surprising" Origin and Nature of Financial Crises: A Macroeconomic Policy Proposal." In *Jackson Hale Symposium on "Financial Stability and Macroeconomic Policy"*. Federal Reserve Bank of Kansas City.

Chib, Siddhartha, and Edward Greenberg (1994). "Bayes Inference in Regression Models with ARMA (p, q) Errors." *Journal of Econometrics*, 64(1-2), 183–206.

Del-Negro, Marco, and Christopher Otrok (2008). "Dynamic Factor Models with Time-Varying Parameters: Measuring Changes in International Business Cycles." Staff Reports 326, Federal Reserve Bank of New York.

Devereux, Michael B., and James Yetman (2010). "Leverage Constraints and the International Transmission of Shocks." NBER Working Papers 16226, National Bureau of Economic Research, Inc.

Diebold, Francis X., Canlin Li, and Vivian Z. Yue (2008). "Global Yield Curve Dynamics and Interactions: A Dynamic Nelson-Siegel Approach." *Journal of Econometrics*, 146(2), 351–363.

Diebold, Francis X., and Kamil Yilmaz (2009). "Measuring Financial Asset Return and Volatility Spillovers, with Application to Global Equity Markets." *Economic Journal*, 119(534), 158–171.

Dungey, Mardi, Vance L Martin, and Adrian R Pagan (2000). "A Multivariate Latent Factor Decomposition of International Bond Yield Spreads." *Journal of Applied Econometrics*, 15(6), 697–715.

Forbes, Kristin J., and Roberto Rigobon (2002). "No Contagion, Only Interdependence: Measuring Stock Market Comovements." *Journal of Finance*, 57(5), 2223–2261.

Gregory, Allan W., and Allen C. Head (1999). "Common and Country-Specific Fluctuations in Productivity, Investment, and the Current Account." *Journal of Monetary Economics*, 44(3), 423–451.

Hamilton, James D. (1994). *Time Series Analysis.* Princeton: Princeton University Press.

Harvey, A.C. (1991). *Forecasting, Structural Time Series Models and the Kalman Filter.* Cambridge University Press.

Hodrick, Robert J, and Edward C Prescott (1997). "Postwar U.S. Business Cycles: An Empirical Investigation." *Journal of Money, Credit and Banking*, 29(1), 1–16.

Kehoe, Patrick J., and Fabrizio Perri (2002). "International Business Cycles with Endogenous Incomplete Markets." *Econometrica*, 70(3), 907–928.

King, Mervyn, Enrique Sentana, and Sushil Wadhwani (1994). "Volatility and Links between National Stock Markets." *Econometrica*, 62(4), 901–33.

Kollmann, Robert (1996). "Incomplete Asset Markets and the Cross-Country Consumption Correlation Puzzle." *Journal of Economic Dynamics and Control*, 20(5), 945–961.

Kose, M. Ayhan, Christopher Otrok, and Charles H. Whiteman (2003). "International Business Cycles: World, Region, and Country-Specific Factors." *American Economic Review*, 93(4), 1216–1239.

Kose, M. Ayhan, Christopher Otrok, and Charles H. Whiteman (2008). "Understanding the Evolution of World Business Cycles." *Journal of International Economics*, 75(1), 110–130.

Kose, M. Ayhan, and Kei-Mu Yi (2001). "International Trade and Business Cycles: Is Vertical Specialization the Missing Link?." *American Economic Review*, 91(2), 371–375.

Lumsdaine, Robin L., and Eswar S. Prasad (2003). "Identifying the Common Component of International Economic Fluctuations: A New Approach." *Economic Journal*, 113(484), 101–127.

Negishi, Takashi (1960). "Welfare Economics and Existence of an Equilibrium for a Competitive Economy." *Metroeconomica*, 12(2-3), 92–97.

Obstfeld, Maurice, Jay C. Shambaugh, and Alan M. Taylor (2009). "Financial Instability, Reserves, and Central Bank Swap Lines in the Panic of 2008." NBER Working Papers 14826, National Bureau of Economic Research, Inc.

Sekine, Toshitaka (2009). "On Recent Monetary Policy in Japan." Bank of Japan.

Shin, Hyun Song (2010). *Risk and Liquidity*. Oxford University Press.

Stockman, Alan C, and Linda L Tesar (1995). "Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements." *American Economic Review*, 85(1), 168–85.

Ventura, Jaume (2002). "Bubbles and Capital Flows." CEPR Discussion Papers 3657, C.E.P.R. Discussion Papers.

Appendix

A Derivation of the Model

From the optimization problem define in (4) to (7), we can derive the first order conditions as follows:

$$
\begin{aligned}
u_c(c_t, h_t) &= u_c(c_t^*, h_t^*), \\
u_h(c_t, h_t) &= u_c(c_t, h_t) f_h(z_t, h_t, k_t), \\
u_h(c_t^*, h_t^*) &= u_c(c_t^*, h_t^*) f_h(z_t, z_t^*, h_t^*, k_t^*), \\
1 &= q_t \left[\left(1 - \phi\left(\frac{i_t}{i_{t-1}}\right)\right) - \phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}} \right] + \beta \frac{u_c(c_{t+1}, h_{t+1})}{u_c(c_t, h_t)} q_{t+1} \phi\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2, \\
1 &= q_t^* \left[\left(1 - \phi\left(\frac{i_t^*}{i_{t-1}^*}\right)\right) - \phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t^*}{i_{t-1}^*} \right] + \beta \frac{u_c\left(c_{t+1}^*, h_{t+1}^*\right)}{u_c(c_t^*, h_t^*)} q_{t+1} \phi\left(\frac{i_{t+1}^*}{i_t^*}\right)\left(\frac{i_{t+1}^*}{i_t^*}\right)^2, \\
q_t &= \beta \frac{u_c(c_{t+1}, h_{t+1})}{u_c(c_t, h_t)} \left[f_k(z_{t+1}, h_{t+1}, k_{t+1}) + q_{t+1}\left[1 - \delta + \phi'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2\right]\right], \\
q_t^* &= \beta \frac{u_c\left(c_{t+1}^*, h_{t+1}^*\right)}{u_c(c_t^*, h_t^*)} \left[f_k\left(z_{t+1}, z_{t+1}^*, h_{t+1}^*, k_{t+1}^*\right) + q_{t+1}^*\left[1 - \delta + \phi'\left(\frac{i_{t+1}^*}{i_t^*}\right)\left(\frac{i_{t+1}^*}{i_t^*}\right)^2\right]\right],
\end{aligned}
$$

where q_t and q_t^* are the ratios of the Lagrangian multipliers on the resource constraint over (6) and (7), respectively. They are the relative prices of the capital in a utility unit and therefore considered to be the theoretical stock prices. As for functional forms, we assume that

$$
\begin{aligned}
u(c_t, h_t) &= \log(c_t) - \chi \frac{h_t^2}{2}, \\
f(\bar{z}_t, z_t, h_t, k_t) &= y_t = (\exp(\bar{z}_t)\exp(z_t) h_t)^{1-\alpha} k_t^{\alpha}, \\
\phi\left(\frac{i_t}{i_{t-1}}\right) &= \phi\left(\frac{1}{2}\left(\frac{i_t}{i_{t-1}}\right)^2 - \frac{i_t}{i_{t-1}} + \frac{1}{2}\right).
\end{aligned}
$$

y_t denotes the output. The technology shocks follow an AR(1) process:

$$
\begin{aligned}
z_t &= \rho z_{t-1} + u_t, \\
z_t^* &= \rho z_{t-1}^* + u_t^*, \\
\bar{z}_t &= \rho \bar{z}_{t-1} + \bar{u}_t,
\end{aligned}
$$

where u_t, u_t^* and $\bar{u}_t$ denote *iid* shocks.

A.1 Real Interest Rates

Since we solve the planner's problem, we do not derive the equations for relative prices. Real interest rates in this economy can be derived by consumer i's optimization problem with respect to bond holdings in each country. A representative home consumer i maximizes the utility

$$\sum_{t=0}^{\infty} \beta^t u\left(c_t, h_t\right),$$

subject to the budget constraint:

$$a_{t+1} + \mathrm{E}_t\left[p_{t,t+1} b_{t+1}\right] + c_t + i_t \leq w_t h_t + r_t^k k_t + \left(1 + r_t\right) a_t + b_t,$$

and the law of motion for capital:

$$k_{t+1} = (1-\delta) k_t + \left(1 - \phi\left(\frac{i_t}{i_{t-1}}\right)\right) i_t.$$

a_t and b_t denote amounts of financial assets and the Arrow security. $p_{t,t+1}$ and r_t^k denote the price of the Arrow security and the cost of capital. From the first order necessary condition with respect to financial assets and the Arrow securities, we can derive

$$\begin{aligned} u_c\left(c_t, h_t\right) &= \beta\left(1 + r_{t+1}\right) u_c\left(c_{t+1}, h_{t+1}\right), \\ p_{t,t+1} u_c\left(c_t, h_t\right) &= \beta u_c\left(c_{t+1}, h_{t+1}\right). \end{aligned}$$

Similarly, the optimization problem from the foreign consumer j^*, we can obtain

$$\begin{aligned} u_c\left(c_t^*, h_t^*\right) &= \beta\left(1 + r_{t+1}^*\right) u_c\left(c_{t+1}^*, h_{t+1}^*\right), \\ p_{t,t+1} u_c\left(c_t^*, h_t^*\right) &= \beta u_c\left(c_{t+1}^*, h_{t+1}^*\right). \end{aligned}$$

The last equation can be derived from the constant real exchange rate normalized to unity. We can assume this without loss of generality under the assumption of two symmetric countries. As a result, we can derive

$$r_t = r_t^* \ \forall t. \tag{8}$$

Thus, real interest rates are equated across countries.

Table 2: Parameter Calibration

parameters	value
α	0.3
β	0.99
δ	0.025
ϕ	2
χ	5
ρ	0.9

A.2 Parameters

We calibrate the parameters as in Table 2. They are all on quarterly basis.

B Dynamic Factor Analysis

B.1 Methodology

The applications of the dynamic factor analysis, such as based on Harvey (1991), to understand the co-movements of the international economic as well as financial developments are vast. Among them, we closely follow Kose, Otrok and Whiteman (2003, 2008), Diebold, Li, and Yue (2008), and Sekine (2009), that use the Markov Chain Monte Carlo (MCMC) methods to estimate the large number of parameters in this multi-country analysis.

We estimate a state space model for reduced form errors, $\mathbf{u_t}$, in (1):

$$\begin{aligned} \mathbf{u_t} &= \mathbf{\Gamma} f_t + \boldsymbol{\nu_t}, \\ f_t &= \psi f_{t-1} + \xi_t, \\ \boldsymbol{\nu_t} &= \mathbf{\Phi} \boldsymbol{\nu_{t-1}} + \boldsymbol{\zeta_t}. \end{aligned} \tag{9}$$

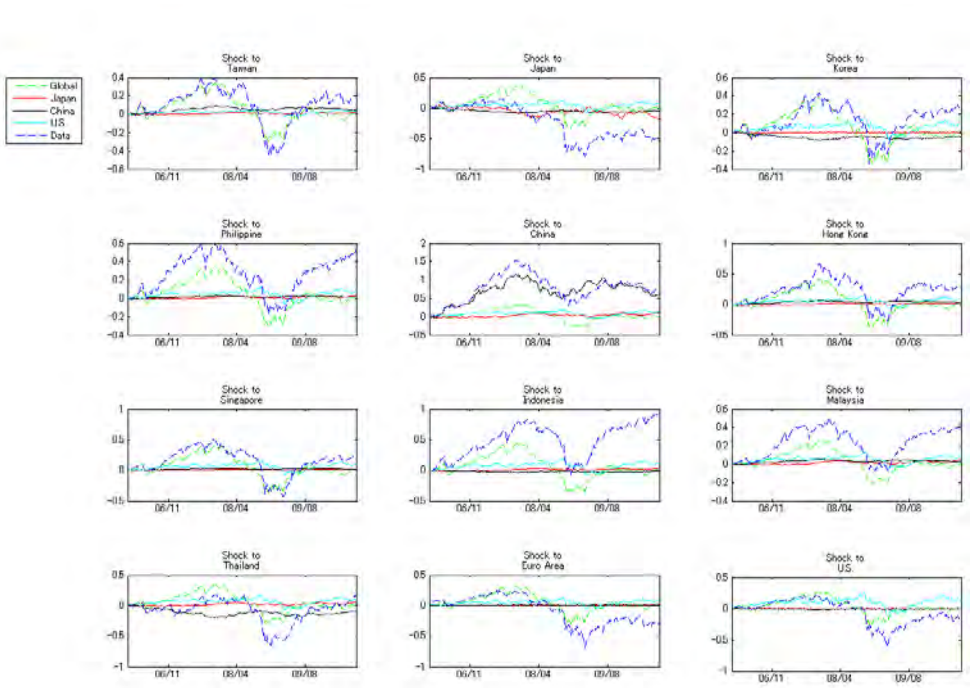
f_t and ξ_t denote the global factor and shock, that affect all countries simultaneously. ν_t and ζ_t denote a $(n-1)\times 1$ vector of country specific factors and shocks. Note the spillover index captures the degree of interactions both in positive and negative relationships, while the global factor is the influence, which affects all economies simultaneously and in the same directions.

Parameter, ψ, and parameter matrices, Γ and Φ, are computed by the maximum likelihood estimation using the Kalman filter with the MCMC method on (9). The variance-covariance matrix of ζ_t is assumed to be a diagonal matrix with diag-

Table 3: Prior Distribution

$\psi \sim N(0,1)$
$\mathbf{\Phi} \sim N(\mathbf{0}, \mathbf{I})$
$\Gamma_i \sim N(0,1)$
$1/\sigma_i \sim \text{Gamma}(0.5, 0.005)$

Figure 13: Factors for Stock Price



onal component, σ_i. The conditional densities are computed from 20,000 samples simulated using the algorithm proposed by Chib and Greenberg (1994).[20] Table 1 displays the prior distributions. With parameters and factors in (9) at hand, we can compute the contributions of the global shock, ξ_t, and the country-specific (idiosyncratic) shocks, $\boldsymbol{\zeta}_t$, respectively on $\Delta \mathbf{z_t}$ in (1).

B.2 Results on Stock Prices

Figure 13 illustrates the sources of fluctuations in stock markets during the recent financial crisis. Contributions from country's specific factors are small, while the global factor has significant effects on stock prices. Especially, in Japan and the

[20] For the details of the MCMC used in this paper, see Appendix in Diebold, Li, and Yue (2008).

US, the country's own factors do not play significant roles in fluctuations of stock prices. On the other hand, the domestic specific factor, however, explains most of the dynamics of the stock price in China.