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Expanding the boundaries of monetary policy in Asia and the Pacific

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Monetary and Economic Department

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Contents

Opening remarks

Keynote speech

Contributed papers

Foreword

Frank Packer and James Yetman

Bank Indonesia and the Bank for International Settlements (BIS) co-hosted a research conference on "Expanding the boundaries of monetary policy in Asia and the Pacific" on 20–21 August 2015 in Jakarta. The event was the wrap-up conference of a research programme of the BIS Representative Office for Asia and the Pacific that had been approved by the Asian Consultative Council of central bank Governors in February 2014.

The topic was motivated by the increased importance of financial stability in the conduct of monetary policy and the expanding set of monetary policy tools being employed. Within this overall theme, the following issues for the Asia-Pacific region were identified: (i) monetary policy objectives and strategies; (ii) instruments to manage monetary conditions; (iii) the assessment of monetary conditions; and (iv) transmission mechanisms.

The conference brought together senior officials and researchers from central banks, international organisations and academia. This volume is a collection of the speeches, papers and prepared discussant remarks from the conference. This foreword summarises the contents of the conference and provides a synopsis of the discussions for time-constrained readers.

Objectives and strategies

Monetary frameworks remain primarily focused on price stability, but financial stability considerations have become more prominent. This raises questions about how monetary policy strategies should develop to incorporate these new considerations, including the choice of analytical frameworks and tools, and communication strategies. In his opening address to the conference, Agus Martowardojo (Bank Indonesia) stressed that price stability on its own has proven insufficient to bring about successful outcomes. Emerging market central banks have increasingly sought to find a "middle solution" that also moderates exchange rate movements and resists extreme capital flows.

In the first conference paper, Soyoung Kim (Seoul National University) and Aaron Mehrotra (BIS) analyse the question of how central banks deal with policy trade-offs resulting from potential conflicts between price and financial stability objectives. The Asia-Pacific region represents fertile territory for this topic, as many economies with inflation targeting central banks have adopted macroprudential policies in order to safeguard financial stability.

Using structural vector autoregression techniques, Kim and Mehrotra show that tighter macroprudential policies aimed at containing credit growth also have a significant negative impact on inflation. The results suggest that the trade-offs for policymakers are binding, given the high frequency of episodes where low inflation coincides with buoyant credit growth. Kazuo Momma (Bank of Japan), in his discussion of the paper, emphasises the challenge of defining the social loss function, in particular with respect to the costs of deflation, and the very divergent views within the central banking community regarding this.

Incorporating financial stability considerations into monetary policy does not necessarily imply that monetary policy should be tightened in response to asset price bubbles. In his keynote address to the conference, John Williams (Federal Reserve Bank of San Francisco) outlined the limitations of using policy interest rates to resist asset price bubbles. He provided new evidence on the effect of monetary policy on property prices across a wide set of OECD countries, based on a novel identification strategy. Williams' conclusion was that using interest rates to resist a house price bubble can be unacceptably costly. His estimates indicated that preventing the run-up in house prices seen in the US before 2007 using interest rate tools would have required sacrificing more than 10% of output.

Instruments to manage monetary conditions

The range of monetary policy instruments used by central banks in addition to the interest rate has grown, as has the use of prudential and capital flow management tools. There has been greater focus on how to influence long-term rates, which are seen to play a more important role than in the past. All this raises questions about the demarcation, interaction and effectiveness of the various tools.

The paper by Ken Kuttner (Williams College) and James Yetman (BIS) uses bank data to investigate the effects on bank lending of different liquidity management tools used by central banks in seven Asian economies. The authors find that hiking reserve requirements to sterilise foreign exchange purchases retards lending growth by more than the issuance of central bank bills does, and smaller and weaker banks are affected disproportionately by changes in reserve requirements. Discussant Martin Bodenstein (National University of Singapore) concludes that central banks need to think more deeply about how to correct the distortions between banks that are introduced or exacerbated by the choice of sterilisation tool.

Juda Agung, Solikin Juhro, Harmanta and Tarsidin (Bank Indonesia) contributed a paper to the programme that illustrates the Bank's efforts to include macroprudential tools into a model of the Indonesian economy. Discussant Iikka Korhonen (Bank of Finland) notes that the paper takes a relatively optimistic view of policymakers' ability to use a mix of monetary policy and macroprudential measures to achieve price and financial stability objectives. Korhonen asks whether the next step might be to assess the relative importance of macroprudential measures related to foreign exchange operations and short-term capital movements in place of measures related to domestic lending.

Assessment of monetary conditions

Even as the boundaries of monetary policy expand, the assessment of current monetary conditions remains an essential prerequisite for informing policy direction. In particular, the equilibrium real interest rate – often referred to as the natural rate of interest – provides a benchmark against which policymakers can compare policy rates and evaluate the monetary policy stance.

The paper by Feng Zhu (BIS) estimates the natural interest rates in Asia-Pacific economies. Relying on frequency domain techniques, and focusing on the relationship of the interest rate with long-run components of population characteristics, globalisation and a range of macroeconomic and financial variables, Zhu finds that, with the exception of China and also Thailand since 2005, the natural interest rate has declined substantially in Asia-Pacific economics since the early or mid-1990s, by over 4 percentage points on average. That said, Zhu emphasises the large uncertainties surrounding these estimates, and calls for monetary policy rules which are robust to such uncertainties. Discussant Solikin Juhro (Bank Indonesia) supports the idea that policymakers should not rely excessively on these intrinsically noisy indicators when making monetary policy decisions.

Transmission mechanisms

Understanding the transmission mechanism of monetary policy, particularly as policy takes unconventional forms and is conducted in the midst of increasingly globalised financial markets, remains a work in progress. Important research questions include how the evolving funding structure of banks influences interest rate pass-through, the effects of deepening capital and of long-term domestic bond markets, the role of institutional investors and asset managers and external factors more generally, the strength of the risk-taking channel and changes in expectations formation and investor sentiment.

The paper by Enisse Kharroubi and Fabrizio Zampolli (BIS) estimates the sensitivity of domestic interest rates to foreign interest rates at both short and long maturities, as well as the degree of pass-through from domestic short-term to long-term rates. Accounting for heterogeneous effects across countries as well as common factors, they find that central banks tend to have less leverage on long-term rates when their exchange rates are volatile as well as when their economy is more financially open, suggesting a world closer to Rey's dilemma than Mundell's trilemma. In her discussion of the paper, Mardi Dungey (University of Tasmania) emphasises that network effects themselves may be very important in transmitting information. She also suggests that controlling for ambient news transmission might improve estimation.

The paper by Piti Disyatat (Bank of Thailand) and Phurichai Rungcharoenkitkul (BIS) asks whether globalisation has compromised central banks' ability to manage domestic financial conditions. Studying the dynamics of bond yields in 31 advanced and emerging market economies, and isolating a contagion component from co-movements unrelated to economic fundamentals, the authors conclude that emerging market economies are less susceptible to global contagion than advanced economies. In his discussion, Paul Mizen (University of Nottingham) suggests more work would be useful to confirm how robust the results are, particularly to assumptions behind the decomposition of yields into their various components. He asks whether similar results would be obtained if bond premia were assumed to depend on market and bond characteristics as well as macro and financial factors, along the lines of some other studies from the finance literature.

Panel discussion

The conference also included a policy panel discussion by senior central bank officials focusing on the boundaries of monetary policy as they apply to economies in the Asia-Pacific region. The panel was chaired by Perry Warjiyo (Bank Indonesia). John Williams suggested that, if low interest rates are the new normal, consequences for central banks include: (i) increased periods with policy rates stuck at zero; (ii) QE actions no longer being "unconventional"; (iii) growing concerns about the link between low rates and excessive risk-taking; and (iv) the need to question whether 2% is too low an inflation target. On multiple goals, he suggested that there are legal and resource limits to what a central bank can do. Sukhdave Singh (Central Bank of Malaysia) argued that central banks should not be afraid of broader mandates as the risks that they face are multifaceted. Having narrow mandates could restrict the peripheral vision of central banks, which could lead them to ignore risks and fail to address them pre-emptively. In fact, the policies of central banks with narrow mandates could themselves have unintended side effects and be a source of risks that ultimately undermine both financial and macroeconomic stability. Diwa Guinigundo (Bangko Sentral ng Pilipinas) emphasised the complementarity of monetary and financial stability tools and welcomed the ongoing expansion of the central bank toolkit.

Programme

Wednesday 19 August 2015

19:00	**Informal welcome dinner hosted by the BIS**	

Thursday 20 August 2015

09:00–09:20	**Opening address**	
	Agus Martowardojo (Bank Indonesia)	
09:35–10:50	**Paper 1:**	**Maintaining price and financial stability by monetary and macroprudential policies – evidence from Asia and the Pacific**
	Chair:	Sukudhew Singh (Bank Negara Malaysia)
	Authors:	Soyoung Kim (Seoul National University) and Aaron Mehrotra (Bank for International Settlements)
	Discussant:	Kazuo Momma (Bank of Japan)
11:10–12:25	**Paper 2:**	**A comparison of liquidity management tools in seven Asian economies**
	Chair:	Doddy Zulverdi (Bank Indonesia)
	Authors:	Ken Kuttner (Williams College) and James Yetman (Bank for International Settlements)
	Discussant:	Martin Bodenstein (National University of Singapore)
13:45–14:45	**Keynote address**	
	Introduction:	Hyun Song Shin (Bank for International Settlements)
	Speaker:	John Williams (Federal Reserve Bank of San Francisco)
14:45–16:00	**Paper 3:**	**A spectral perspective on natural interest rates in Asia-Pacific: changes and possible drivers**
	Chair:	Diwa Guinigundo (Bangko Sentral ng Pilipinas)
	Author:	Feng Zhu (Bank for International Settlements)
	Discussant:	Solikin M Juhro (Bank Indonesia)
16:30–17:45	**Paper 4:**	**Managing monetary and financial stability in a dynamic global environment: Bank Indonesia's policy perspectives**
	Chair:	Chris Kent (Reserve Bank of Australia)
	Authors:	Juda Agung, Solikin M Juhro, Harmanta and Tarsidin (Bank Indonesia)
	Discussant:	Iikka Korhonen (Bank of Finland)
19:00–21:00	**Conference dinner hosted by BI**	

Friday 21 August 2015

08:00–09:00	**Paper 5:**	**Monetary independence in a financially integrated world: what do measures of interest rate co-movement tell us?**
	Chair:	Kazuo Momma (Bank of Japan)
	Authors:	Fabrizio Zampolli and Enisse Kharroubi (Bank for International Settlements)
	Discussant:	Mardi Dungey (University of Tasmania)
09:00–10:00	**Paper 6:**	**Financial globalisation and monetary independence**
	Chair:	Kazuo Momma (Bank of Japan)
	Authors:	Piti Disyatat (Bank of Thailand) and Phurichai Rungcharoenkitkul (Bank for International Settlements)
	Discussant:	Paul Mizen (University of Nottingham)
10:15–11:40	**Policy panel**	
	Moderator:	Perry Warjiyo (Bank Indonesia)
	Panellists:	Sukudhew Singh (Central Bank of Malaysia)
		Diwa Guinigundo (Bangko Sentral ng Pilipinas)
		John Williams (Federal Reserve Bank of San Francisco)
		Hyun Song Shin (Bank for International Settlements)
11:40–11:45	**Closing remarks**	

List of participants

Central banks

Reserve Bank of Australia	Chris Kent Assistant Governor (Economic)
Bank of Finland	Iikka Korhonen Head of Research
Hong Kong Monetary Authority	Frank Leung Acting Head, Economic Research
Bank Indonesia	Agus Martowardojo Governor
	Perry Warjiyo Deputy Governor
	Juda Agung Executive Director of Economic and Monetary Policy Department
	Doddy Zulverdi Executive Director of Monetary Management Department
	Solikin M Juhro Director of Economic and Monetary Policy Department
	Harmanta Acting Group Head of International Department
Bank of Japan	Kazuo Momma Assistant Governor
Bank of Korea	Ho Soon Shin Director General of Financial Markets Department
Central Bank of Malaysia	Sukudhew Singh Deputy Governor
Bangko Sentral ng Pilipinas	Diwa Guinigundo Deputy Governor
Bank of Thailand	Piti Disyatat Executive Director
	Warapong Wongwachara Team Executive of Monetary Policy Strategy
Federal Reserve Bank of San Francisco	John Williams President and Chief Executive Officer

Academic institutions

University of Tasmania	Mardi Dungey Professor of Economics & Finance
Seoul National University	Soyoung Kim Professor
National University of Singapore	Martin Bodenstein Professor
University of Nottingham	Paul Mizen Professor
Williams College	Ken Kuttner Professor

Bank for International Settlements

Head Office	Hyun Song Shin Economic Adviser and Head of Research
	Aaron Mehrotra Senior Economist
BIS Representative Office for Asia and the Pacific	Madhusudan Mohanty Head of Economics and Financial Markets for Asia and the Pacific
	Frank Packer Regional Adviser
	James Yetman Principal Economist
	Fabrizio Zampolli Principal Economist
	Feng Zhu Senior Economist

"The challenges of expanding the boundaries of monetary policy"

Opening address at the Bank Indonesia-BIS Research Conference: Expanding the boundaries of monetary policy in Asia and the Pacific

Agus D W Martowardojo[1]

Honourable speakers, distinguished guests, ladies and gentlemen,

Good morning to you all.

I am delighted to welcome you to this research conference on "Expanding the boundaries of monetary policy in Asia and the Pacific" co-hosted by Bank Indonesia and the BIS. I would like to especially thank our international guests who have travelled a long way to be with us today.

This Conference will showcase some of the research being conducted as part of a research programme that was endorsed by the Asian Consultative Committee of BIS in February 2014.

The objective of this Conference is to facilitate a discussion of key monetary policy issues of relevance to central banks in Asia-Pacific and beyond.

On this occasion, we will discuss current issues connected with expanding the boundaries of monetary policy, where the key question is how to reshape policy frameworks and formulate optimal policy responses, to cope better with global interconnectedness.

I hope the conference will help shed further light on this.

The global financial crisis that swept the globe in 2008–09 provided a number of valuable insights, including the lesson that merely maintaining price stability alone through monetary policy is insufficient. On top of price stability, financial system stability is also a prerequisite, both of which ultimately determine macroeconomic stability.

Financial spillovers associated with extraordinary monetary policy easing in advanced economies have prompted many central banks and academics to do some soul-searching about the appropriate framework, not just for monetary policy, but also for the regulatory and capital account policies that can best deal with these shocks. Since 2009, the configuration of monetary policies in major countries has created a challenging environment for small open economies in conducting their policy.

In the post-crisis global period, the relative fundamental strength of emerging market economies was already drawing in substantial capital inflows. The additional

[1] Governor of Bank Indonesia.

push from this extraordinary stimulus, and the reach-for-yield behaviour associated with it, has compounded the pressure.

Increasing global financial market interconnectedness, including large capital inflows and outflows, has put pressure on the implementation of monetary policy in many emerging economies. Hence, many emerging market central banks have found themselves at a critical juncture where broad reappraisals of their monetary and capital account policy frameworks were necessary.

A surge in foreign capital inflows, for instance, compounds the complexity of challenges faced in terms of domestic monetary management. Large and persistent capital inflows undermine the effectiveness of monetary management, bearing in mind that measures to manage liquidity in the economy, such as an interest rate increase, could subsequently be offset by the sheer magnitude of the capital inflows.

We also have seen an obvious example recently, where a competitive devaluation strategy has been pursued by policymakers in advanced economies and large emerging countries with the aim of boosting economic growth by going for export-led growth. These so-called currency wars have instigated capital outflows and exchange rate pressures in emerging markets, which were already on the back foot because of sliding commodity prices and fears over tighter US monetary policy.

This exposes a dilemma for monetary policy in many emerging markets, as raising policy rates to prevent excessive currency weakness will further worsen the slowdown in economic growth.

Maintaining price stability alone through monetary policy is insufficient. The surge in foreign capital inflows, for example, has significant implications for the domestic economy, particularly in the form of excess liquidity. Unless capital flows are properly managed, the excess liquidity can precipitate financial instability and eventually disrupt macroeconomic stability.

In many emerging countries, the orientation of monetary policy in the midst of dynamic global environment is tactically directed not only at controlling inflation but also at managing exchange rates and capital flows, with the aim of maintaining both monetary and financial stability.

We have seen the monetary authority's preference for shifting from a "corner solution" towards a "middle solution". There should be a more accommodative response that takes into account a certain latitude for managing exchange rate movements within a certain range (not fully flexible) and restricting movements of foreign capital.

The expanding boundaries of monetary policy have further implications. To preserve financial stability, central banks must also take into account fiscal risk, balance of payment sustainability and structural policies.

Thus, monetary policy is also directed at supporting the achievement of objectives such as a target for the current account deficit and sustainable economic growth.

The multiple challenges facing monetary policy due to a surge in capital flow volatility suggest that we should employ multiple instruments. We believe that an instrument mix would allow us to address these multiple dilemmas.

Hence, in some countries in which monetary policy is anchored to the achievement of low and stable prices, there is a good reason to implement a less rigid Inflation Targeting Framework (ITF), known as flexible ITF.

Flexible ITF requires the integration of monetary and macroprudential policy, including a capital flow and and exchange rate management policy. Thus, the policy mix should be an optimal response to tackling multiple challenges in managing monetary and financial stability.

On that note, we at the central bank would be more effective in maintaining macroeconomic stability if we were also mandated to promote financial system stability. Strengthening the monetary and financial system stability framework requires an appropriate integration of monetary and macroprudential policy.

The objectives achieved through monetary and macroprudential policies should be mutually reinforcing. Steps to empower financial system resilience will also improve monetary policy, including protecting the economy from destructive fluctuations in the financial system. On the other hand, macroeconomic stability will lessen the vulnerability of the financial system, which has procyclical characteristics.

Now, I will move to home issues by sharing our experience in implementing the policy mix.

The global financial crisis signified that central banks are clearly required to take a more active role, primarily in developing new capability to confront a more complex and interconnected global financial market.

Bank Indonesia has the specific role of supporting the sustainability of economic development through three elements, namely: (a) monetary stability, (b) financial system stability, and (c) a reliable payment system.

Within the dynamics of the global economy and financial market uncertainties, Bank Indonesia has since mid-2013 consistently implemented monetary policy with a tightening bias. This stance is imperative in preserving market confidence, mitigating the second-round impact of fuel price increases, and coping with the current account deficit.

The pro-stability policy stance and the assurance of financial system stability has underpinned investor confidence in the quality of Indonesia's macroeconomic policy management.

In 2014, capital inflows in the form of portfolio investment continued to be abundant. These inflows have sustained bullishness in the stock market and government securities market.

Our policy also aims to ensure the current account deficits that have occurred in the last three years will be maintained within the range of 2.5–3% of gross domestic product (GDP).

We believe that a well maintained current account is crucial for the achievement of a strong and balanced economic growth as well as the continuity of job creation.

Furthermore, through "ahead of curve" policy action, we aim to preserve the strong confidence of investors in the consistency and quality of our macroeconomic policy management amid the prospect of a higher global interest rate in the near future.

These efforts are important in maintaining the stability of global fund flows into our capital market, and particularly into the government bond investments that finance the current account deficit.

We also observe that efforts to maintain macroeconomic stability need to be supported by the observance of prudential principles by business sectors, particularly sectors that have access to foreign debt.

In this regard, corporates are obliged to conduct hedging by implementing hedging ratio rules and maintain adequate foreign exchange liquidity by applying liquidity ratio rules.

As mentioned earlier, the global economy recovery remains uneven and uncertain, and the risks of volatility can be rapidly propagated through the financial market channel.

On the other hand, the Indonesian economy is still struggling with structural issues that disrupt the efficiency and competitiveness of the supply side. Under these circumstances, an accommodative monetary policy would trigger inflationary pressure and increase the current account deficit.

Considering the overall constellation of the global and domestic economy that is still confronted with formidable challenges, future economic policies should remain focused on measures to ensure the sustainability of economic growth.

This requires at least two key aspects: the orientation of monetary policy towards stability, and a bold structural reform policy aiming to promote capacity, capability and competitiveness on the supply side.

Through the synergy between the monetary and structural policies, we are confident that our economy will be able to achieve sustainable growth.

Going forward, Bank Indonesia is committed to pursuing a consistent and prudent monetary policy as well as macroprudential policies that promote stability.

The integration of monetary and macroprudential policies will be further strengthened, given that monetary policy in some circumstances is less effective in mitigating financial system risks and imbalances.

The global crisis taught us that the achievement of low and stable inflation does not necessarily deliver financial system stability, an important lesson.

Excessive risk-taking and the loosening of credit standards can occur even in circumstances where macroeconomic stability is preserved and interest rates are low.

Efforts to maintain macroeconomic stability cannot be separated from efforts to safeguard the financial system, and vice versa. In this context, macroprudential policy is very important in filling in the gaps that cannot be reached by monetary policy, especially in relation to the risk of financial imbalances.

On that note, we will improve our capability to prevent and mitigate key risks which are potentially systemic and can create financial imbalances. Hence, the macroprudential policy framework will be strengthened to support policy formulation, regulation and supervision.

Macroprudential policy, regulation and supervision will be more effective if coordinated with the policies of other authorities. Therefore, the coordination with Financial Services Authority (OJK) will continue to be strengthened in a number of areas including data and information exchange as well as the development of an integrated information system. Likewise, the effectiveness of coordination with the Ministry of Finance and the Indonesia Deposit Insurance Corporation (LPS) will be enhanced through the Coordination Forum on Financial System Stability (FKSSK).

The expanding boundaries of monetary policy are a challenge to all of us. Central banks need to explore the issue deeply through research and analysis. That is the objective of this conference, to discuss these issues based on our research.

In closing, let me offer my special thanks to the distinguished speakers for taking part in this important endeavour and for sharing with us your expertise. All of us here very much look forward to your contributions through today and tomorrow. I would also like to thank the BIS for kindly co-hosting this event.

To all conference participants, I welcome your spirited discussions as I have already noticed there are many experts present among us. Thank you for being here. I wish you a fruitful conference and a pleasant stay in Jakarta.

Measuring the effects of monetary policy on house prices and the economy

John C Williams[1]

It's a pleasure to participate in this excellent conference dealing with important and timely issues. This is my first visit to Indonesia and my second trip to Southeast Asia this year. This is a truly fascinating part of the world – in many ways distinct from neighbouring regions but also very much connected to the global economy – and I look forward to learning a great deal during my time here. Before I go any further, I should note that, as always, the views I express here are my own and do not necessarily reflect those of others in the Federal Reserve System. With that out of the way, let me get to the topic of my talk.

The great unresolved question in central banking today is: should monetary policy be used to foster financial stability, even at the expense of achieving other macroeconomic goals such as inflation and employment? Rivers of ink have already been spilled on this question and no doubt much more will be in coming years. In my talk today, however, I will take a step back from the "big picture" policy questions, such as the pros and cons of "lean" vs "clean" and the appropriate roles of fiscal, regulatory and monetary policies in addressing risks to financial stability. Instead, I will put on my researcher's hat and focus narrowly on one particular issue that is central to thinking about the role of monetary policy in supporting financial stability – the effects of monetary policy on house prices and the overall economy.

Monetary policy, housing and financial stability

Why focus on house prices? Although monetary policy's influence on house prices represents only one channel by which it affects financial stability, it is an important one for a number of reasons. First, the global financial crisis provides an all-too-real example of the devastating effects of a debt-fuelled housing boom and crash. And real estate finance has grown enormously in many countries[2] and is therefore likely to remain a key source of risk to financial stability. Second, standard economic theory tells us that monetary policy should affect house prices and housing finance more generally.[3] All else equal, higher interest rates increase the cost of owning a house, which implies a lower asset value. Hence, there is a *prima facie* case for considering a role for monetary policy in tempering housing booms in support of financial stability. Third, there is a wealth of data and research on this issue that provides a rich opportunity for analysis and testing of various hypotheses. Of course, this last

[1] President and CEO, Federal Reserve Bank of San Francisco.

[2] Jordà, Schularick and Taylor (2014). See also Mian and Sufi (2014).

[3] Kuttner (2012).

argument exposes me to the criticism that I am foolishly looking under a lamppost because the light is better there, but so be it.

In fact, the effect of monetary policy on house prices is only half of the story: When considering the potential benefits of monetary policy for combatting the risk of a housing boom and ultimately for financial stability, it's equally important to gauge the effects on other macroeconomic variables of interest, such as inflation and economic activity.[4] In many circumstances, macroeconomic and financial stability goals may be well aligned. For example, if the housing sector and the overall economy are both booming, then tighter monetary policy may serve to both reduce the risks to the financial system and keep economic activity from exceeding desired levels. But, in other circumstances, macroeconomic and financial stability goals may conflict, and policymakers face a trade-off between the two. As a case in point, Lars Svensson has argued that, in Sweden, the costs of higher interest rates in terms of higher unemployment exceed the benefits in terms of reducing financial stability risks.[5] Therefore, it is important to quantitatively gauge the costs and benefits of using monetary policy to influence house prices when macroeconomic and financial stability goals do not coincide.

Measuring the effects of monetary policy

The question remains: how does one best estimate the effects of monetary policy on house prices and other economic variables of interest? Economists typically take one of two approaches. The first is to use economic theory to describe the relationship between variables, say interest rates and house prices. The model can then be used to evaluate the "counterfactual" experiment of a rise in interest rates and compute the simulated effect on house prices or other variables.[6] The main strength of this model-based approach is that it gives a clear theoretically grounded answer to the question. The potential shortcoming is that the answer is only as good as the model is at providing a reasonably accurate description of the relationships that occur in the real world. Specifically, standard textbook theories may provide an inadequate description of the determination of house prices.[7] This suggests looking to a more evidence-based approach.

The second approach focuses more squarely on the empirical evidence and relies less directly on economic theory. In a nutshell, the empirical approach looks at what has typically happened to other variables when interest rates go up (or down). The strengths and weaknesses of this approach are the mirror image of those of the model-based approach. The main strength is that one does not rely so much on having an accurate model. The weakness is that it's hard to distinguish between statistical correlation and economic causation. Interest rates go up and down in response to economic conditions and also tend to be highly correlated with other variables. However, to answer the question about the effects of a policy decision to

4 Yellen (2014).

5 Svensson (2014).

6 Dokko (2009). See also Svensson (2014) and Ungerer (2015).

7 Kuttner (2012).

change interest rates, it is crucial for one to properly identify times when policy changes are not a response to economic developments, but rather the driver of them.

Recent research provides an ingenious way to identify monetary policy actions that are arguably exogenous to domestic economic conditions. It examines the effects of changes in interest rates in countries that have given up their ability to freely adjust interest rates on their own because they fixed their exchange rate to a foreign currency.[8] In such circumstances, changes in domestic interest rates are tied to developments in a foreign country, such as the United States, and not to domestic conditions. Thus, to trace out the effects of monetary policy, one can simply look at the responses of domestic economic variables to changes in interest rates.

Findings

Applying this method to a sample of 17 countries over the past 140 years indicates that monetary policy has significant and persistent effects on real house prices and output. Graph 1 shows the responses of short-term interest rates, real house prices, real GDP per capita and the inflation rate following a shock to monetary policy. These results are based on a slightly modified version of recent research by Òscar Jordà, Moritz Schularick and Alan Taylor.[9] The sample covers 1870–2013 (except for the interwar period of 1914–45 and the oil crisis years of 1973–80). The estimated responses have been scaled so that the initial rise in short-term interest rates is 1 percentage point. The shaded regions show the 90% confidence regions of the estimated effects.

Two years after a 1 percentage point increase in the short-term interest rate, real house prices are estimated to decline by over 6%, while real GDP per capita declines by nearly 2%. This implies a ratio of 3.3 in terms of the decline in house prices for a 1% decline in the level of output after two years. Looking at a longer time horizon of three or four years (not shown in the graph), the ratio rises to about 3½.

Although imprecisely estimated, inflation also responds negatively to a monetary policy shock after a two-year lag. One caveat in interpreting this result is that by construction the sample only includes countries with fixed exchange rates. Many countries today have adopted inflation targeting or similar regimes with explicit mandates for low inflation, which likely alters the inflation responses to monetary policy shocks relative to a fixed exchange rate regime.

Robustness of findings

These findings are based on the average response of house prices and other variables to changes in monetary policy. But, do they depend on specific circumstances? In particular, is monetary policy more or less powerful during housing or real estate debt booms that are frequently precursors to financial crises? To assess this possibility, I examined estimated responses to monetary policy during periods when house prices

8 Jordà, Schularick and Taylor (2015a, b).

9 Jordà, Schularick and Taylor (2015a).

or mortgage debt are high (or low) relative to their underlying trends. In neither case are the estimated effects of monetary policy meaningfully different from the estimates shown in Graph 1.

One potential concern with using such a long time sample is that structural change has fundamentally altered the effects of monetary policy on the economy. To assess that possibility, the same analysis is conducted using only data from the period after the Second World War. For this shorter sample, the estimated effect on house prices is somewhat larger and the effect on output is smaller. This results in a larger estimated ratio of 5.7 for the decline in house prices relative to that in output, compared with the full-sample estimates.

The main result that monetary policy affects house prices and output is consistent with other estimates reported in the literature. Table 1 provides a summary of findings from numerous research papers using different samples and methodologies. For comparison, the first line of the table reports the results using the full-sample "baseline" estimates described above and shown in Graph 1; the second line reports the results using just the postwar sample. The remainder of the table reports results from other studies. In particular, these studies use different methods to identify exogenous movements in monetary policy than the approach I described earlier. The table reports the percent change in house prices and a measure of economic activity (typically real GDP) two years after a monetary policy shock. The results have been scaled so that the initial movement in the short-term interest rate is 1 percentage point. In cases where I could not get the precise estimates from the author, the numbers reported in the table are estimates based on a visual inspection of the charts included in the papers.

Although the individual estimates differ, the estimated ratios of the effect on house prices relative to that on real GDP after two years tend to be clustered between 3 and 6, with a median estimate of about 4. It is worth noting that one of the outliers likely in part reflects the specific measure of economic activity used: Ungerer (2015) reports industrial production, which tends to be more cyclically sensitive than GDP. Overall, the results on the ratio of the effects on house prices relative to GDP appear to be robust, especially for studies that include a large set of countries.

To put this in perspective, consider the magnitude of the run-up in house prices in the United States over 2000–06. Graph 2 shows the US house price-to-rent ratio over the past 40 years. In the five years running up to the peak in the spring of 2006, the house price-to-rent ratio increased over 50%. Based on the empirical estimates described above, to offset this increase using monetary policy would require a decline in real GDP per capita of over 12%. That is far larger than the 5½% peak-to-trough decline in real GDP per capita the United States actually experienced in the Great Recession. Jordà, Schularick and Taylor conduct a similar analysis using a different measure of house price overvaluation, and reach the same overall conclusion.[10]

Not all of these research papers report effects on inflation; however, consistent with the findings reported above, those that do also find that inflation moves in the same direction as house prices.[11] As noted above, the effects on inflation likely

[10] Jordà, Schularick and Taylor (2015b).

[11] Assenmacher-Wesche and Gerlach (2008). See also Jarocinski and Smets (2008), Iacoviello and Minetti (2008), Calza, Monacelli and Stracca (2013), and Sá, Towbin and Wieladek (2011).

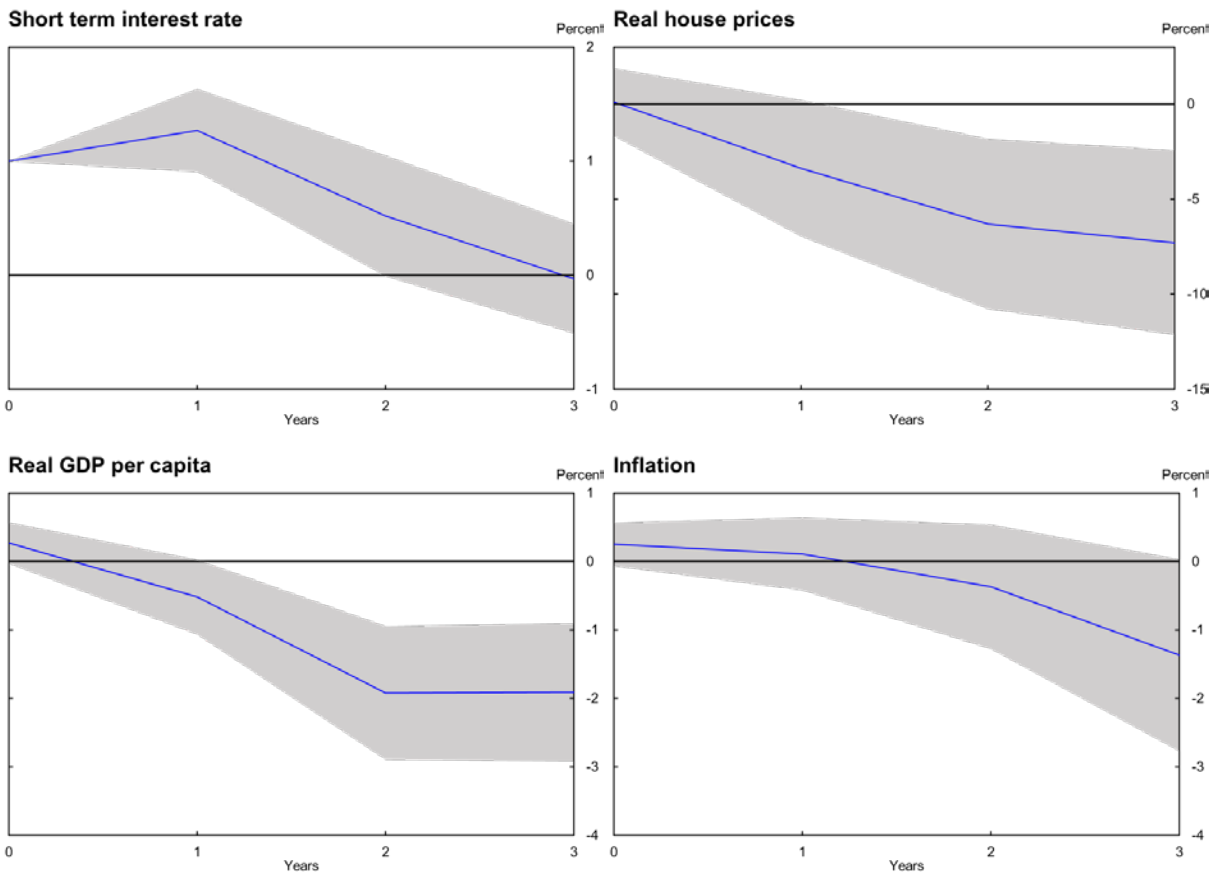
depend on the monetary policy regime, and this issue needs further study. Nonetheless, these findings add to the potential macroeconomic costs of directing monetary policy at house prices or other financial stability goals.[12]

Conclusion

In summary, I draw two main conclusions from a large volume of research on the effects of monetary policy on house prices. Both are robust across countries, samples, methodologies and other factors. First, monetary policy actions have sizeable and significant effects on house prices in advanced economies. That is, an increase in interest rates tends to lower real (inflation-adjusted) house prices. Second, this reduction in house prices comes at significant costs in terms of reductions in real gross domestic product and inflation. A typical estimate is that a 1% loss in GDP is associated with a 4% reduction in house prices. This implies a very costly trade-off of using monetary policy to affect house prices when macroeconomic and financial stability goals are in conflict.

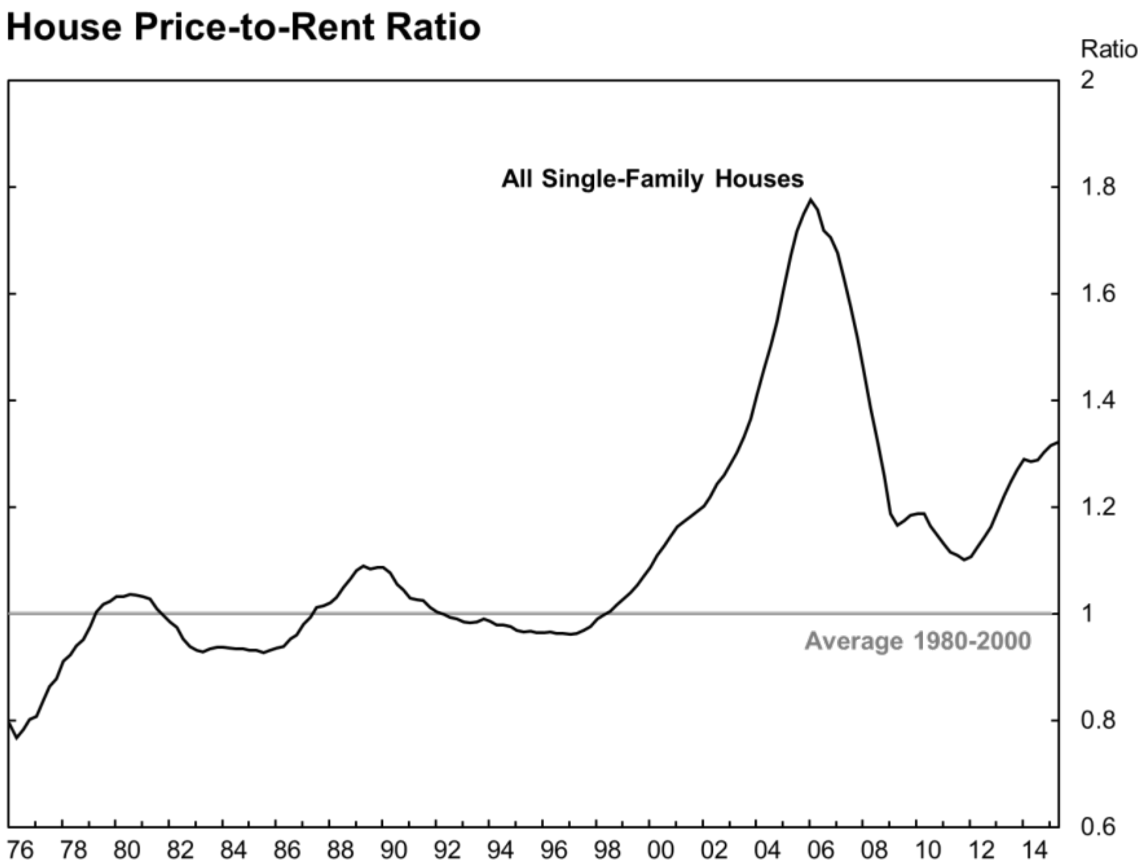
12 See Williams (2015) for further discussion.

Estimated effects of monetary policy shock Graph 1



Note: Pooled estimates across 17 countries, based on data update to Jordà, Schularick and Taylor (2015a). Sample: annual data from 1870–2013, excluding the interwar period (1914–45) and the oil crises period (1973–80).

US house price booms and busts | Graph 2



Note: Ratio of CoreLogic single-family house price index and owner-equivalent rent component of the price index for personal consumption expenditures, scaled to equal one at average value over 1980–2000.

Estimated effects of 1 percentage point monetary policy shock after two years — Table 1

Source	Number of countries	House Prices	Economic Activity	Ratio
BASELINE ESTIMATES (BASED ON JORDÀ, SCHULARICK AND TAYLOR)				
Full sample	17	–6.3	–1.9	3.3
Postwar sample	17	–8.2	–1.4	5.7
INTERNATIONAL EVIDENCE				
Sá, Towbin and Wieladek	18	–7.8	–7.6	1.0
Assenmacher-Wesche and Gerlach	17	–10.8	–3.0	3.6
Goodhart and Hofmann	17	–7.2	–1.7	4.2
Iacoviello and Minetti	4	–8.8	–2.1	4.2
Calza, Monacelli and Stracca	19	–2.3	–0.3	7.9
US EVIDENCE				
Fratantoni and Schuh		–1.7	–2.1	0.8
Ungerer		–7.2	–9.3	0.8
Otrok and Terrones		–5.7	–1.9	2.9
Jarocinski and Smets		–7.8	–1.3	6.0
Del Negro and Otrok		–10.4	–0.9	12.0
Median				3.9

Notes: Responses reported as percent change two years after the shock. Economic activity measured as real GDP except for the following: Otrok and Terrones [global GDP]; Sá, Towbin and Wieladek and Calza, Monacelli and Stracca [private consumption]; Ungerer [industrial production]; Fratantoni, and Schuh [real non-housing GDP]; and Jordá, Schularick and Taylor [real GDP per capita].

References

Assenmacher-Wesche, K and S Gerlach (2008): "Financial structure and the impact of monetary policy on asset prices", Swiss National Bank, Working Paper, no 2008-16, http://www.snb.ch/n/mmr/reference/working_paper_2008_16/source/working_paper_2008_16.n.pdf.

Calza, A, T Monacelli and L Stracca (2013): "Housing finance and monetary policy", *Journal of the European Economic Association*, no 11, pp 101–22.

Del Negro, M and C Otrok (2007): "99 Luftballons: monetary policy and the house price boom across U.S. states", *Journal of Monetary Economics*, vol 54, no 7, October, pp 1962–85.

Dokko, J, B Doyle, M Kiley, J Kim, S Sherlund, J Sim and S Van den Heuvel (2009): "Monetary policy and the housing bubble", *Finance and Economics Discussion Series*, no 2009-49, Board of Governors of the Federal Reserve System, www.federalreserve.gov/pubs/feds/2009/200949/200949pap.pdf.

Fratantoni, M and S Schuh (2003): "Monetary policy, housing, and heterogeneous regional markets", *Journal of Money, Credit, and Banking*, vol 35, no 4, pp 557–89.

Goodhart, C and B Hofmann (2008): "House prices, money, credit, and the macroeconomy", *Oxford Review of Economic Policy*, vol 24, no 1, pp 180–205.

Iacoviello, M and R Minetti (2008): "The credit channel of monetary policy: evidence from the housing market", *Journal of Macroeconomics*, vol 30, no 1, pp 69–96.

Jarocinski, M and F Smets (2008): "House prices and the stance of monetary policy", *Federal Reserve Bank of St. Louis Review*, vol 90, no 4, July/August, pp 339–65, https://research.stlouisfed.org/publications/review/08/07/Jarocinski.pdf.

Jordà, Ò, M Schularick and A Taylor (2014): "The great mortgaging: housing finance, crises, and business cycles", Federal Reserve Bank of San Francisco, Working Paper, no 2014-23, September, www.frbsf.org/economic-research/publications/working-papers/wp2014-23.pdf.

——— (2015a): "Betting the house", *Journal of International Economics*, vol 96, no 1, pp 2−18.

——— (2015b): "Interest rates and house prices: pill or poison?", *Federal Reserve Bank of San Francisco Economic Letter*, no 2015-25, August, www.frbsf.org/economic-research/publications/economic-letter/2015/august/interest-rates-and-house-prices-central-bank-goals/.

Kuttner, K (2012): "Low interest rates and housing bubbles: still no smoking gun", Williams College Department of Economics, Working Paper, no 2012-01, web.williams.edu/Economics/wp/Kuttner-smoking-gun.pdf.

Mian, A and A Sufi (2014): *House of Debt*, University of Chicago Press.

Otrok, C and M Terrones (2005): "House prices, interest rates, and macroeconomic fluctuations: international evidence", conference paper, Federal Reserve Bank of Atlanta, www.frbatlanta.org/news/conferen/housing 2005/otrok_terrones.pdf.

Sá, F, P Towbin and T Wieladek (2011): "Low interest rates and housing booms: the role of capital inflows, monetary policy, and financial innovation", *Globalization and*

Monetary Policy Institute Working Paper, no 79, Federal Reserve Bank of Dallas. https://www.dallasfed.org/assets/documents/institute/ wpapers/2011/0079.pdf.

Svensson, L (2014): "Inflation targeting and 'leaning against the wind'", *International Journal of Central Banking*, vol 10, no 2, June, pp 103–14, www.ijcb.org/journal/ijcb14q2a5.htm.

Ungerer, C (2015): "Monetary policy, hot housing markets, and leverage", Board of Governors of the Federal Reserve System, *Finance and Economics Discussion Series*, no 2015-048, dx.doi.org/10.17016/FEDS.2015.048.

Williams, J (2015): "Macroprudential policy in a microprudential world", *Federal Reserve Bank of San Francisco Economic Letter*, no 2015-18, June, www.frbsf.org/economic-research/publications/economic-letter/2015/june/macroprudential-policy-in-a-microprudential-world/.

Yellen, J (2014): "Monetary policy and financial stability", speech at the 2014 Michel Camdessus Central Banking Lecture, International Monetary Fund, Washington DC, July 2, www.federalreserve.gov/newsevents/speech/yellen 20140702a.htm.

Maintaining price and financial stability by monetary and macroprudential policy – evidence from Asia and the Pacific

Soyoung Kim[1] and Aaron Mehrotra[2]

Abstract

The Great Financial Crisis of 2008–09 led many central banks to adopt explicit financial stability objectives. This raises the question of how central banks deal with the policy trade-offs resulting from potential conflicts between price and financial stability objectives. This paper presents some results from ongoing research investigating this issue for inflation targeting central banks in the Asia-Pacific region (Kim and Mehrotra (2015), (2016a) and (2016b)). We show that macroprudential policies to safeguard financial stability have also had a significant impact on inflation, potentially creating challenges for policymakers given the frequency of episodes during which low inflation has coincided with buoyant credit growth.

JEL classification: E58; E61.

Keywords: multiple objectives, financial stability, price stability, macroprudential instruments, monetary policy.

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1. Introduction

The Great Financial Crisis (GFC) of 2008–09 provided a stark reminder that price stability is not sufficient to guarantee financial stability, leading many central banks to adopt explicit financial stability objectives or make changes to existing arrangements. This does not imply that financial stability objectives are new. Monetary authorities have arguably aimed at safeguarding financial stability even before they were mandated to do so by laws or statutes. In fact, a stronger focus on financial stability brought central banks closer to their 19th and 20th century roots in preventing and alleviating financial sector distress.[3] But explicit financial stability objectives raise a number of pertinent issues for policymakers, including in the areas of governance, accountability and policy objectives, as highlighted by a central bank study group chaired by Stefan Ingves (BIS (2011)).

For the 12 central banks in the Asia-Pacific region that are members of the BIS,[4] 10 have explicit financial stability objectives written in laws or statutes (Jeanneau (2014)). The adoption of financial stability objectives, coupled with the well established goal of price stability for the region's central banks (Filardo and Genberg (2010)), raises the question of how central banks would deal with policy trade-offs that may arise from a conflict between the objectives of price and financial stability. One potential trade-off results from the use of macroprudential policies to safeguard financial stability. As noted in BIS (2015), macroprudential policies can lead to a reallocation of spending over time by influencing the availability and cost of credit. Thus, it cannot be ruled out that macroprudential policies have aggregate demand effects, beyond their immediate impact on financial stability.

As part of our ongoing research programme, we examine empirically how inflation targeting central banks in the Asia-Pacific region have managed the objectives of price and financial stability (Kim and Mehrotra (2015), (2016a) and (2016b)). The focus is on identifying policy trade-offs and interactions that may have arisen over time. The analysis is done by means of structural vector autoregressions (SVARs) that identify both monetary and macroprudential policy shocks and allow for interactions between policies and the assumed target variables. The central bank's financial stability objective is defined as one of keeping credit relative to output below a "safe" threshold.

We find that, while macroprudential policies do indeed affect credit growth, they have also had an economically and statistically significant impact on inflation. Tighter macroprudential policies have contributed at times to disinflationary pressures, including in periods during which inflation has been below target. Similarly, expansionary macroprudential shocks have contributed occasionally to above-target inflation. We also find that changes in interest rates affect credit growth, and the relative responses of credit and prices to interest rate policy shocks appear to be similar to their relative response to macroprudential policy shocks.

Our results thus suggest that – ex post – there may have been short-term policy trade-offs for central banks between financial stability and price stability objectives.

3 See Williams (2014).

4 These 12 economies are Australia, China, Hong Kong SAR, India, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore and Thailand.

Such trade-offs may not arise if higher inflation pressures coincide with strong credit growth, as we find that monetary policy and macroprudential policy shocks have similar impacts on credit and the price level. They may also be less of a concern if the central bank's price stability objective does not strongly focus on short-term inflation stabilisation.[5] However, greater challenges could arise if a central bank focused on stabilising short-run inflation dynamics at times when inflation was low but credit growth was strong. Recent developments bear evidence on the empirical relevance of policy trade-offs, as low inflation has frequently coincided with strong growth in credit and asset prices (BIS (2015)).[6]

A caveat worth bearing in mind is that the results we obtained are conditional on the types of policy action undertaken and the intensity of these measures in the economies under study. It is plausible that the effects of macroprudential measures on the real economy are strong only if they are used with sufficient intensity. The impact on the real economy will also depend on the types of measure undertaken.

This paper motivates and describes our research work on the topic. Section 2 provides a review of some of the related literature, focusing on the existing research on the various objectives of central banks. Section 3 reviews the objectives and instruments of Asia-Pacific central banks related to price and financial stability, and discusses their counterparts in our estimated model. Section 4 presents selected empirical results and Section 5 concludes.

2. Related literature

The literature on multiple central bank objectives has traditionally focused on the role of output stabilisation in monetary policy. Even as price stability has become the cornerstone of most central banks' policy frameworks, empirical evidence suggests that real economy considerations have been important in practice. One of the most explicit cases is the United States, with the Federal Reserve's mandate of maximum employment and stable prices being enshrined in the Federal Reserve Reform Act of 1977.[7] But a similar observation also holds for central banks that explicitly pursue inflation targeting. Their price stability objective is often stated as a medium-term goal, thus recognising the importance of stabilising real economic activity in the short run (Svensson (1999)).

Regarding the long-run trade-off between the levels of output and inflation, it is generally thought to be limited, at least for moderate and positive levels of inflation. If policymakers attempt to stimulate output by increasing the rate of inflation, inflation expectations and wage setting will eventually adjust in an upward direction, with no permanent decrease in the unemployment rate or upward shift in long-term

5 While we find that macroprudential policies affect both credit growth and inflation, we do not investigate whether measures taken against the build-up of financial imbalances reduce the volatility of inflation over long horizons. Arguably, central banks also need to weigh the risks of future inflation and output volatility that could potentially arise from financial distress against the shorter-term costs of reacting to current financial imbalances. See also BIS (2015).

6 Many central banks have highlighted the policy trade-offs involved in countering disinflationary pressures and containing increases in household indebtedness and property prices. See Bank of Korea (2015), Central Bank of Norway (2014) and Sveriges Riksbank (2014).

7 The Federal Reserve also has an objective of moderate long-term interest rates.

growth. But policymakers may still face a choice between stabilising the variance of output and inflation in the short run. Consider a positive disturbance to inflation expectations. If policymakers react strongly to such a shock by increasing interest rates, inflation variability will be smaller but output variability will be larger around its trend (Walsh (1998)). An optimal policy frontier can be computed, representing the best attainable outcomes for the policymaker in terms of inflation and output variability (Fuhrer (1997)). In forward-looking New Keynesian models, there need not be a conflict between stabilising both the output gap and inflation, but this "divine coincidence" is dependent on various assumptions about the economy (Blanchard and Gali (2007)).

Even with the documented policy trade-offs, the primacy of price stability typically prevails in analytical frameworks. Woodford (2003) shows that when monetary policy is conducted so as to maximise the welfare of the population, output stabilisation typically obtains a small weight relative to inflation.[8] Another reason to focus on price stability stems from uncertainty regarding the degree of economic slack, especially in real time. Orphanides (2004) shows that, if estimates of the output gap at times of policy decisions are erroneous, even a forward-looking approach to monetary policy could result in macroeconomic instability. And when there is considerable uncertainty about the economy, a high weight on real economic activity can lead to poor outcomes. Welfare is improved by policies emphasising inflation control and communication about the explicit inflation target (Orphanides and Williams (2005)). Yet another factor works through the credibility of the anti-inflationary policy of the central bank. If economic agents think that the central bank cares about output stabilisation, this may lead to greater increases in wages and prices in the expectation that the central bank will accommodate such increases, worsening the inflation/output trade-off (Chari et al (1998) and Mishkin (2002)).

The GFC stimulated research incorporating financial stability objectives in macroeconomic models with monetary policy. Woodford (2012) argues for a central bank loss function that includes inflation, the output gap and a measure of financial stability. When the risk of a financial crisis is elevated, the monetary authority should tighten policy even if prices and/or output undershoot the levels that would have otherwise prevailed. Thus, policy should lean against a credit boom or other manifestations of financial imbalances.[9] Better outcomes can be achieved for both macroeconomic and financial stability if an additional instrument exists to counter financial risks. Theoretically, and in line with the Tinbergen principle, the assignment of separate policy instruments to their respective price and financial stability targets could allow for interventions in opposite directions when required to achieve both objectives (Cesa-Bianchi and Rebucci (2013)).[10]

But, in practice, complications are likely to arise due to policy interactions. Monetary and macroprudential policies can enhance or diminish each other's effectiveness (Claessens (2013)). As an example, monetary policy affects incentives for private sector risk-taking and thus financial stability (Borio and Zhu (2012)). Jordà et

[8] See, however, Debortoli et al (2015).

[9] In contrast, Svensson (2010) argues that the impact of policy rates on financial stability is small but that the impact on resource utilisation and inflation is large, implying that it is costly to use policy rates to safeguard financial stability.

[10] See Angelini et al (2014), and Gelain and Ilbas (2014) for examples of DSGE models incorporating both macroprudential and monetary policies.

al (2015) use a large data set to document how loose monetary conditions have historically boosted real estate lending and house price bubbles, especially in the postwar period. Shin (2015) argues that changes to debt-to-income or loan-to-value ratios work through similar mechanisms as monetary policy, by bringing spending forward or postponing it, thus affecting credit growth and aggregate demand. Bruno et al (2015) show that monetary and macroprudential tools work as complements, with a positive correlation observed between changes in the two instruments' settings in the Asia-Pacific region. At the same time, policy interactions and effectiveness may vary over time. Hofmann and Peersman (2015) document that the impact of monetary policy shocks on credit and house prices in the United States has increased over time, making a policy of leaning against the wind now more potent than in the past.

3. Financial stability objectives and instruments

Formal objectives in the Asia-Pacific region

The GFC provided further impetus to the adoption of financial stability objectives by central banks. In some cases, it triggered changes in existing objectives. Based on a review of 114 central bank laws and statutes, 82% of central banks had explicit financial stability objectives in 2014 (Jeanneau (2014)). Table 1 lists the economies where monetary authorities have such objectives in the Asia-Pacific region.

Central banks in the region differ regarding the scope of activities that the financial stability objective applies to. For seven institutions, the objective appears to pertain to all of the central bank's activities and functions. For three others, a specific function or task is mentioned: payment system stability (Australia); settlement of funds among financial institutions and lender of last resort function (Japan); and monetary and credit policies (Korea). Yet, even within these activities, the objectives state that overall financial stability or financial system stability should be "contributed to" (Australia); "maintained" (Japan); or "paid attention to" (Korea), thus indicating rather broad objectives.

Financial stability objectives in laws or statutes in the Asia-Pacific region — Table 1

Objective appears to apply in principle to all the central bank's activities and functions			
China	Hong Kong SAR	Indonesia	Malaysia
New Zealand	Singapore	Thailand	
Objective is attached to a specific function or task			
Australia	Japan	Korea	

Sources: Jeanneau (2014); central bank websites, BIS.

The financial stability goals just discussed have been adopted alongside more conventional monetary policy objectives (Table 2). Eight out of 12 Asia-Pacific central banks are formally pursuing inflation targeting or follow a regime with an explicitly defined price stability target, whereas two base their policies on exchange rate anchors. Two central banks have no explicitly stated targeting regime, either in terms of inflation or the exchange rate. However, even for the non-inflation targeters, price stability typically plays a major role in policy. In Singapore, the exchange rate is an intermediate target, and the primary objective of monetary policy is the promotion of price stability. Stability of the value of the currency (China) and monetary stability (Malaysia) can also be interpreted as emphasising the importance of price stability (Filardo and Genberg (2010)).

Given the existence of multiple objectives, a relevant issue for policy trade-offs relates to the ranking of the different objectives. In the case of New Zealand, for example, financial stability is explicitly subordinated to the primary objective of price stability.[11] However, for most economies the law is silent on the relative ranking of objectives. The case of Malaysia is noteworthy in that the financial stability objective ranks equally with monetary stability, with the law granting the Central Bank of Malaysia wide-ranging powers to intervene in the financial system to promote financial stability.[12]

Monetary policy frameworks in the Asia-Pacific region — Table 2

Inflation targeting framework or similar	Exchange rate anchor	Other regimes[1]
Australia	Hong Kong SAR (US dollar)	China
India	Singapore (composite)	Malaysia
Indonesia		
Japan[2]		
Korea		
New Zealand		
Philippines		
Thailand		

[1] Includes countries that have no explicitly stated targeting regime either in terms of inflation or the exchange rate. [2] Japan is not formally an inflation targeter but follows a monetary policy regime with a "price stability target" of 2%.

Source: Central bank websites.

Of course, even when no explicit objective is mentioned in law, central banks can have financial stability as an implicit objective and may even have in place a formal financial stability policy framework. Ravalo (2013) mentions that, while financial stability is not explicitly mentioned in the charter of Bangko Sentral ng Pilipinas, the Financial Stability Committee was created as an internal body to address the potential build-up of systemic pressures.

[11] The Reserve Bank of New Zealand Act 1989 states that "The primary function of the Bank is to formulate and implement monetary policy directed to the economic objective of achieving and maintaining stability in the general level of prices" and that "In formulating and implementing monetary policy the Bank shall have regard to the efficiency and soundness of the financial system" (Sections 1A and 10, respectively).

[12] The Central Bank of Malaysia Act 2009 states that "The principal objects of the Bank shall be to promote monetary stability and financial stability conducive to the sustainable growth of the Malaysian economy" (Section 5). See also Caruana (2014).

Financial stability objectives and instruments in the model

In Kim and Mehrotra (2015) and (2016b), we use a leverage-based measure of financial stability, constructed using the total amount of credit extended to the private sector. In particular, we use a measure of the total credit-to-GDP gap that captures the deviation of total credit-to-GDP from its long-run trend. Previous research has demonstrated the favourable performance of the credit-to-GDP gap as an early warning indicator of banking system distress (see Borio and Lowe (2002), and Borio and Drehmann (2009)).[13] It has been adopted as a reference point for the use of countercyclical capital buffers under the Basel III framework (BCBS (2010), and Drehmann and Tsatsaronis (2014)).

We include macroprudential policies in our model as the primary tool for achieving financial stability. This reflects their widespread adoption to mitigate systemic financial risks. As a source of data for macroprudential policy measures, we use the database for policy actions on housing markets set up by Shim et al (2013), which includes both non-interest rate monetary policy measures and prudential tools. The monetary policy measures – ie reserve requirements, credit growth limits and liquidity requirements – affect the amount of funds that are available for lending to the private sector. The prudential tools – ie maximum loan-to-value ratio, maximum debt-service-to-income ratio, risk weights on housing loans and loan-loss provisioning on housing loans – are used by the authorities to target credit to housing.

Measures of macroprudential policy actions are included in our estimated model as an index, accumulated over time. Thus, a macroprudential policy tightening (loosening), regardless of the type of measure undertaken or its intensity, will increase (decrease) the level of the index by one unit, with the new value maintained until another policy action is taken. Owing to such a definition of the index, the effects of policies in our empirical framework should be interpreted as average responses to the various policy actions, acknowledging that there may be considerable uncertainty with respect to the impact of individual measures. However, as shown in Kim and Mehrotra (2015) and (2016a), we also experiment with an alternative macroprudential index using a different source of macroprudential policies[14] (while applying an identical methodology to construct the index) and find that the results are similar.

4. Empirical evidence

The model

In Kim and Mehrotra (2015), (2016a) and (2016b), we construct an SVAR model to identify monetary and macroprudential policy actions, analyse interactions between

[13] In emerging market economies undergoing rapid transformation, credit gaps may be affected by structural changes such as financial deepening. Although evidence suggests that credit gaps are relevant indicators for such economies as well (Drehmann and Tsatsaronis (2014)), it is also argued that vulnerabilities should not be assessed by relying solely on a mechanical rule.

[14] Our alternative source of macroprudential policies is Lim et al (2013).

policies and policy trade-offs, and examine the effects of interest rate and macroprudential policy actions on price and financial stability.

The model comprises five endogenous variables, including two policy instruments: the interest rate (*R*) and the measure of macroprudential policy (*PP*) from Shim et al (2013). The consumer price index (*CPI*) is used as the target variable for monetary policy and total credit to the private sector (*CRD*) as the target for macroprudential policy. Real GDP (*RGDP*) captures economic activity. Following Sims (1980), a recursive structure on contemporaneous structural parameters is assumed. The three macroeconomic variables (*CPI*, *RGDP* and *CRD*) are contemporaneously exogenous to the two policy instruments. Most of our results are based on panel VAR models (Kim and Mehrotra (2015) and (2016a)) but we also estimate VAR models for individual economies (Kim and Mehrotra (2015)).

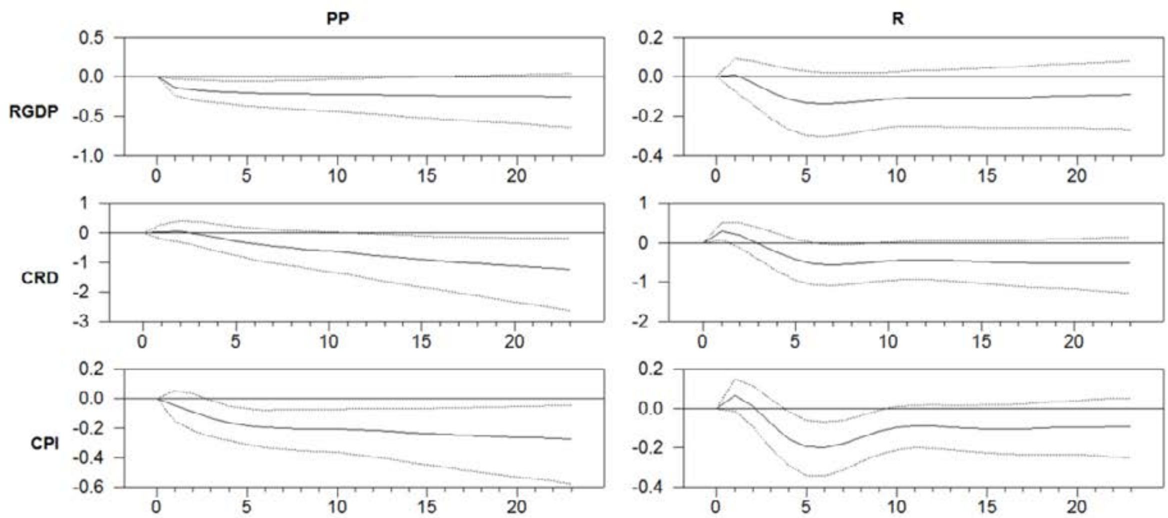
Our sample includes Australia, Indonesia, Korea and Thailand. The estimations are performed using quarterly data.[15]

Selected results from SVARs

Selected impulse responses from the panel SVAR are shown in Graph 1. The first column shows the responses of real GDP, credit growth and consumer prices to a macroprudential policy shock while the second one shows the responses of the same variables to an interest rate shock. Both policy shocks are contractionary and result in

Selected impulse responses from panel SVAR model

Graph 1



Note: The column headings denote the relevant shocks and the row headings the responses of the indicated variable to each shock. *RGDP* = real GDP, *CRD* = total credit, *CPI* = consumer price index, *PP* = macroprudential policy measure and *R* = policy interest rate. For example, the impulse response in the first row, second column, shows the response of real GDP to an interest rate shock.

Source: Authors' calculations.

[15] See Kim and Mehrotra (2015) for details on the estimation.

a statistically significant fall in prices and credit.[16] The response to macroprudential policies is notable. A tightening in such policies also has a significantly negative impact on real GDP. In Kim and Mehrotra (2015), we document how periods of inflation below or within the central bank's target have often coincided with buoyant credit, as measured by the credit-to-GDP gap, in inflation targeting economies of the Asia-Pacific region. Tighter macroprudential policies to stem credit growth during such periods could then risk pushing inflation (further) below target.

We apply an historical decomposition to investigate the role of policy shocks in explaining the dynamics of the target variables at different points in time (Kim and Mehrotra (2015) and (2016b)). We are particularly interested in finding episodes where monetary policy shocks may have added to financial stability risks – defined here as excessive growth in credit – or when macroprudential policy actions may have negatively affected price stability in the short run – so that inflation was pushed away from target. For instance, in the second case, we identify the quarters during which inflation was off-target and analyse the historical decomposition of consumer prices to infer how macroprudential shocks contributed to price dynamics during those periods. Doing so, we unveil some episodes where macroprudential policy shocks indeed contributed to the deviation of inflation from the target.

We also consider the behaviour of inflation expectations during such episodes (Kim and Mehrotra (2015)). Arguably, deviations of inflation from target may be less worrisome if inflation is expected to move back to target quickly. In such a case, even if inflation was currently away from target, the central bank may have been able to use monetary tools to counter financial imbalances. Alternatively, it could let regulatory authorities undertake prudential measures without a counteracting interest rate response, as long as expected inflation remains on target. Using Consensus Forecasts, we show that macroprudential policy actions have at times pushed inflation further away from the target when near-term inflation expectations were also deviating from the target. Finally, we show results related to the contribution of monetary policy shocks to credit growth during periods when the credit gap is signalling risks to financial stability.

5. Conclusion

Central banks have increasingly adopted explicit financial stability objectives, often in the context of well-established price stability mandates. In ongoing work (Kim and Mehrotra (2015), (2016a) and (2016b)), we analyse the trade-offs and interactions between price and financial stability policies in the Asia-Pacific region, where the authorities of many economies have used macroprudential instruments with the aim of safeguarding financial stability. The empirical analysis is done by means of structural vector autoregressions that identify both interest rate and macroprudential policy shocks. The financial stability objective for the central bank is assumed to be one of containing credit within "safe" thresholds, drawing on the literature on early warning indicators of banking system distress.

[16] See Zdzienicka et al (2015) for a recent analytical comparison of the impact of monetary and macroprudential policies on financial conditions in the United States.

We find that, while macroprudential policies do indeed affect credit growth, they have also had an economically and statistically significant impact on inflation, with tighter macroprudential policies contributing to disinflationary pressures. The estimated model dynamics suggest that macroprudential and monetary policies work through related channels, affecting aggregate demand. The results could also indicate potential policy challenges when low inflation coincides with buoyant credit growth.

Our ongoing research should be seen as one of the first steps in a broader research agenda to quantify the macroeconomic effects of macroprudential policy and investigate its interaction with monetary policy. Future research on the interaction between macroprudential and monetary policies may usefully consider differentiating between the various measures of macroprudential policy; analysing a larger sample of economies; and shedding more light on the systematic part of macroprudential policy.

References

Angelini, P, S Neri and F Panetta (2014): "The interaction between capital requirements and monetary policy", *Journal of Money, Credit and Banking*, vol 46, no 6, pp 1073–112.

Bank for International Settlements (2011): *Central bank governance and financial stability*, a report from a Study Group of the Central Bank Governance Group.

——— (2015): *85th Annual Report*.

Bank of Korea (2015): *Monetary Policy Report*, April.

Basel Committee on Banking Supervision (2010): *Guidance for national authorities operating the countercyclical capital buffer*, December.

Blanchard, O and J Gali (2007): "Real wage rigidities and the New Keynesian model", *Journal of Money, Credit and Banking*, vol 39, no 1, pp 35–65.

Borio, C and M Drehmann (2009): "Assessing the risk of banking crises – revisited", *BIS Quarterly Review*, March, pp 29–46.

Borio, C and P Lowe (2002): "Assessing the risk of banking crises", *BIS Quarterly Review*, December, pp 43–54.

Borio, C and H Zhu (2012): "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?", *Journal of Financial Stability*, vol 8, no 4, pp 236–51.

Bruno, V, I Shim and H S Shin (2015): "Comparative assessment of macroprudential policies", *BIS Working Papers*, no 502.

Caruana, J (2014): "Redesigning the central bank for financial stability responsibilities", Speech at the 135th Anniversary Conference of the Bulgarian National Bank, Sofia, 6 June.

Central Bank of Norway (2014): *Monetary Policy Report*, no 1/14.

Cesa-Bianchi, A and A Rebucci (2013): "Does easing monetary policy increase financial instability", *IADB Working Paper Series,* no IADB-WP-387.

Chari, V, L Christiano and M Eichenbaum (1998): "Expectation traps and discretion", *Journal of Economic Theory*, vol 81, no 2, pp 462–92.

Claessens, S (2013): "Interactions between monetary and macroprudential policies in an interconnected world", paper prepared for the Bank of Thailand-IMF conference on Monetary Policy in an Interconnected World, Bangkok, 31 October–2 November 2013.

Debortoli, D, J Kim, J Lindé and R Nunes (2015): "Designing a simple loss function for the Fed: does the dual mandate make sense", *Federal Reserve Bank of Boston Working Papers*, no 15-3.

Drehmann, M and K Tsatsaronis (2014): "The credit-to-GDP gap and countercyclical capital buffers: questions and answers", *BIS Quarterly Review*, March, pp 55–73.

Filardo, A and H Genberg (2010): "Targeting inflation in Asia and the Pacific: lessons from the recent past", *BIS Papers*, no 52, pp 251–73.

Fuhrer, J (1997): "Inflation/output variance trade-offs and optimal monetary policy", *Journal of Money, Credit and Banking*, vol 29, no 2, pp 214–34.

Gelain, P and P Ilbas (2014): "Monetary and macroprudential policies in an estimated model with financial intermediation", *National Bank of Belgium Working Paper*, no 258.

Hofmann, B and G Peersman (2015): "Revisiting the US monetary transmission mechanism", mimeo.

Jeanneau, S (2014): "Financial stability objectives and arrangements – what's new?", *BIS Papers*, no 76, pp 47–58.

Jordà, O, M Schularick and A Taylor (2015): "Betting the house", *Journal of International Economics*, forthcoming.

Kim, S and A Mehrotra (2015): "Managing price and financial stability objectives – what can we learn from the Asia-Pacific region?", *BIS Working Papers*, no 533.

——— (2016a): "Effects of monetary and macroprudential policies – evidence from four inflation targeting economies", mimeo.

——— (2016b): "Managing price and financial stability objectives in inflation targeting economies in Asia and the Pacific", mimeo.

Lim, C, I Krznar, F Lipinsky, A Otani and X Wu (2013): "The macroprudential framework: policy responsiveness and institutional arrangements", *IMF Working Papers*, no WP/13/166.

Mishkin, F (2002): "The role of output stabilization in the conduct of monetary policy", *International Finance*, vol 5, no 2, pp 213–27.

Orphanides, A (2004): "Monetary policy rules, macroeconomic stability, and inflation: a view from the trenches", *Journal of Money, Credit and Banking*, vol 36, no 2, pp 151-75.

Orphanides, A and J Williams (2005): "Imperfect knowledge, inflation expectations and monetary policy", in B Bernanke and M Woodford (eds), *The Inflation Targeting Debate*, pp 201–34.

Ravalo, J (2013): "Challenges of executing a financial stability policy objective at the Central Bank of the Philippines", in *Macroprudential Frameworks in Asia*, edited by R Maino and S Barnett, pp 6–16.

Shim, I, B Bogdanova, J Shek and A Subelyte (2013): "Database for policy actions on housing markets", *BIS Quarterly Review*, September, pp 83–95.

Shin, H S (2015): "Macroprudential tools, their limits and their connection with monetary policy", panel remarks at IMF Spring Meeting: Rethinking macro policy III: progress or confusion?, Washington DC, 15 April.

Sims, C (1980): "Macroeconomics and reality", *Econometrica*, vol 48, no 1, pp 1–48.

Svensson, L (1999): "Inflation targeting: some extensions", *Scandinavian Journal of Economics*, vol 101, no 3, pp 337–61.

Svensson, L (2010): "Inflation targeting" in B Friedman and M Woodford (eds), *Handbook of Monetary Economics*, vol 3, pp 1237–302.

Sveriges Riksbank (2014): "Repo rate cut by half a percentage point to 0.25 per cent", press release, 3 July.

Walsh, C (1998): "The new output-inflation trade-off", *FRBSF Economic Letters*, no 04, 6 February.

Williams, J (2014): "Financial stability and monetary policy: happy marriage or untenable union?", presentation to the Deutsche Bundesbank Conference on Housing Markets and the Macroeconomy: Challenges for Monetary Policy and Financial Stability, Eltville am Rhein, 5 June.

Woodford, M (2003): *Interest and prices*.

——— (2012): "Inflation targeting and financial stability", *NBER Working Papers*, no 17967.

Zdzienicka, A, S Chen, F Diaz Kalan, S Laseen and K Svirydzenka (2015): "Effects of monetary and macroprudential policies on financial conditions: evidence from the United States", *IMF Working Papers*, no 15/288.

Comments on "Maintaining price and financial stability by monetary and macroprudential policy – evidence from Asia and the Pacific"

Kazuo Momma[1]

(Slide 1)

1. First of all, I would like to express my gratitude to Bank Indonesia and BIS for inviting me to this great conference and I am honoured to have an opportunity to discuss an excellent paper by Soyoung and Aaron.

2. I would like to comment on the paper from the viewpoints of its motivation, analysis and its implications, in that order.

(Slide 2)

1. The motivation of this paper is straightforward. The global financial crisis has made us strongly aware of the importance of financial stability and therefore macroprudential policy. Thus, first of all, it is essential to know that macroprudential policy is effective in delivering financial stability in the first place. Second, we need to know if macroprudential policy has implications for price stability as well, because, if this is the case, monetary policy would be affected one way or the other. This issue immediately raises the question on the opposite causality: whether or not a feedback from monetary policy to financial stability may also exist. Putting them together, what we want to know is whether we have to recognise what may be called cross-spillover effects between macroprudential policy and monetary policy. And, if we do, a very critical question that immediately follows is how strong those cross-spillovers are. In other words, are macroprudential and monetary policies perfect substitutes or are they still sufficiently independent of each other that they can be regarded as two different sets of policies? As long as they are sufficiently independent, cross-spillovers may not be so problematic, at least in theory. I will come back to this very important point in a minute. In the meantime, I want to point out that the third motivation of this paper is to discuss all of the above in the Asia-Pacific context.

2. I think these motivations are all well founded. Before, turning to further discussion, let me make sure that we have broadly common understandings on the reasons behind the importance of financial stability.

(Slide 3)

1. First, we had a number of lessons, including the period leading up to the 2008 Global Financial Crisis, which made us believe that a financial bubble tends to grow when price stability is maintained. Second, if not a financial bubble, disproportionate risk-taking in the financial sector compared with real economic activity has been widely observed in many countries in recent years under current extremely accommodative global monetary conditions. Third, in particular from the emerging market economies' perspective, the effects of monetary policy spillover from

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advanced economies may be successfully countered if measures other than interest rates are available in order to control domestic financial conditions.

(Slide 4)

1. Now let me turn to the issues regarding interaction or cross-spillover between financial stability instruments and price stability instruments. One important point is that they do not have to be completely independent to each other. Some cross-spillovers are fine. But they should not be perfect substitutes for each other, or even near-perfect in a practical sense, in order to keep the possibility alive that financial and price stability would be achieved at the same time. This is the prerequisite for the Tinbergen principle to work: you have two sufficiently independent instruments, and then you can achieve two objectives. If those two instruments are not sufficiently independent, however, some other policies, maybe fiscal and/or structural policies, would be called upon for the sake of financial or price stability.

2. Another very important issue in practical policy settings is, even if the Tinbergen principle works in theory, how to make it work in the real world through effective coordination between price stability policy and financial stability policy no matter whether it is within a central bank or between relevant authorities. But this institutional policy framework issue is out of the scope of this paper.

(Slide 5)

1. Now let me make some comments on the analysis. Generally speaking, I think that the method of the analysis and the data used for the analysis are quite sensible. Unfortunately, the number of countries examined here is limited to only four: Australia, Indonesia, Korea and Thailand. But this is not the authors' fault. This is simply due to data limitation. After all, macroprudence is relatively new area and there are always inherent challenges regarding data. Actually, it is encouraging that data collection efforts are ongoing and useful databases are increasingly available including the one on the policy actions on housing markets, which is used in this paper's analysis.

2. One possible way to circumvent the problem of data limitation is to broaden the geographical scope toward outside Asia, particularly some European countries. That way, we may also be able to get more useful insights with regard to similarities and differences between Asia-Pacific and Europe. If not by refinement of this paper itself, such an approach is worth exploring in some future similar works.

3. With regard to the analytical method including structural VARs, I think this is a fairly sensible approach when one wants to assess cross-spillovers of two different policies on their two different policy objectives. I also applaud the reasonably wide range of robustness testing that was done, which gives credibility to the empirical results.

(Slide 6)

1. Now let me turn to the implications. The broad results of the analysis seem to be fairly reasonable and encouraging. First, macroprudential measures have the intended effect on financial stability, at least qualitatively. So, they are effective. Second, there are some cross-spillovers between macroprudential and monetary policy but they are far from perfect substitutes. These results are quite encouraging because this theoretically implies that, with an optimal combination of macroprudential and monetary policies, we will be able to achieve financial stability and price stability at the same time. In other words, Tinbergen's principle is going to

work if we are doing it right. Suggesting this possibility based on empirical evidence is a very important contribution of this paper.

(Slide 7)

1. At the same time, however, some important questions remain unanswered once we start asking ourselves about how to apply these findings to actual policy decision makings.

2. First, it is worth exploring why, in the real world, there has been a bias towards low inflation and high credit growth in Asia-Pacific, despite the theoretical possibility of an optimal policy combination. In this regard, counterfactual analysis, based on the estimated VAR of this paper, to identify the optimal combination of macroprudential and monetary policies would be interesting. It is easy to expect that macroprudential policy should have been tighter and monetary policy should have been easier in a qualitative sense. But it would be interesting to know how far actual policies have been deviating from the optimal policy combination. This would be followed by the question why actual policy has deviated persistently from the optimal one. Is this because policy authorities simply didn't know the optimal policy parameters? Or is this because the optimal solution lies outside the range of feasible combination of two policies? Or is this because of lack of coordination, or other institutional failure?

(Slide 8)

1. The second issue I would like to raise is: is it appropriate to continue assigning the price stability mandate exclusively to the monetary policymaker? Given the finding that macroprudential policy and monetary policy have cross-spillover effects on their respective mandates, the logically appropriate mandate structure is that both macroprudential and monetary policy authorities should be jointly responsible for both financial and price stability. In this regard, everybody has recently been talking about the importance of the monetary policy authority taking into account financial stability. But discussion is scarce over whether the macroprudential authority should consider price stability. This asymmetry may be called into question. As a matter of fact, according to this paper, macroprudential policy contributes to CPI even more than monetary policy. The relative importance of macroprudential and monetary policy in their capacity to affect the inflation rate should be further explored, given its profound implications for the very notion that monetary policy is the best and the most powerful measure to control inflation and deflation. For example, this relative importance issue should be tested against wider historical or geographical samples and with more careful treatment of commodity prices, for example, and other global factors. The bottom line here, however, is that as long as macroprudential policy has some implication for price stability, responsibility and accountability for price stability may have to be borne by macroprudential and monetary policymakers jointly.

2. A quick counterargument may be that joint responsibility for price stability could complicate policy communications: simplicity is the king particularly in the context of anchoring inflation expectations. However, if cross-spillover effects are indeed significant, there is no such a thing as a simple and straightforward way to understand the policy transmission in the first place. This may be an inconvenient truth, but we cannot ignore this. Simple communication may not be useful anyway, if the real world is actually much more complex.

(Slide 9)

1. The third issue is about the assessment of trade-offs between financial stability and price stability. How much financial stability should we sacrifice for how much gain in

price stability, and vice versa? In other words, we need to know the loss function with regard to deviations from the two policy mandates. Without this, we would not be able to define an optimal combination of macroprudential and monetary policies in the first place. For example, a recent BIS paper (C Borio, M Erdem, A Filardo and B Hofmann, "The costs of deflations: a historical perspective", *BIS Quarterly Review*, March 2015) says that mild deflation, even for a relatively sustained period, is not very costly to the economy. If this is true, monetary authorities would be able to allow inflation to deviate downward rather substantially and even somewhat persistently if it is needed to ensure long-run financial stability. On the other hand, low inflation can be regarded as dangerous in the context of the zero lower bound of interest rates. If you emphasise this point, it would be better to avoid a lower-than-target inflation as far as financial stability risks are not imminent. This line of discussion ultimately comes down to the need to revisit the definition of price stability and financial stability.

(Slide 10)

1. Finally, I would like to raise one more issue, which is important in the context of US monetary policy normalisation.

2. In an environment where US monetary policy is being tightened, many emerging economies may have to tighten their own monetary policy to prevent excessive exchange rate depreciation and capital outflows, particularly where large external debt have been accumulated. This means that monetary policy is biased towards financial stability, possibly at the expense of an economic slowdown and thus downward pressure on inflation. In such circumstances, therefore, whether or not easier macroprudential measures can be used to offset disinflationary pressures would be critically important.

(Slide 11)

1. The bottom line is that this paper has made a great contribution to the identification of cross-spillover effects between financial stability policy and price stability policy based on Asian experience.

2. This great contribution makes us all the more aware that there remain many issues which need to be explored further by future research.

A comparison of liquidity management tools in seven Asian economies[1]

Ken Kuttner[2] and James Yetman[3]

Abstract

We develop a simple theoretical model and then use bank data from seven Asian economies to investigate the effects on bank lending of different liquidity management tools used by central banks. We find that hiking reserve requirements to sterilise foreign exchange purchases will retard bank lending growth more than the issuance of central bank bills does, and that smaller and weaker banks are affected disproportionately by changes in reserve requirements.

Keywords: Liquidity management, bank loan supply.

JEL classification: C23, E52, G21.

1 We benefited from comments by Dave Cook, Martin Bodenstein and conference participants at the BIS workshop and Bank Indonesia-BIS conference on "Expanding the boundaries of monetary policy in Asia and the Pacific" (in July 2014 and August 2015 respectively) and seminar participants at the Bank for International Settlements (Hong Kong SAR). The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank for International Settlements. Tracy Chan, Agne Subelyte and Steven Kong provided excellent research assistance.

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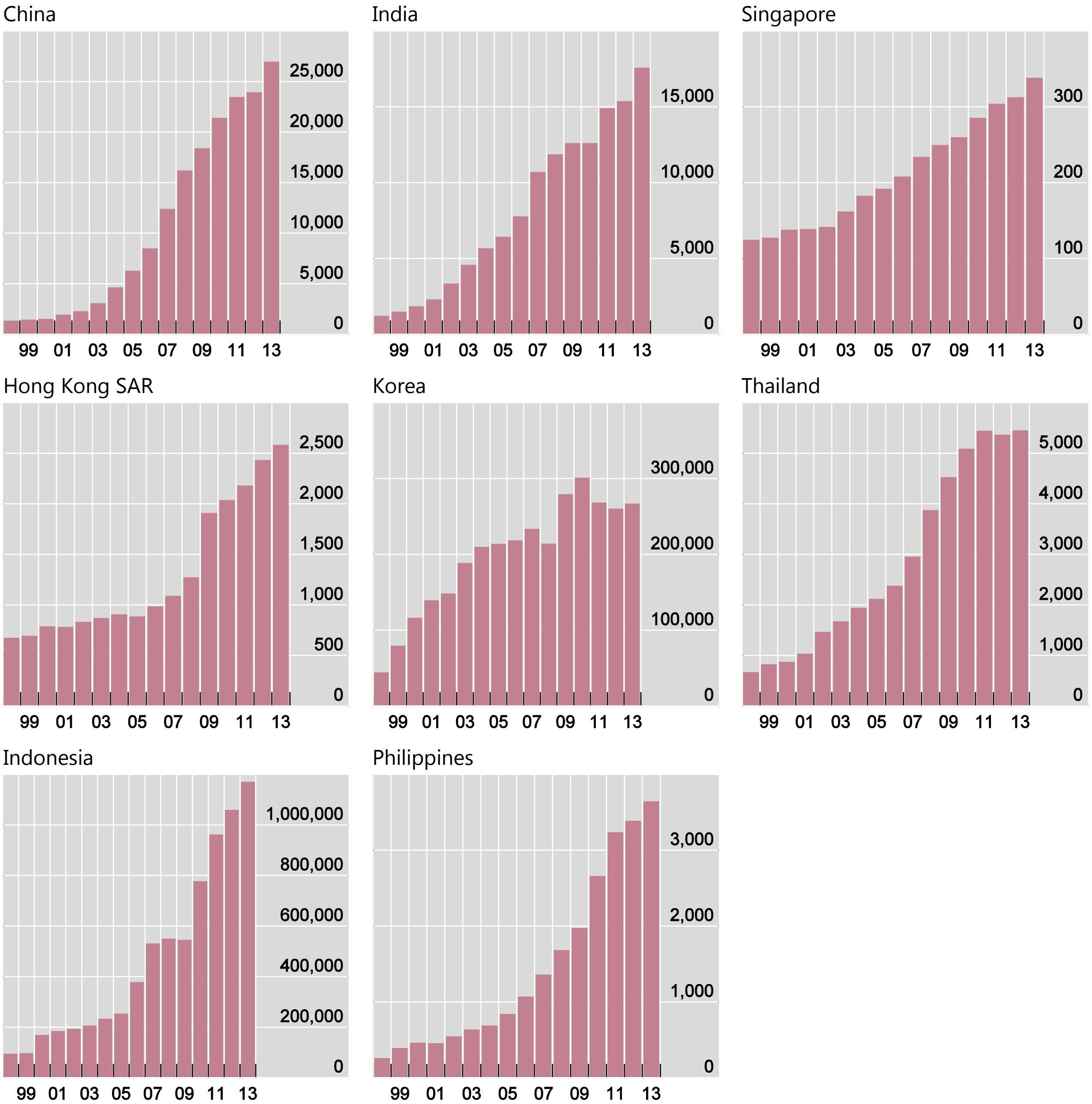
1. Introduction

Faced with sustained capital inflows in recent years, many Asian central banks have intervened heavily in foreign exchange markets to check the pressure on their currencies to appreciate. As a consequence, foreign exchange reserves have rapidly accumulated, as shown in Graph 1. Graph 2 illustrates further that increases in foreign assets account for nearly all of the change in the size of the central bank balance sheets in the region over recent years. In the absence of offsetting policy actions, these increases in the size of the balance sheet will create excess banking system reserves. To mitigate this effect, central banks have resorted to using sterilisation tools

Foreign exchange reserves

In domestic currency, billions

Graph 1



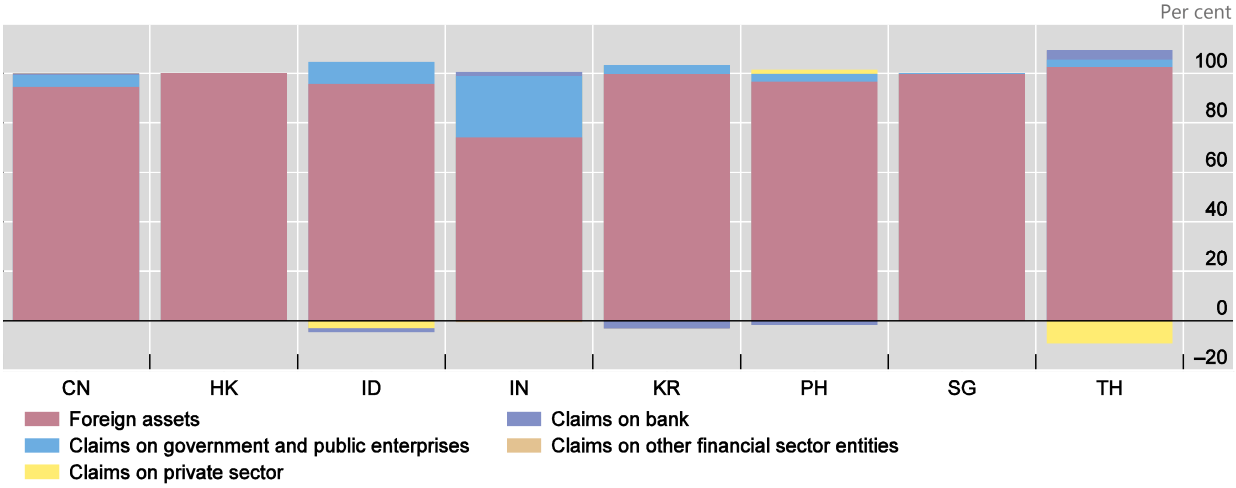
Source: IMF, *International Financial Statistics*.

in an effort to absorb the liquidity created by the foreign exchange intervention, thus maintaining monetary independence.[4]

Change in composition of central bank assets in emerging Asia, 2002–13[1]

As a percentage of change in total assets

Graph 2



CN = China; HK = Hong Kong; ID = Indonesia; IN = India; KR = Korea; PH = Philippines; SG = Singapore; TH = Thailand.

[1] Up to January 2013 for KR.

Sources: IMF *International Financial Statistics*; BIS calculations.

Reserve requirements and other liquidity management tools, such as central bank bills,[5] have come into widespread use as sterilisation tools. As shown in Graph 3, the central banks of Korea and Thailand have issued significant quantities of bills, accounting for 4.7% and 11.5% of their respective banking system assets as of 2013. China, Indonesia and the Philippines, on the other hand, have relied heavily on changes in reserve requirements. In fact, China's voluminous increase in reserves has been largely offset by the ratcheting up of the required reserve ratio from 6% in 1999 to 20% in 2013.

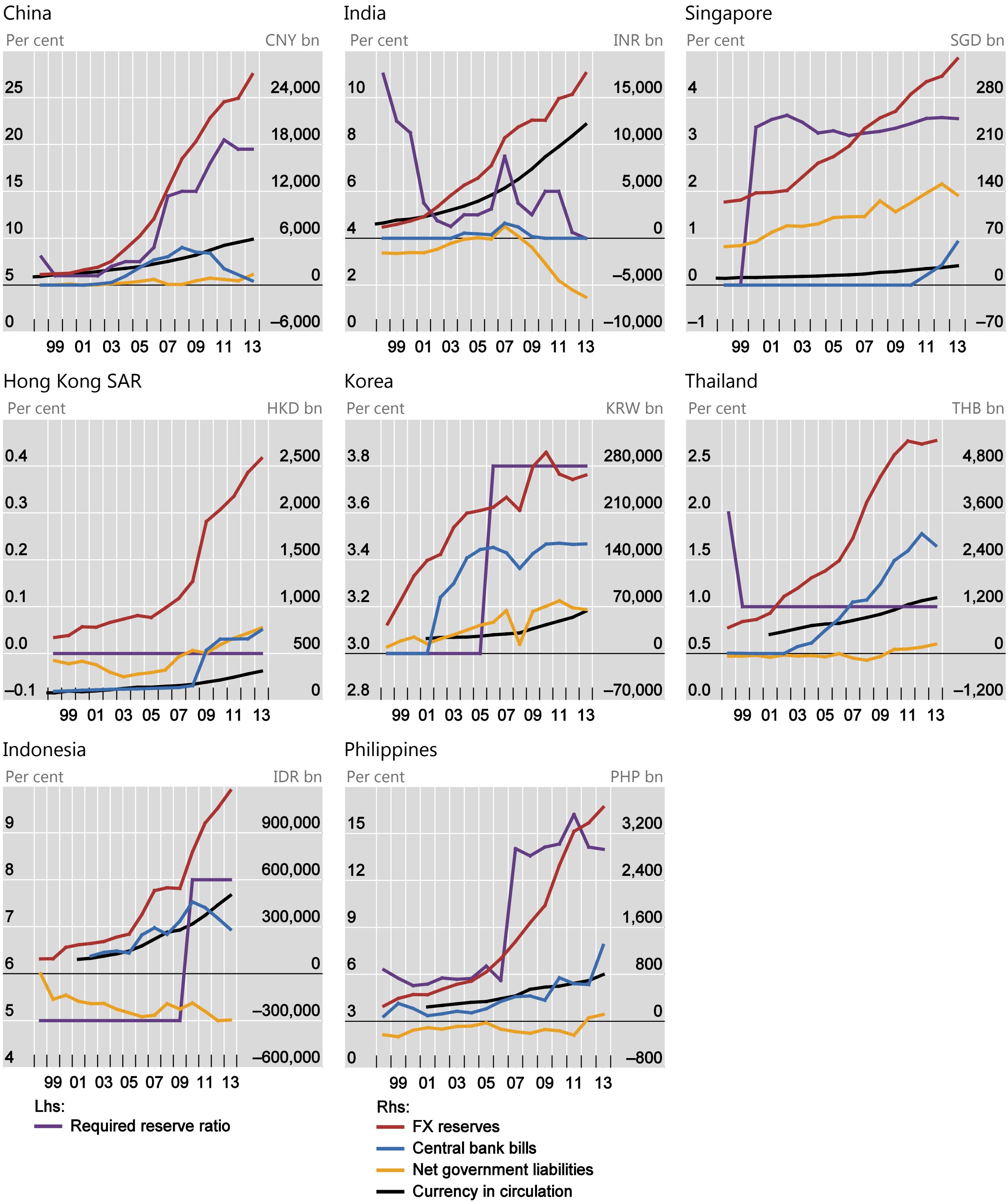
Another way to characterise economies' differing degrees of reliance on the various tools is to illustrate the link between the change in foreign exchange reserves and the size of liabilities associated with sterilisation. Table 1 displays the coefficient from simple linear regressions of the change in central bank bills and a change in required reserves (computed as the change in the required reserves ratio × lagged bank deposits), respectively, on the change in foreign exchange reserves. The regression equations are estimated economy by economy over the 1999–2013 period (or else the longest period for which data are available), and each includes a constant. The results illustrate the variation in the use of sterilisation instruments: required

4 See the discussion in Ho and McCauley (2008), who document that policy rates have generally remained close to target levels in Asian economies, despite high levels of foreign exchange intervention, as evidence of successful sterilisation and the maintenance of monetary policy independence.

5 Throughout this paper, we include special deposit accounts (for the Philippines) and term deposits (for Indonesia) in our definition of central bank bills, given their similar characteristics. Precise definitions, by country, are available upon request.

Policy tools

Graph 3



Sources: IMF; Bloomberg; CEIC; Datastream; national sources; BIS.

reserves dominate in sterilisation operations in China, while central bank bills play a larger role in Hong Kong SAR, Korea, Singapore and Thailand, and both tools are important in Indonesia, India and the Philippines.[6]

Effects of change in FX reserves on:

Table 1

	ΔCB bills	Δrequired reserves
China	0.08	0.66
Hong Kong SAR	0.54	-
Indonesia	0.20	0.21
India	0.29	0.23
Korea	0.25	–0.01
Philippines	0.35	0.21
Singapore	0.36	0.00
Thailand	0.24	0.00

Source: Authors' calculations

The efficacy of these tools in reducing excess reserves ("draining liquidity") is not in doubt. However, actions may have unintended consequences for the financial system generally, and for bank lending in particular. Requiring banks to hold additional reserves is costly, while issuing central bank bills alters the composition of assets in the financial system. Using bank-level data from seven Asian economies, our goal is to assess the two tools' impact on loan supply, and the extent to which the effects depend on bank-specific characteristics.

Emerging Asia provides a rich environment in which to investigate these effects for at least three reasons. First, there is considerable variation in the choice of tools, both across different economies and over time.[7] Second, the large scale of foreign exchange intervention in recent history has resulted in greater use of liquidity management tools, increasing the likelihood that we will be able to identify the effects of different tools more easily than might be possible using data for other regions.

Third, these liquidity management tools have been used to substantially sterilise foreign exchange intervention. To the extent that this has been successful, we are able to examine the effect of liquidity management conditional on the stance of monetary policy. That is, where liquidity management is used primarily to offset the effect of foreign exchange intervention and maintain the stance of monetary policy, rather than to change the stance of monetary policy, we may be able to avoid confounding the effect of the use of liquidity management tools with changes in the stance of monetary policy.

The closest papers to ours are those that looked at the effect on the behaviour of banks of central bank policies associated with foreign exchange intervention. For example, Cook and Yetman (2012) studied the effects of foreign exchange

6 In the case of Hong Kong SAR, we treat the issuance of Exchange Fund Paper as equivalent to central bank bills, given their similar characteristics. However, they are officially considered to be part of the monetary base in Hong Kong and are often used by banks to manage liquidity; see Cook and Yetman (2012, p 50) for a discussion.

7 See Ma et al (2011) for a detailed discussion of the use of different liquidity management tools in China, where it appears that the use of tools depends in part on their relative cost of implementation.

intervention on a number of key ratios for 55 banks in Asia over the 2003–07 period using Compustat data. One result from their paper is that a 1 percentage point increase in foreign exchange reserves is associated with a 1% decline in bank loans relative to total bank assets, largely driven by a fall in the aggregate size of loans, suggesting that reserves accumulation crowds out bank lending. They also found that this effect is larger for banks that started with high loan-to-deposit ratios. One important difference between their approach and the one taken here is that they focused on the effect of growth in foreign exchange reserves – an asset on the balance sheet of the central bank – whereas we assess the effect of different central bank liabilities.

Also focusing on the relationship between the behaviours of central banks and commercial banks, Gandanecz, Mehrotra and Mohanty (2014) examined 79 banks from 24 emerging market economies over the 2001–11 period using Bankscope data. They found that increased bank holdings of government securities and holdings of available-for-sale securities (which includes central bank paper) as a share of credit to the private sector led to an expansion in credit to the private sector over time, especially for well capitalised banks. This suggests that, rather than crowding out lending by banks, the issuance of central bank bills may allow some banks to increase the aggregate size of loans that they make. Our approach differs from Gandanecz et al (2014) in that we focus on 69 banks, all from emerging Asian economies, that have engaged in high levels of foreign exchange intervention. We also compare the effects of two different tools that may be used to manage liquidity changes in response to foreign exchange intervention, rather than focusing solely on the effect of an increase in a proxy for central bank securities, and consider interactions with a range of bank characteristics, in addition to the degree of capitalisation.

The next section sketches a simple conceptual framework for thinking about the effects on the banking system of alternative sterilisation tools. Section 3 discusses the considerations involved in the formulation of the regression model. Section 4 introduces the data and the results are presented in Section 5. Finally, Section 6 discusses policy implications and conclusions.

2. Sterilisation and its effects on the financial system

This section develops a framework for thinking about the possible effects of sterilisation policies on bank lending, similar in spirit to Bianchi and Bigio (2014). The basic idea is that banks finance illiquid loans by issuing deposits, taking into account the need to hold sufficient liquid reserves to settle claims by other banks when funds are transferred between institutions. The quantity of loans versus liquid assets therefore reflects a trade-off between maximising the returns on the banks' loan portfolios and reducing liquidity risks. In our context, foreign exchange intervention, and the use of liquidity management tools of various kinds by the central bank, influences both the assets and liabilities on the banks' balance sheets, and therefore the optimal quantity of lending.

Before getting to the banking model, it is useful to begin with a simple, abstract accounting of how sterilisation affects the balance sheets of the financial sector and the central bank. Figure 1 depicts a stylised central bank balance sheet. On the asset side, the central bank holds foreign exchange reserves (X) and government bonds

(GB). The liability items include bank reserves (R, made up of required reserves [RR] and excess reserves [ER]) central bank bills (Q^B) and government deposits (GD).[8]

A stylised central bank balance sheet — Figure 1

Assets	Liabilities
X	$R = RR + ER$
GB	Q^B
	GD
	currency

For the purposes of this paper, we will largely ignore GB, on the grounds that the region's central banks hold relatively small quantities of government debt, and the size of these holdings varies little over time (as seen earlier in Graph 2). We will also ignore GD since government balances at the central bank are to a large extent exogenous and not used for monetary purposes.

Now consider a capital inflow, in which a foreign investor uses dollars to buy a local currency-denominated financial asset, A. In other words, domestic residents (although not necessarily banks) own more X and less A. With no offsetting transfer of assets, this would put pressure on the currency to appreciate and generate a current account deficit.

Responding to the exchange rate pressure, the central bank intervenes in the foreign exchange market, purchasing X. What else adjusts to ensure that the central bank's balance sheet remains balanced? If left unsterilised, the purchase of X increases R. Netting out the transactions: the A held by the financial system is lower, and R is higher.

Initially at least, the increase in R is in the form of excess reserves and leads to a decline in the interest rate and an expansion in loans and deposits, stimulative effects that may conflict with monetary policy objectives. One sterilisation option is to short-circuit this effect by raising the required reserve ratio. This has no effects on the aggregate balance sheets of the private financial system and the central bank, but it increases banks' demand for bank reserves, constraining deposit-taking and lending.

Alternatively, the central bank could sterilise the effect of their intervention in other ways. In many countries outside Asia, the standard means of sterilisation is for the central bank to sell off some of its government bonds, leaving the liability side of the balance sheet unchanged. Netting out the transactions, in the private sector, A is lower and GB is higher; the increase in X on the central bank's balance sheet is offset by the reduction in GB. There are no monetary implications, and the financial effects are likely to be small to the extent that A and GB are close substitutes in investors' portfolios. However, as noted earlier, in the Asian region, central banks hold very few government bonds (especially relative to the scale of foreign exchange intervention in recent years), so this is not an option. This also limits the ability to use reverse repos

8 Why Q^B? Because central bank bills are liquid assets, and the B distinguishes central bank-issued Q from liquid assets from other sources, such as the government.

(the temporary sale of government securities) to offset the expansionary effects of intervention.

Another alternative is for the central bank to issue its own non-monetary liabilities, Q^B, possibly by first using R to pay for the X and subsequently absorbing the additional R by exchanging it for Q^B.[9] When the dust has settled, the private sector owns less A and more Q^B; the central bank owns more X and owes more Q^B. In terms of the accounting, this combination of transactions is not unlike sterilisation through the sale of government bonds. However, to the extent that central bank bills are closer substitutes for reserves than the government bonds it would have sold, had that been an option, the increased supply of Q^B may have subtle effects on affect banks' portfolio choice and lending decisions.

To see how this works, consider a generic model of banks' portfolio allocation and deposit-taking. The bank's objective is to maximise profits generated by the interest on a portfolio of assets that includes loans (L), liquid assets (Q, including but not limited to central bank bills, Q^B) and reserves (R), minus the interest rate on deposits (D). The bank is subject to a reserve requirement, $R \geq \phi D$, where ϕ is the required reserve ratio. The marginal cost of raising funds by taking new deposits is the deposit rate plus the "reserves tax" (since reserves are remunerated at a lower rate of interest than that received on loans). If the interest rate on reserves is the deposit rate, for example, then the marginal funding cost is given by $r^D + \phi(r^L - r^D)$.

The mechanistic "money and banking textbook" approach to solving for the bank's optimal behaviour is a special case of this model with $Q = 0$ and a binding reserve constraint (at the prevailing lending and deposit rates, banks have more lending opportunities than they can satisfy, given the level of reserves in the system). Banks are at a corner solution. Assuming no currency "leakage," a unit increase in R increases D by the factor $1/\phi$. The impact on deposits can be neutralised by raising ϕ by $1/D$ times the change in reserves. But with D constant, forcing banks to hold a higher level of reserves will crowd out lending one-for-one, as $L = (1-\phi)D$. In addition, increasing the required reserve ratio will increase the cost of raising new loanable funds through additional deposit taking.

The impact of an exogenous increase of Q^B in this setup depends on where those liquid assets end up. To take the polar case, suppose $r^Q > E(r^L) - \mu$, where μ represents the cost of intermediation (generally an increasing function of L). In this case, banks would choose to purchase the entire stock of Q^B (again putting them at a corner solution). The increase in Q again crowds out L one-for-one. On the other hand, the issuance of Q^B does not increase banks' marginal cost of funds financed by new deposit taking. (Note that the cost of funds is not relevant in the mechanistic scenario since it is assumed that $E(r^L) - \mu > r^D + \phi(r^L - r^D)$.)

Things get a little more interesting when banks are not at a corner, and optimal levels of Q and D are both likely to vary in response to central bank actions. For this to be the case we need banks to have some motivation for holding excess reserves and liquid assets, whose rates of return are presumably less than the lending rate, even when adjusted for intermediation costs. One plausible story is that excess reserves (ie any R in excess of ϕD) and Q are likely to yield liquidity services, providing a buffer against adverse liquidity shocks (unanticipated interruptions in funding,

9 This may be thought of as equivalent to a standing facility in which banks deposit excess reserves at the central bank.

interbank payments or deposit outflows, for example). The volume of excess reserves and liquid assets banks choose to hold will then involve trading off the marginal benefit of liquidity against the opportunity cost of holding those low-return assets.

A simple, partial equilibrium framework is one in which banks maximise:

$$\max E(r^L)L + r^Q Q + r^R R - r^D D - g(ER,Q) \tag{1}$$

with respect to D and Q, where $ER = R - \phi D$ (excess reserves), taking all three interest rates as exogenous.[10] The g function represents a Diamond-Dybvig (1983) expected illiquidity cost, where $\partial g/\partial ER$ and $\partial g/\partial Q$ are both negative (more liquid assets of either type lower the expected illiquidity cost). In addition, it is reasonable to assume that $\partial^2 g/\partial ER \partial Q > 0$, meaning that an increase in Q reduces the marginal benefit of holding additional R.

The balance sheet identity imposes a constraint on the volume of loans, $L = D - Q - R$. Required reserves are set by the central bank, and may be treated as exogenous from banks' standpoint. While we have glossed over many other realistic aspects of bank behaviour (for example, we could add an intermediation/monitoring cost that banks pay, as an increasing function of L), these are not essential to our analysis. In addition, our model focuses on the liquidity dimension of banks' optimisation problem, ignoring the potentially important role of capital.

The bank's first-order condition with respect to D is given by:

$$E(r^L) - r^D = -\phi \partial g/\partial ER. \tag{2}$$

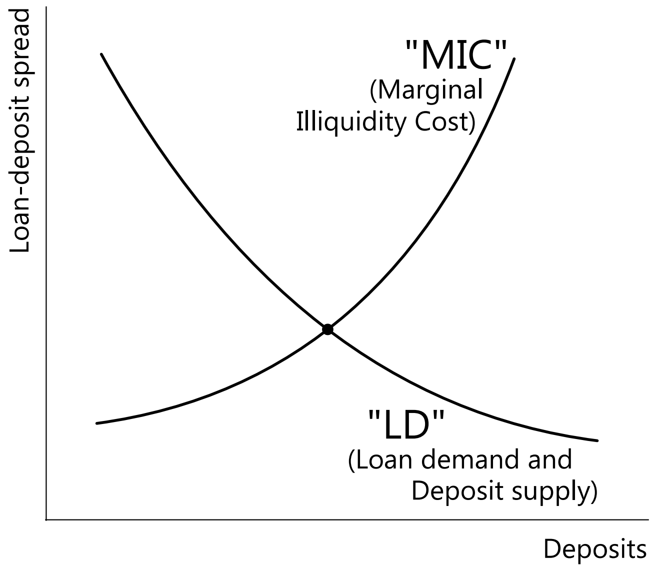
The interpretation of the first-order condition is as follows. Suppose an Indonesian bank takes an additional rupiah in deposits and makes a new loan. The marginal benefit of the transaction is the spread between the deposit and loan rates. Making the loan reduces excess reserves by ϕ, however; the marginal cost associated with the liquidity reduction is $\phi \partial g/\partial ER$.

The first-order condition is depicted in Figure 2. The downward-sloping "LD" (Loan-Deposit) curve embodies the assumptions that private-sector loan demand makes the lending rate a decreasing function of the volume of loans, and deposit supply is an increasing function of deposits. The upward-sloping curve "MIC" (Marginal Illiquidity Cost) curve shows the marginal cost of illiquidity, as a function of D, conditional on a given level of Q. Equation (2) is satisfied at the intersection of the two curves.

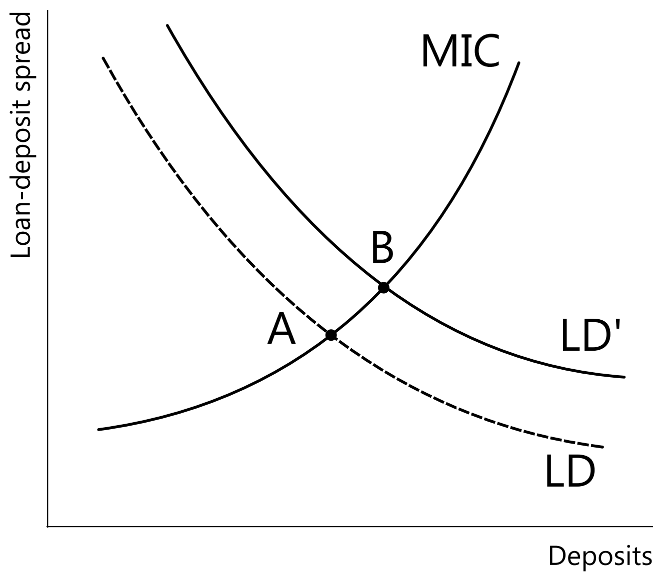
Now consider the effect of an increase in R, along with an increase in ϕ calibrated to leave the levels of deposits and excess reserves unchanged. If banks did not take any additional deposits, the volume of lending would decrease and the loan rate would rise. This is shown in Figure 3 as an upward shift in the LD curve to LD'. The increase in the loan-to-deposit spread gives the bank an incentive to hold fewer excess reserves and therefore deposits increase. The quantitative impact on lending depends on the marginal liquidity benefit of reserves: low if the benefit is small (eg shallow MIC, plentiful liquidity), high if liquidity is scarce (steep MIC, scarce liquidity).

10 The assumption of exogenous interest rates means the model should be interpreted as representing the aggregation of individual price-taking banks.

Lending benefits and illiquidity costs Figure 2



An increase in the reserve requirement Figure 3



The first-order condition with respect to Q is similar:

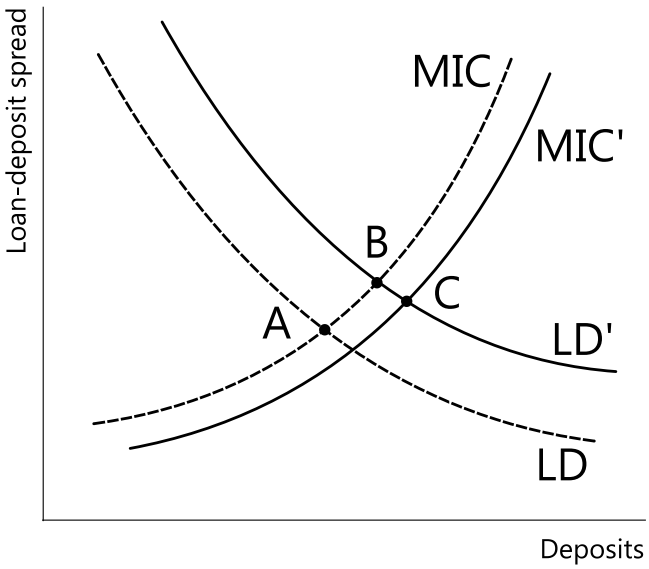
$$E(r^L) - r^Q = -\partial g/\partial Q. \quad (3)$$

The interpretation is as follows. Suppose a bank reallocates a rupiah from liquid assets to make a new loan. The benefit is the spread. The cost is the forgone liquidity provided by the asset. The equilibrium spread should therefore reflect the marginal benefit of the liquidity provided by the asset.

Consider first the case in which the banking system absorbs the entire increase in Q^B, which would occur if $r^Q > E(r^L) - \mu$. In this case, bills are so attractive relative to loans that banks will be happy to absorb the full increase in supply.

The first-order effect would be one-for-one crowding out, as before. However, the increase in Q on the balance sheet makes the bank more liquid, and this reduces the need to hold excess reserves as a liquidity buffer. (This is reflected in the assumption about the cross partial derivative.) Banks will lend more, narrowing the loan-to-deposit interest rate spread relative to what it would otherwise have been, until it reflects the reduction in $\phi\partial g/\partial ER$. This is shown as an outward shift in the MIC curve in Figure 4.

An increase in central bank bills — Figure 4



There is no reason to expect that all of the newly issued Q^B will remain in the banking system, however. The volume of liquid assets banks choose to purchase will depend on their yield relative to the expected return on loans. Thus, the bank's optimal choices of D and Q will be determined by the joint solution to the two first-order conditions, plus the balance sheet constraint, along with a downward-sloping loan demand curve (giving $E(r^L)$ as a function of L) and an upward-sloping deposit supply curve (giving r^D as a function of D).

In this situation, the issuance of central bank bills affects bank lending only to the extent that the increase in Q^B drives up r^Q. This in turn will depend on the extent of the market for liquid, domestic currency-denominated bill-like assets from other sources, such as short-term government debt. The impact on r^Q of an increase in Q^B is more likely to be large if comparable liquid assets are in short supply.

While obviously not a fully articulated economic model of banking behaviour, this framework suffices to illustrate two points about the effects of issuing central bank bills, vis-à-vis increasing reserve requirements:

1. To the extent that central bank bills provide liquidity services, banks' purchases of those assets will tend to have a smaller impact on loan supply than an increase in reserve requirements; and
2. When banks are free to choose the optimal portfolio allocation across loans and liquid assets, the impact on bank lending of central bank bill issuance will depend on the size of the issuance relative to the relevant market, and the demand for liquid assets elsewhere in the financial system.

Both considerations suggest that sterilisation using central bank bills is likely to have smaller effects on loan supply than a change in required reserves of a comparable magnitude.

3. Empirically assessing the effects of sterilisation on bank lending

Our empirical work follows the general strategy developed by Kashyap and Stein (2000). Their objective was to assess the impact of US monetary policy, and how the effects differed depending on bank characteristics. Using bank-level data from 1976 to 1993, they found that the impact of monetary policy on lending was strongest on banks which had less liquid balance sheets, or were relatively small. The same approach has been taken by a number of more recent papers, such as Ippolito et al (2013).

Our approach is similar to the Kashyap-Stein "one-step" specification, in that it involves regressing changes in bank-level lending growth on aggregate economy-level variables representing sterilisation policies (in this case, changes in required reserves and central bank bills), interacting these variables with bank attributes. However, an important difference between our work and that of Kashyap and Stein is our use of two different policy measures based on the central bank balance sheet, rather than a scalar indicator of the stance of monetary policy.

For the purposes of modelling the impact of sterilisation, we will make two additional simplifications to the stylised balance sheet in Figure 1. One is to consolidate government assets and liabilities, *GB* and *GD*, into net government liabilities, *NGL*. We do this because *GB* is small in most economies in our sample and has varied little in recent years, as illustrated in Graph 2, even as foreign exchange reserves have been rapidly accumulating in Asia. Thus it does not appear to be used for sterilisation purposes. Similarly, *GD* is likely to be driven by non-monetary considerations. We will therefore include *NGL* in the regression as a control, but do not focus on its effects on loan growth.

The second simplification is to ignore the quantity of currency in the economy, which is typically supplied elastically to meet transactions requirements. Consequently, currency follows a relatively smooth trend, as shown in Graph 3, and the effect of any variable growing at a constant rate will be absorbed into the intercept term.

Ignoring the bank- and economy-specific controls and the interaction terms for the moment, the starting point for the empirical analysis is an equation of the form:

$$\Delta L_{ijt}/A_{ijt-1} = \beta_0 + \beta_1\, \Delta X_{jt} + \beta_2\, \Delta Q^{B}_{jt} + \beta_3\, \Delta RR_{jt} + \beta_4\, \Delta ER_{jt} + \beta_5\, \Delta NGL_{jt}$$
$$+ \text{ bank attributes } + \text{ economy controls } + \text{ interaction terms,} \qquad (4)$$

where X is foreign exchange reserves, Q^B is the bills (and similar liabilities) issued by the central bank, RR is required reserves, ER is excess reserves and NGL is net government liabilities. The i subscript indexes banks, j economies and t time.

This specification fails to take into account the adding-up constraint on the balance sheet, however. Leaving currency growth aside, changes in the four categories of liabilities should (approximately) equal the change in foreign exchange reserves. If the balance sheet depicted in Figure 1 were complete, then the five regressors would be highly correlated (*perfectly* correlated in the absence of random fluctuations in the currency component). In practice, however, our idealised taxonomy is likely to omit some quantitatively significant balance sheet items, which will reduce the correlation. If we regress the change in FX reserves on the changes in other balance sheet items listed in equation (4) in levels, for example, we obtain R^2's of 0.8 or above for five of the economies in our sample, the only exceptions being Thailand (0.5) and the Philippines (0.2).[11] We will therefore estimate two versions of the regressions. One drops the change in foreign exchange reserves (ΔX), consistent with the assumption that foreign exchange intervention accounts for the most of the variance in ΔQ^B and ΔR; the second includes ΔX along with the other balance sheet variables.

An additional twist is that an expansion in the volume of deposits will increase the level of required reserves, RR, even in the absence of a change in the required reserve ratio. The raw ΔRR is therefore not an appropriate gauge of sterilisation. In its place we use a variable intended to capture the impact of a change in the required reserve ratio on the level of required reserves *for a given level of deposits*,

$$\Delta RR^*_{jt} = (\phi_{jt} - \phi_{jt-1})D_{jt-1} , \tag{5}$$

where ϕ is the required reserve ratio. We correspondingly replace the change in excess reserves with

$$\Delta ER^*_{jt} = \Delta R_{jt} - \Delta RR^*_{jt} , \tag{6}$$

where ΔR_{jt} is total reserves, to preserve the underlying adding up constraint between central bank balance sheet elements.

To account for size differences across economies, and for the scale of the policy interventions relative to the sizes of the respective financial systems, all of the central bank variables are expressed as shares of the sum of total banking system assets plus government debt.

We include five bank-level variables in the regression: lags of the log of total assets, the Tier-1 capital ratio, the ratio of liquid to total assets and non-performing loans (NPL) as a share of total assets, as well as the long-term bond rating of the bank. The bond rating is the long-term foreign currency credit rating from Capital Intelligence, converted to numerical scale, where a higher number indicates a more highly rated bank.

Finally, the regressions include interaction terms involving the policy variables and each of the four bank attributes in turn, intended to assess the policies'

[11] We considered including Singaporean banks in our sample. However, there is no detectable link between the balance sheet policy tools and foreign exchange intervention in the case of Singapore (the R^2 in this regression is 0.0), so they are excluded from our panel.

differential effects across banks. With these modifications and additions to equation (4), our basic regression model becomes:

$$\Delta L_{ijt}/A_{ijt-1} = \kappa_i + \alpha_1 \ln(A)_{ijt-1} + \alpha_2 (K/A)_{ijt-1} + \alpha_3 (Q/A)_{ijt-1} + \alpha_4 (NPL/A)_{ijt-1} + \alpha_5 LTRating_{jt} + \delta_1 \Delta\ln(Y)_{jt} + \delta_2 \Delta r_{jt} + \beta_1 \Delta X_{jt} + \beta_2 \Delta Q^B_{jt} + \beta_3 \Delta RR^*_{jt} + \beta_4 \Delta ER^*_{jt} + \beta_5 \Delta NGL_{jt} + \gamma_1 Z_{ijt-1} \Delta Q^B_{jt} + \gamma_2 Z_{ijt-1} \Delta RR^*_{jt} + \gamma_3 Z_{ijt-1} \Delta ER^*_{jt} + \gamma_4 Z_{ijt-1} \Delta NGL_{jt}, \quad (7)$$

where A is bank assets, K is Tier-1 capital, Q is liquid assets, NPL is non-performing loans, $LTRating$ is the long-term foreign-currency bond rating of the bank, r is the short-term interest rate (the policy rate), Y is real GDP and κ_i is a bank fixed effect. (Ideally, we would also include a bank-level measure of excess reserves, but these data are available for only a very small number of banks.) The Z variable represents one of the five bank attributes included in the regression (L/A, K/A, Q/A, NPL/A or $LTRating$). As mentioned earlier, the policy variables are normalised by the lagged sum of the economy's total banking assets and government debt.

4. Data

Our bank data are drawn from Bankscope. We focus on "commercial banks", "savings banks" and "cooperative banks" from those economies for which there has been a high degree of foreign exchange intervention in recent years and for which there are more than two years of (annual) data available. To ensure that our results are not driven by small banks, we restrict our attention to those for which there are long-term bond ratings available in the Bankscope database, which are likely to account for the lion's share of total banking system assets in each economy. Our sample includes banks from seven economies: China, Hong Kong SAR, India, Indonesia, Korea, the Philippines and Thailand.

We also collect bank characteristics from Bankscope to use in our regressions: bank size – defined as the log of total assets measured in millions of US dollars, Tier-1 capital ratio, liquid assets as a share of total assets, reserves for non-performing loans as a share of total assets and long-term foreign-currency bond rating. These variables typically enter with a one-year lag due to concerns about endogeneity.

At each stage, data were checked carefully, and observations that defied plausibility, or likely reflected extraordinary bank-specific factors that might unduly influence our results, were dropped. These included observations where Tier-1 capital or total bank capital exceeded the total value of bank assets, gross loans (or gross loans plus liquid assets) exceeded total assets, the change in gross loans from one year to the next was more than 90% of total assets, liquid assets were more than five times as large as deposits plus short-term funding, gross loans were less than 9% of total assets, or Tier-1 capital was negative.

Once the data sample was cleaned up, we are left with data for 69 banks, with start dates that vary by bank, anywhere from 2005 to 2012, with final observations in our data set typically for 2013. Data for Malaysia and Chinese Taipei were also considered but dropped due to the small number of observations. Those from Singapore were also excluded because we could find no link between balance sheet policy tools and foreign exchange intervention in Singaporean data, as mentioned in the previous section.

The total number of bank-year observations used in our regressions is 445. Table 2 displays the total number of bank observations, by economy and by year, for which all the variables included in our regressions are available. Table 3 displays the share of total bank assets that these banks represent, for each year and economy, which average 50%.

Number of bank observations, by economy and year — Table 2

	06	07	08	09	10	11	12	13	Total
China	2	7	7	10	10	10	10	7	63
Hong Kong	8	10	10	11	11	11	11	11	83
Indonesia	5	7	7	8	8	8	8	7	58
India	1	12	12	15	16	17	18	18	109
Korea					4	4	7	7	22
Philippines	2	8	8	8	8	8	8	8	58
Thailand	6	6	6	6	7	7	7	7	52
Total	24	50	50	58	64	65	69	65	445

Sources: Bankscope; authors' calculations.

Share of total bank assets included in sample, by economy and year, % — Table 3

	06	07	08	09	10	11	12	13	Mean
China	4	51	48	62	62	61	58	41	48
Hong Kong	66	69	72	72	73	73	75	71	71
Indonesia	20	46	40	52	47	45	45	36	41
India	4	30	36	66	70	75	79	83	55
Korea					22	15	34	33	26
Philippines	16	59	51	57	56	54	57	58	51
Thailand	49	47	35	37	51	47	51	47	45
Mean	27	50	47	58	54	53	57	53	50

Sources: Bankscope; IMF; authors' calculations.

Descriptive statistics of our key bank-level variables included in the regressions are given in Table 4. The following graphs display the bank-specific characteristics of the resulting data set. Graph 4 illustrates that, for some banks, all of their assets are divided between loans and liquid assets. But for most, their portfolio lies well below the 45-degree line, indicating that they hold some other illiquid assets, in addition to loans. Graph 5 illustrates that, for most of the observations in our sample, reserves for non-performing are small as a share of total assets. Graph 6 shows that large banks' capital ratios are clustered around 10%, while there is much more dispersion among smaller banks. Graph 7 suggests that there is a positive correlation in our data between the level of Tier-1 capital and the share of liquid assets on the bank balance sheet. Graph 8 suggests that there is surprisingly little relationship between the level of Tier-1 capital and the long-term credit rating of banks in our sample. However, Graph 9 illustrates a strong relationship between bank size and credit rating, such that larger banks are rated more highly than smaller ones.

Summary bank-level descriptive statistics

Table 4

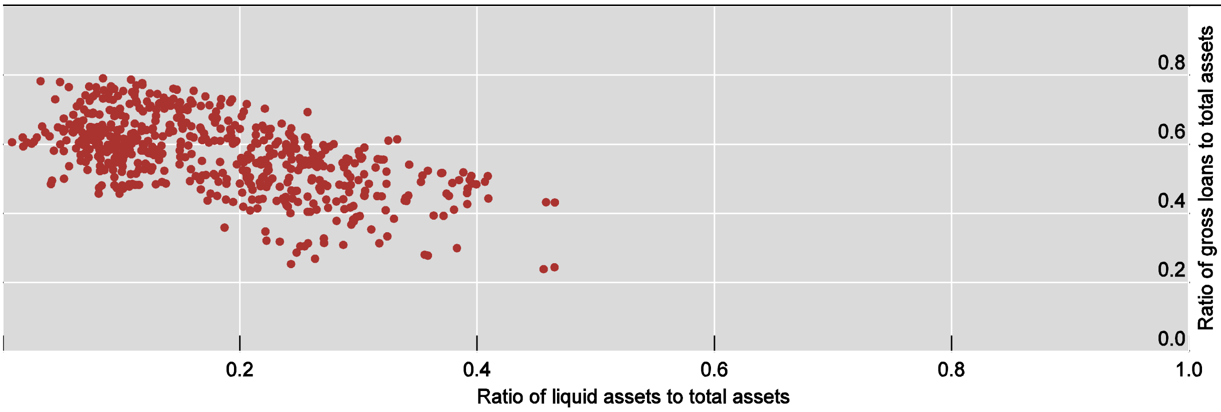
	Mean	Standard deviation	Percentiles 10	50	90
Change in loans / lagged assets	0.100	0.099	0.005	0.086	0.214
Tier-1 capital ratio	0.111	0.036	0.076	0.104	0.156
Liquid assets / total assets	0.185	0.096	0.074	0.180	0.308
Reserves for NPLs / total assets	0.015	0.013	0.003	0.011	0.032
Long-term bond rating[1]	13.4	2.6	10	13	17

[1] Bond ratings are converted from a letter scale to a numerical scale which ranges in our sample from 5 (C) to 20 (AA).

Sources: Bankscope; authors' calculations.

Relationship between the ratio of liquid assets to total assets and the ratio of gross loans to total assets

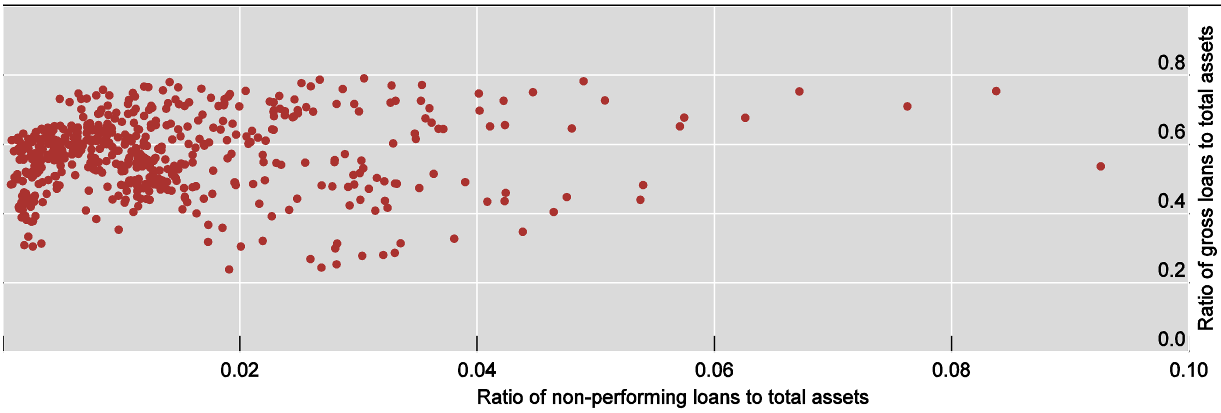
Graph 4



Sources: Bankscope; authors' calculations.

Relationship between the ratio of reserves for non-performing loans to total assets and the ratio of gross loans to total assets

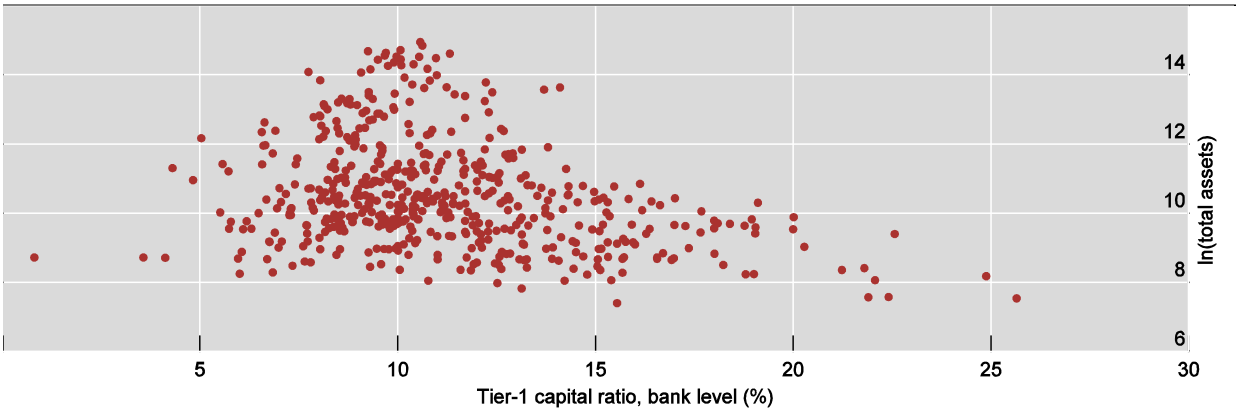
Graph 5



Sources: Bankscope; authors' calculations.

Relationship between Tier-1 capital ratio and total assets

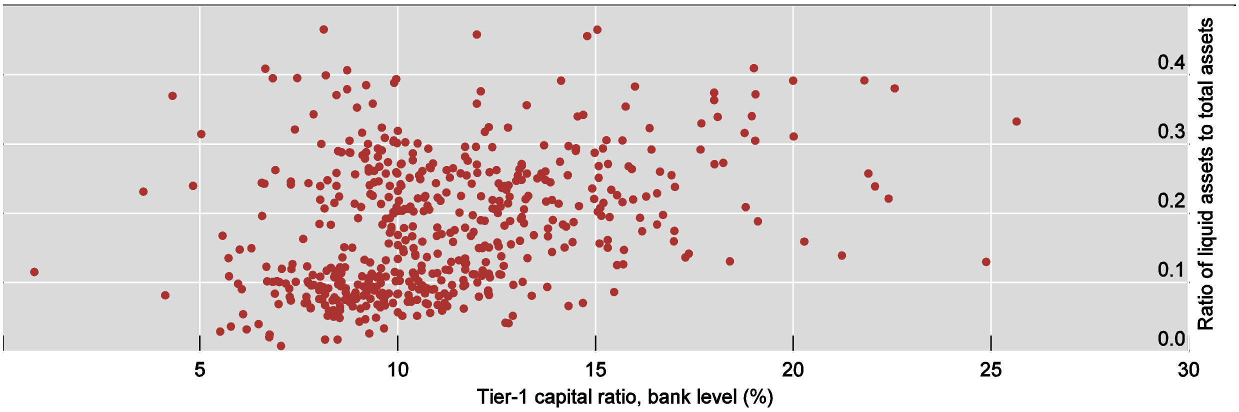
Graph 6



Sources: Bankscope; authors' calculations.

Relationship between Tier-1 capital ratio and the ratio of liquid assets to total assets

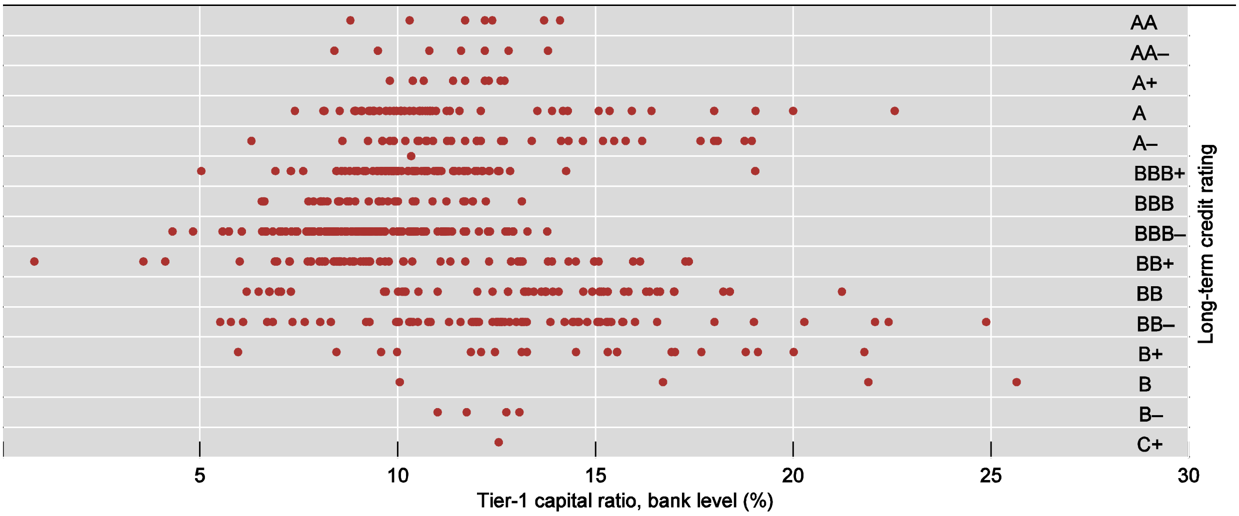
Graph 7



Sources: Bankscope; authors' calculations.

Relationship between Tier-1 capital ratio and long-term credit rating

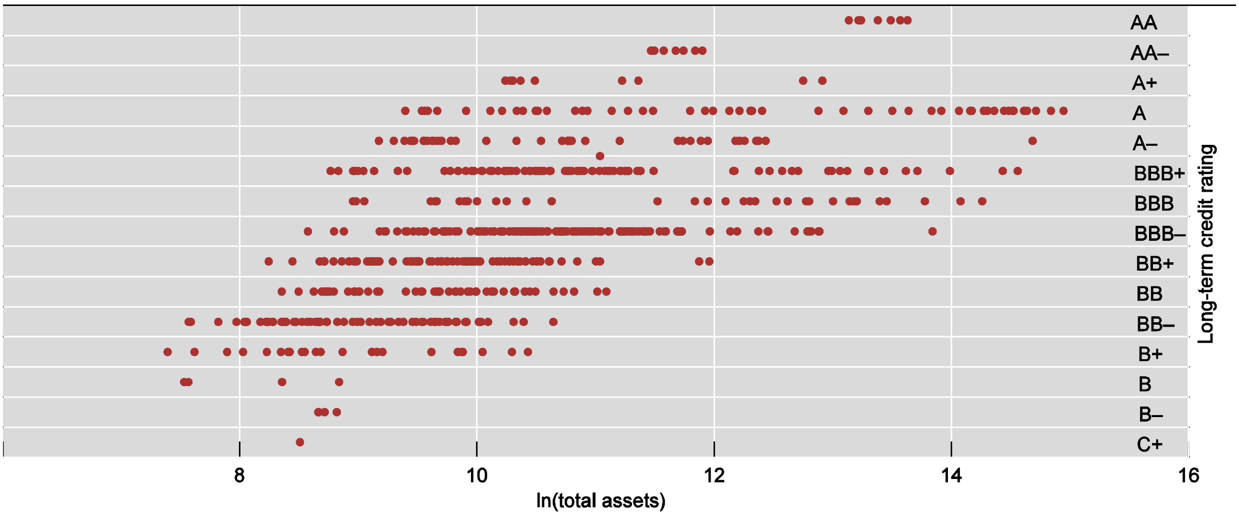
Graph 8



Sources: Bankscope; authors' calculations.

Relationship between total assets and long-term credit rating

Graph 9



Sources: Bankscope; authors' calculations.

Most of the central bank balance sheet data are taken from national sources. In the cases of Indonesia and the Philippines, we supplement the central bank securities series by including additional instruments that behave in a very similar way to central bank securities, and are also heavily used as liquidity management tools. For Indonesia we proxy this as the sum of BI certificates and term deposits. For the Philippines, where the central bank is unable to issue its own securities, we use Special Deposit Accounts instead. In order to avoid confounding FX intervention with changes in the local currency value of existing reserves, the ΔX in our regressions is the change in the dollar value of foreign exchange reserves, converted to local currency at the previous year's exchange rate.

5. Results

The first step in the empirical analysis is to estimate a bank-level loan-growth model. This consists of equation 7, but without the policy variables (the terms involving the β coefficients) or the interaction terms (involving the γs).

The first column of Table 5 shows the results with the regression that includes only the bank-level variables. The parameter estimates are plausible and, except for the ratio of liquid to total assets, statistically significant. Loan growth is higher for small and well capitalised banks with a low level of reserves for non-performing loans, and those with higher long-term bond ratings.

The remaining four columns report the results of regressions that also include year fixed effects (column 2), economy-level data (column 3), both (column 4) and year × economy fixed effects (column 5). The main takeaway is that the inclusion of the aggregate variables has relatively little effect on the coefficients on the bank-level variables, although the statistical significance of the various coefficients varies across specifications. The coefficients are not generally affected by the inclusion of year and year×economy fixed effects, although the coefficient on the capital ratio becomes (insignificantly) negative in one case.[12]

Bank loan growth regressions

Table 5

		Year	Macro	Year+macro	Year*economy
Lagged size	–0.136***	–0.264***	–0.135***	–0.267***	–0.213***
	(–6.26)	(–6.24)	(–5.70)	(–6.02)	(–6.69)
Lagged capital ratio	0.660***	0.295	0.521**	0.362	–0.201
	(3.23)	(1.40)	(2.15)	(1.62)	(–0.70)
Lagged liquid assets	0.083	0.265**	0.160	0.232**	0.123
	(0.79)	(2.56)	(1.45)	(2.14)	(1.21)
Lagged NPL reserves	–1.601***	–0.474	–1.624***	–0.657	–1.601***
	(–2.85)	(–0.82)	(–3.01)	(–1.03)	(–2.79)
Long–term rating	0.023***	0.018**	0.023***	0.015*	0.017**
	(2.95)	(2.56)	(3.20)	(1.94)	(2.34)
Real GDP growth			0.065	–0.387*	
			(0.37)	(–1.95)	
Change in interest rate			1.304***	0.306	
			(3.10)	(0.51)	
Year effects	N	Y	N	Y	N
Year × economy effects	N	N	N	N	Y
Observations	445	445	445	445	445
Within R-squared	0.230	0.398	0.266	0.408	0.676
Between R-squared	0.0000	0.0033	0.0003	0.0017	0.0066
Overall R-squared	0.0064	0.0081	0.0109	0.0069	0.0354

Source: Authors' calculations.

To give an idea of the quantitative importance of the different explanatory variables, consider the results including year dummies and macro variables (the second column from the right). Mean loan growth is 10% per year across our sample of banks, and mean Tier-1 capital is 11%. A 1 percentage-point increase in Tier-1 capital is associated with a 0.4 percentage points more loan growth, as a share of total assets. For liquid assets, the average level is 18% of total assets, and a 1 percentage-point increase in this ratio is associated with 0.23% faster loan growth. NPLs have a quantitatively larger effect: their average level is 1.5% of total assets, and a 1 percentage-point increase is associated with a 0.7 percentage point reduction in loan growth.

Some of the estimated coefficients on the macro variables are a little puzzling, however. When no year fixed effects are included, the coefficient on the change in the interest rate is positive, suggesting that tighter monetary policy increases loan growth. This may result from the fact that the central bank is responding to economic conditions, possibly including loan growth, in setting the interest rate. Correctly identifying the impact of monetary policy would require a proxy for exogenous policy

12 The small number of banks for some economies in the early part of the sample means that some of the year×economy dummies cannot be estimated.

change (ie "shocks"). Fortunately this is not our objective, and therefore beyond the scope of our study.

Bank loan growth regressions

Table 6

	With FX		Without FX	
Lagged size	–0.118***	–0.276***	–0.131***	–0.277***
	(–4.32)	(–6.08)	(–5.23)	(–6.37)
Lagged capital ratio	0.612**	0.316	0.528**	0.307
	(2.52)	(1.36)	(2.12)	(1.30)
Lagged liquid assets	0.146	0.211*	0.169	0.212*
	(1.35)	(1.95)	(1.53)	(1.95)
Lagged NPL reserves	–2.00***	–0.461	–1.528***	–0.405
	(–3.64)	(–0.71)	(–3.10)	(–0.65)
Long–term rating	0.025***	0.017**	0.024***	0.017**
	(3.21)	(2.42)	(3.21)	(2.38)
Real GDP growth	0.157	–0. 326	0.109	–0.343*
	(0.83)	(–1.45)	(0.60)	(–1.70)
Change in interest rate	1.488***	0.513	1.278***	0.469
	(3.72)	(0.82)	(2.84)	(0.81)
Change in FX reserves	0.633**	–0.084		
	(2.07)	(–0.22)		
Change in CB bills	0.020	–0.044	0.112	–0.033
	(0.24)	(–0.56)	(1.45)	(–0.46)
Change in required reserves	–0.686	–1.62**	0.167	–1.539***
	(–1.15)	(–2.44)	(0.34)	(–2.80)
Change in excess reserves	0.008	–0.035	0.246	–0.006
	(0.02)	(–0.10)	(0.60)	(–0.02)
Change in net gov liabilities	–0.829*	–0.989**	–0.605	–0.959**
	(–1.82)	(–2.26)	(–1.38)	(–2.21)
Year fixed effects	N	Y	N	Y
P-value for exclusion of CB bills and required reserves	0.48	0.016	0.30	0.021
Sum of coefficients on FX and required reserves	–0.05	–1.54***		
Sum of coefficients on FX and CB bills	0.65**	0.04		
Net impact of increase in required reserves and decrease in CB bills	–0.71	–1.58**	0.05	–1.51***
Observations	445	445	445	445
Within R-squared	0.287	0.425	0.273	0.425
Between R-squared	0.0005	0.0017	0.0007	0.0017
Overall R-squared	0.0180	0.0072	0.0136	0.0071

Source: Authors' calculations.

The next step is to estimate a model that includes the policy variables (the terms involving the βs in equation 7). The results are reported in Table 6. The inclusion of the policy variables leaves the estimates of the coefficients on the bank and macro variables largely unchanged.

The results for the policy variables are mixed, in terms of both interpretation and statistical significance. The first column, which includes the change in foreign exchange reserves but excludes year dummies, indicates that purchases of foreign exchange have positive and statistically insignificant effects on bank lending. This makes sense at some level: macroeconomic booms tend to be associated with strong bank lending and capital inflows, which prompt foreign exchange intervention. The relationship is therefore not likely to be causal. This is consistent with the fact that the effect disappears when year fixed effects are included, as shown in the second column, which are likely to be picking up region-wide exchange rate pressures.

Reassuringly, increases in required reserves tend to reduce bank lending in three of the four specifications, included the two where the estimate is statistically significant. In contrast, the estimated coefficients on the change in central bank securities are small and never statistically significant. Interestingly, the coefficients on the two sterilisation variables are *jointly* highly significant in the cases with year fixed effects, reflecting the fact that the two policies are often adjusted concurrently.

Interpreting the individual coefficients on the balance sheet variables is tricky, however. This is because the coefficient on the change in foreign exchange reserves is the effect of intervention *holding the other balance sheet variables constant*. Since the omitted balance sheet item is some unspecified "other" category, it is not clear exactly what policy this corresponds to. Similarly, the coefficient on the central bank securities variable captures the increase in that liability category and a reduction in the mysterious "other" category.

It is therefore more informative to look at linear combinations of coefficients that represent well defined policies. One such policy is an increase in foreign exchange reserves, accompanied by an increase in required reserves, corresponding to the sum of the estimated β_1 and β_3. The negative coefficient, significant when year fixed effects are included, indicates that this combination of policies tends to result in a decline in bank lending. Also of interest is the impact of an increase in foreign exchange reserves accompanied by an increase in central bank securities, the sum of β_1 and β_2. This is small, but positive, suggesting that sterilising foreign exchange purchases with issuance of central bank securities appears to promote bank lending.

Care is required in interpreting this result, however. Again, the reason is that both policies are heavily affected by macroeconomic developments: a booming economy and rapid loan growth tends to be associated with appreciation pressure, foreign exchange purchases *and* sterilisation. Further, the use of liquidity management tools could be used to try to offset excessive loan growth that results from factors other than foreign exchange intervention. This will tend to bias the parameter estimates upwards, explaining the large positive coefficients on central bank bills and the weak statistical significance of the coefficient on required reserves.

Fortunately, the two sterilisation variables' joint dependence on macroeconomic conditions can be finessed by examining the *difference* between the respective coefficients. To the extent that the two are affected proportionately by macro factors, subtracting β_2 from β_3 will give the relative impact of increasing the reserve requirement vis-à-vis purchasing central bank bills. Or, to put it another way, it would capture the effect on bank lending of increasing the former and reducing the latter by the same amount.

The results show that increases in reserve requirements generally slow lending growth, compared with the issuance of central bank bills (although the effect is statistically insignificant in the specifications without year fixed effects). This is consistent with the predictions of the stylised model sketched in Section 2. In terms of the magnitudes involved, if reserve requirements are increased to offset a reduction in central bank bills, and the size of each change is equal to 1 percentage point of the sum of total domestic bank assets plus domestic currency local bonds, our point estimates indicate that this leads to a slowdown in loan growth, as a share of total bank assets, of around 1.5 percentage points.

The next question is whether the policies affect different banks in different ways. To see whether this is the case, we interact the two liquidity management tools with lagged values of the four bank characteristics already included in the regression. The results are presented in Table 7.

Regressions with interactions between policies and bank attributes — Table 7

	Bank attribute (Z)				
	Size	Capital	Liquidity	NPL reserves	LT rating
Change in CB bills	1.265***	–0.271	0.063	–0.133	0.253
	(2.75)	(–0.83)	(0.21)	(–0.89)	(0.33)
Change in required reserves	3.497*	–4.693***	–1.762*	–3.106***	3.0486
	(1.75)	(–3.19)	(–1.74)	(–3.53)	(1.65)
Change in excess reserves	0.354	0.475	0.025	0.373	0.407
	(0.94)	(1.21)	(0.07)	(0.98)	(1.02)
Change in net gov liabilities	–0.917**	–0.805*	–0.969**	–0.806*	–0.861*
	(–2.06)	(–1.79)	(–2.31)	(–1.82)	(–1.95)
Central bank bills × Z	–0.140***	1.211	–0.458	4.032	–0.029
	(–2.75)	(0.64)	(–0.34)	(0.60)	(–0.40)
Required reserves × Z	–0.462***	28.77**	1.005	87.37**	–0.399**
	(–2.74)	(2.54)	(0.33)	(2.36)	(–2.49)
Observations	445	445	445	445	445
Within R-squared	0.436	0.436	0.425	0.433	0.433
Between R-squared	0.0024	0.0025	0.0017	0.0022	0.0022
Overall R-squared	0.0081	0.0078	0.0071	0.0078	0.0077
Relative impact of raising required reserves and reducing central bank bills					
10th percentile of Z	–0.573	–2.290***	–1.721*	–2.760***	–0.461
	(–0.82)	(–2.91)	(–1.84)	(–3.22)	(–0.66)
Average Z	–1.148**	–1.347**	–1.566**	–1.779***	–1.690**
	(–2.12)	(–2.49)	(–2.46)	(–3.25)	(–2.60)
90th percentile of Z	–1.889***	–0.159	–1.381***	–0.416	–3.047**
	(–3.06)	(–0.25)	(–2.74)	(–0.61)	(–2.56)

Note: regressions include year fixed effects.

Source: Authors' calculations

As in the previous set of regressions, the coefficients on the policy variables are hard to interpret, given the relationship between those variables and macroeconomic conditions. In addition, interpreting the interaction terms requires knowing something about the scale of the bank attributes. Consequently, rather than describe the individual parameter estimates, we will focus on the same linear combinations of coefficients, discussed above in the context of Table 6, evaluated at the mean, 10th and 90th percentiles of the distributions of the attributes.

The column labelled "Size" reports the parameter estimates, and the estimated effect of a policy of increasing reserve requirements and reducing central bank bills by a corresponding amount, from a regression in which the policy variables are interacted with the log of total assets. The results show that the impact on lending is more pronounced for large banks. For banks at the 90th percentile of the size distribution, a policy shift of a magnitude corresponding to 1% of total banking system assets plus local currency government securities slows loan growth by a statistically significant 1.9 percentage points, compared with a statistically insignificant 0.6 percentage points for banks at the 10th percentile. A formal test does not reject the hypothesis of equal effects, however, due to the imprecision of the estimate for small banks.

We also see differences when we distinguish between banks on other dimensions. As shown in the "Capital" column, a policy of shifting away from central bank bills and toward reserve requirements has a disproportionately large effect on banks with low levels of capital: 2.3 percentage points (significant at the 1% level) for banks at the 10th percentile, compared with 0.2 (statistically insignificant) for those at the 90th percentile. The difference is sufficiently large in this case for us to reject the hypothesis of equal coefficients at the 5% level. Banks with low NPL reserves are also more strongly affected: 2.76 (significant at the 1% level) at the low end of the distribution, versus an insignificant 0.42 for those with a high level of NPL reserves; the hypothesis of equal coefficients is rejected at the 5% level. Finally, highly rated banks (the "LT rating" column) are more responsive to the substitution of reserve requirements for central bank bills, with a reduction in loan growth of 3.0 percentage points versus 0.5 for those with low ratings. The difference is significant at the 10% level.

There is virtually no difference between the estimated responses of high-liquidity and low-liquidity banks, however. As shown in the "Liquidity" column, the impact is approximately 1.5 for all banks. This is somewhat surprising, as one might have expected relatively illiquid banks (ie those with low levels of excess reserves) to be disproportionately affected by actions that would drain or sequester reserves. The explanation for this finding might simply be that our measure of liquidity – total liquid assets as a share of total assets – is too broad, as it includes much more than just bank reserves. Interacting the policy variables with a variable capturing banks' reserve positions is likely to have revealed significant differences on this dimension, but unfortunately bank-level data on excess reserves are not available.

Taken together, the results in Table 7 indicate that large, highly rated banks with few non-performing loans are relatively more affected by a policy of shifting away from central bank bills and towards reserve requirements for sterilisation purposes. A reasonable conjecture is that these are the banks for which the level of reserves is a constraint, or at least a first-order consideration in their lending and deposit-taking decisions. Small banks with low credit ratings and high levels of non-performing loans are likely to be constrained on margins other than liquidity. The result that low-capital banks are more sensitive to the policy is a little puzzling in this context, as one might expect their lending to be constrained by capital rather than reserve requirements; but this result may be due to the strong negative correlation between size and capital ratio.

As a final robustness exercise, we investigate the relative impact of raising reserve requirements and reducing central bank bills dropping one economy from the sample at a time. We report these results, including one bank attribute at a time in the regressions, in Table 8. The results are most sensitive to the exclusion of China, an economy which has alternately made vigorous use of both central bank bills and reserve requirements at various points over our sample, and hence considerably improves our ability to identify a separate effect of the two tools. Regardless, in most cases we consider, an increase in reserve requirements and offsetting reduction in central bank bills has a negative effect on the growth of bank lending. And, with no exceptions, all statistically significant coefficients are negative. A robust result in our sample is thus that increasing reserve requirements has a larger negative effect on bank lending than issuing central bank bills.

Relative impact of raising required reserves and reducing central bank bills

Table 8

		Bank attribute (Z)				
		Size	Capital	Liquidity	NPL reserves	LT rating
All	10th percentile of Z	–0.57	–2.29***	–1.72*	–2.76***	–0.46
economies	Average Z	–1.15**	–1.35**	–1.57**	–1.78***	–1.69**
	90th percentile of Z	–1.89***	–0.16	–1.38***	–0.42	–3.05**
Ex	10th percentile of Z	0.30	–0.59	0.12	–1.08	0.43
CN	Average Z	–0.05	0.13	0.20	–0.26	–0.50
	90th percentile of Z	–0.41	1.00	0.31	0.97	–1.68
Ex	10th percentile of Z	–0.28	–2.27*	–1.51	–2.45**	–0.25
HK	Average Z	–0.87	–1.28	–1.35	–1.42	–1.24
	90th percentile of Z	–1.61	0.02	–1.14	–0.01	–2.39*
Ex	10th percentile of Z	–0.65	–2.23**	–2.38	–2.90**	0.01
ID	Average Z	–0.97	–1.41***	–1.68*	–1.72**	–2.00**
	90th percentile of Z	–1.39	–0.44	–0.81	0.13	–3.79**
Ex	10th percentile of Z	0.35	–2.21***	–1.91*	–3.50***	0.01
IN	Average Z	–0.78	–1.19**	–1.56**	–1.86***	–1.78***
	90th percentile of Z	–2.31***	0.13	–1.22**	0.04	–3.38***
Ex	10th percentile of Z	–0.57	–2.39***	–1.82*	–2.96***	–0.46
KR	Average Z	–1.18**	–1.40**	–1.63**	–1.85***	–1.66**
	90th percentile of Z	–2.03***	–0.12	–1.41***	–0.31	–3.23***
Ex	10th percentile of Z	–1.79	–3.43***	–2.10*	–1.27	–1.50
PH	Average Z	–2.08*	–2.14***	–2.57***	–2.54***	–2.27**
	90th percentile of Z	–2.47***	–0.40	–3.21***	–4.37***	–3.21***
Ex	10th percentile of Z	–0.96	–1.80**	–0.98	–2.43***	–0.70
TH	Average Z	–1.14*	–1.35**	–1.41**	–1.86***	–0.73
	90th percentile of Z	–1.39**	–0.79	–1.88***	–1.16**	–0.75

Note: regressions include year fixed effects.

Source: Authors' calculations.

6. Summary and conclusions

Heavy foreign exchange intervention in the Asian region, together with varying use of sterilisation methods, provides a useful laboratory for investigating the effects of different liquidity management tools on bank lending. Based on a simple theoretical model developed in Section 2, we suggested that hiking reserve requirements to sterilise foreign exchange purchases will retard bank lending growth more than the issuance of central bank bills.

We then tested this prediction using bank-level data from seven Asian economies, and found that the evidence is generally supportive. Because foreign exchange intervention and sterilisation both respond to macroeconomic conditions, which are closely linked with bank lending, it is hard to sort out the absolute effects of individual sterilisation policies. However, it is still possible to say something about their relative effects. The main finding is that relaxing reserve requirements and instead issuing bills will increase loan growth. There is also evidence suggesting that smaller and weaker banks are affected disproportionately by changes in reserve requirements.

We have focused on central bank bills (and close substitutes such as term deposits) and required reserves as sterilisation tools. But, in fact, many central banks use a wider range of tools to manage the liquidity effects of foreign exchange intervention, such as accepting short-term deposits from banks and other standing facilities. To draw implications of our results for these alternative tools, one possibility is that the distinguishing feature of central bank bills is that is that they are market-based instruments; banks are not typically forced to hold them, but are instead responding to price incentives when they choose to do so. In contrast, required reserves are, by definition, a non-market-based tool that is imposed on banks. There are other possible distinguishing characteristics as well. For example, where non-banks are able to purchase central bank bills this may dilute the negative effects of sterilisation on credit growth. But we leave further investigation of these issues to future work.

Our results have implications for the use of liquidity management tools that are likely to extend beyond Asia. For example, many advanced economies have engaged in quantitative easing that has had the effect of rapidly expanding central bank balance sheets and the quantity of liquidity in the banking system. If or when conditions "normalise" in these economies, central banks may be faced with the need to rapidly absorb excessive liquidity in order to achieve domestic policy objectives. While the source of excess liquidity is very different from that characterising the Asian experience, the implications of different tools that may be used to soak up the surplus liquidity for bank lending are likely to bear parallels with those outlined here.

References

Bianchi, J and S Bigio (2014): "Banks, liquidity management and monetary policy", *NBER Working Paper*, no 20490.

Cook, D and J Yetman (2012): "Expanding central bank balance sheets in emerging Asia: a compendium of risks and some evidence", *BIS Papers*, no 66, pp 30–75.

Diamond, D and P Dybvig (1983): "Bank runs, deposit insurance, and liquidity", *Journal of Political Economy*, vol 91, no 3, pp 401–19.

Gandanecz, B, A Mehrotra and M Mohanty (2014): "Foreign exchange intervention and the banking system balance sheet in emerging market economies", *BIS Working Paper*, no 445.

Ho, C and R McCauley (2008): "The domestic financial consequences of reserve accumulation: some evidence from Asia", in R Rajan, S Thangavelu and R Parinduri (eds), *Exchange rate, monetary and financial issues and policies in Asia*, World Scientific (Singapore) pp 117–53.

Ippolito, F, A Ozdagli and A Perez (2013): "Is bank debt special for the transmission of monetary policy? Evidence from the stock market", *Federal Reserve Bank of Boston Working Paper*, no 13/17.

Kashyap, A and J Stein (2000): "What do a million observations say about the transmission of monetary policy?", *American Economic Review*, vol 90, no 3, pp 407–28.

Ma, G, Y Xiandong and L Xi (2011): "China's evolving reserve requirements", *BIS Working Papers*, no 360.

Comments on "A comparison of liquidity management tools in seven Asian economies"

Martin Bodenstein[1]

Summary

This paper assesses how the choice of sterilisation tool for foreign exchange interventions impacts bank lending. The paper's theoretical and empirical results suggest that both increases in reserve requirements and the issuance of central bank bills are effective in absorbing excess liquidity in the banking system, and that the former can slow bank lending by more. The issuance of central bank bills may actually increase bank lending in some cases. Overall, the effects are more pronounced for increases in reserve requirements and increases in reserve requirements disproportionately impact small and weaker banks.

These findings are obtained from panel data for eight Asian countries with the data running from 2000 to 2013, ie the years after the Asian financial crisis. The estimation strategy follows the one-step procedure in Kashyap and Stein (2000). The fixed effect panel regression seeks to explain bank lending by bank attributes, attributes of the economy, central bank assets and liabilities, and interaction terms.

Comments on data

Before embedding this paper into a broader context, a few technical comments are in order. Data comparability across countries is always an issue in international studies and this paper is no exception. The definition of required reserves differs vastly across central banks. What asset classes are subject to reserve requirements at which financial institutions in the different countries? For example, many developing countries apply lower reserve ratios to small rural banks. Also, depending on the use of reserve requirements for the purpose of monetary policy, banks may strategically choose to allocate assets to avoid such requirements.

Broader perspective

To place this paper in a broader policy context, I distinguish between two liquidity ("bank reserves") positions of the banking system. The system can be either in deficit or in surplus. The system's liquidity position impacts the transmission of monetary policy, the conduct of central bank, and the central bank's income.

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If the system faces a structural liquidity deficit, commercial banks are forced to borrow from the central bank to meet reserve requirements and interbank payments. The central bank focuses on injecting liquidity into the market, and it determines the conditions of the transactions by setting the price, quality, and quantity of the assets and the required collateral. This situation used to describe the position of the banking system in the United States and the euro area before the 2007–08 Global Financial Crisis.

When the banking system faces a structural liquidity surplus, the situation of the central bank is fundamentally changed. Commercial banks may not be forced to transact with the central bank any more. And the central bank may find itself in a weaker position to determine the conditions of the transactions with regard to price, quality, and quantity of the assets and the required collateral.

How does a surplus situation come into existence? A liquidity surplus can arise from sustained growth in any assets of a central bank, but the most common sources are growth in (net) foreign assets and (net) government lending. In the emerging economies of East, South and Southeast Asia, central banks drastically increased their holdings in foreign currency assets after the Asian financial crisis and have generated excess liquidity in the financial system through exchange rate interventions. As a result of this asset accumulation, central bank balance sheets have grown. An interesting aside to this issue is the fact that many aspects and challenges of the liquidity management in emerging Asia are similar to those faced by central banks in the developed world upon normalisation of their monetary policy.

To mange the liquidity surplus, central banks can employ the very same tools as under a liquidity deficit, namely required reserves, open market operations and standing facilities. These three tools can be used to provide or drain liquidity. In the case of a liquidity surplus, however, the additional question arises whether the central bank wants to push the system into liquidity deficit.

In the case of emerging Asia, central banks have resorted mostly to changing reserve requirements and/or the issuance of central bank bills in open market operations. Central bank bills have several appealing features. They are marketable instruments issued by the central bank, of any maturity (often below two years), denomination (domestic or foreign), or interest rate (fixed or flexible). The operations with these securities are unrestricted in size except for market appetite or law. Furthermore, central bank bills can be tradable in secondary markets and permit equitable distribution of liquidity when interbank markets are not well developed. Absent large holdings of government debt by the central bank – as is commonly the case in developing Asia – absorbing reserves through open market operations in central bank bills is a close substitute for operations with government debt.

Despite the appeal of central bank bills, reserve requirements remain a popular tool for managing a liquidity surplus situation, as they provide a simple and cheap way of absorbing liquidity. See the paper by the authors for country details. However, in contrast to central bank bills, reserve requirements are often unremunerated and represent a tax on financial intermediation. They constrain deposit-taking and lending, and incentivise banks to engage in activities that are not subject to reserve requirements. Also the precision of the instrument with respect to the volume of reserves absorbed has been called into question as the outcomes are dependent on bank balance sheets. Finally, changes in reserve requirements may have a differential impact on banks, as reserve holdings can vary importantly across banks.

Reconnecting to the paper

In the light of the various characteristics of reserve requirements and central bank bills, I close by asking the normative question about the desirable characteristics of a tool that is employed to drain liquidity. Many lists can be drawn up for this purpose, and the following is only one. A good tool for draining liquidity in a surplus situation should:

- be easy to employ and transparent to implement;
- be powerful and effective;
- require limited action to offset the unintended consequences of sterilisation; and
- keep distortions in the banking sector to a minimum.

Overall, central bank bills seem to score higher than reserve requirements when taking the above list as a yardstick. This paper has taken an important step towards supporting this view. According to the authors, reserve requirements were found to slow bank lending while the issuance of central bank bills could actually result in an increase in bank lending. Furthermore, increases in reserve requirements disproportionately impact small and weaker banks and lead to distortions in the banking sector. However, more quantitative evidence is required to arrive at a final assessment.

For references and background see:

Ho, C (2008): "Implementing monetary policy in the 2000s: operating procedures in Asia and beyond", *BIS Working Papers*, no 253.

Nyawata, O (2012): "Treasury bills and/or central bank bills for absorbing surplus liquidity: the main considerations", *IMF Working Paper*, no WP/12/40.

Gray, S and P Runchana (2015): "Issuance of central bank securities: international experiences and guidelines", *IMF Working Paper*, no WP/15/106.

A spectral perspective on natural interest rates in Asia-Pacific: changes and possible drivers[1]

Feng Zhu[2]

Abstract

I study the evolution of the equilibrium real interest rate, also known as the natural or neutral interest rate, in Asia-Pacific. Simple estimates based on a statistical approach suggest that, except for China, and Thailand since 2005, the natural interest rate may have declined substantially in Asia-Pacific economies since the early or mid-1990s, by over 4 percentage points on average. In many economies the rate has turned negative. The tendency has become more accentuated in the 2000s, especially following the onset of the Global Financial Crisis. The natural interest rate appears to vary significantly over time and across economies. Nevertheless, simple natural interest rate estimates are unreliable, and large uncertainties and sizeable heterogeneity in the estimates of the equilibrium real interest rate call for caution as well as monetary policy rules which are robust to such uncertainties.

I use frequency-domain techniques to examine the relationship between the long-run component of real interest rate and those of population characteristics, globalisation, and a range of macroeconomic and financial variables (eg credit and asset prices). I estimate spectral and cospectral densities, coherency and the frequency-specific coefficients of correlation and regression proposed by Zhu (2005). The association seems to be broad and strong between the natural interest rate and the low-frequency trend components of demographic and global factors in Asia-Pacific, but weak between the natural interest rate and trends in asset prices, credit-to-GDP ratio and trend growth in many economies in the region. In most cases, the natural interest rate seems to be correlated with broad measures of long-term financial sector development, and trends in savings rate and investment ratio. Understanding the underlying factors driving changes in each economy's natural interest rate is important for the correct calibration and implementation of monetary policy.

Keywords: asset price, credit, demography, equilibrium real interest rates, frequency-domain methods, globalisation, natural interest rates, population ageing, trend growth.

JEL classification: E43, E44, E52, F62, J11.

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I. Introduction

Lower growth rates and slow global recovery, especially following the recent Global Financial Crisis and the Great Recession, have raised concerns on whether the global economy has arrived at a "new normal" with lower trend growth and higher unemployment. The slower-than-expected trend growth has been accompanied by an extended period of very low or negative real interest rates, prompting questions on whether we also live now in a world of "new neutral" with lower equilibrium real interest rates.

The century-old concept of an equilibrium real interest rate, also known as the natural or neutral interest rate, dates back to Knut Wicksell (1898), who suggests that "there is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them. This is necessarily the same as the rate of interest which would be determined by supply and demand if no use were made of money and all lending were effected in the form of real capital goods". Friedman (1968) extends the idea, proposing a "natural rate of unemployment", and in his words, using "the term 'natural' for the same reason Wicksell did – to try to separate the real forces from monetary forces". More recently, Woodford (2003) proposes a neo-Wicksellian or New Keynesian framework for the analysis of monetary policy, where the natural rate of interest plays a key role in the fluctuations of output and inflation.

The equilibrium real interest rate could potentially serve as an important benchmark for policymakers, who have long been searching for reliable indicators to help formulate and guide monetary policy.[3] This is even more relevant considering that most central banks conduct monetary policy by setting a target for a short-term nominal interest rate, eg an overnight money market rate. The equilibrium real interest rate provides a standard benchmark against which the policymakers can directly measure the policy rates and evaluate the policy stance.[4] Furthermore, the rate is also of great relevance to budgetary decisions and longer-term fiscal planning.

IMF (2014) finds that "real interest rates worldwide have declined substantially since the 1980s". King and Low (2014) estimate a "world real interest rate" and find that the weighted rate has declined from a peak of 4.93% in the first quarter of 1992 to –0.48% in the second quarter of 2013. Bernanke (2015a) observes that the exceptionally low global interest rates, both short- and long-term, are not a "short-

3 As Greenspan (1993) puts it, "One important guidepost is real interest rates, which have a key bearing on longer run spending decisions and inflation prospects. In assessing real rates, the central issue is their relationship to an equilibrium interest rate, specifically, the real rate level that, if maintained, would keep the economy at its production potential over time. Rates persisting above that level, history tells us, tend to be associated with slack, disinflation, and economic stagnation — below that level with eventual resource bottlenecks and rising inflation." Canzoneri, Cumby and Diba (2015) suggest that "it is most important for monetary policy to be able to track the (unobserved) natural rate of interest in environments in which that rate takes big and sustained swings away from its long run equilibrium". To achieve full employment of resources, in Bernanke's (2015a) words, the Federal Reserve needs to push market interest rates "toward levels consistent with the equilibrium rate, or – more realistically – its best estimate". In a recent speech, Yellen (2015) suggests that "as the equilibrium real funds rate continues to rise, it will accordingly be appropriate to raise the actual level of the real federal funds rate in tandem, all else being equal."

4 Indeed, the constant term in the alternative benchmark Taylor (1993, 1997) rules, is a real policy interest rate consistent with full employment and stable prices, where the output gap is eliminated and inflation is equal to its long-run equilibrium value.

term aberration" but a long-term trend. Low real interest rates may matter to policymakers for various reasons. When they stay low in normal times, adverse shocks are more likely to lead policymakers to drive real rates lower or even negative in their quest for full employment and price stability. In addition, low nominal and real interest rates may lead to an accumulation of financial imbalances and undermine financial stability. According to Summers (2014), low rates may increase investors' risk-taking, promote irresponsible lending and make Ponzi financial structures more attractive.

The downward trend in real interest rates has been accompanied by an apparent decline in estimated equilibrium real interest rates, which have again been at the centre stage in recent policy debates. Barsky, Justiniano and Melosi (2014) find the natural rate negative in the last three recessions and "has remained persistently depressed since 2008". Williams (2015) identifies a "moderate secular decline (in the US natural rate) over the two decades preceding the Great Recession", and a "more substantial decline during the Great Recession". Yellen (2015) points out that some current external estimates of a close-to-zero equilibrium real federal funds rate fall well below the FOMC's assessment of longer-run levels. Moreover, there is also a discrepancy between, eg the recently updated Laubach-Williams (2003) estimate of – 0.16% for the fourth quarter of 2014, and the 1–2% range provided by Hamilton, Harris, Hatzius and West (2015).

There are several competing theories behind the decline in equilibrium real interest rates. First, globalisation, especially trade and financial integration have helped forge a global market where domestic factors have begun to play a less prominent role. Financial integration implies that a larger share of global savings is channelled into cross-border financing of investment. In this vein, Bernanke (2005) proposes the "global saving glut" hypothesis, whereby the real interest rate falls to equilibrate the market for global savings as desired savings outstrip desired investment, and savings originating in China and other emerging economies hold down long-term interest rates. Caballero (2006) suggests the existence of a "safe asset shortage" due to rising global demand, as in emerging economies with rapid growth and high savings, there is only a limited availability of local safe assets in these undeveloped capital markets. Nevertheless, it is argued that these alone could not explain Greenspan's (2005) "conundrum" of anomalously low long-term interest rates. Although China's current account surplus has shrunk from over 10% in 2007 to 1.6% in 2013 and 2.1% in 2014, global interest rates have further declined (see Graph B.1.2, left-hand panel).

Second, many economists link the apparent decline in equilibrium real interest rates to a "new normal" world of lower potential output and trend growth, manifested in sluggish growth persisting in the major economies following the financial crisis. This has often been attributed to, among other factors, a secular deficiency in aggregate demand, significant financial frictions, unfavourable demographic trends, ebbing innovations, debt overhang and insufficient structural policies.[5]

[5] Lo and Rogoff (2014) survey alternative explanations for the sluggish economic growth persisting in many advanced economies after the onset of the financial crisis, and find it difficult to quantify and discern the effects of different long-term factors on economic growth until the post-financial-crisis debt overhang significantly abates.

One notable thesis, that of "secular stagnation", was first proposed by Alvin Hansen (1934, 1939) and recently resurrected by Summers (2013, 2014a, 2014b) and Krugman (2013, 2014). The idea is that a low and declining rate of population growth and a slower pace of technological advance result in lower returns, less investment and consumer spending, creating a situation of persistently inadequate demand.[6] This leads to a declining natural rate of interest. Hansen (1939) considers that the *essence* of secular stagnation is the "sick recoveries which die in their infancy and depressions which feed on themselves and leave a hard and seemingly immovable core of unemployment",[7] a scenario of slow jobless recoveries that the world has grown accustomed to in more recent times.

Related to this new-normal slow growth scenario is the "new neutral" thesis focusing on the exceedingly low real policy rates in many advanced and emerging economies alike. McCulley (2003) considers the US natural rate much lower than commonly assumed. In Clarida's (2014) view, central banks now operate in a world where average policy rates are set well below their pre-crisis levels, a direct consequence of the "global leverage overhang and moderate rates of potential trend growth". Clarida (2015) suggests that global factors have played a key role, with the lower US neutral policy rate driven by a slowdown in "global potential growth", and "a persistent excess of global saving relative to desired investment opportunities".

Other economists have cast doubts on the relevance of the hypothesis of secular stagnation and its inevitability. Eichengreen (2014) opines that the global economy is not predestined to suffer from secular stagnation, and "if the US experiences secular stagnation, the condition will be self-inflicted".[8] Eichengreen (2015) points out that, based on the life cycle theory, slower population growth and greater life expectancy actually imply lower savings rates. Bernanke (2015a) criticises the proponents' lack of consideration of the international dimension and global factors affecting domestic spending, and he questions whether an economy's equilibrium real interest rate can stay negative for an extended period. Gordon (2014a, b) attributes the diminished long-run growth potential to a return of US technological progress to its low historical norm, besides the structural headwinds of stagnant population and average US education level, rising inequality, productivity slowdown and elevated public debt. Hamilton, Harris, Hatzius and West (2015) argue that the recent slow growth is likely due more to temporary "headwinds" which may be dissipating, as the balance sheet repair continues with the help of an easy monetary policy.

All of the arguments above are quite relevant to the Asia-Pacific economies. Real interest rates have trended down in this region too, as growth has slowed and inflation has dropped in many Asian economies in recent years. This has posed

6 According to Keynes (1937), "in an era of a declining population, … demand tends to be below what was expected and a state of over-supply is less easily corrected. Thus a pessimistic atmosphere may ensue".

7 Eichengreen (2015) defines secular stagnation as a "downward tendency of the real interest rate, reflecting an excess of desired saving over desired investment, resulting in a persistent output gap and/or slow rate of economic growth".

8 According to Eichengreen (2014), a US secular stagnation would reflect the country's failure "to address its infrastructure, education and training needs", "to take steps to repair the damage caused by the Great Recession and support aggregate demand in an effort to bring the long-term unemployed back into the labour market." In his view, "these are concrete policy problems with concrete policy solutions".

significant challenges for policymakers seeking guidance from estimates of the natural rates of interest and unemployment to implement monetary policy. Yet there have been so far very few attempts to estimate and assess equilibrium real interest rates for the emerging economies, and even fewer for emerging Asia.[9] This paper attempts to fill this lacuna by providing some simple estimates and, in so doing, shed light on the evolution of equilibrium real interest rates in a number of Asia-Pacific economies. In particular, I examine the roles of demographic trends, globalisation, financial intermediation and trend growth in the evolution of natural interest rates in the region to determine whether these factors may account for the changes over time and differences across countries in the natural rate estimates.

Several results emerge. First, I find that except for China, and also Thailand since 2005, the natural interest rate has declined substantially in the Asia-Pacific economies since the early or mid-1990s, by over 4 percentage points on average. In many economies the rate has turned negative. The tendency has become more accentuated in the 2000s, especially since the onset of the Global Financial Crisis and the Great Recession. Second, the natural interest rate estimates vary significantly over time and across economies. Third, the association seems to be broad and strong between the natural interest rate and the low-frequency trend components of demographic and global factors in Asia-Pacific, but it appears to be weak between the natural interest rate and trends in asset prices, credit-to-GDP ratio and trend growth in many economies in the region. In most cases, the natural interest rate does seem to be correlated with broadly measured long-term financial sector development, and trends in savings rate and investment ratio.

Nevertheless, large uncertainties and sizeable heterogeneity in the estimates of the equilibrium real interest rate call for caution as well as monetary policy rules that are robust to such uncertainties. In addition, understanding the underlying factors driving changes in the each economy's natural interest rate is important for the correct calibration and implementation of monetary policy.

The rest of the paper is structured as follows. In the next section, I review the existing approaches to the estimation of equilibrium real interest rates. In Section III, I give a detailed account of the empirical methodology, namely the estimation of frequency-domain indicators. Section IV presents results on equilibrium real interest rate estimates in Asia-Pacific based on spectral time series analyses. Section V discusses the monetary policy implications and Section VI concludes. The appendices include a detailed description of tools for frequency domain analysis; graphs of the estimates of the natural interest rate and its relationship with macro, financial, demographic and global factors; and a description of data.

II. Estimating the equilibrium real interest rate

The equilibrium real interest rate, or the natural or neutral rate, has been defined in various ways based on economic theory. Often the natural rate is taken as the rate that equates saving and investment; or the one that is equal to the marginal productivity of capital. In fact, the natural rate is most meaningful in a general equilibrium, and is more appropriately defined as the rate that is consistent with full

9 There are exceptions, see, for example, Goyal (2008) and Goyal and Arora (2013).

employment and aggregate price stability. For Woodford (2003), the natural rate is the "equilibrium real rate of return when prices are fully flexible". Williams (2003) terms it as the "real fed funds rate consistent with real GDP equalling its potential level (potential GDP) in the absence of transitory shocks to demand", with the potential GDP defined as the "level of output consistent with stable price inflation, absent transitory shocks to supply". Similarly, Ferguson (2004) defines the natural rate as the "real interest rate consistent with the eventual full utilization of resources". Bernanke (2015b) calls it "the real interest rate consistent with full employment of labor and capital resources, perhaps after some period of adjustment".

The equilibrium real interest rate is unknown and has to be estimated. There are four broad approaches to its estimation. The purely statistical approach is model-independent and based on Wicksell's idea that the "natural interest rate" is essentially a rate that prevails in the long run, so it is necessarily slow-moving. To measure the natural rate, one deflates a nominal interest rate by a suitable measure of inflation or its expectations, and then extracts the trend component of the resulting real rate. Under the assumption that, on average, actual rates are at or near their equilibrium values, one takes simple historical averages or moving averages of the real interest rate series over an appropriate time span. The measures rely on data and on the time-series trend-cycle decomposition techniques, taking an agnostic view on the underlying theories. One therefore avoids conflicting estimates of the natural rate that can be derived from the same set of data but differ due to disagreement on its definition and model assumptions. Hamilton, Harris, Hatzius and West's (2015) follow this approach.

Second, financial market-based approaches extract information about the equilibrium real interest rate from the yield curve. Bomfim (2001) points out that a major drawback of the approach is that the long rates may move relative to short rates "for reasons other than a changing differential between actual and equilibrium short-term interest rates". Indeed market participants may misprice interest rate risks, and the long rates may also reflect changes in monetary policy, eg large-scale asset purchases in the major advanced economies. He proposes to estimate a forward-looking natural rate using yields on the US Treasury's inflation-indexed securities (TIPS), as the TIPS yields are not distorted by inflation expectations or inflation risk premiums. Yet such securities exist only in a few advanced markets, and it remains difficult to apply this technique more broadly.

A third, hybrid method is to align a carefully chosen econometric method with economic theory to identify and estimate the natural interest rate as an unobserved component in time-series models. The reduced-form models range from simple univariate regressions on the main determinants of the equilibrium real interest rate, to more elaborate vector autoregressive (VAR) models. A common reaction-function approach is to use Taylor-type feedback rules and take the estimated intercept as the natural rate. Taylor (1993) suggests a natural interest rate estimate of 2% for the US economy. Rotemberg and Woodford (1997) embed a feedback rule within a structural VAR model and estimate the US natural rate to be 3% from Q1 1980 to Q4 1995. In a more sophisticated approach, Laubach and Williams (2003) evaluate the natural rate using the Kalman filter. Specifically, they analyse US inflation and output dynamics in a restricted VAR model, jointly estimating the time-varying natural interest rate, potential output, and trend growth rate. They find a close link between the natural rate and trend growth, yet they concede that the natural rate estimates are "very imprecise and subject to considerable real-time measurement error". Garnier and

Wilhelmsen (2005) apply the method to the euro area and find that its natural rate has declined gradually since the early 1960s.

A fourth, more elaborate approach relies on structural models to better identify an economy's unobservable natural interest rate, in which the structural shocks likely to drive the evolution of the natural rate are well specified. Bomfim (1997) uses the MIT-Penn-SSRC (MPS) Keynesian model of the US economy to obtain an equilibrium federal funds rate series. The concept of the natural interest rate is especially appealing in Woodford's (2003) neo-Wicksellian framework: in the New Keynesian dynamic stochastic general equilibrium (DSGE) models with nominal rigidities,[10] the natural rate is defined as the real interest rate that would prevail when prices are fully flexible. In a situation of "divine coincidence" without the trade-off between the stabilisation of inflation and output gap, monetary policy simply tracks the estimated natural rate as the benchmark in every period. Edge, Kiley and Laforte (2008) rely on the evolution of natural rates of output and interest estimated from a DSGE model for the US economy to explain macroeconomic fluctuations. Based on estimated DSGE models for the US and euro area economies, Andrés, López-Salido and Nelson (2009) find that real money balances are valuable in anticipating future variations in the natural interest rate.

The structural general equilibrium approach has the advantage of allowing for the accounting of the sources of fluctuations in the equilibrium real interest rate. One significant drawback, more so in the aftermath of the Global Financial Crisis, is that the DSGE models have yet to better account for non-linearities and provide a convincing and realistic description of the functioning of financial intermediation in the economy.

The natural interest rate is often taken as constant, eg the original Taylor rule assumes an equilibrium real rate of 2%. Yet Wicksell (1898) points out that the natural rate is "never high or low in itself, but only in relation to the profit which people can make with the money in their hands, and this, of course, varies. In good times, when trade is brisk, the rate of profit is high, and, what is of great consequence, is generally expected to remain high; in periods of depression it is low, and expected to remain low." Laubach and Williams (2003), Mésonnier and Renne (2007) and Trehana and Wu (2007) explicitly take into account time variation in the natural rate estimates.

I take the first, statistical, approach and estimate the natural interest rate for a number of Asia-Pacific economies by identifying a time-varying trend in short-term policy rates, isolating the long-run component in the time series. The paper acknowledges the time-varying nature of the natural interest rate and treats it as such in the estimation.

III. Methodology and data

The equilibrium real interest rate is unknown and unobservable; it can only be estimated, and unfortunately, the existing literature indicates that the estimates tend to be imprecise. This is particularly the case when economies face large shocks or go through structural changes. This section illustrates two empirical approaches I use to estimate the time-varying natural interest rates in Asia-Pacific, and to assess their

10 See, for example, Smets and Wouters (2003) and Christiano, Eichenbaum and Evans (2005).

relationship with trend growth rates, demographic trends, financial developments and an index of globalisation. I first apply the well known time-domain Hodrick-Prescott (1980, 1997) filter to these series to obtain the trend components for these variables and examine their correlations; I then use various different tools of spectral analysis of time series in the frequency domain to evaluate the relationship between natural interest rate estimates and the above-mentioned potential drivers.

III.1. Data and variables[11]

The empirical analysis is based on annual and quarterly data for 13 Asia-Pacific economies: Australia, China, Hong Kong SAR, India, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore, Thailand and the United States, spanning the period Q1 1950–Q4 2014. To get the data as early in time as possible, the empirical analysis focuses on annual data, with the downside of having fewer data points available.

The set of data series comprises macroeconomic real and price variables (real GDP, real private consumption, employment, unemployment rate, consumer price index or CPI, GDP deflator, Consensus Economics © CPI forecasts and real effective exchange rate or REER), demographic variables (growth in total and working age population, shares of those aged between 39 and 64 years and of those aged above 64 years in total population, total and old age dependency ratios, and life expectancy), financial variables (real equity and housing prices, total bank lending, total credit to the private sector, financial development index of Sahay et al (2015) which measures the depth, access and efficiency of financial institutions and financial markets), and external or global variables (KOF globalisation indices of Dreher (2006) and Dreher, Gaston and Martens (2008); King-Low (2014) world real interest rate, global official liquidity, G7 and G20 aggregate policy rate).

The key variable is obviously the real interest rate, which is obtained by deflating a nominal interest rate by a suitable measure of inflation or its expectations. The choice of the type and maturity of the nominal interest rate is relatively straightforward: central banks are most interested in a natural rate benchmark towards which the policymakers can adjust the policy rates. Therefore I focus on short-term nominal interest rates that are either policy rates or their closest market counterparts. For most economies, this means an interbank overnight rate. In China's case, I use an average of interbank overnight, seven-day repo and three-month deposit rates. For Hong Kong SAR and New Zealand, the one-month HIBOR rate and 30-day Bank Bill rate are used, respectively. To obtain longer historical series, I supplement the series with less appealing alternatives, such as discount rates.

To compute an *ex ante* real interest rate, it is important to have an appropriate measure of inflation expectations. One measure is the difference between the interest rates on nominal US Treasuries and on US Treasury's inflation-indexed securities, yet inflation-indexed bonds are uncommon in the region. Another measure is private sector forecasts, which are scarce for most economies in our sample. While Consensus Economics © forecasts are available, they only start in the last quarter of 1989 or later for the economies in the region. A more practical alternative is to use the forecasts from a simple autoregressive model of actual inflation to proxy the expected inflation, as in Blanchard and Summers (1984) and Hamilton, Harris, Hatzius and West (2015). I

[11] Annex C provides details of the definition, construction and sources of data used in this paper.

take a similar approach. I first use the Hodrick-Prescott filter and other spectral methods to decompose the inflation rate into the trend and cyclical components, I then use the trend component as the expected inflation to obtain the *ex ante* real interest rate. The approach has the advantage that trend inflation can be seen as a proxy for the long-run equilibrium inflation rate, a target for central banks pursuing price stability.

III.2. Empirical methods

Spectral analysis of time series is appealing, as covariance stationary processes can be uniquely decomposed into mutually uncorrelated components, each associated with a specific frequency (band). Spectral or frequency-domain methods have a long tradition in the economic analysis of time series. Granger (1966) provides evidence that macroeconomic time series tend to be persistent and have a "typical spectral shape" with much of the power of the time series concentrating in the very low frequencies, ie the long run. Granger and Rees (1968) apply spectral methods to analyse the term structure of interest rates. Hannan (1963a, 1963b) pioneered spectral regression analysis, which was introduced to economics by Engle (1974, 1978, 1980). Phillips (1991) applies it to integrated time series to obtain asymptotically median unbiased estimates of cointegrating coefficients. Spectral regression allows us to focus on specific frequency bands, and permit a non-parametric treatment of regression errors.

Instead of working directly in the frequency domain, economists often rely on linear filters that decompose data into trend and cycle components converted back into the time domain. These include the Lucas (1980) exponential smoothing filter, the Hodrick-Prescott (1980, 1997) and the Baxter-King (1999) band-pass filter. Due to finite data length, these filters are only approximations to the ideal filters, and filter leakage, compression and exacerbation are inevitable. Moreover, simple correlation and regression analyses average relationships within each frequency band, this could mask possibly large variations within any pre-specified band.

We use frequency-domain methods to study how estimated equilibrium real interest rates may behave in Asia-Pacific economies, and how they relate to potential natural rate drivers such as demographics, globalisation, financial developments and growth at different frequencies in different economies. Engle (1974) points out that "there is little discussion of whether the same model applies to all frequencies. It may be too much to ask of a model that it explain both slow and rapid shifts in the variables, or both seasonal and non-seasonal behaviour. It is at least reasonable to test the hypothesis that the same model applies at various frequencies." Zhu (2005) uncovers significant difference in the inflation-output trade-offs across the spectrum, from the short to the long run. Zhu (2012) finds that the credit and output relationship varies greatly from the short to the long run, being strong in the very low frequencies but rather weak in business-cycle and higher frequencies.

Significant cross-frequency differences in how the natural rates relate to the potential drivers may have important implications for policymaking. In this paper, I take a more direct approach and examine such linkages in the entire spectrum. I first estimate conventional spectral indicators including spectral and cross-spectral densities, coherency, transfer function, gain and phase-to-frequency ratio. I then assess the natural interest rate linkages estimating frequency-specific coefficients of correlation (FSCC) and regression (FSCR) proposed by Zhu (2005).[12] To obtain the coefficient estimates, I apply a data extraction procedure based on Fourier and inverse Fourier transforms. I convert the data back into the time domain, where conventional statistics can be calculated.

The FSCC is superior to traditional indicators, such as coherence and cospectrum, by providing a real-valued, normalised and signed measure of the strength of multiple correlation. Unlike coherence, the FSCC is signed. Compared with the cospectrum, it is standardised taking values in the [–1,1] range, providing a clear indication of the strength of correlation independent of data scale. The FSCR has the advantage of being easily applied to any specific frequency, and the statistical inference with both FSCC and FSCR estimates is straightforward.

IV. Estimating equilibrium real interest rates

A visual inspection of the equilibrium real interest rates, estimated based on the Hodrick-Prescott (1981) filtering technique, suggests both commonality and diversity (Graphs B.2.1 and B.2.2 in Annex B.2). First, the estimated natural interest rates have fallen significantly since the early and mid-1990s. In most cases, the decline has been sizeable, above 4 percentage points. In some economies, the decline started earlier, eg Singapore and Thailand in the early 1980s and the United States in the late 1980s. In addition, the fall has apparently been accentuated in the aftermath of the 2007–09 Global Financial Crisis. In contrast, the estimated equilibrium real interest rate has been on an upward trend in China since 1993, when data became available. In Thailand's case, the natural rate apparently started to rebound from a low of 0.61% in 2005 to reach 1.60% in 2014.

Second, natural rate estimates in the Asia-Pacific economies show different patterns of evolution, and the rates can differ substantially from each other at any single point of time. In particular, Japan's natural interest rate has evolved in a notably different way. It rose significantly from the low, negative levels in the first years of the 1970s to a peak in the early 1980s, but has experienced a long secular decline since then.

Notably, while negative equilibrium real interest rates were less common in the past, they have become a standard feature in many regional economies in the aftermath of the Global Financial Crisis. Out of Australia, China, Malaysia and Thailand, the natural rates are now at historically low levels. While the natural rates in New Zealand, Singapore and Thailand have stayed positive throughout the sample period, all other economies have experienced negative natural interest rates in the past.

The frequency-domain analysis focuses on the likely factors behind the secular decline in equilibrium real interest rates, namely, changing demographic trends, rising globalisation, financial sector developments and slowing trend growth. The analysis is based on the estimates of a set of traditional frequency-domain indicators: spectral density, or power spectrum, estimated using Welch's method, which records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process; cospectral density, also known as

[12] Annex A provides an exposition of frequency-domain analysis used in this paper. For further details, see Zhu (2005, 2012).

cross-power spectral density or cospectrum, estimated using Welch's averaged modified periodogram method, which represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band; squared coherence, or coherency, estimated using Welch's averaged periodogram method, which, like the coefficient of determination R^2, measures the strength of linear association between two stochastic processes at a specific frequency or frequency band; gain or transfer is analogous to a standardised regression coefficient at a given frequency; and the phase measures the timing or average phase lead of one series over another at different frequencies, which incorporates all relevant information about leads and lags.

The estimates of traditional spectral indicators are presented in Annex B.3, along with the estimates of Zhu's (2005) frequency-specific coefficients of correlation and regression. In all graphs, the shaded grey area indicates the business-cycle frequency range of between six quarters (marked by "H") and 32 quarters (marked by "L"). The area between 0 and L is the low-frequency range which contains the trend component, which is of primary interests to the analysis when low-frequency, long-run relationships are examined in comparison with their business-cycle- and high-frequency counterparts.

Spectral density estimates indicate that almost all demographic, global, macroeconomic and financial variables under study have the "typical spectral shape" of Granger (1966). The spectral density estimates indicate that most of these variables are very persistent in Asia-Pacific economies, with much of the power of their spectral density concentrating in the very low frequencies, ie the long run of beyond 32 quarters. This suggests that understanding trends are crucial to the analysis. However, one major exception is asset prices, of which the power is more evenly distributed across the frequency range, or more heavily concentrated in higher frequencies. This is the case for real housing price inflation in Australia, and for real equity price inflation in China, India, Indonesia and Japan. In a number of cases, eg real housing price inflation in Korea and real equity price inflation in Malaysia, asset prices actually have more power in the business cycle (six to 32 quarters) or higher frequencies. This implies that cycles in equity or housing prices may carry more power than trends. It is no wonder that trend equity or housing price inflation turns out to have a relatively weak association with the equilibrium real interest rate in the analysis.

Similarly, estimates of cross-spectral density, coherency, gain and frequency-specific coefficients of correlation and regression suggest that association between real interest rates and many of the demographic, global, macroeconomic and financial variables I examine are often strongest in the very low frequencies (ie the long run) in Asia-Pacific, but such an association is not always strong in absolute terms. In particular, real interest rates seem to be more associated with many financial variables in higher frequencies, implying that real GDP growth and asset market or credit market developments are not as crucial to the understanding of evolution of the equilibrium real interest rate as many of us have assumed, and other factors, especially globalisation and demographic trends may matter more.

The following subsections give a detailed account of the correlations of these factors with the estimates of equilibrium real interest rates in the Asia-Pacific economies.

IV.1. Demographic trends

As the world population continues to expand, it has been ageing rapidly (Graph B.1.1 in Annex B.1). Population ageing is likely to reduce per capita GDP growth and prompt changes in the savings and investment dynamics. Ageing tends to decrease saving in the advanced economies and boost the equilibrium real interest rate, but it tends to make labour scarcer relative to capital, reducing the interest rate. In the emerging economies, at higher growth rates, saving is higher as the population is expected to age, which depresses the world equilibrium interest rate.

Empirical work suggests that demographic trends and changes in population structure may have an important impact on the equilibrium real interest rate. For example, simulations by Börsch-Supan (2004) suggest a 1.5 percentage-point decline in the European Union's natural rate in the next 30 years. Population ageing has already profoundly affected the Japanese economy.[13] Indeed Japan's working-age population began to decline in absolute terms in the mid-1990s, and both Korea and China are expected to face similar challenges in the coming decades. According to its National Bureau of Statistics, China's working age population has continued to decline since 2012, accompanied by rising labour costs.

I use several variables to describe population dynamics. First, the shares of those aged between 39 and 64 years and of those aged above 64 years in total population, which correspond to the population groups that save most for retirement or dissave in retirement, respectively. The patterns of their saving and consumption have a direct impact on an economy's saving-investment dynamics, and hence the equilibrium real interest rate. Second, the total and old age dependency ratios indicate an economy's ability to sustain non-working age population. Third, rising life expectancy may influence individual decisions on work, consumption and saving. As life expectancy rises, retirement is postponed yet periods of retirement lengthen. Savings can rise in the aggregate as workers save more or they can fall due to the dissaving of retirees. Fourth, growth in the working age population has slowed or turned negative in many advanced economies, and the secular trend has started to affect some emerging economies. This reduces an economy's long-term growth potential and its natural interest rate.

As Graph B.1.1 shows, the King-Low (2014) world real interest rate has followed a broad downward trend, falling from a peak of 4.80% in 1993 to a trough of –0.08% in 2012. This has been accompanied by the continued rise in people aged between 39 and 64 years and of those aged above 64 years, and the groups' shares in the world population. At the same time, the growth rate in the world working age population has slowed to less than half its previous rate in less than two decades. Spectral analysis provides further interesting details of the relationship between real interest rate and population dynamics in Asia-Pacific (Graphs in Annex B.3). First, while spectral density estimates indicate that trend is the most important component in the share of people aged 39–64 in total population and old age dependency ratio, there are clear four distinct cycles in higher frequencies of less than six quarters, for all economies in the sample. The demographic trend and cycles may then be translated into their relationships with the real interest rate, as indicated by the cospectral density estimates.

[13] See Shirakawa (2011) and Shirai (2012).

Second, a strong association between demographic trends and the equilibrium real interest rate is seen in most spectral indicators in many economies. This is most apparent in the cospectral density and coherency estimates. However, correlation patterns can differ, and in some cases, the sign of correlation, raising important issues regarding economic reasoning behand the relationship between demographic trends and the natural interest rate. Two important exceptions may be China and Korea, where correlation coefficient estimates at around 32 quarters point to statistically insignificant correlations between the equilibrium real interest rate and the population share of those aged 39–64 and the old-age dependency ratio; but they indicate a statistically significant, strong and negative correlation of –0.75 with working age population growth in China, but a large positive correlation in Korea. The old-age dependency ratio correlates negatively with the natural interest rate in Japan but positively in the United States, while working age population growth has a strong positive correlation with the natural interest rate in both countries. Hence population ageing and shrinking working age population lower the equilibrium real interest rate in Japan, but the more complex US population dynamics, largely due to immigration, may imply a different relationship here.

IV.2. Globalisation

Another potential driver of the decline in equilibrium real interest rates is globalisation. The gradual elimination of barriers to cross-border trade and financial transactions has led to an ever more integrated global market for goods and services, labour and financing. As a consequence, the potential output, CPI and asset price dynamics of one economy have become increasingly dependent on those of other economies. Indeed, as the degree of globalisation rises in the major economies, the King-Low (2014) world real interest rate has continued to decline (Graph B.1.2). One key element might have been China's integration into the world economy. Measured by the KOF economic globalisation index, China's globalisation level surpassed that of Japan in 1995, and again in the early 2000s after China's accession to the World Trade Organisation in December 2001. In addition, China's savings rate began a rapid rise in 2001, which probably more than compensated for the decline in the Japanese and US savings rates (Graph B.1.3). These coincided with a steep descent in the world real interest rate starting in 2001.

Global financial integration implies a decreased home bias, as savings in one economy can be used to finance investment in another and domestic interest rates become more closely related. Focusing on the surge of interest rates in the early 1980s, Blanchard and Summers (1984) highlight the global nature of such rate increases. Barro and Sala-i-Martin (1990) postulate a global capital market where the interest rate is determined by global investment demand and desired saving. Bosworth (2014) considers capital markets highly integrated globally, so that it makes little sense to study interest rates within a closed-economy framework. Moreover, global official liquidity could have played a major role with the advent of large-scale asset purchase programmes by central banks in major advanced economies since late 2008, prompting a second steep descent in the world real interest rate (Graph B.1.3, left-hand panel).

For want of a more appropriate indicator of global trade and financial integration, I use the KOF overall globalisation index developed by Dreher (2006) and Dreher, Gaston and Martens (2008), which summarises the economic, social and political dimensions; and the KOF index of economic globalisation, and sub-indices of the actual trade and capital flows, and of trade and capital account restrictions. I also use an indicator of global official liquidity, which is the sum of the total assets of the central banks in the advanced economies and the foreign reserves of the major emerging economies. Other global liquidity indicators, such as the G7 and G20 aggregate (weighted average) policy rate, are considered, and it is well known that domestic interest rates have over time become more strongly correlated with interest rates in the advanced economies.

Spectral density estimates indicate a large persistence in KOF globalisation indices (Graphs in Annex B.3). Estimates of cospectral density, squared coherence and frequency-specific correlation coefficient suggest that globalisation, overall or economic, is more strongly associated with the equilibrium real interest rate than many other variables in most economies in the region. There is again sizeable heterogeneity: while the evidence is strong in Australia, Malaysia, Japan and the United States, the case is weaker among some emerging Asian economies. In particular, estimates of frequency-specific correlation coefficient indicate that the correlation of KOF overall and economic globalisation indices with the equilibrium real interest rate is not significantly different from zero in China, Indonesia, the Philippines and Thailand, in some cases contradicting evidence provided by other spectral indicators such as cospectral density and coherency. One possibility is that the emerging economies, albeit more globalised than before, are still some distance away from the level of globalisation achieved by the advanced economies, and their interest rates may be more prone to various domestic factors or controls, leading to a weaker association.

IV.3. Financial sector developments

A third driver may be changes in the functioning of financial intermediation due to sizeable financial frictions in the wake of the crisis. There are reasons why financial sector developments may matter for the evolution of the equilibrium real interest rate. As Hamilton, Harris, Hatzius and West (2015) point out, the natural rate may vary according to how monetary policy is transmitted through longer-term interest rates, credit availability and various asset prices including exchange rates. Sustained changes to regulatory policy, such as those we see in the aftermath of the Global Financial Crisis, may change the financial infrastructure and affect the natural rate.

There is evidence that recessions and financial crises may cause permanent damage to an economy and dislocate its equilibrium real interest rates.[14] In addition, financial market frictions may matter for the natural interest rate. De Fiore and Tristani (2011) find that natural rate dynamics may react to exogenous shocks in qualitatively different ways, depending on the underlying model assumptions. While financial market turbulence leads to a fall in the natural rate in their model, which is characterised by nominal rigidities with borrower-lender information asymmetry, it has no macroeconomic impact if financial markets are frictionless. Hamilton, Harris,

[14] Cerra and Saxena (2008) and Reinhart and Rogoff (2009) find highly persistent output effects from deep recessions around the world. Cecchetti and Zhu (2009) suggest that, most often, output level falls permanently and growth rate rises after financial crises. Ball (2014) examines 23 OECD countries and finds that the potential output loss from the Great Recession varies greatly across countries, but is large in most cases. The long-term effects of recessions seem to be consistent with the hysteresis hypothesis of Blanchard and Summers (1986). Reifschneider, Wascher and Wilcox (2013) argue that a recession reduces an economy's potential output.

Hatzius and West (2015) consider a more robust policy rule, which reacts to changes in financial conditions when policymakers have doubts about the true value of the natural interest rate. The rule may be helpful if, eg changes in the natural rate reflect variations in the marginal product of capital, information on which may be contained in equity prices.

I use a number of financial variables, namely, the financial development index of Sahay et al (2015), real credit growth and the growth rates in real housing and equity prices to examine how they correlate with equilibrium real interest rates in the long run. The financial development index developed by Sahay et al (2015) measures the depth, access and efficiency of financial institutions and financial markets. A visual examination shows that, while the decline in world real interest rate seems to be associated with the sustained improvement in the financial development index in China and Japan, its relationship with global credit growth is less clear (Graph B.1.3, right-hand panel).

Estimates of spectral indicators provide a number of interesting findings (Graphs in Annex B.3). First, growth in real equity or housing prices is generally uncorrelated with the estimated equilibrium real interest rate, and much of the correlation between asset prices and the real interest rate occurs at high or very high frequencies, well below four quarters. One exception may be Japan, where the estimated frequency-specific coefficients of correlation point to a positive correlation of close to 0.6 in the low-frequency range, which was contradicted by a very low reading in the squared coherence estimate. Second, compared with real equity and housing prices, the credit-to-GDP ratio tends to have a stronger association with the equilibrium real interest rate estimate at very low frequencies, eg in Australia, India, Indonesia, Malaysia and the Philippines, but the association is generally weak. Long-term credit market developments may therefore have a mild relationship with the evolution of equilibrium real interest rate.

Consistent with earlier observations, broad financial sector development as measured by the financial development index developed by Sahay et al (2015), in the very low frequencies (long run), is indeed more strongly associated with the equilibrium real interest rate estimate in most economies in the region. Again there are exceptions, eg India, Indonesia and Thailand. And in several cases, while cospectral density and coherency estimates indicate the existence of association, this is contradicted by evidence provided in the estimates of frequency-specific correlation coefficients.

To sum up, long-term developments in the financial sector, especially when defined broadly, may be associated with the evolution of equilibrium real interest rate, but credit market per se, and asset prices in particular, are estimated to have rather weak association with the natural interest rate. Improvement in a country's financial infrastructure could play a role in the evolution of the equilibrium real interest rate.

IV.4. Trend growth

One issue that has recently attracted much attention is how closely trend growth is associated with the equilibrium real interest rate. Estimation of the natural rates, eg Laubach and Williams (2003), often embodies a close relationship between the two, with the estimation becoming predicated on this relationship. Yet Bosworth (2014) identifies only a weak relationship between real interest rates and economic growth.

Leduc and Rudebusch (2014) examine private sector professional forecasts and historical data, but they find little evidence that declines in the long-run potential growth rate of the economy translate into lower interest rates. A visual examination of the relationship between the world real interest rate and growth rates in the advanced and emerging economies does not provide a clear-cut pattern and a careful analytical study may help (Graph B.1.1, right-hand panel).

Evidence from the spectral analysis is mixed, and several messages emerge (Graphs in Annex B.3). First, in a number of economies, the estimated correlation between the equilibrium real interest rate and trend growth is not statistically significant: this is the case in Australia, China, Indonesia, and the Philippines. Indeed a stronger relationship between the real interest rate and real GDP growth tends to happen in the high-frequency range of less than four quarters, eg in Australia, India, Korea, Malaysia, the Philippines and the United States, as indicated by coherency estimates. In some other economies, such as Japan, Korea and Thailand and the United States, the estimated correlation between the equilibrium real interest rate and trend growth is strong. The overall evidence is rather mixed, with significant cross-economy heterogeneity. Second, many economies observe a statistically significant correlation of their savings rate and investment ratio with the equilibrium real interest rate. The notable exceptions are China and India, and also Indonesia (investment ratio) and Thailand (savings rate). The correlation is estimated to be stronger in Japan, Korea and Malaysia.

The results suggest that the relationships between the equilibrium real interest rate and trend growth and other macroeconomic variables are more complex than once assumed, and the large disparity in the estimated relationships across the Asia-Pacific economies suggest that more work needs to be done to update economic theory so as to improve our understanding of the equilibrium real interest rate and provide a sound foundation for monetary policymaking.

V. Implications for monetary policy

Can we rely on the estimated equilibrium real interest rates to guide monetary policy? Orphanides and Williams (2002) suggest that, for central banks pursuing price stability and full employment through the adjustment of short-term interest rates in response to economic developments, they need "accurate, quantitative, contemporaneous readings of the natural rate of interest and the natural rate of unemployment". Yet Friedman (1968), the proponent of the concept of "natural rate of unemployment", points out that the policymakers would not know the true natural rate.

One key challenge is that the natural rate estimates are known to be imprecise and subject to a high degree of uncertainty, which greatly reduces their practical usefulness. Laubach and Williams (2003) find the natural interest rate estimates very imprecise and subject to considerable real-time measurement error. Clark and Kozicki (2005) conclude that the natural rate estimates are prone to a "high degree of specification uncertainty, an important one-sided filtering problem, and considerable imprecision due to data uncertainty", and conclude that "statistical estimates of the equilibrium real rate will be difficult to use reliably in practical policy applications". Obtaining good estimates is even harder in most Asia-Pacific economies, as data tend to be of short span and less reliable, and data and model uncertainties are typically greater. There is significant heterogeneity in terms of the stage of economic and financial sector development, political, socio-economic and market institutions, and monetary policy framework, and different economies also tend to face shocks which may differ substantially in terms of their nature and persistence.

Our analysis suggests that the estimates of the equilibrium interest rates in Asia Pacific in general vary substantially over time and across economies. The perceived degree of imprecision and uncertainty is sizeable. For instance, the HP-filtered estimates of the natural interest rate in all economies vary significantly depending on the value of the smoothing parameter λ (Graph B.2.1). Indeed, for annual data, while Hodrick and Prescott (1981) propose a value of 100 for the smoothing parameter λ, Ravn and Ulhig (2002) suggest that $\lambda = 6.25$ is more appropriate. I experimented with different values for the smoothing parameter, namely, $\lambda = \{6.25, 100, 400, 800, 1600, 6400, 25600, 129600\}$, the resulting equilibrium real interest rate estimates turn out to be very different, with the difference going well above 2 percentage points. In the case of Thailand, for example, the difference in the 2014 estimates with $\lambda = 6.25$ and $\lambda = 6400$ is almost 4 percentage points; and more seriously, when one estimate points to a strong recent upward trend, the other estimate suggests a secular decline in Thailand's natural interest rate. Indeed this is a common issue with many filters, where the choice of the degree of smoothing belongs to the researcher, but monetary policy obviously cannot reply on the subjectivity of such decisions.

Some economists argue that the estimation precision may improve with those estimates based on carefully specified structural models tailored to each economy and a well implemented estimation technique. Yet such estimates may depend on specific model assumptions, which may be too strong or lack empirical foundations. For instance, the natural rate estimates of Laubach and Williams (2003) predicate a strong relationship between trend growth and the natural rate. Yet, spectral estimates in this paper suggest that such a relationship is quite weak in many economies in the region. Existing natural interest rate models tend to be closed-economy and ignore demographic trends; this paper shows that global factors and population dynamics do matter for changes in the natural interest rate. Model uncertainty is aggravated by data uncertainty: besides the difficulties in correctly specifying a convincing model for an emerging economy, data tend to be too short or imprecise to best serve the quantification of any economy in emerging Asia. Therefore the use of the current natural rate frameworks to implement monetary policy runs many risks, given the uncertainties surrounding the natural rate estimates and the underlying factors driving the natural rate movements.[15]

Understanding how different factors may influence the equilibrium real interest rate is important for monetary policy considerations. First, some factors, such as population dynamics, may be structural and out of the monetary policymaker's direct control, and can be better addressed with structural measures. This may have been the case of Japan in the last two decades, where the natural interest rate estimate is

15 As Friedman (1968) put it, "what if the monetary authority chose the 'natural' rate – either of interest or unemployment – as its target? One problem is that it cannot know what the 'natural' rate is. Unfortunately, we have as yet devised no method to estimate accurately and readily the natural rate of either interest or unemployment. And the 'natural' rate will itself change from time to time. But the basic problem is that even if the monetary authority knew the 'natural' rate, and attempted to peg the market rate at that level, it would not be led to a determinate policy. The 'market' rate will vary from the natural rate for all sorts of reasons other than monetary policy."

shown to have a strong positive correlation with trends in working age population growth and economic globalisation and a strong negative correlation with the trend in the old-age dependency ratio (Graph B.3.5.4). In fact, if Japan's natural interest rate did fall substantially due to population ageing and a sustained reduction in the working force, then even a very low or near-zero policy rate in a low-inflation or deflationary environment may not necessarily imply a real interest rate close to the natural rate, with the policy stance being tighter than perceived. Furthermore, monetary accommodation itself would do little to amend the structural deficiency; only structural measures encouraging labour force growth and participation may address the problem.

Second, as the spectral analysis shows, factors such as globalisation are likely to be relevant for the determination of natural rate of interest in most economies (Graphs in Annex B.3). This complicates a central bank's task of monetary policy evaluation, as the underlying natural rate has grown increasingly dependent on external factors. Policymakers may need to pay greater attention to external developments, beyond the narrow focus on domestic price and output gaps.

Third, a close relationship between the natural interest rate and financial sector developments in some economies would imply that monetary policy tracking the natural rate benchmark needs to carefully monitor the emergence and evolution of possible financial imbalances and take into account financial conditions. Concerns with financial stability and the impact of regulatory changes may therefore factor into monetary policy considerations. Yet correlations of the natural interest rate and asset price trends are shown to be weak in many economies in Asia-Pacific (eg Australia, India, Indonesia, Japan, Korea, Malaysia, the Philippines and Thailand). This is true, to a lesser extent, in terms of long-term credit market developments, although trends in a broad financial development index do seem to correlate with natural interest rates in many economies. Therefore each central bank needs to carefully assess the likely impact of financial sector components on its equilibrium real interest rate, and avoid the temptation of overreacting to asset market fluctuations.

Last but not least, Clark and Kozicki (2005) and Hamilton, Harris, Hatzius and West (2015) consider the link between trend growth and the equilibrium real interest rate to be quite weak. This turns out to be the case for a number of Asia-Pacific economies, eg Australia, India, Indonesia, Malaysia, the Philippines and the United States, as the estimates of many spectral indicators reveal. The weak linkage between the equilibrium real interest rate and trend growth in many economies may undermine many structural natural rate estimates predicated on such linkages, increasing the uncertainty surrounding some existing equilibrium real interest rates. However, the equilibrium real interest rate's linkages with savings rate and investment ratios tend to be stronger in many economies.

One important caveat about my estimates of equilibrium real interest rates is that they are filtered trends rather than true "equilibrium" values, under the assumption that the trends may faithfully reflect the equilibrium. Indeed it is possible that the actual real interest rate may deviate from their equilibrium values for an extended period of time, especially for an economy hit by large and persistent shocks. Yet there is no assurance that structural estimates, many of which are based on linear models, would fare any better under these circumstances. Another caveat is that the estimates of spectral indicators tend to be less accurate with small sample sizes, and in the cases of frequency-specific correlation and regression estimates for some Asia-Pacific economies, the data are too short to provide any reliable reading of the relationship between the real interest rate and its possible driving factors in the frequency range of beyond eight years.

The heightened uncertainties surrounding the natural interest rate estimates call for policy rules which are robust to such uncertainties. Canzoneri, Cumby and Diba (2015) find that, for a central bank, tracking the natural interest rate is important for household welfare, especially "in an environment where interest rates take large and persistent swings around their long run equilibrium values, making it difficult for the policy rate to catch up with its natural rate". Orphanides and Williams (2002) conclude that "uncertainty about natural rates in real time recommends against relying excessively on these intrinsically noisy indicators when making monetary policy decisions". Drawing lessons from the 1970s and the late 1990s, they advise that "the policy rule should incorporate a biased protection against measurement error and respond only modestly to estimates of the natural rates of interest and unemployment". Similarly, Hamilton, Harris, Hatzius and West (2015) reach the conclusion that it pays to inject more inertia into the monetary policy reaction function when the uncertainty around the natural interest rate is high, by placing higher weights on the lagged values of the policy rate. To guard against misconceptions about the natural rate, they defend the adoption of a later but steeper path for US federal funds rate normalisation.

In addition to the difficulties in obtaining accurate and timely estimates of the equilibrium interest rates, the recurrent binding zero lower bound on nominal interest rate may pose a significant challenge for central banks intending to implement interest rate targets against natural rate benchmarks. In Asia-Pacific, this has been a serious issue for the Bank of Japan in the last two decades and for the Federal Reserve more recently, and it may potentially become an issue for other central banks, although most economies in the region still have quite some room for manoeuvre in the foreseeable future.

VI. Conclusion

This paper estimates the equilibrium real interest rate for a number of Asia-Pacific economies, and studies its relationships with demographics, the process of globalisation, indicators of financial sector developments, and macroeconomic variables such as trend growth. I take a purely statistical approach and focus on the empirics, applying the time-domain Hodrick-Prescott (1981, 1997) filter and frequency-domain tools, including both traditional spectral indicators and the frequency-specific correlation and regression techniques proposed by Zhu (2005).

The spectral analysis uncovers a number of interesting empirical facts for the Asia-Pacific economies. First, the estimated natural interest rates started to trend down in some economies in the region as early as the 1980s, and the tendency has become more accentuated in the 2000s, especially since the onset of the Global Financial Crisis and the Great Recession. Second, the natural interest rate estimates vary significantly over time and across economies, ranging from –1.32%, –0.47% and –0.37% to 4.20%, 5.27% and 5.96% in Indonesia, Japan and Korea, respectively. Third, the association seems to be broad and strong between the natural interest rate and the low-frequency trend components of demographic and global factors in Asia-Pacific, but it appears to be weak between the natural interest rate and trends in asset prices, credit-to-GDP ratio and trend growth in many economies in the region. In most cases, the natural interest rate does seem to be correlated with broadly measured long-term financial sector development, and trends in savings rate and investment ratio.

Nevertheless, large uncertainties and sizeable heterogeneity in the estimates of the equilibrium real interest rate call for caution as well as monetary policy rules which are robust to such uncertainties. In addition, understanding the underlying factors driving changes in the each economy's natural interest rate is important for the correct calibration and implementation of monetary policy.

References

Andrés, J, J López-Salido and E Nelson (2009): "Money and the natural rate of interest: structural estimates for the United States and the euro area", *Journal of Economic Dynamics & Control*, vol 33, pp 758–76.

Attanasio, O, S Kitao and G Violante (2007): "Global demographic trends and social security reforms", *Journal of Monetary Economics*, vol 54, pp 144–98.

Ball, L (2014): "Long-term damage from the great recession in OECD countries", working paper.

Barsky, R, A Justiniano and L Melosi (2014): "The natural rate and its usefulness for monetary policy making", *American Economic Review Papers and Proceedings*, vol 104, no 5, pp 37–43.

Baxter, M and R King (1999), "Measuring business cycles: Approximate band-pass filters for economic time series", *Review of Economics and Statistics*, vol 81, no 4, pp 575–93.

Barro, R and X Sala-i-Martin (1990): "World real interest rates", in O Blanchard and S Fischer (eds*), NBER Macroeconomics Annual*, MIT Press, pp 15–61.

Bernanke, B (2005): "The global saving glut and the U.S. current account deficit", Sandridge Lecture, Virginia Association of Economists, Richmond, 10 March.

——— (2015a): "Why are interest rates so low", Brookings Institution, 30 March.

——— (2015b): "Why are interest rates so low, part 2: secular stagnation", Brookings Institution, 31 March.

Bernanke, B and M Gertler (1989): "Agency costs, net worth, and business fluctuations", *American Economic Review*, vol 79(1), pp 14–31.

——— (1990): "Financial fragility and economic performance", *Quarterly Journal of Economics*, vol 105, no 1, pp 87–114.

Bernanke, B, M Gertler and S Gilchrist (1996): "The financial accelerator and the flight to quality", *Review of Economics and Statistics*, vol 78, no 1, pp 1–15.

——— (1999): "The financial accelerator in a quantitative business cycle framework", in J Taylor and M Woodford (eds), , *Handbook of Macroeconomics*, vol 1, pp 1341–93, Elsevier, Chapter 21.

Beyer, A and R Farmer (2007): "Natural rate doubts", *Journal of Economic Dynamics & Control*, vol 31, pp 797–825.

Blanchard, O and L Summers (1984): "Perspectives on high world real interest rates", *Brookings Papers on Economic Activity*, no 1984:2, pp 273–334.

——— (1986): "Hysteresis and the European unemployment problem", *NBER Macroeconomics Annual*.

Bomfim, A (1997): "The equilibrium fed funds rate and the indicator properties of term-structure spreads", *Economic Inquiry*, vol 35, no 4, pp 830–46.

——— (2001): "Measuring equilibrium real interest rates: what can we learn from yields on indexed bonds?", Federal Reserve Board

Börsch-Supan, A (2004): "Commentary: cross-border macroeconomic implications of demographic change", in *Global demographic change: economic impacts and policy challenges*, Federal Reserve Bank of Kansas City Symposium, Jackson Hole.

Bosworth, B (2014): "Interest rates and economic growth: are they related?", Brookings Institution, Working Paper.

Caballero, R (2006): "On the macroeconomics of asset shortages", *NBER Working Paper*, no 12753.

Canzoneri, M, R Cumby and B Diba (2015): "Monetary policy and the natural rate of interest", *Journal of Money, Credit and Banking*, vol 47, no 2-3, pp 383–413.

Cecchetti, S and F Zhu (2009): "Real consequences of financial crises", Bank of Mexico international conference on "*Challenges and strategies for promoting economic growth*", 19–20 October.

Cerra, V and S Saxena (2008): "Growth dynamics: the myth of economic recovery", *American Economic Review*, vol 98, no 1, pp 439–57.

Clark, T and S Kozicki (2005): "Estimating equilibrium real interest rates in real time", *North American Journal of Economics and Finance*, vol 16, pp 395–413.

Clarida, R (2014): "Navigating the new neutral", PIMCO.

——— (2015): "The Fed is ready to raise rates: will past be prologue?", *International Finance*, pp 1–15.

Christiano, L, M Eichenbaum and C Evans (2005): "Nominal rigidities and the dynamic effects of a shock to monetary policy", *Journal of Political Economy*, vol 113, pp 1–45.

De Fiore, F and O Tristani (2011): "Credit and the natural rate of interest", *Journal of Money, Credit and Banking*, vol 43, pp 407–40

Dreher, A (2006): "Does globalization affect growth? Evidence from a new index of globalization", *Applied Economics*, vol 38, no 10, pp 1091–110.

Dreher, A, N Gaston and P Martens (2008): *Measuring Globalisation – Gauging its Consequences*, Springer.

Edge, R, M Kiley and J-P Laforte (2008): "Natural rate measures in an estimated DSGE model of the U.S. economy", *Journal of Economic Dynamics & Control*, vol 32, pp 2512–35.

Eichengreen, B (2014): "Secular stagnation: a review of the issues", in C Teulings and R Baldwin (eds), *Secular Stagnation: Facts, Causes and Cures*, Centre for Economic Policy Research (CEPR) Press, pp 41–6.

Eichengreen, B (2015): "Secular stagnation: the long view", *NBER Working Paper*, no 20836.

Engle, R (1974): "Band spectrum regression", *International Economic Review*, vol 15, no 1, pp 1–11.

Engle, R (1978): "Testing price equations for stability across spectral frequency bands", *Econometrica*, vol 46, pp 869–81.

——— (1980): "Exact maximum likelihood methods for dynamic regressions and band spectrum regressions", *International Economic Review*, vol 21, no 2, pp 391–407.

Ferguson, R (2004): "Equilibrium real interest rate: theory and application", Remarks to the University of Connecticut School of Business Graduate Learning Center and the SS&C Technologies Financial Accelerator, Hartford, Connecticut, 29 October.

Garnier, J and B Wilhelmsen (2005): "The natural real interest rate and the output gap in the euro area: a joint estimation", *ECB Working Paper*, no 546.

Gordon, R (2014a): "The demise of U.S. economic growth: restatement, rebuttal, and reflections", *NBER Working Paper*, no 19895.

——— (2014b): "The turtle's progress: secular stagnation meets the headwinds", in C Teulings and R Baldwin (eds), *Secular Stagnation: Facts, Causes and Cures*, Centre for Economic Policy Research (CEPR) Press, pp 47–59.

Goyal, A (2008): "The natural interest rate in emerging markets", Indira Gandhi Institute of Development Research, working paper, no 2008-014.

Goyal, A and S Arora (2013): "Estimating the Indian natural interest rate and evaluating policy", Indira Gandhi Institute of Development Research, working paper, no 2013-017.

Granger, C (1966): "The typical spectral shape of an economic variable", *Econometrica*, vol 34, no 1, pp 150–61.

——— (1969): "Investigating causal relations by econometric models and cross-spectral methods", *Econometrica*, vol 37, no 3, pp 424–38.

Granger, C and H Rees (1968): "Spectral analysis of the term structure of interest rates", *Review of Economic Studies*, vol 35, no 1, pp 67–76.

Greenspan, A (1993): "Testimony on 1993 Monetary Policy Objectives to the U.S. Senate", on 20 July.

——— (2005): "Testimony of Chairman Alan Greenspan", Committee on Banking, Housing and Urban Affairs, U.S. Senate, on 16 February.

Hall, R (2014): "Quantifying the lasting harm to the U.S. economy from the financial crisis", *NBER Working Paper*, no 20183.

Hamilton, J, E Harris, J Hatzius and K West (2015): "The equilibrium real funds rate: past, present, and future", University of California at San Diego, working paper.

Hannan, E (1963a): "Regression for time series", in M Rosenblatt (ed), *Time Series Analysis*, Wiley.

——— (1963b): "Regression for time series with errors of measurement", *Biometrika*, vol 50, pp 293–302.

Hansen, A (1934): "Capital goods and the restoration of purchasing power", *Proceedings of the Academy of Political Science*, vol 16, no 1, pp 11–9.

——— (1939): "Economic progress and declining population growth", *American Economic Review*, vol 29, no 1, pp 1–15.

Hanson, S and J Stein (2012): "Monetary policy and long-term real interest rates", Federal Reserve Board Finance and Economics Discussion Series, no 2012-46.

Hodrick, R and E Prescott (1981): "Postwar U.S. business cycles: an empirical investigation", *Discussion Papers*, no 451, Northwestern University.

——— (1997): "Postwar U.S. business cycles: an empirical investigation", *Journal of Money, Credit and Banking*, vol 29, no 1, pp 1–16.

International Monetary Fund (2014): "Perspectives on global real interest rates", *World Economic Outlook*, April, Chapter 3.

Keynes, J (1937): "Some economic consequences of a declining population", *Eugenics Review*, vol 19, pp 13–17.

King, M and D Low (2014): "Measuring the "world" real interest rate", *NBER Working Paper*, no 19887, National Bureau of Economic Research.

Krueger, D and A Ludwig (2007): "On the consequences of demographic change for rates of returns to capital, and the distribution of wealth and welfare", *Journal of Monetary Economics*, vol 54, pp 49–87.

Krugman, P (2013): "Bubbles, regulation, and secular stagnation", *New York Times* blog, 25 September.

——— (2014): "Four observations on secular stagnation", in C Teulings and R Baldwin (eds), *Secular Stagnation: Facts, Causes and Cures*, Centre for Economic Policy Research (CEPR) Press, pp 61–8.

Laubach, T and J Williams (2003): "Measuring the natural rate of interest", *Review of Economics and Statistics*, vol 85, no 4, pp 1063–70.

Leduc, S and G Rudebusch (2014): "Does slower growth imply lower interest rates?", *FRBSF Economic Letter*, Federal Reserve Bank of San Francisco, no 2014-33.

Lo, S and K Rogoff (2014): "Secular stagnation, debt overhang and other rationales for sluggish growth, six years on", paper presented at the 13th Annual BIS Conference, Lucerne, Switzerland.

Lucas, R (1980): "Two illustrations of the quantity theory of money", *American Economic Review*, vol 70, no 5, pp 1005–14.

McCulley, P (2003): "Needed: central bankers with far away eyes", PIMCO.

Orphanides, A, R Porter, D Reifschneider, R Tetlow and F Finan (2000): "Errors in the measurement of the output gap and the design of monetary policy", *Journal of Economics and Business*, vol 52, no 1/2, pp 117–41.

Orphanides, A and S van Norden (2002): "The unreliability of output gap estimates in real time", *Review of Economics and Statistics*, vol 84, no 4, pp 569–83.

Orphanides, A and J Williams (2002): "Robust monetary policy rules with unknown natural rates", *Brookings Papers on Economic Activity*, vol 2, pp 63–118.

Phillips, P (1991): "Spectral regression for cointegrated time series", in W Barnett, J Powell and G Tauchen (eds), *Nonparametric and Parametric Methods in Econometrics and Statistics*, Cambridge University Press, pp 413–35.

Reifschneider, D, W Wascher and D Wilcox (2013): "Aggregate supply in the United States: recent developments and implications for the conduct of monetary policy", Board of Governors of the Federal Reserve System, *Finance and Economics Discussion Series*, no 2013–77.

Reinhart, C and K Rogoff (2009): "The aftermath of financial crises", American Economic Review.

Rotemberg, J and M Woodford (1997): "An optimization-based econometric framework for the evaluation of monetary policy", in B Bernanke and J Rotemberg (eds), *NBER Macroeconomics Annual 1997*, MIT Press, pp 297–346.

Sahay, R, M Čihák, P N'Diaye, A Barajas, R Bi, D Ayala, Y Gao, A Kyobe, L Nguyen, C Saborowski, K Svirydzenka and S Yousefi (2015): "Rethinking financial deepening: stability and growth in emerging markets", *IMF Staff Discussion Note*, no SDN/15/08.

Shirai, S (2012): "Have demographic changes affected Japan's macroeconomic performance? Some implications for monetary policy", speech at the Bank of Finland, the Sveriges Riksbank and Stockholm University, 3–7 September.

Shirakawa, M (2011): "Bubbles, demographic change and natural disasters", speech at the 2011 Bank of Japan Annual International Conference, Tokyo, 1 June.

Smets, F and R Wouters (2003): "An estimated dynamic stochastic general equilibrium model of the euro area", *Journal of the European Economic Association*, vol 1, no 5, pp 1123–75.

Summers, L (2013): "IMF economic forum: policy responses to crises", speech at the IMF Fourteenth Annual Research Conference, Washington, DC, 9 November.

——— (2014a): "U.S. economic prospects: secular stagnation, hysteresis and the zero lower bound", *Business Economics*, vol 49, no 2, pp 65–73.

——— (2014b): "Reflections on the 'new secular stagnation hypothesis'", in C Teulings and R Baldwin (eds), *Secular Stagnation: Facts, Causes and Cures*, Centre for Economic Policy Research (CEPR) Press, pp 65–73.

Taylor, J (1993): "Discretion versus policy rules in practice", *Carnegie-Rochester Conference Series on Public Policy*, vol 39, pp 195–214.

——— (1999): "A historical analysis of monetary policy rules", in J Taylor (ed), *Monetary Policy Rules*, National Bureau of Economic Research, University of Chicago Press, pp 319–48.

Trehana, B and T Wu (2007): "Time-varying equilibrium real rates and monetary policy analysis", *Journal of Economic Dynamics & Control*, vol 31, pp 1584–609

Wicksell, K (1898): *Interest and Prices*, Macmillan, 1936, Translation of 1898 edition by R Kahn.

Williams, J (2003): "The natural rate of interest", *FRBSF Economic Letter*, Federal Reserve Bank of San Francisco, no 2003-32.

——— (2015): "The decline in the natural rate of interest", Federal Reserve Bank of San Francisco, working paper.

Woodford, M (2003): *Interest and prices: foundations of a theory of monetary policy*, Princeton University Press.

Yellen J (2015): "Normalizing monetary policy: prospects and perspectives", remarks at the Federal Reserve Bank of San Francisco research conference "*The new normal monetary policy*", San Francisco, 27 March.

Zhu, F (2005): "The fragility of the Phillips curve: A bumpy ride in the frequency domain", *BIS Working Papers*, no 183, Bank for International Settlements.

——— (2012): "Are financial and business cycles synchronised: a time- and frequency-domain investigation", manuscript, Bank for International Settlements.

Annex A: Frequency domain analysis

In this annex, we illustrate the method we use to estimate frequency-wise correlation and regression estimates, which is based on a simple frequency-specific data extraction procedure.

A.1. A frequency-specific data extraction procedure

Consider a time series vector $x = [x_1, x_2, ..., x_T]^T$. For $s = 1, ..., T$, define the fundamental frequencies as $\omega_s = 2\pi s / T$. The discrete Fourier transform of x at frequency ω_s is

$$w_s x = T^{-1/2} \sum_{t=1}^{T} x_t e^{(t-1) i \omega_s}$$

where

$$w_s = T^{-1/2} \begin{bmatrix} 1 & e^{i\omega_s} & \cdots & e^{(T-1) i \omega_s} \end{bmatrix}$$

Define

$$W = \begin{bmatrix} w_0 \\ w_1 \\ \vdots \\ w_{T-1} \end{bmatrix}$$

W is a unitary matrix such that $W^* W = W W^* = I$, where $*$ indicates the Hermitian conjugate (ie transpose of the complex conjugate). Then $\tilde{x} = Wx$ is the vector of discrete Fourier transform of time series x at all fundamental frequencies ω_s, $s = 1, ..., T-1$.

Define A_s as a $T \times T$ selection matrix which selects the s-th element or row from any data vector or matrix, respectively. It has 1 as the s,s-th element and zeros elsewhere.[16] The data vector of the discrete Fourier transform of time series x at the s-th frequency ω_s is

$$A_s \tilde{x} = A_s W x$$

So there are T data vectors $A_s \tilde{x}$, extracted from the original time series x, each of length T. All but the s-th elements of the s-th data vector $A_s \tilde{x}$ are zero. We then use inverse Fourier transform to convert the complex data vector $A_s \tilde{x}$ back into the time domain. Write the frequency-ω_s inverse Fourier transform of the time series x as

$$\tilde{x}(\omega_s) = L_s x = W^* A_s W x$$

16 To select a frequency band $[\omega_s, \omega_t]$, let the s-th to t-th diagonal elements of A be one.

where $L_s = W^* A_s W$ is a linear operator. Using Fourier and inverse Fourier transforms and the selection matrix A_s, from any data vector x, we can extract T time series $x(\omega_s) = [x_1(\omega_s), x_2(\omega_s), \ldots, x_T(\omega_s)]^T$, each corresponding to a specific frequency ω_s, where $s = 1, \ldots, T$. Based on these frequency-specific data, we can then design frequency-wise correlation and regression coefficients in a conventional way.

A.2. Correlation analysis

For bivariate stochastic processes $z_t = [x_t \quad y_t]^T$, which are assumed to be jointly weakly stationary with continuous spectra, we write the corresponding spectral density matrix as[17]

$$f_{zz}(\omega) = \begin{bmatrix} f_{xx}(\omega) & f_{xy}(\omega) \\ f_{yx}(\omega) & f_{yy}(\omega) \end{bmatrix}$$

where the spectral densities $f_{xx}(\omega)$, $f_{yy}(\omega)$ and the cross-spectral density $f_{xy}(\omega)$ determine the relationship between x_t and y_t at frequency ω. In Cartesian form, the cross-spectral density $f_{xy}(\omega)$ can be written as

$$f_{xy}(\omega) = c_{xy}(\omega) - iq_{xy}(\omega)$$

where $c_{xy}(\omega)$ and $q_{xy}(\omega)$ are real-valued functions known as ***cospectrum*** (or ***cospectral density***) and ***quadspectrum*** (or ***quadrature spectral density***), respectively. The cospectrum $c_{xy}(\omega)$ represents the covariance between coefficients of the in-phase components of two time series, while the quadspectrum $q_{xy}(\omega)$ represents the covariance between coefficients of the out-of-phase components. Cospectrum estimation is equivalent to studying the off-diagonal elements of the variance-covariance matrix between two time series, which are uniquely related to cospectra by Fourier and inverse Fourier transforms.

In polar form,

$$f_{xy}(\omega) = |f_{xy}(\omega)| \exp(i\varphi_{xy}(\omega))$$

where

$$\varphi_{xy}(\omega) = -\arctan\left(\frac{q_{xy}(\omega)}{c_{xy}(\omega)}\right)$$

The ***phase*** $\varphi_{xy}(\omega)$ measures the average phase lead of x_t over y_t, and $\varphi_{xy}(\omega)/\omega$ indicates the extent of time lag. The ***gain*** $G_{xy}(\omega)$ is defined as

17 All concepts described in the Annex for bivariate time series can be easily generalised to multivariate stochastic processes, where exogenous variables can also be introduced.

$$G_{xy}(\omega)=\frac{\left|f_{xy}(\omega)\right|}{f_x(\omega)}$$

This is a standardised version of the regression coefficient of y on x at frequency ω. A small $G_{xy}(\omega)$ indicates that x has little effect on y at frequency ω.

Define the ***complex coherence*** $ccoh_{xy}(\omega)$ at frequency ω as

$$ccoh_{xy}(\omega)=\frac{f_{xy}(\omega)}{\left[f_{xx}(\omega)f_{yy}(\omega)\right]^{1/2}}$$

The complex coherence $ccoh_{xy}$ is the frequency domain analogue of the coefficient of correlation, but since f_{xy} and $ccoh_{xy}$ are complex, it is hard to interpret this indicator in terms of the overall strength of linear correlation between x and y. ***Real coherence*** $rcoh_{xy}$, which we define as the real part of $ccoh_{xy}$, is the cospectrum c_{xy} standardised by the square root of the product of f_{xx} and f_{xy}. It is the coefficient of correlation between coefficients of the in-phase components of two time series x and y. However, a true frequency-specific correlation coefficient needs to account for both the real and complex parts of the complex coherence $ccoh_{xy}$.

One alternative is the ***coefficient of coherence*** of x_t over y_t at frequency ω, defined as $cohe_{xy}(\omega)=\left|ccoh_{xy}(\omega)\right|$.[18] But although it delivers a real number, it fails to reveal the sign of linear correlation at frequency ω. The ***coherency*** $ccoh_{xy}(\omega)$ of x_t over y_t at frequency ω is

$$coh_{xy}(\omega)=cohe_{xy}(\omega)^2=\left|ccoh_{xy}(\omega)\right|^2$$

Analogous to the coefficient of determination (ie R^2) in the time domain, the coherency coh_{xy} is the standardised modulus of cross spectral density. It measures the strength of linear association between two or more variables of interest across frequencies. By Schwarz Inequality, $\forall\omega$, $coh_{xy}(\omega)\in[0,1]$. At frequencies for which $f_{xx}(\omega)f_{yy}(\omega)=0$, we define $coh_{xy}(\omega)=0$, so the two series x_t and y_t are completely unrelated at frequency ω. If $coh_{xy}(\omega)=1$, then one series is an exactly linearly filtered version of the other at frequency ω. In general, coh_{xy} varies with the frequency ω, indicating the changing pattern of linear association across frequencies. Regions of high coherence are of particular interest.

What we need is a frequency-domain analogue of the time-domain coefficient of correlation, corresponding either to a specific frequency ω, or to a frequency band $[\omega_l,\omega_m]$, where $0\le\omega_l\le\omega_m\le 2\pi$. One natural choice would be the complex coherence $ccoh_{xy}$. But although $ccoh_{xy}$ is signed and normalised, since in general

18 Extending the conceptual construct of bivariate coherence to multiple time series, we have multiple and partial coherences.

f_{xy} is complex-valued, so is $ccoh_{xy}$. There is no easy way to graphically illustrate, and to interpret the interplay between the real and complex parts of the complex coherence, even if we are able to represent the indicator in a three-dimensional diagram. Our solution is to take advantage of the proposed simple frequency-domain data recovery procedure, and we define $\rho(\omega)$, the ***frequency-specific coefficient of correlation*** (FSCC) at frequency ω, as follows

$$\rho(\omega)=\frac{Cov(\hat{x}(\omega),\hat{y}(\omega))}{\sqrt{Var(\hat{x}(\omega))}\sqrt{Var(\hat{y}(\omega))}}$$

where $\hat{x}(\omega)$ and $\hat{y}(\omega)$ are frequency-specific time series extracted from data vectors x and y, and $Cov(\bullet)$ and $Var(\bullet)$ stand for covariance and variance, respectively. The confidence interval for $\rho(\omega)$ can be computed in the conventional way.

The frequency-specific coefficient of correlation is normalised to take values in the [-1,1] interval. Unlike cospectral density c_{xy}, the FSCC ρ is free from data scale, hence a true measure of the strength of frequency-ω correlation between x and y. Comparing to coherence coh_{xy}, the FSCC ρ signs the direction of correlation existing in the data. The FSCC estimate is a clear improvement upon cospectrum and coherence estimates, and we use it as the main indicator of strength of bivariate correlation for Phillips relations. When the distribution theories for the cospectral density c_{xy} and the coherence coh_{xy} are complicated, p-values and confidence intervals for the FSCC estimates $\hat{\rho}$'s can be provided in the usual way. In fact, these are often supplied automatically in an econometric or statistical software package.

A.3. Frequency-specific spectral regression

Consider a simple model for two time series $y=[y_1,y_2,...,y_T]^T$ and $x=[x_1,x_2,...,x_T]^T$

$$y=\beta x+\varepsilon$$

where $\varepsilon \sim iid(0,\sigma^2 I)$ and x is uncorrelated with ε. The ***periodogram*** of x and the ***cross-periodogram*** between x and y at frequency ω_s are, respectively

$$I_x(\omega_s)=|w_s x|^2$$

$$I_{xy}(\omega_s)=(w_s x)^*(w_s y)$$

where w_s is defined as before. The s-th frequency spectral regression is

$$A_s\tilde{y}=\beta_s A_s\tilde{x}+A_s\tilde{\varepsilon}$$

where $\tilde{q}=Wq$, for any q, and W is defined as before. The s-th frequency spectral regression coefficient is

$$\tilde{\beta}_s=\left(\tilde{x}^* A_s\tilde{x}\right)^{-1}\tilde{x}^* A_s\tilde{\varepsilon}=I_x(\omega_s)^{-1}I_{xy}(\omega_s)$$

Since the unsmoothed periodogram I_x and the cross-periodogram I_{xy} are not consistent estimators of the spectral and cross-spectral densities, and we are interested in frequency-specific regression coefficients that do not involve averaging over a frequency band to obtain consistent estimates of the sums of periodogram and cross-periodogram ordinates, we may instead use smoothed spectral estimates to estimate β_s:

$$\hat{\beta}_s = \hat{f}_x(\omega_s)^{-1}\hat{f}_{xy}(\omega_s)$$

In general, the estimator $\hat{\beta}_s$ will be complex-valued. To obtain a real-valued estimate, one can take the real part of $\hat{\beta}_s$, but typically, both the real and complex parts of $\hat{\beta}_s$ matter. Or we may simply use the gain, ie the modulus $|\hat{\beta}_s|$, which has the drawback of not allowing us to discern the sign of spectral regressions. We take advantage of the proposed data extraction procedure and run OLS regressions with frequency-specific data. Since the Fourier transform and inverse Fourier transform are linear operations, conventional asymptotic theory continues to apply, and the confidence interval for $\hat{\beta}_s$ can be computed in the usual way (except at the zero frequency). Write the inverse Fourier transform as

$$L_s y = \beta_s L_s x + L_s \varepsilon$$

Simple OLS spectral regressions lead to the ***frequency-specific coefficient of regression*** (FSCR) $\hat{\beta}_s$ corresponding to frequency ω_s

$$\hat{\beta}_s = \left(x^T L_s^T L_s x\right)^{-1} x^T L_s^T L_s y = \left(\hat{x}_s^T \hat{x}_s\right)^{-1} \hat{x}_s \hat{y}_s$$

The great advantage of the data extraction procedure is that it is linear in nature; therefore all inferential apparatus in the conventional OLS regression theory can still be used as usual.

Annex B: Graphs

This annex contains graphs of estimates of the equilibrium real interest rate and its relationship with macroeconomic, financial, demographic and global factors, based on the Hodrick-Prescott (1981) filter and on frequency domain indicators including Zhu's (2005) frequency-specific correlation and regression coefficients.

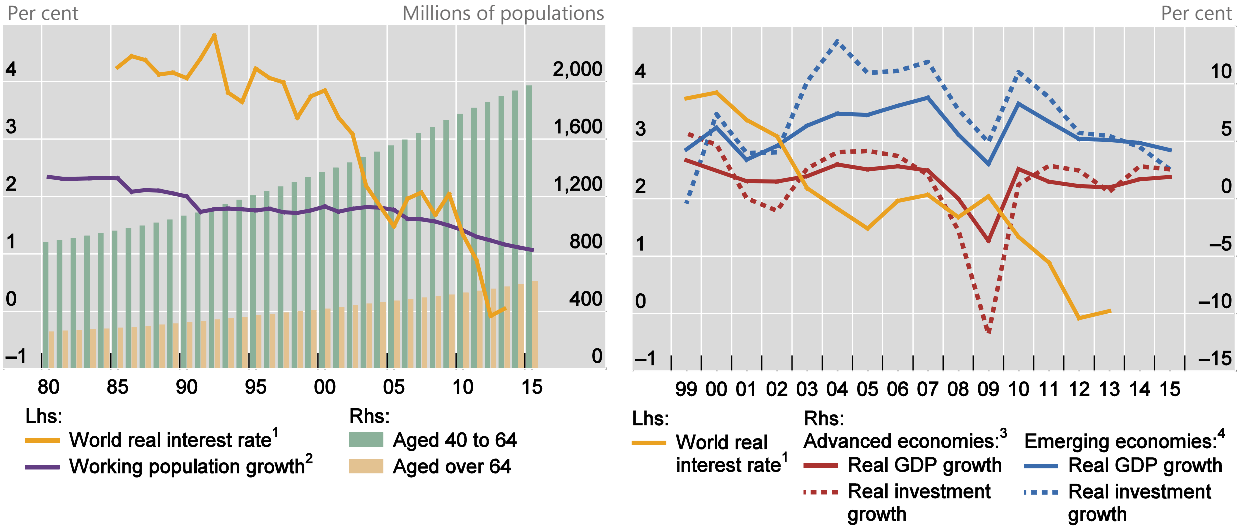
B.1. World real interest rate

Interest rate, demographics and growth

Graph B.1.1

Interest rate and demographics

Interest rate and growth

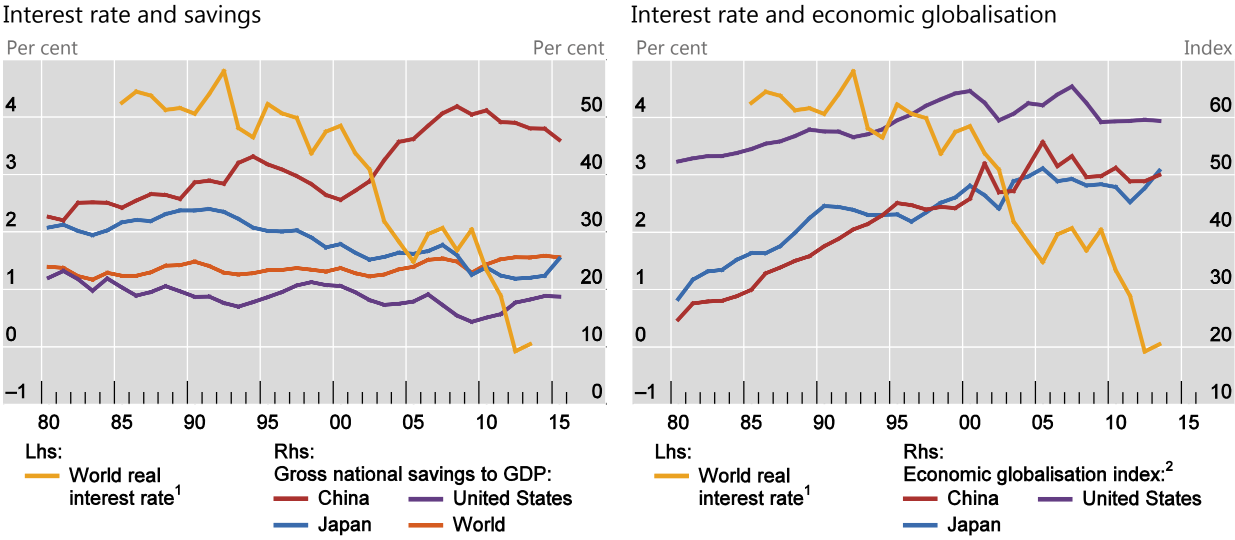


[1] Weighted world real interest rate estimated by King and Low (2014). [2] Working age population is defined as population aged between 15 and 64. [3] Advanced economies: Australia, Canada, Denmark, Japan, euro area, Japan, Sweden, Switzerland, the United Kingdom, and the United States. Weighted averages based on rolling GDP and PPP exchange rates. [4] Emerging economies: Brazil, Chile, China, Czech Republic, Hungary, India, Indonesia, Korea, Mexico, Poland, Russia, South Africa and Turkey. Weighted averages based on rolling GDP and PPP exchange rates.

Sources: King and Low (2014); IMF, *World Economic Outlook*; United Nations; BIS calculations.

Interest rate and global factors

Graph B.1.2

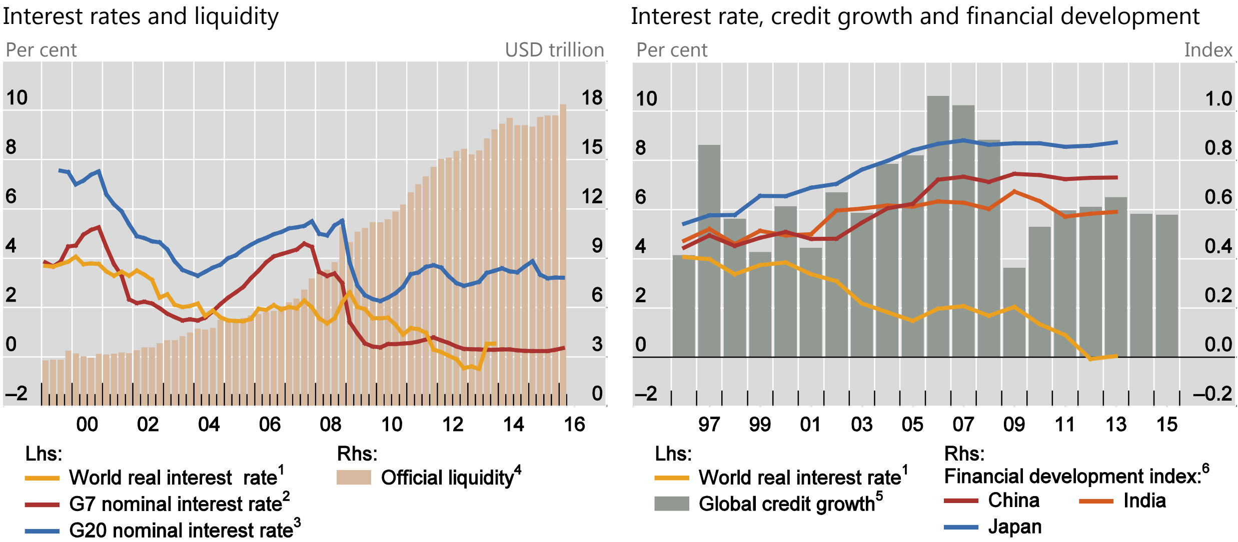


[1] Weighted world real interest rate estimated by King and Low (2014). [2] For details of the overall KOF Index of Globalisation and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008).

Sources: Dreher (2006) and Dreher, Gaston and Martens (2008); King and Low (2014); IMF, *World Economic Outlook*; United Nations; BIS calculations.

Interest rate and financial sector developments

Graph B.1.3



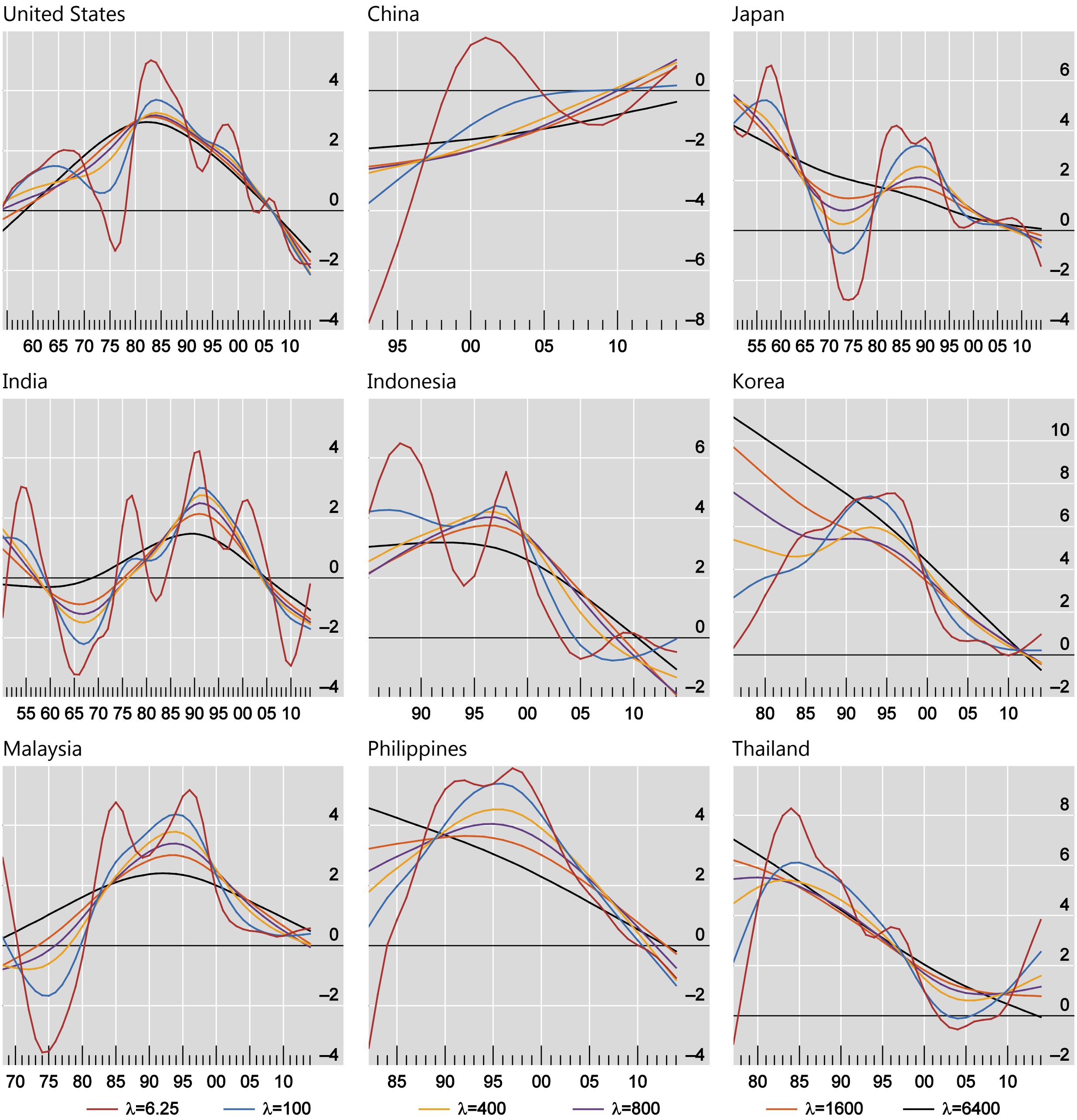
[1] Weighted world real interest rate estimated by King and Low (2014). [2] Weighted averages of nominal three-month interbank interest rates of G7 economies, based on rolling GDP and PPP exchange rates. [3] Weighted averages of nominal three-month interbank interest rates of G20 economies, excluding Argentina and Turkey, based on rolling GDP and PPP exchange rates. European Union is proxied by Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Sweden and the United Kingdom. [4] Sum of central bank balance sheets of advanced economies (Australia, Canada, Denmark, euro area, Japan, Sweden, Switzerland, the United Kingdom and the United States) and foreign exchange reserves of emerging market economies (Brazil, Chile, China, Czech, Hungary, India, Indonesia, Korea, Mexico, Poland, Russia, South Africa and Turkey). [5] Weighted averages of real growth in total credit to private non-financial sector, using rolling GDP and PPP exchange rates and based on the BIS credit data for 38 economies. [6] Data on financial development index come from the data appendix of Sahay et al (2015).

Sources: King and Low (2014); Sahay et al (2015); IMF, *International Financial Statistics*; IMF, *World Economic Outlook*; Datastream; Global Financial Data; national data; BIS.

B.2. Equilibrium real interest rate estimates

Real overnight interest rate

Sensitivity of equilibrium real interest rate estimates,[1] in per cent — Graph B.2.1



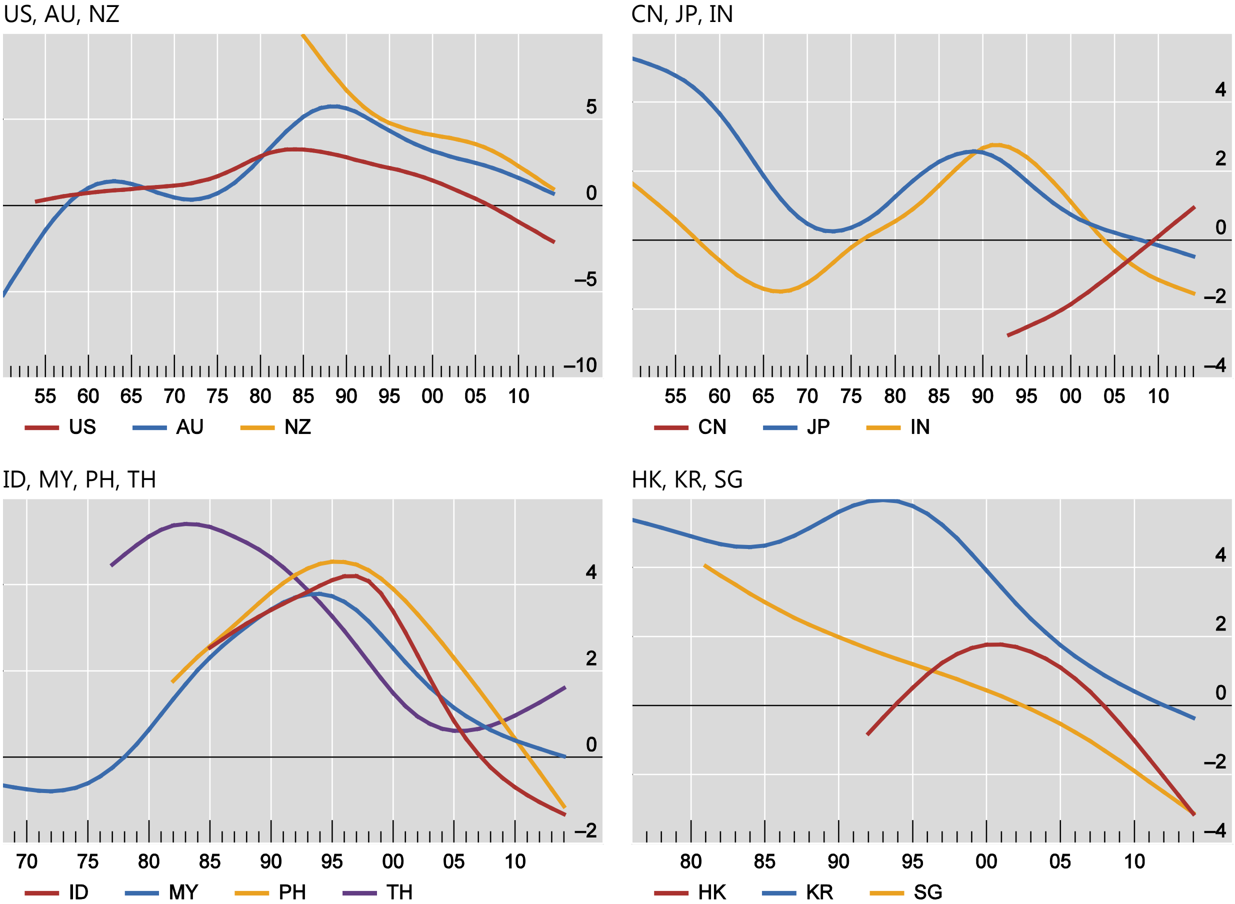
[1] Equilibrium real interest rate estimates are based on the Hodrick-Prescott (1981) filtering technique. The trend component is extracted with the smoothing parameter λ set at 6.25, 100, 400, 800, 1600 and 6400.

Source: Author's calculations.

Estimates of equilibrium real interest rate in Asia-Pacific

Trend in real overnight interest rate,[1] in per cent

Graph B.2.2



AU = Australia; CN = China; HK = Hong Kong; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; NZ = New Zealand; PH = Philippines; SG = Singapore; TH = Thailand; US = United States.

[1] Equilibrium real interest rate estimates are based on the Hodrick-Prescott (1981) filtering technique. The trend component is extracted with the smoothing parameter λ set at 400.

Source: Author's calculations.

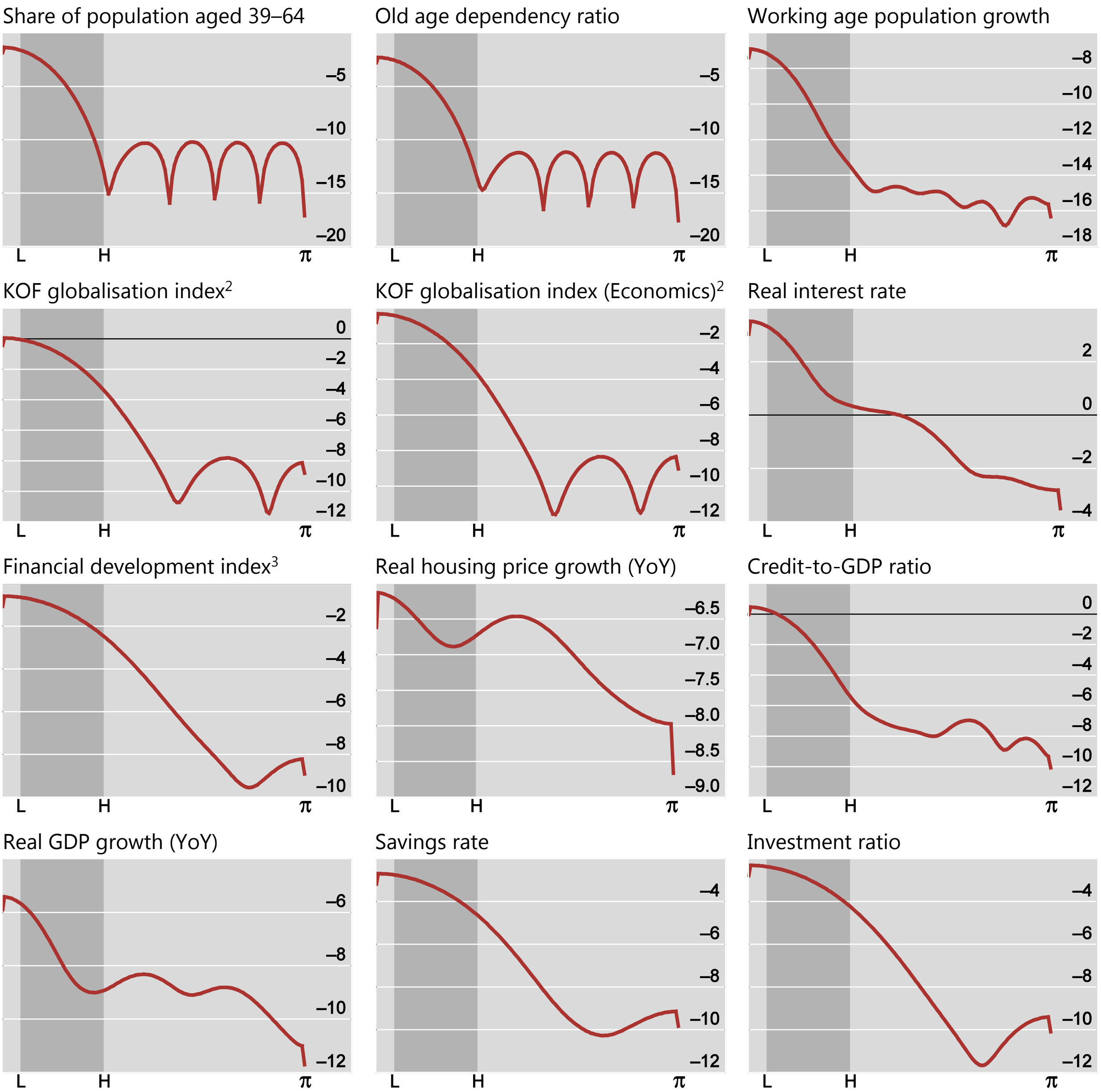
B.3. Spectral analysis of real interest rates

B.3.1. Australia

Spectral density estimates: Australia[1]

In logarithm

Graph B.3.1.1



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

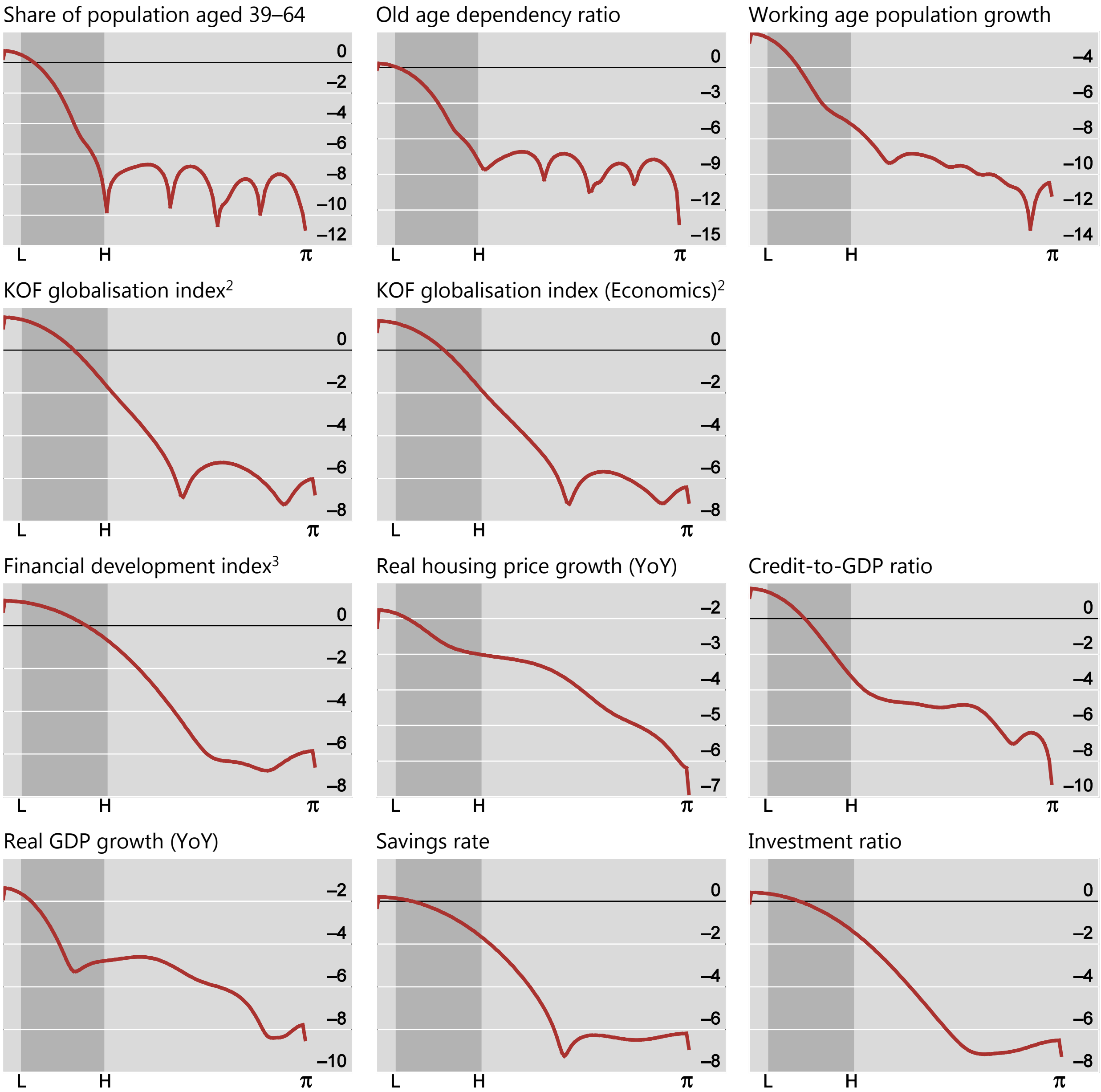
[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: Australia[1]

In logarithm, with real interest rate

Graph B.3.1.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

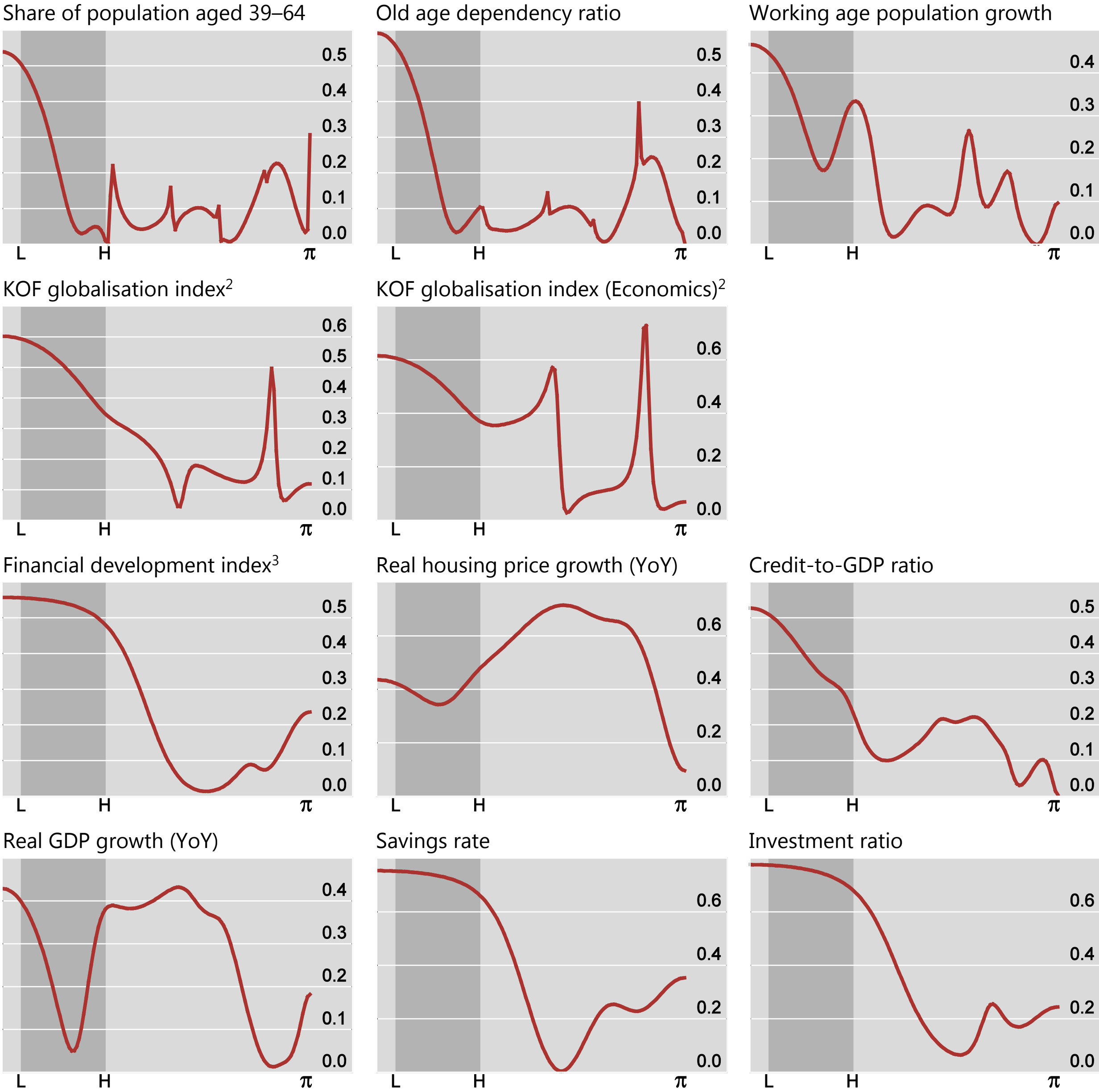
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: Australia[1]

With real interest rate

Graph B.3.1.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

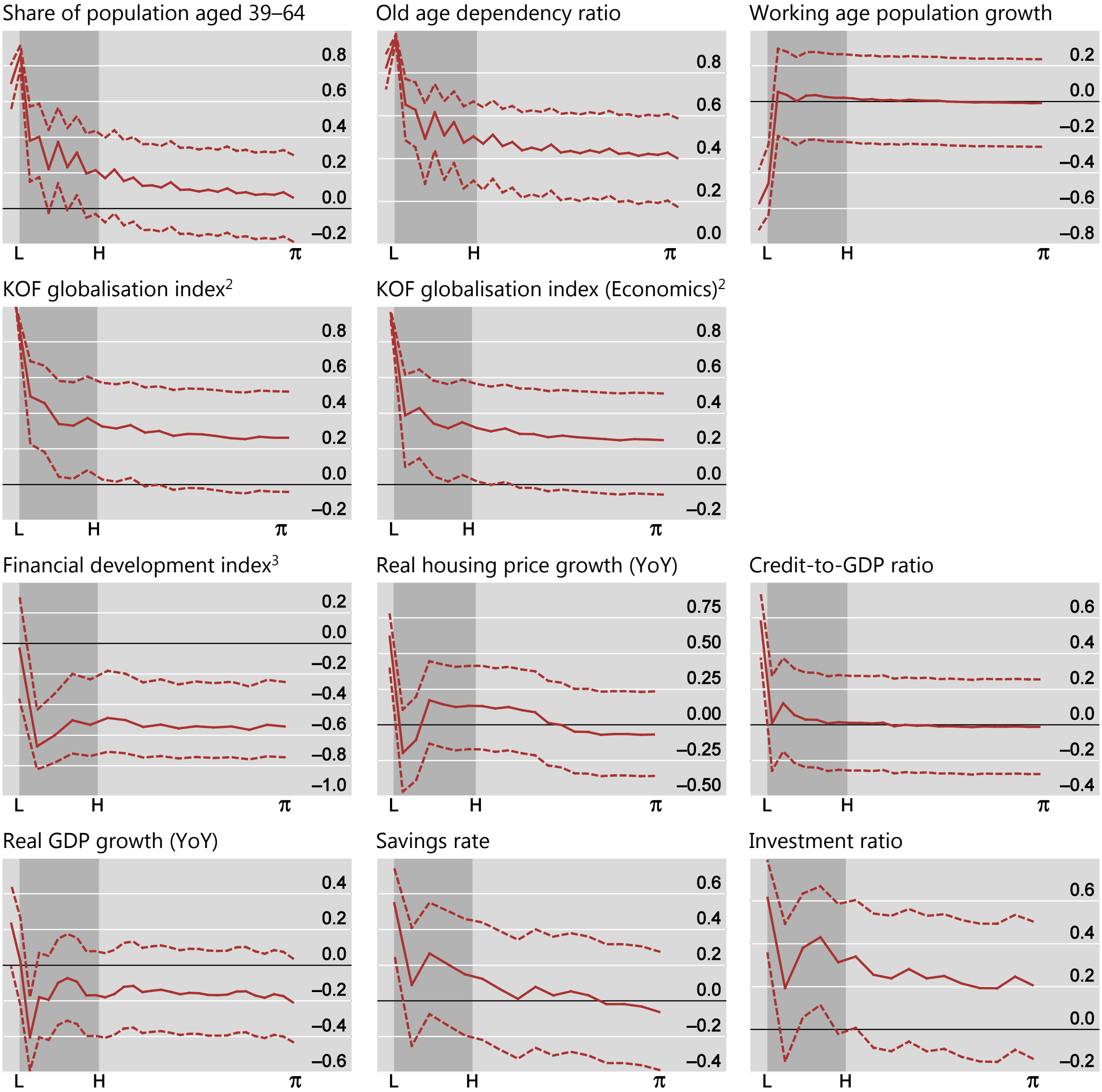
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: Australia[1]

With real interest rate

Graph B.3.1.4



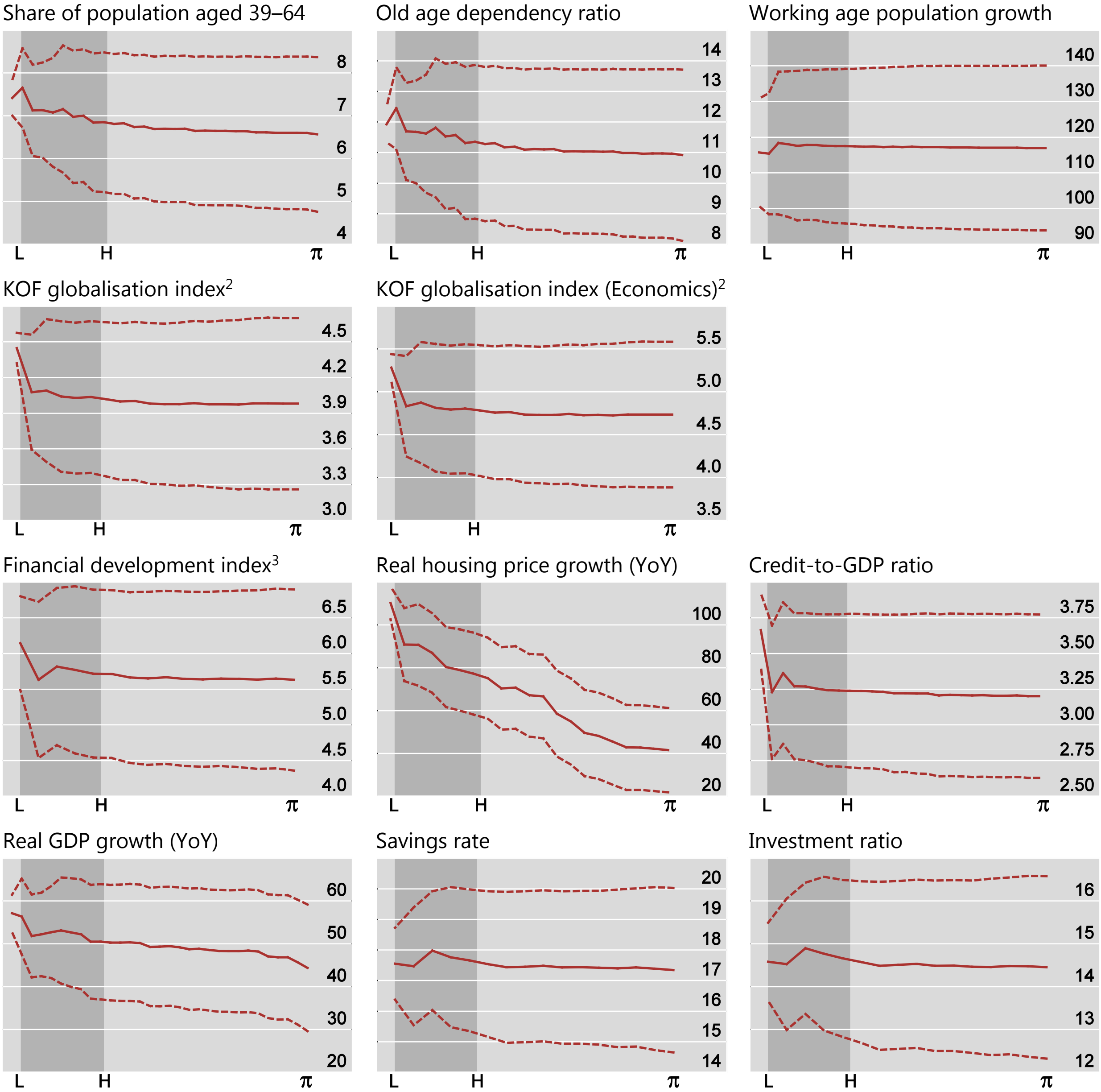
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: Australia[1]

Real interest rate as regressand | Graph B.3.1.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

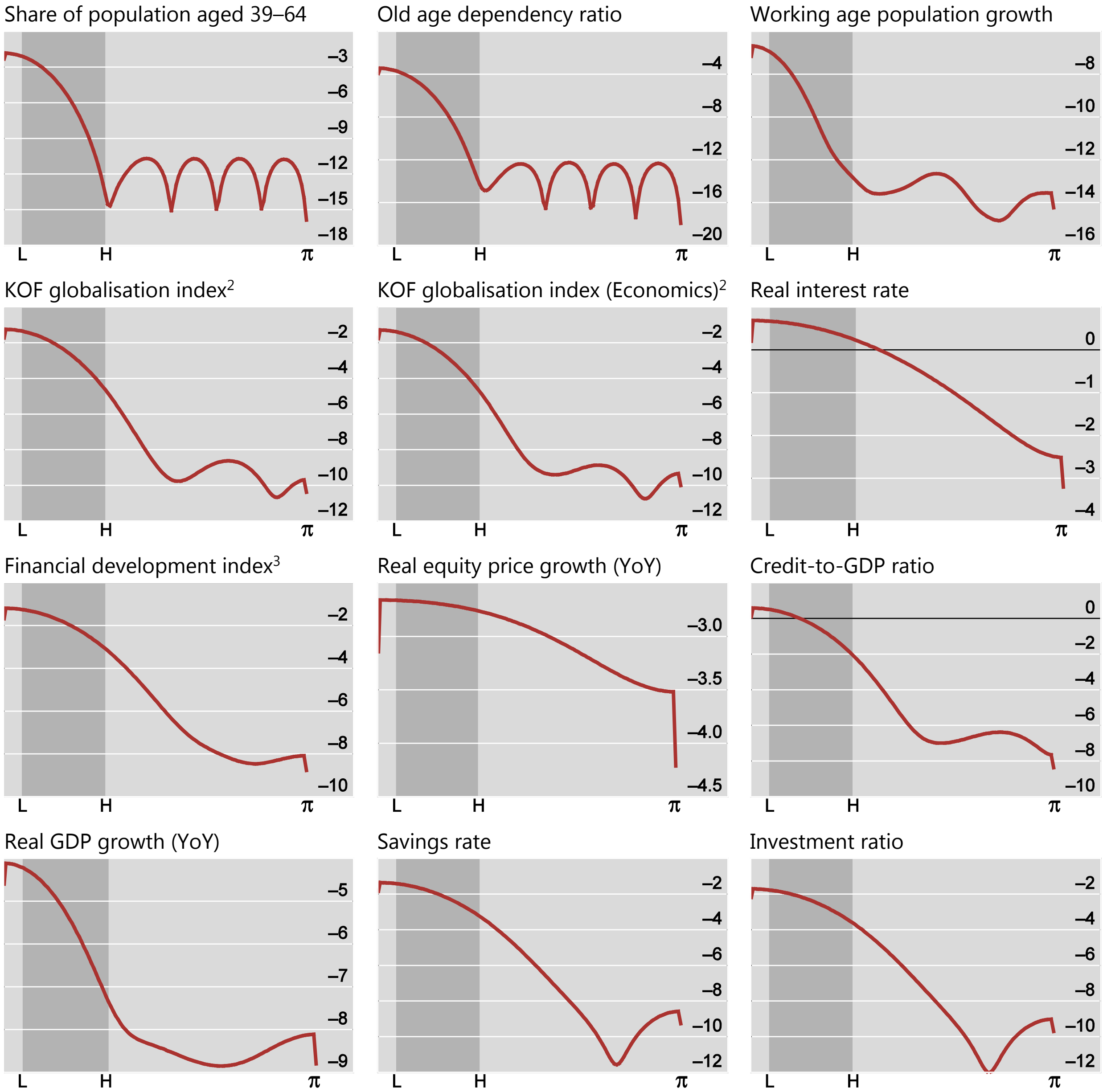
Source: Author's calculations.

B.3.2. China

Spectral density estimates: China[1]

In logarithm

Graph B.3.2.1



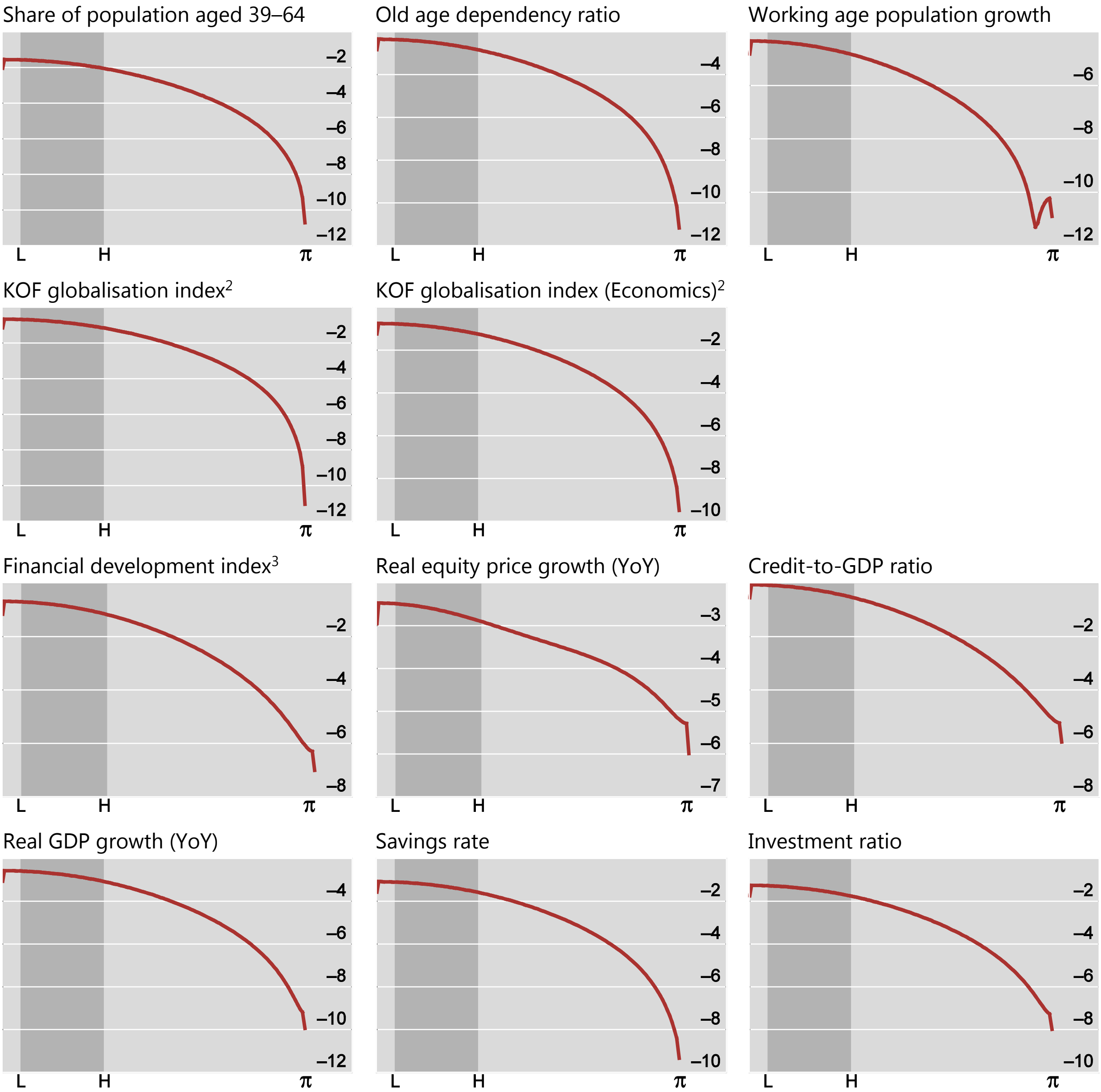
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: China[1]

In logarithm, with real interest rate Graph B.3.2.2



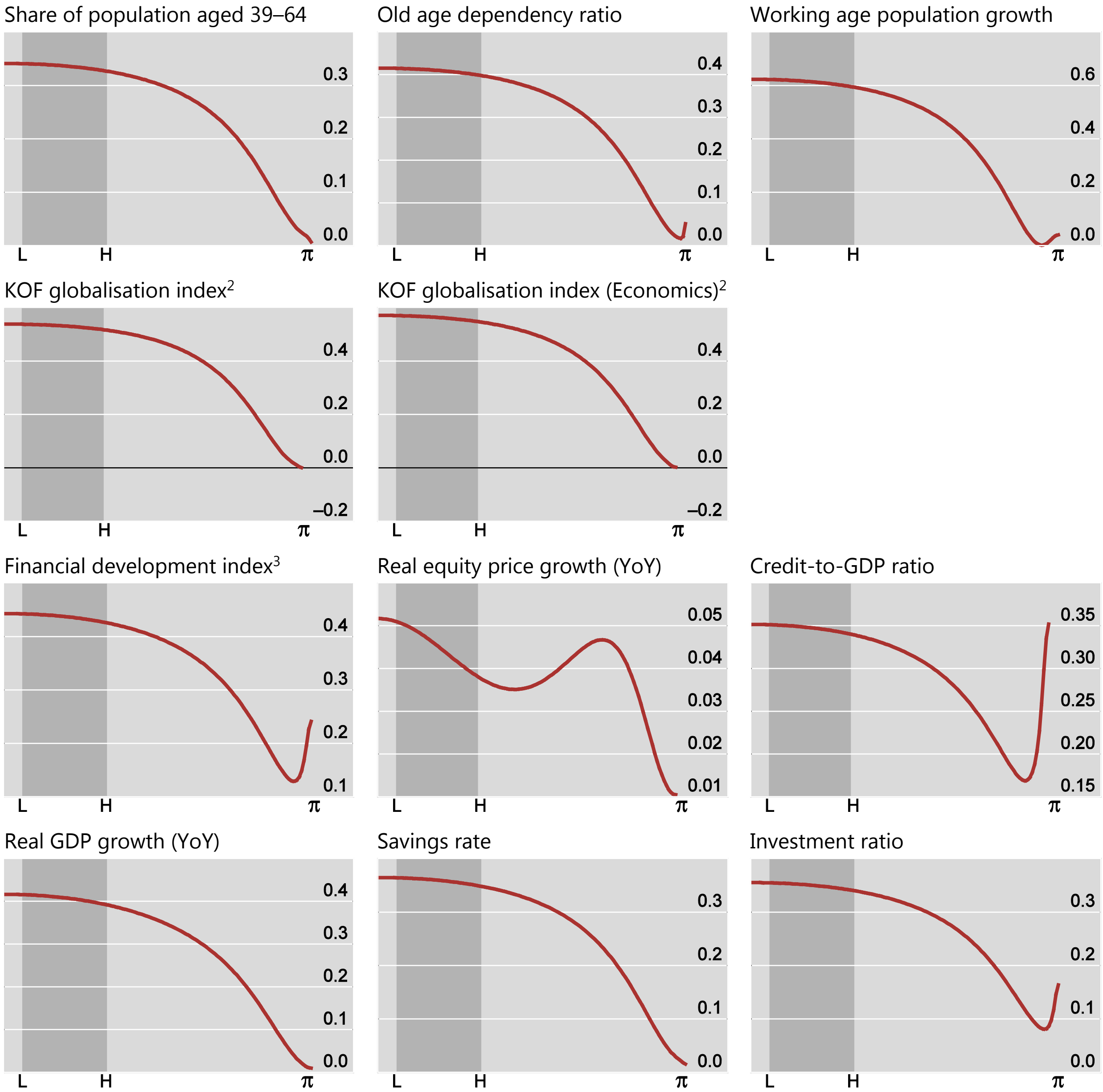
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: China[1]

With real interest rate | Graph B.3.2.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

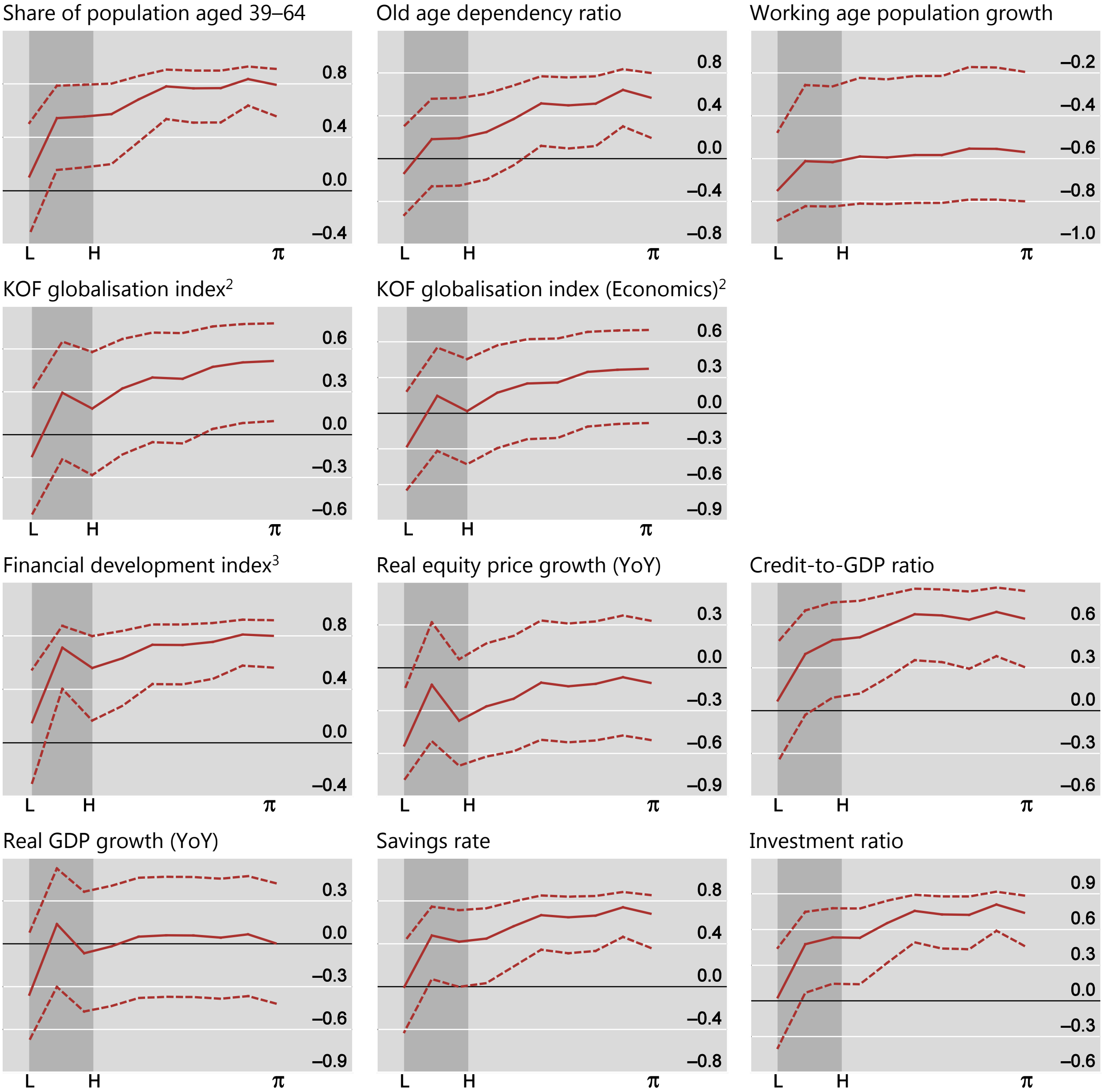
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: China[1]

With real interest rate

Graph B.3.2.4



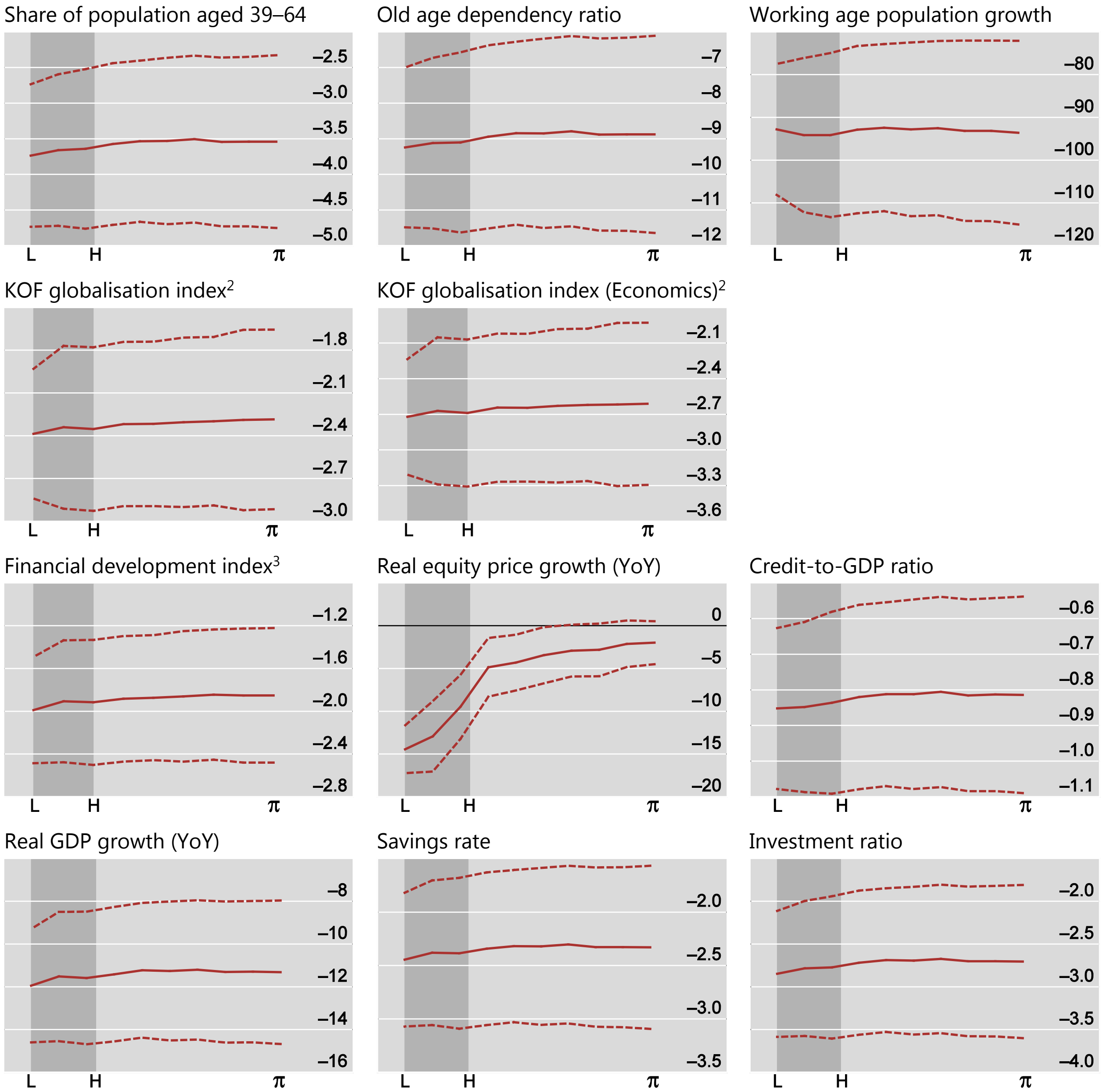
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author’s calculations.

Frequency-specific regression coefficient estimates: China[1]

Real interest rate as regressand Graph B.3.2.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

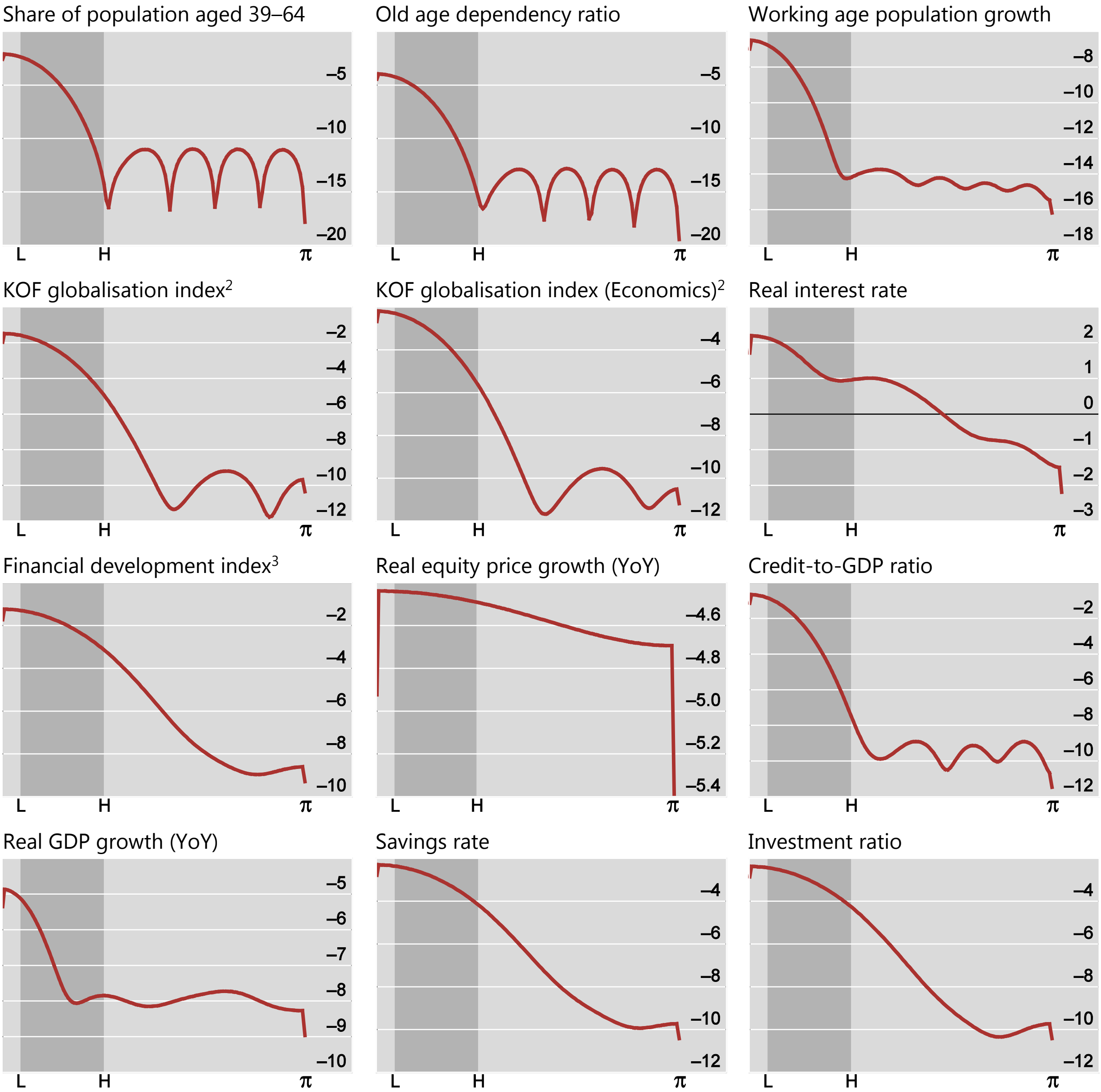
Source: Author's calculations.

B.3.3. India

Spectral density estimates: India[1]

In logarithm

Graph B.3.3.1



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

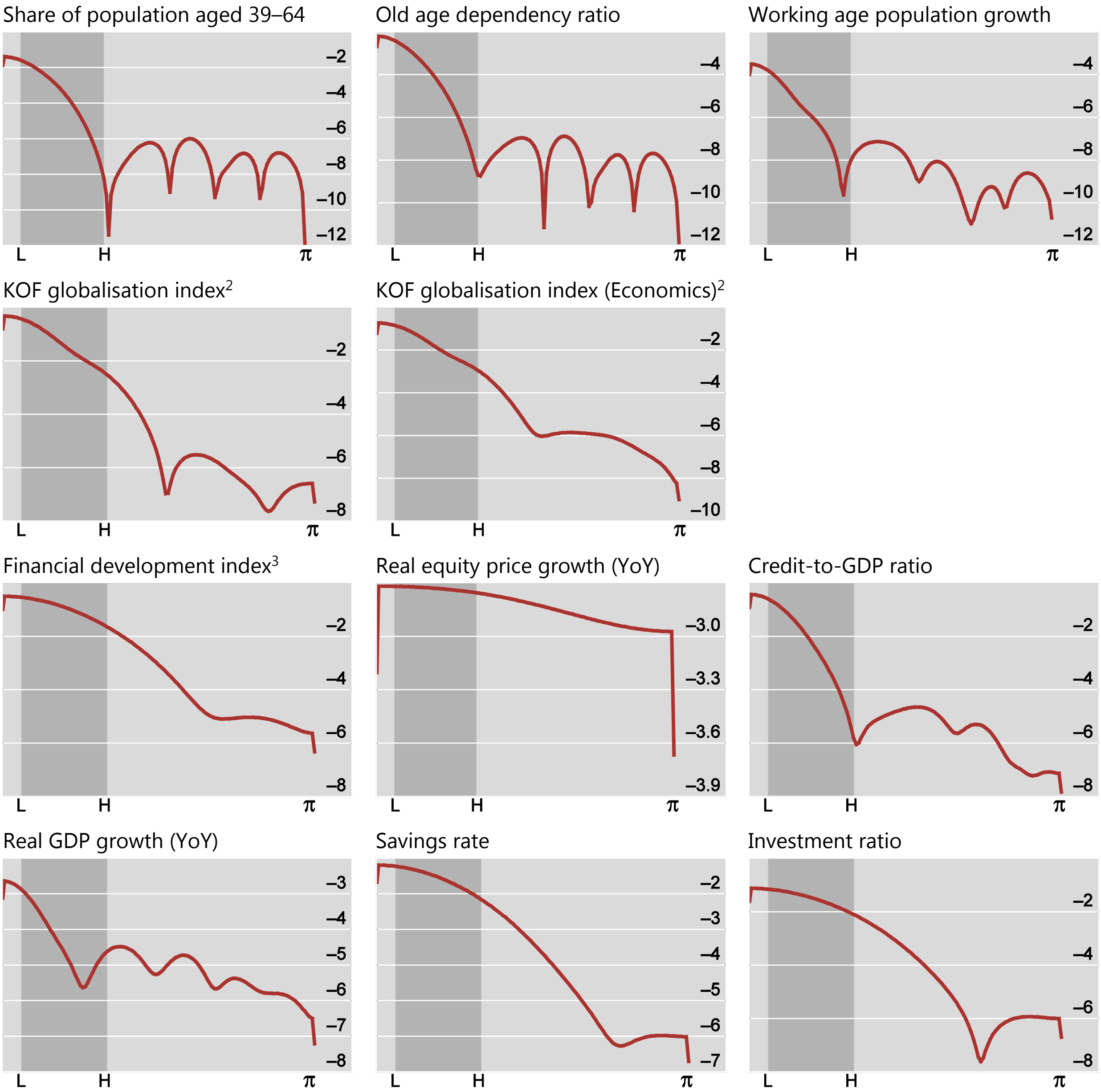
[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: India[1]

In logarithm, with real interest rate

Graph B.3.3.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

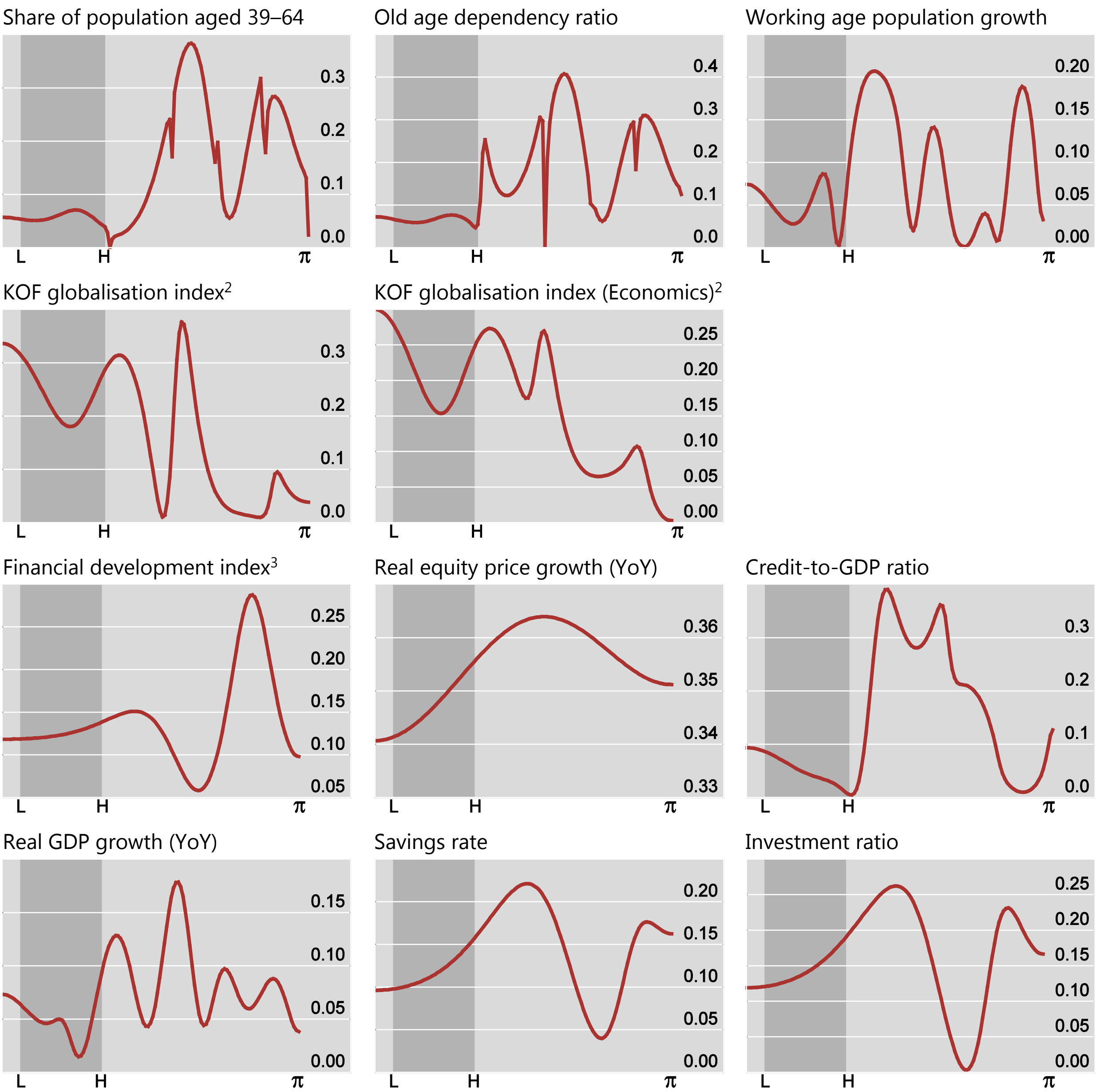
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: India[1]

With real interest rate

Graph B.3.3.3



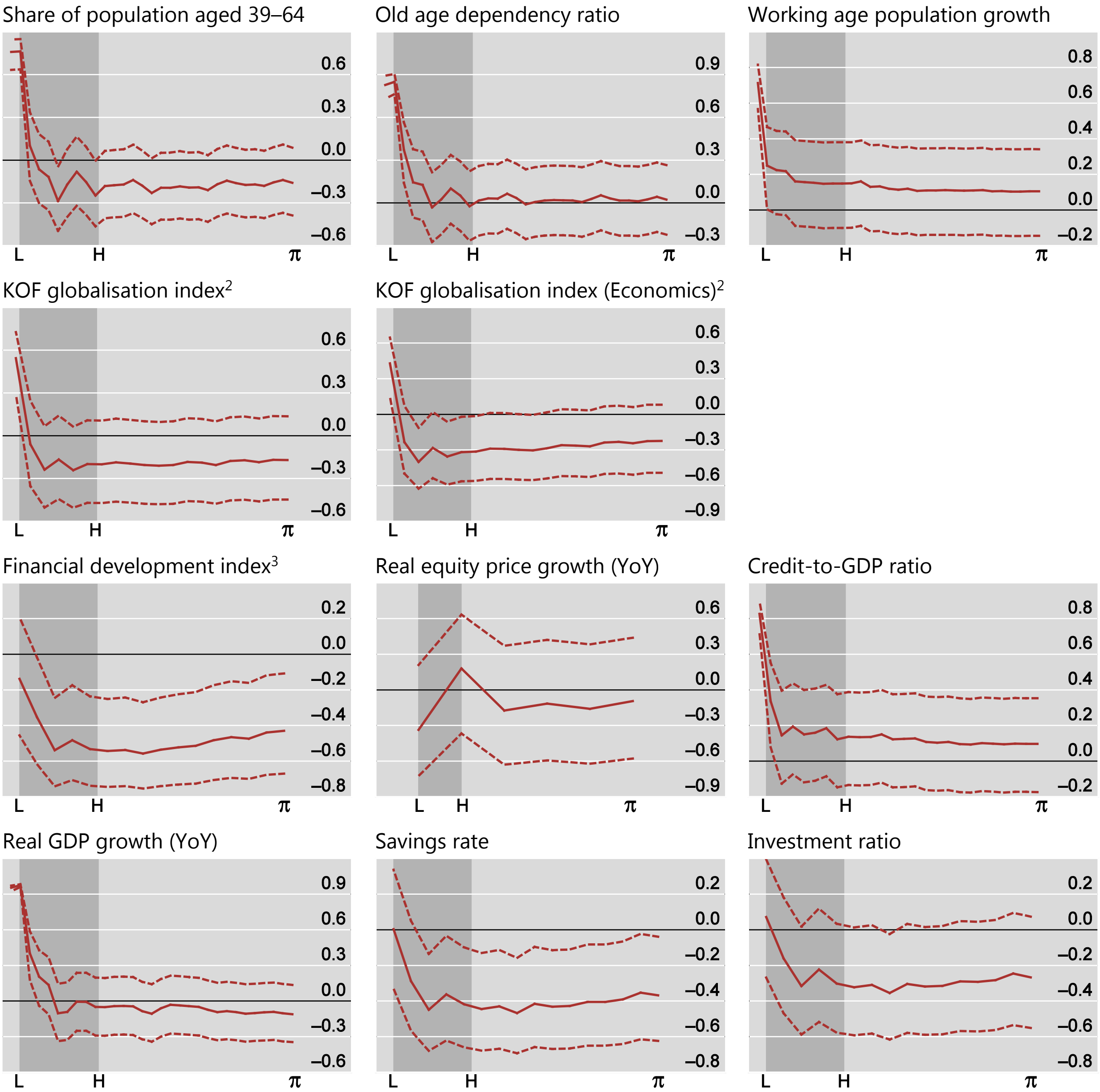
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: India[1]

With real interest rate | Graph B.3.3.4



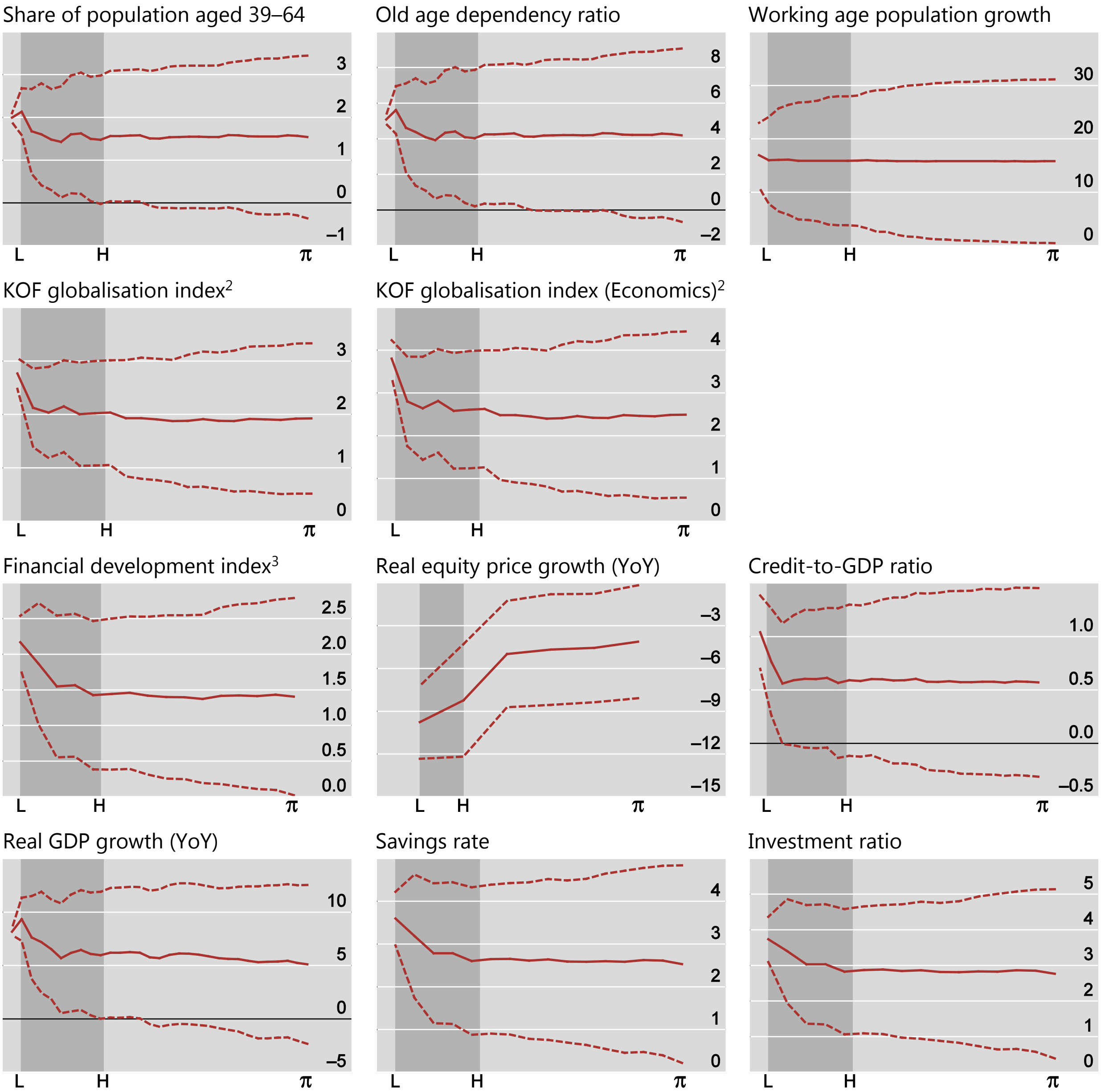
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: India[1]

Real interest rate as regressand — Graph B.3.3.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

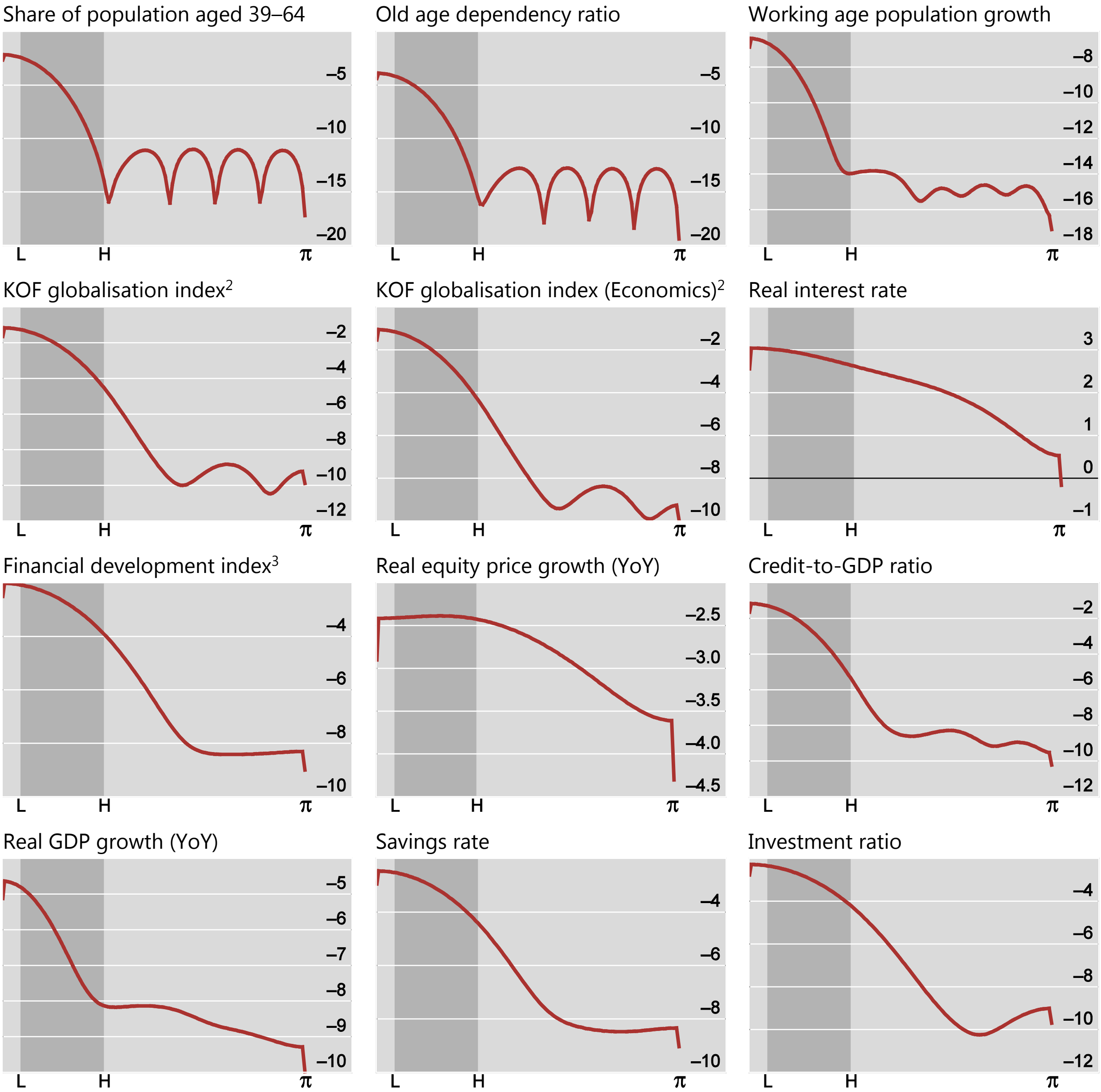
Source: Author's calculations.

B.3.4. Indonesia

Spectral density estimates: Indonesia[1]

In logarithm

Graph B.3.4.1



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

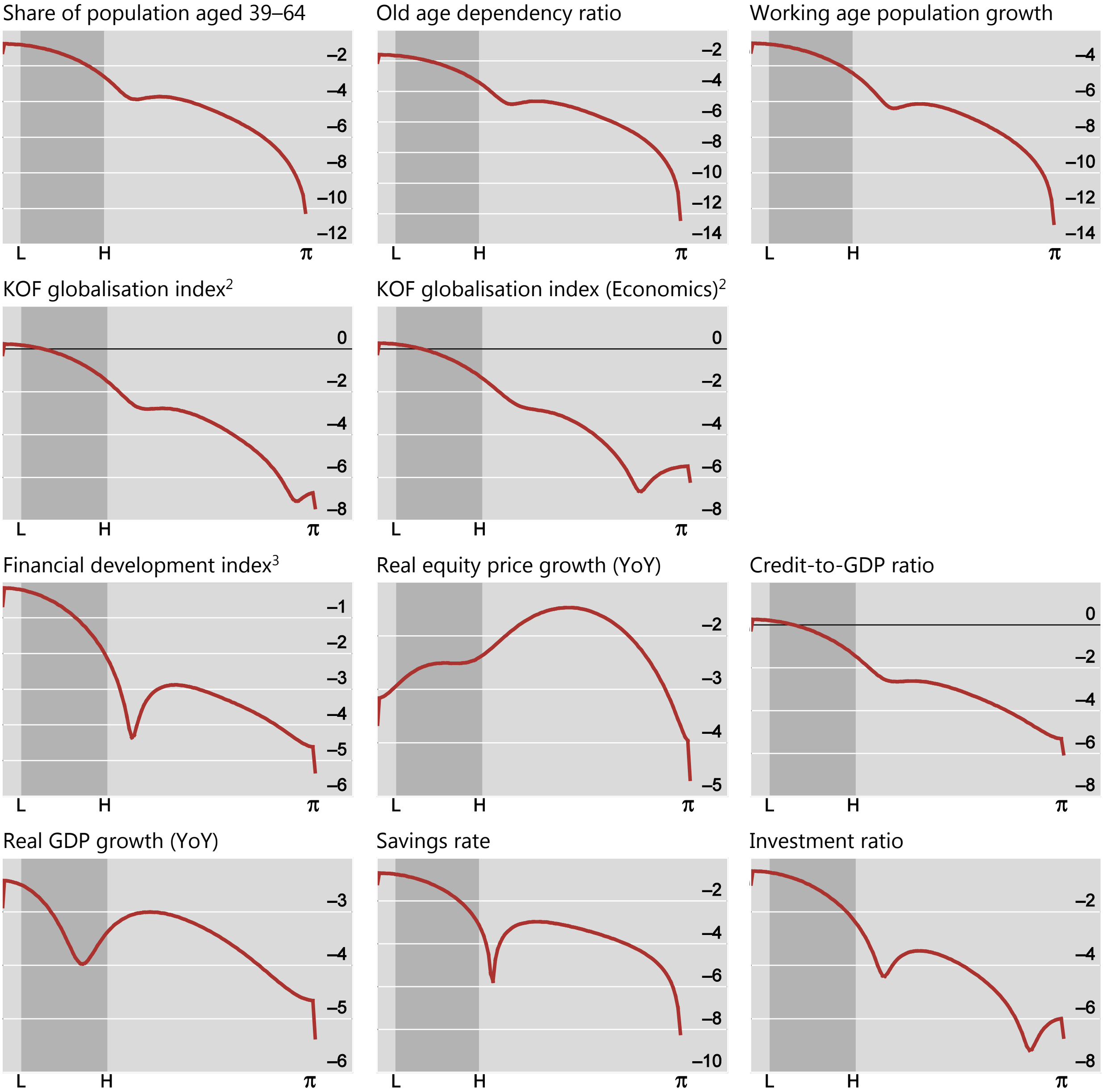
[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: Indonesia[1]

In logarithm, with real interest rate

Graph B.3.4.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

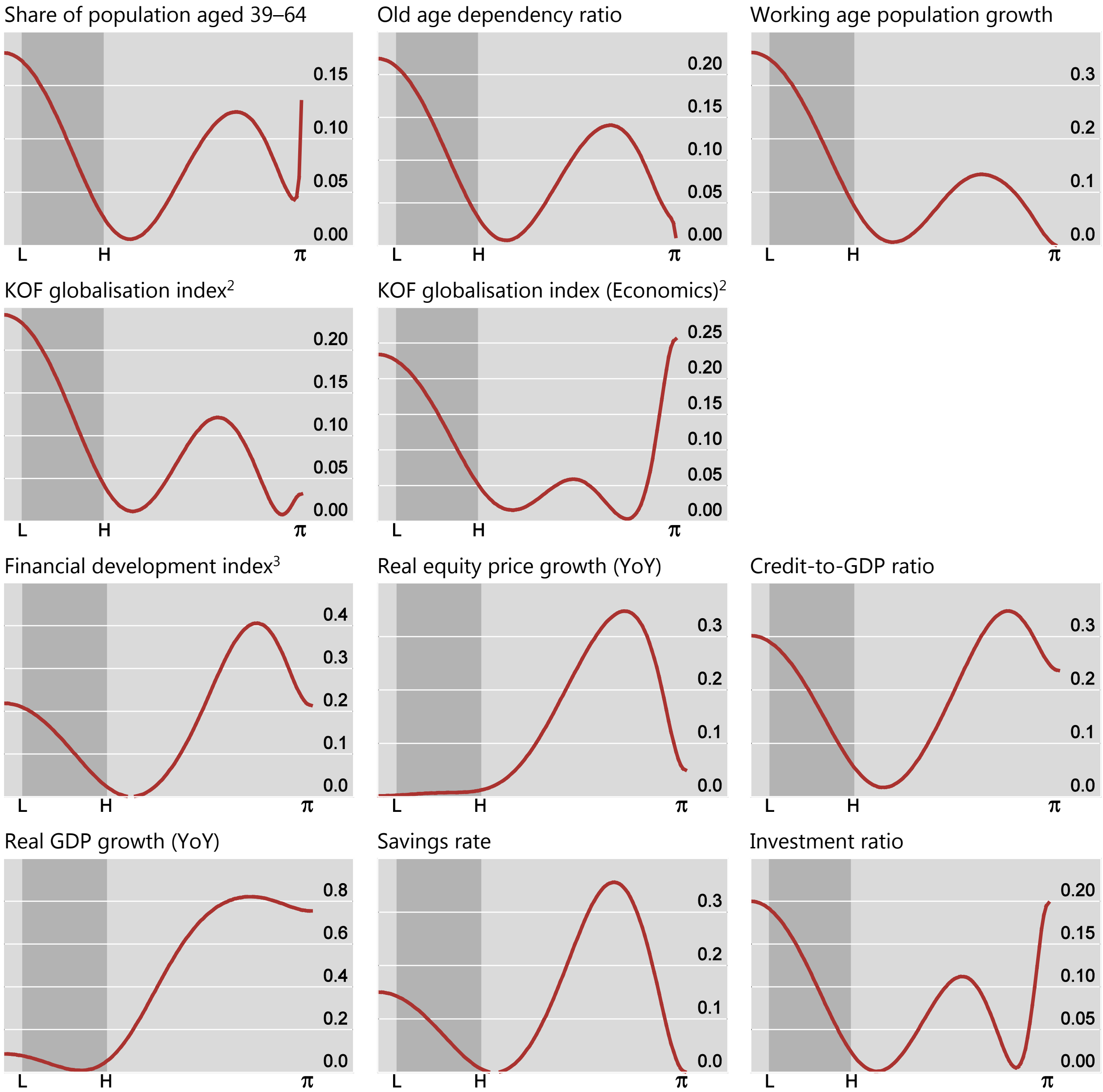
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: Indonesia[1]

With real interest rate

Graph B.3.4.3



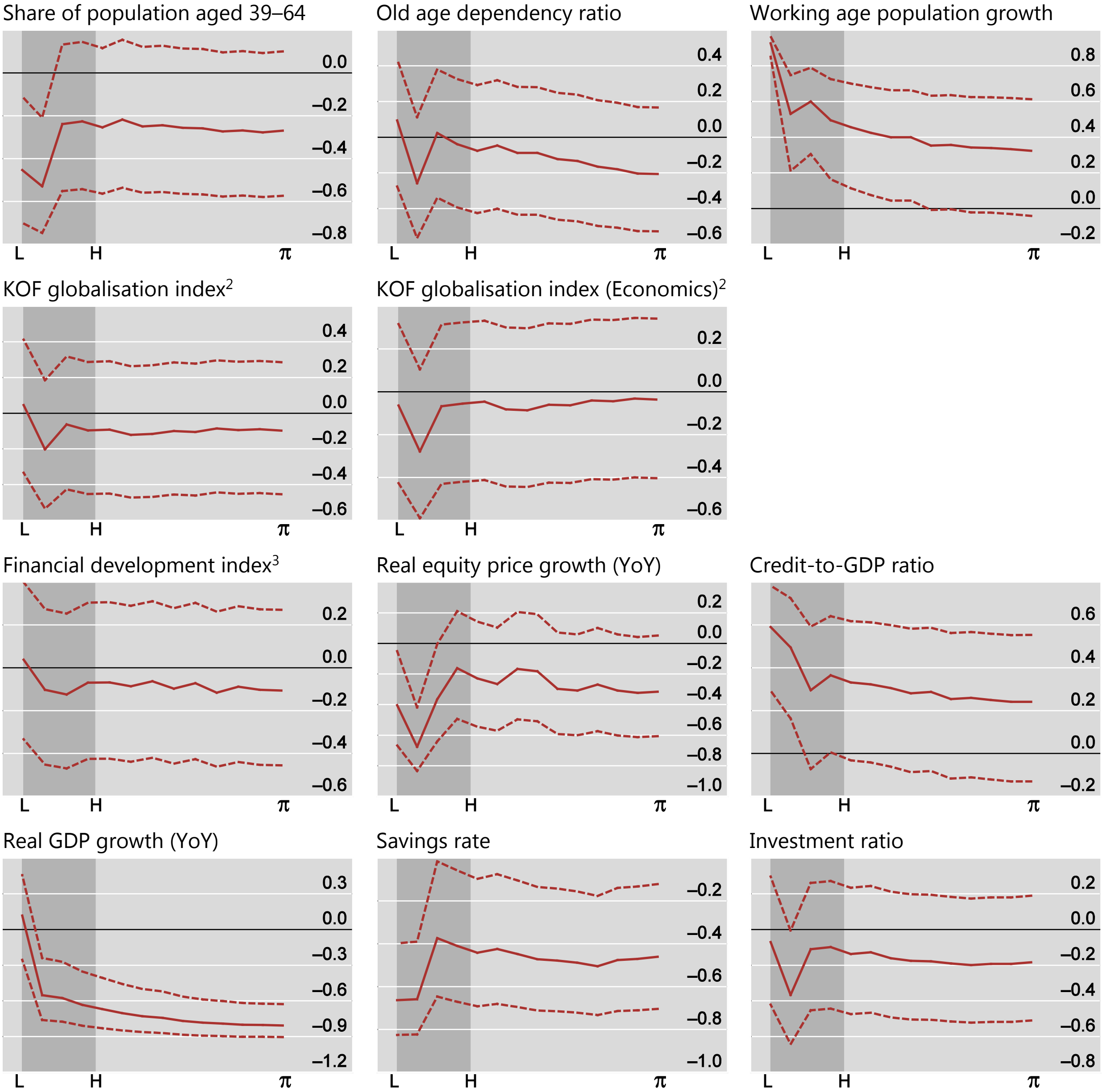
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: Indonesia[1]

With real interest rate Graph B.3.4.4



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

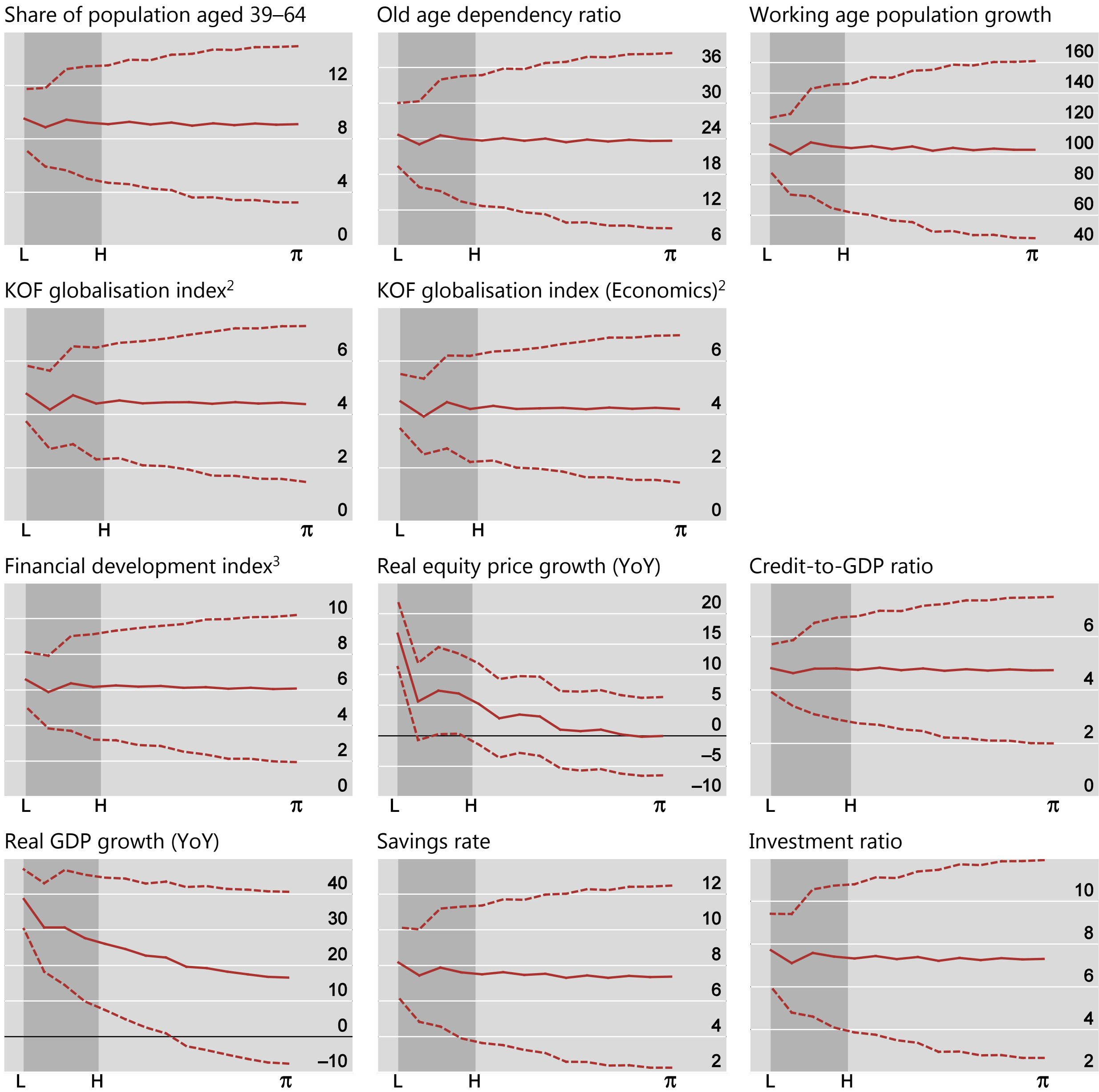
[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: Indonesia[1]

Real interest rate as regressand

Graph B.3.4.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

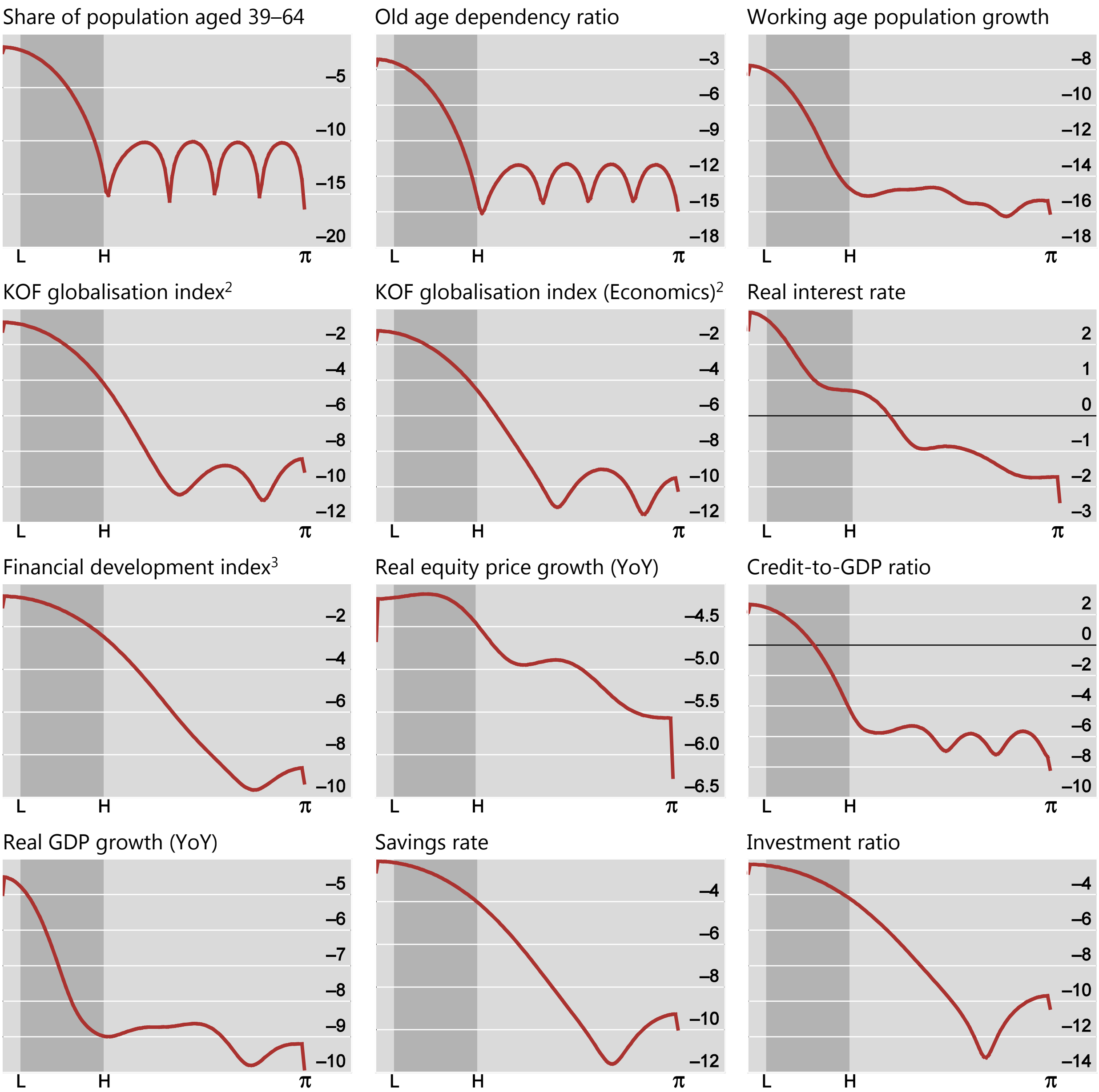
Source: Author's calculations.

B.3.5. Japan

Spectral density estimates: Japan[1]

In logarithm

Graph B.3.5.1



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

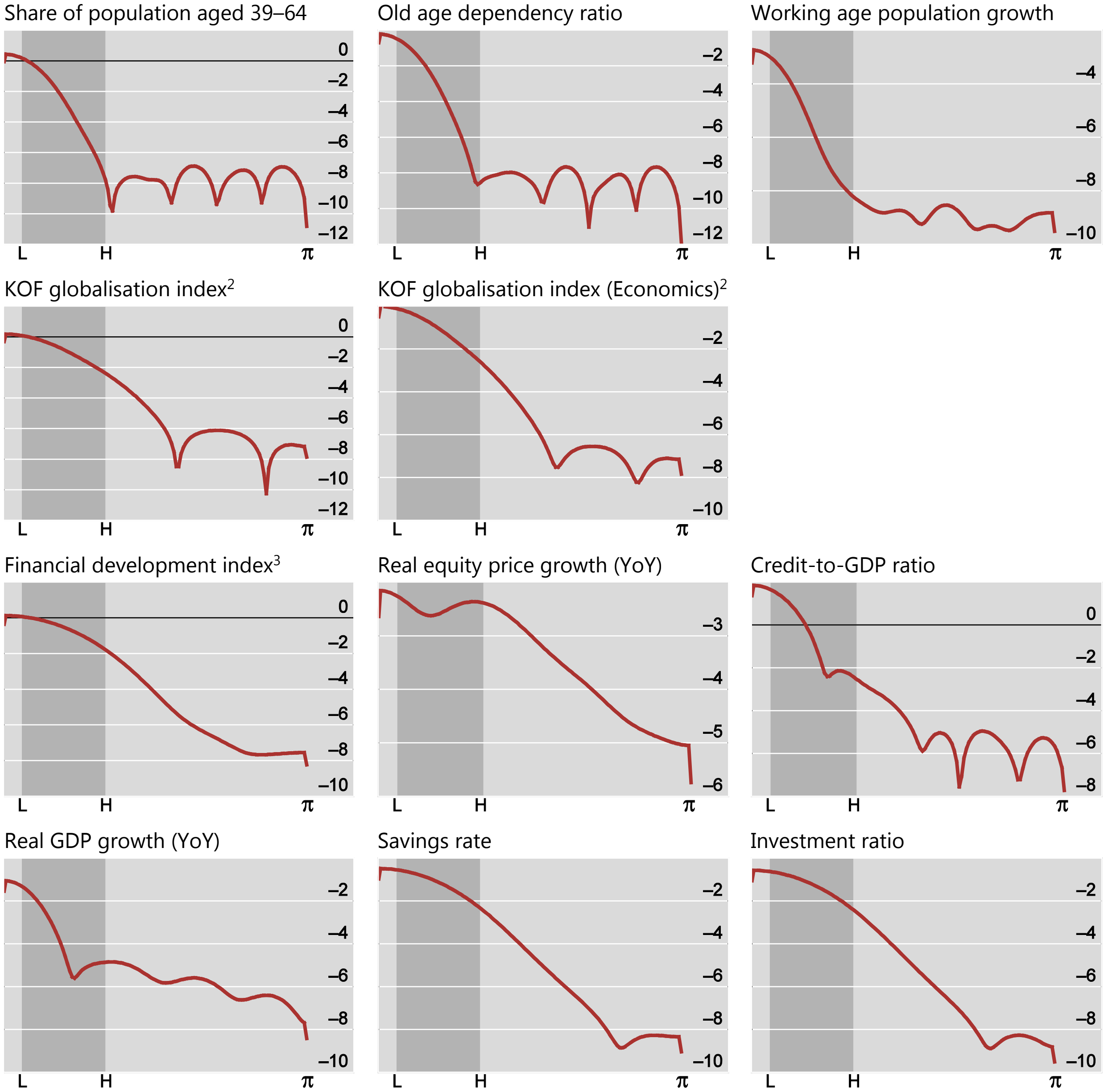
[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: Japan[1]

In logarithm, with real interest rate

Graph B.3.5.2



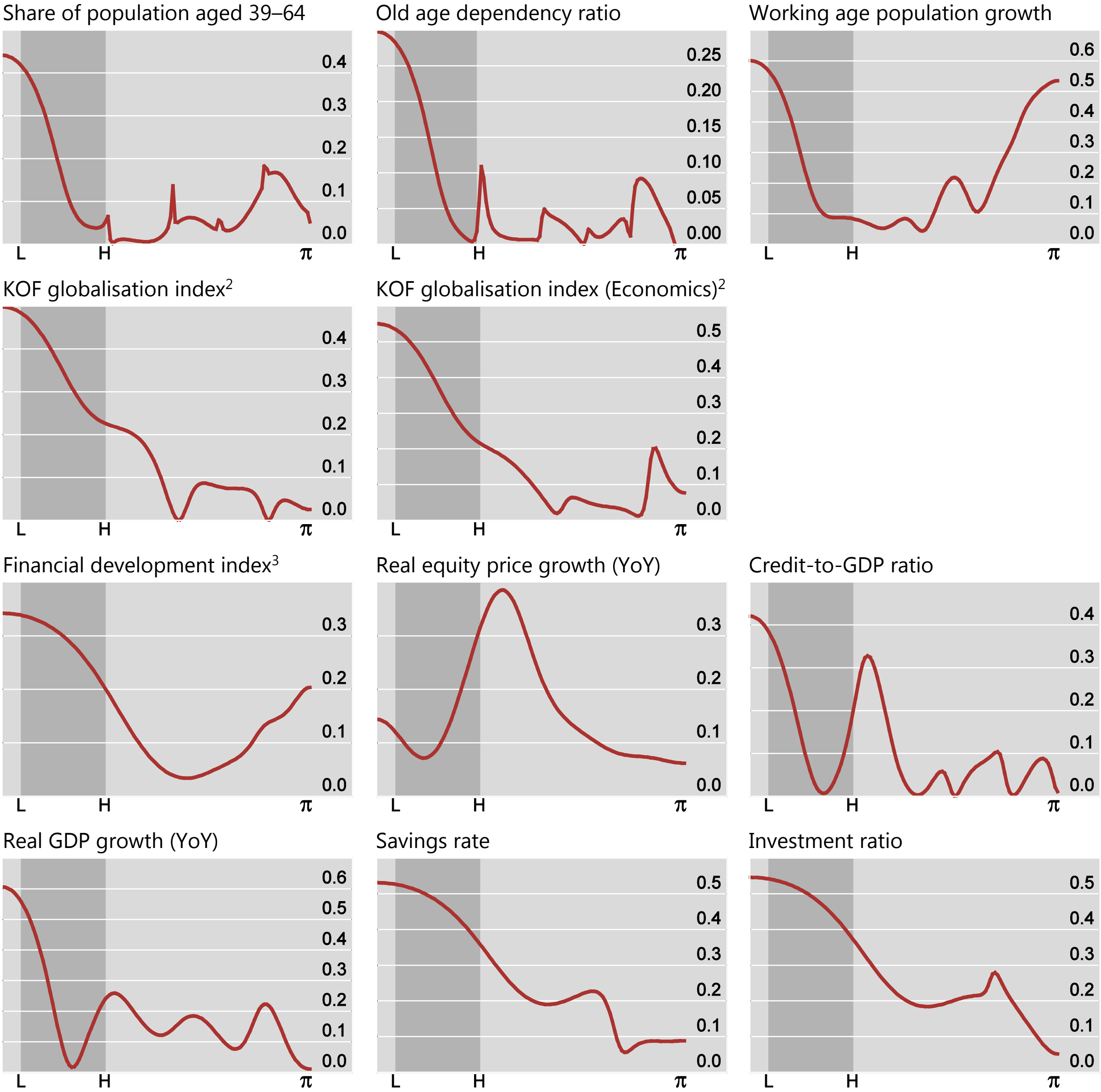
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: Japan[1]

With real interest rate Graph B.3.5.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

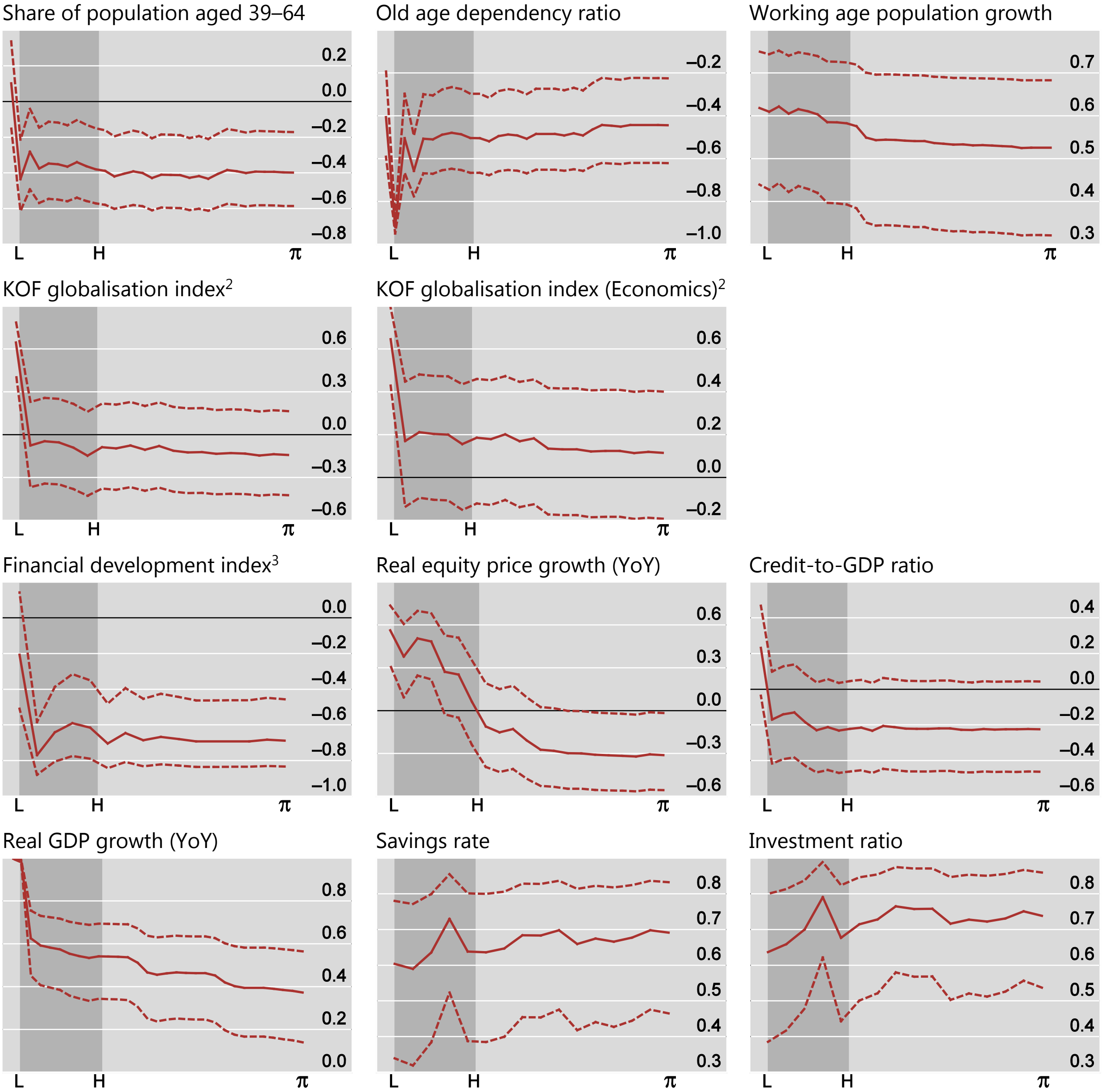
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: Japan[1]

With real interest rate

Graph B.3.5.4



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

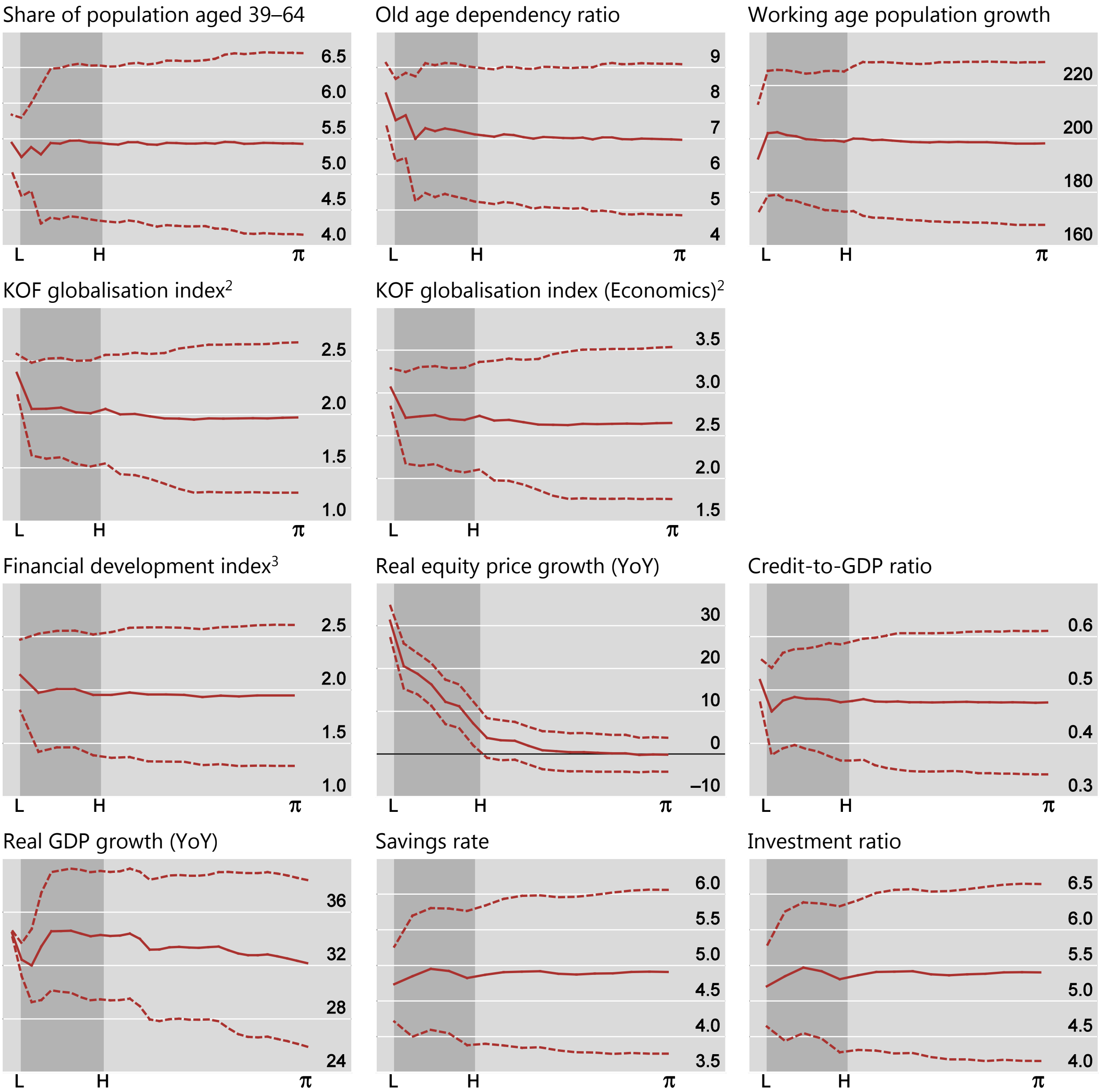
[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: Japan[1]

Real interest rate as regressand

Graph B.3.5.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

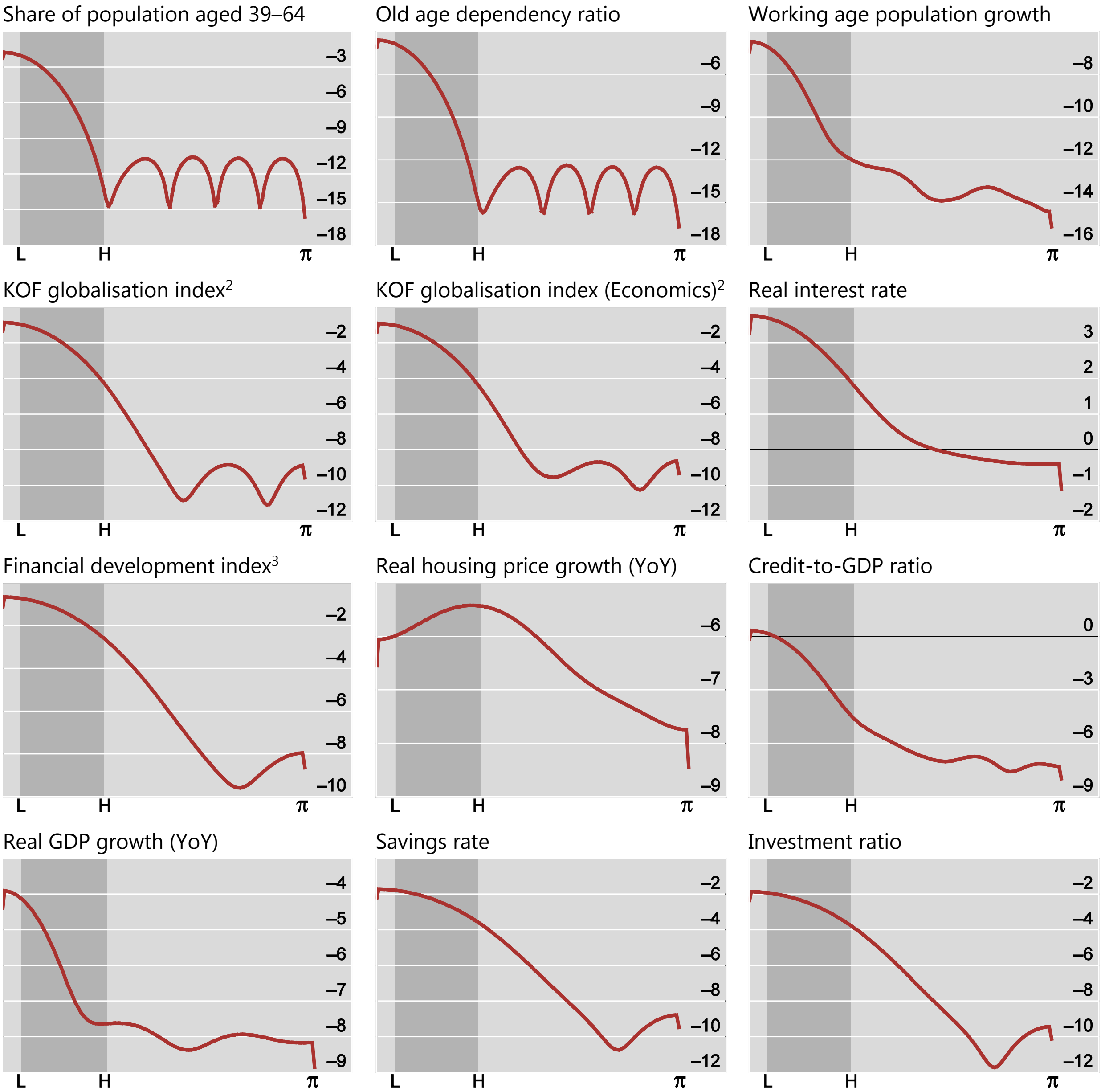
Source: Author's calculations.

B.3.6. Korea

Spectral density estimates: Korea[1]

In logarithm

Graph B.3.6.1



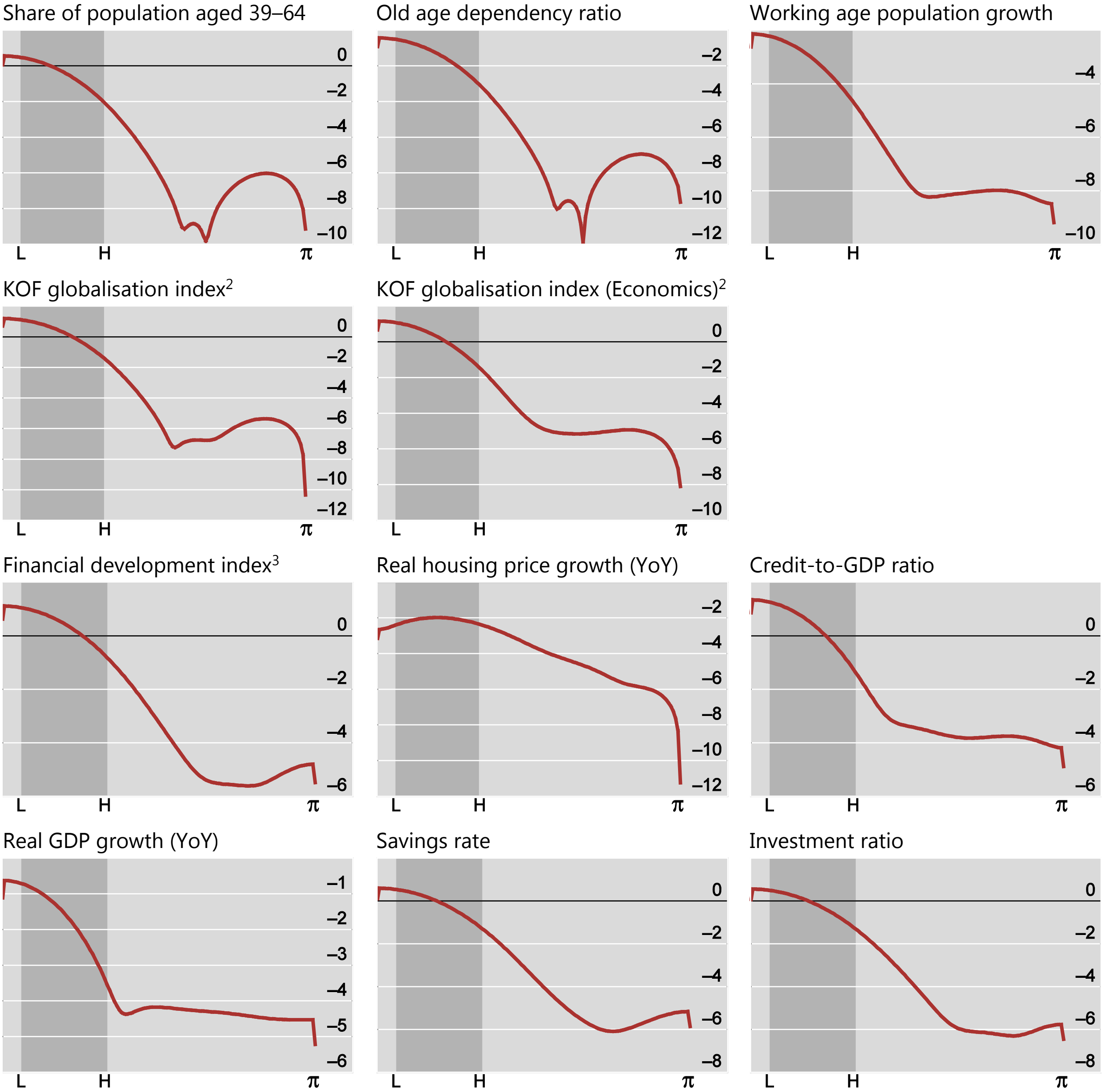
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: Korea[1]

In logarithm, with real interest rate Graph B.3.6.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

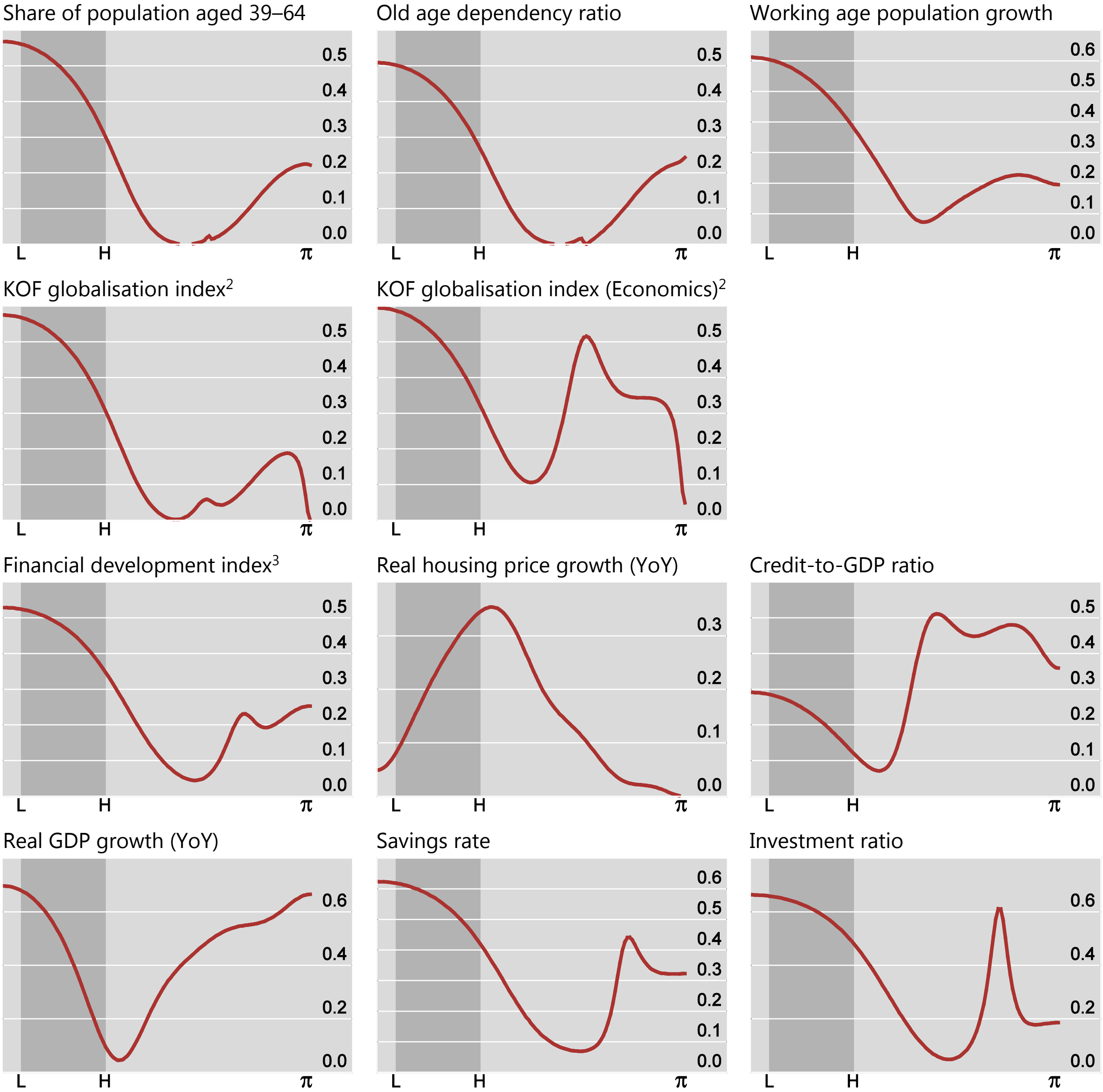
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: Korea[1]

With real interest rate

Graph B.3.6.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

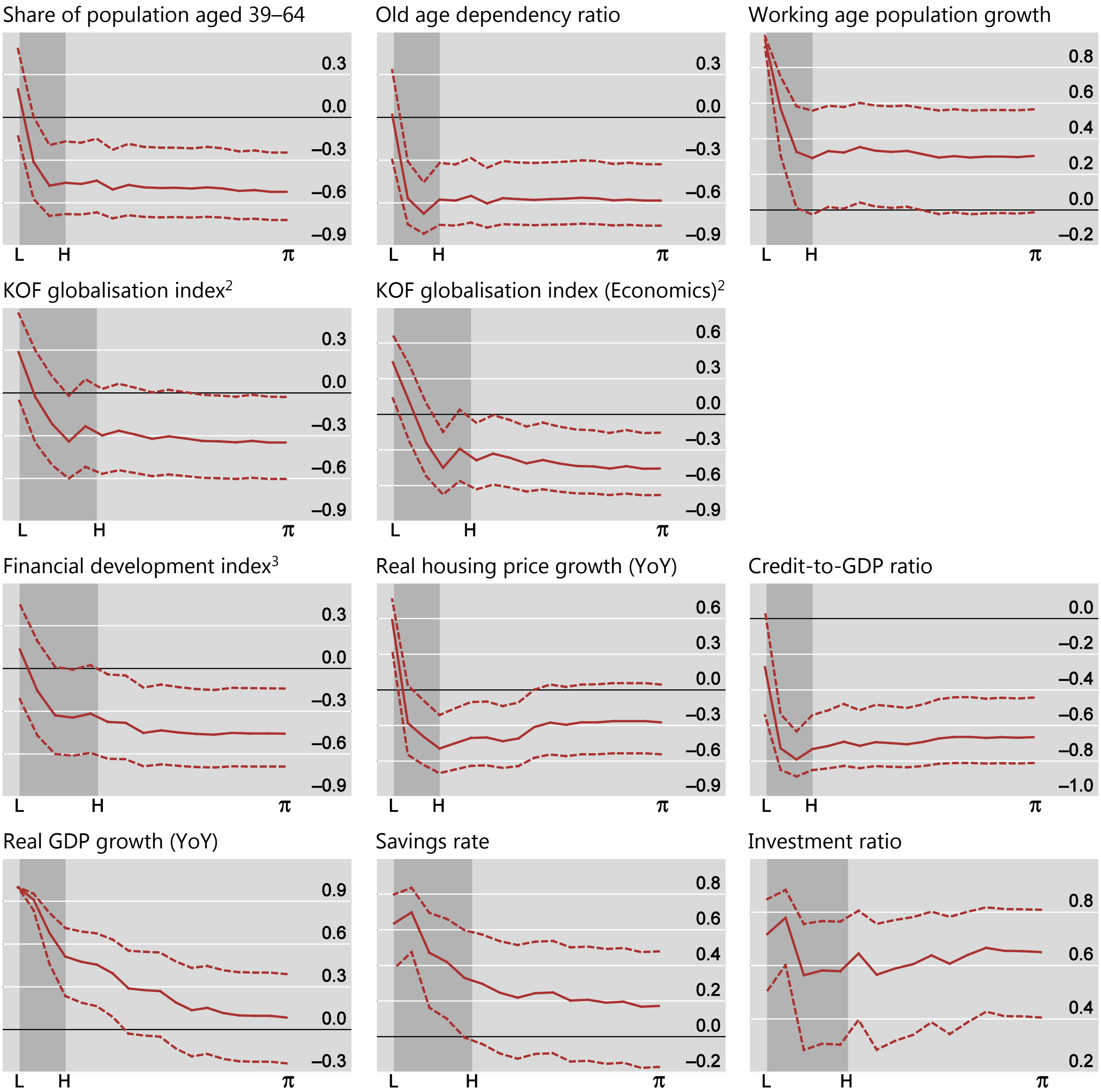
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: Korea[1]

With real interest rate

Graph B.3.6.4



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

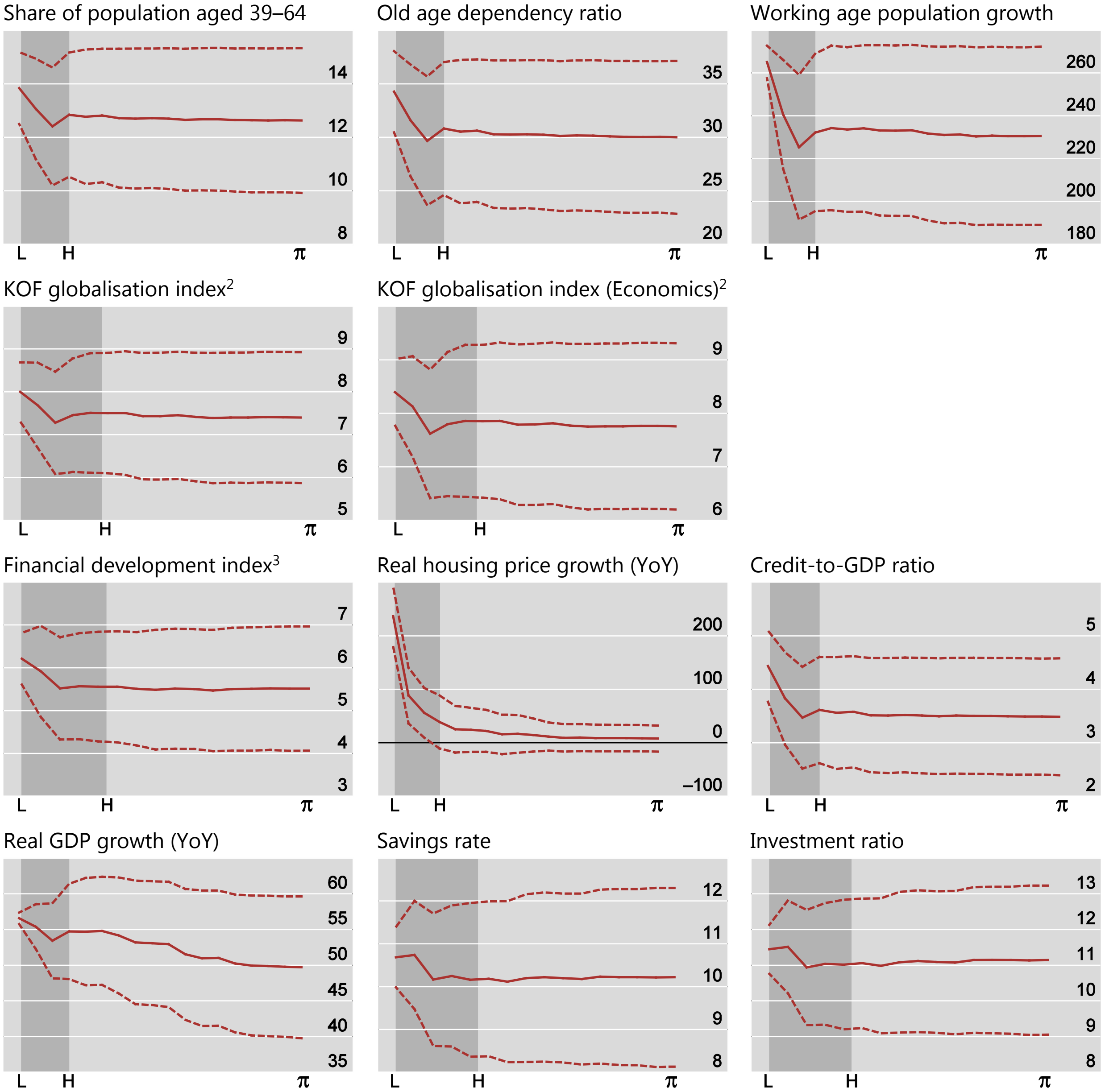
[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author’s calculations.

Frequency-specific regression coefficient estimates: Korea[1]

Real interest rate as regressand

Graph B.3.6.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

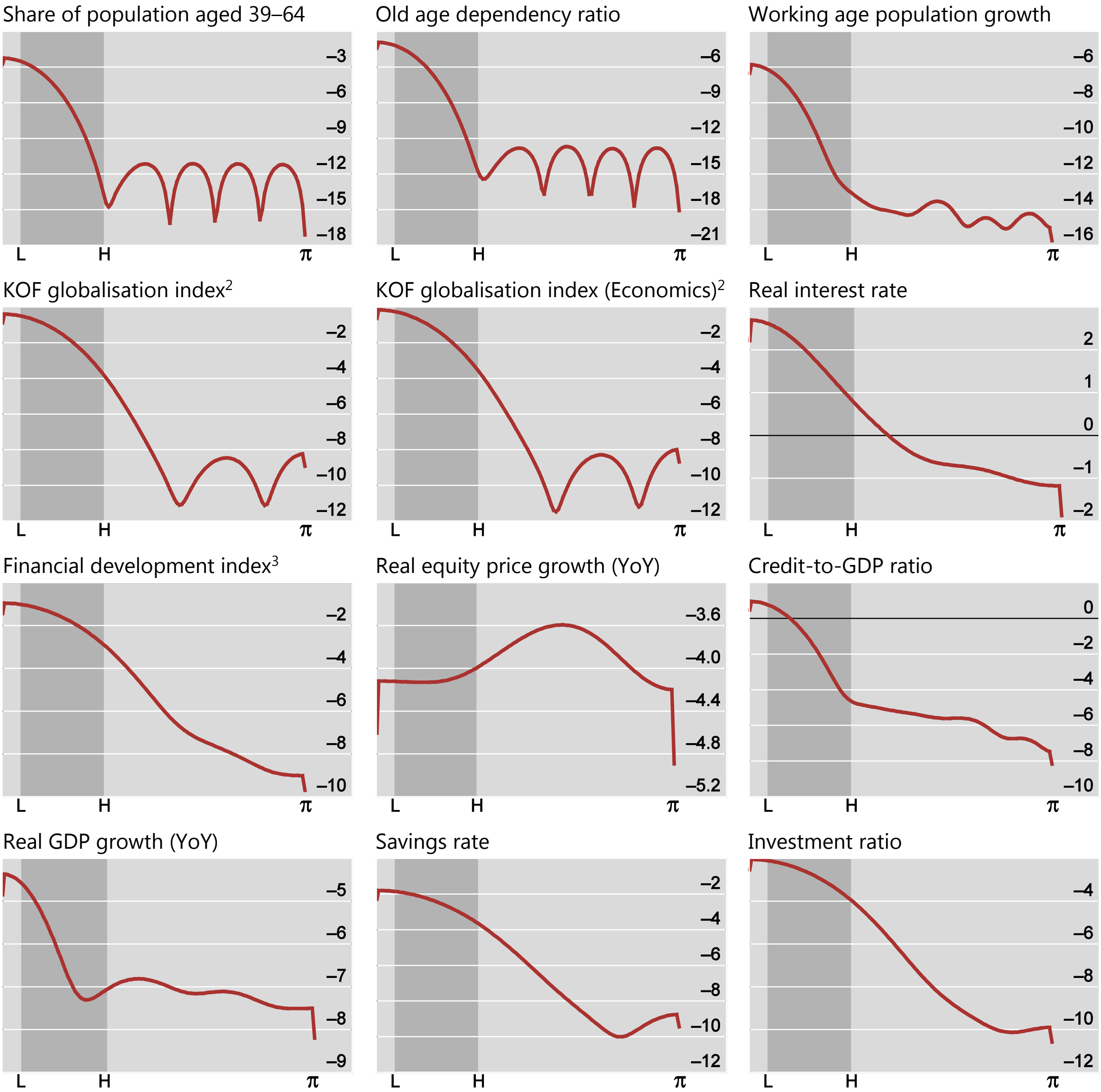
[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

B.3.7. Malaysia

Spectral density estimates: Malaysia[1]

In logarithm — Graph B.3.7.1



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

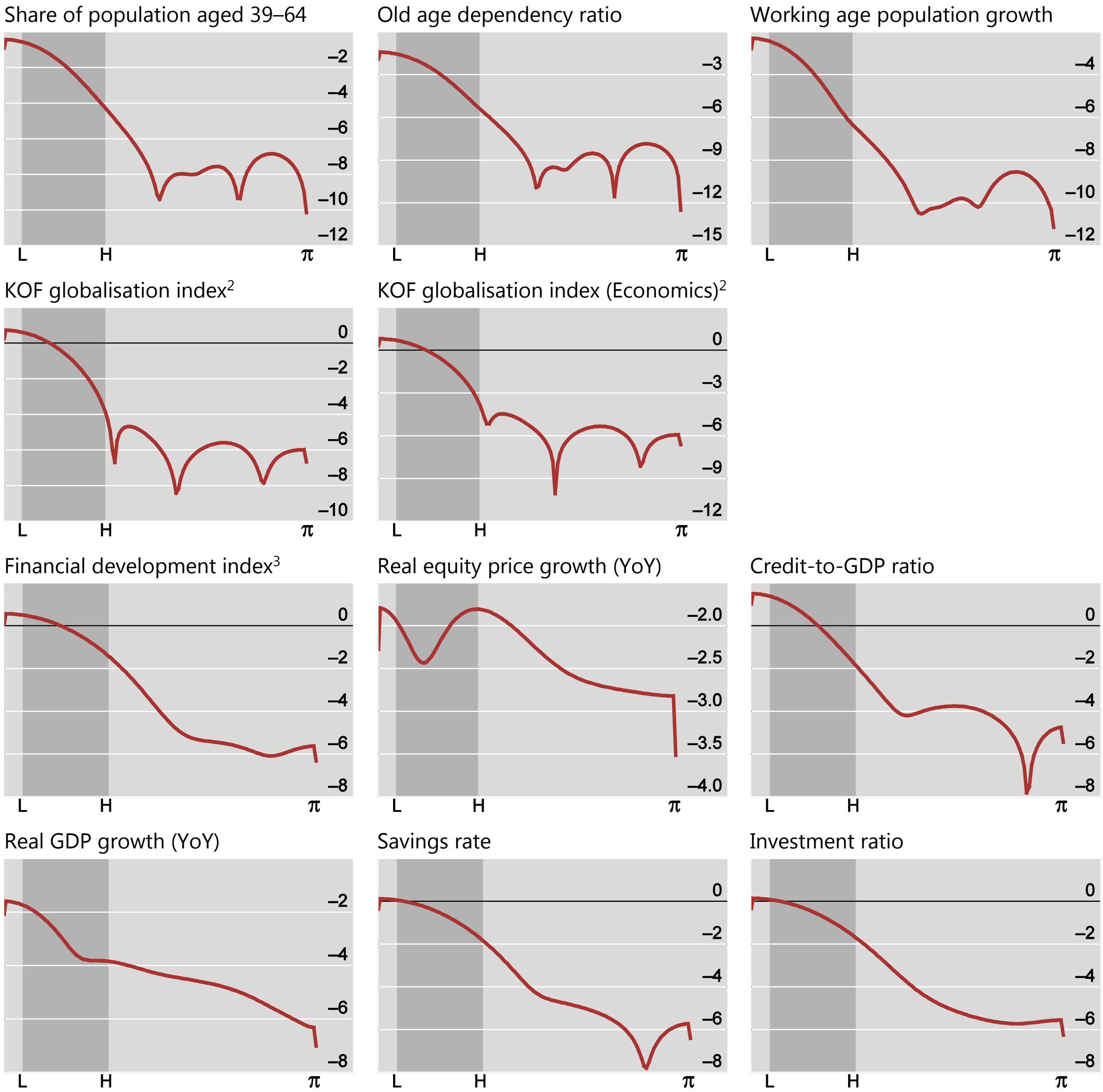
[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: Malaysia[1]

In logarithm, with real interest rate

Graph B.3.7.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

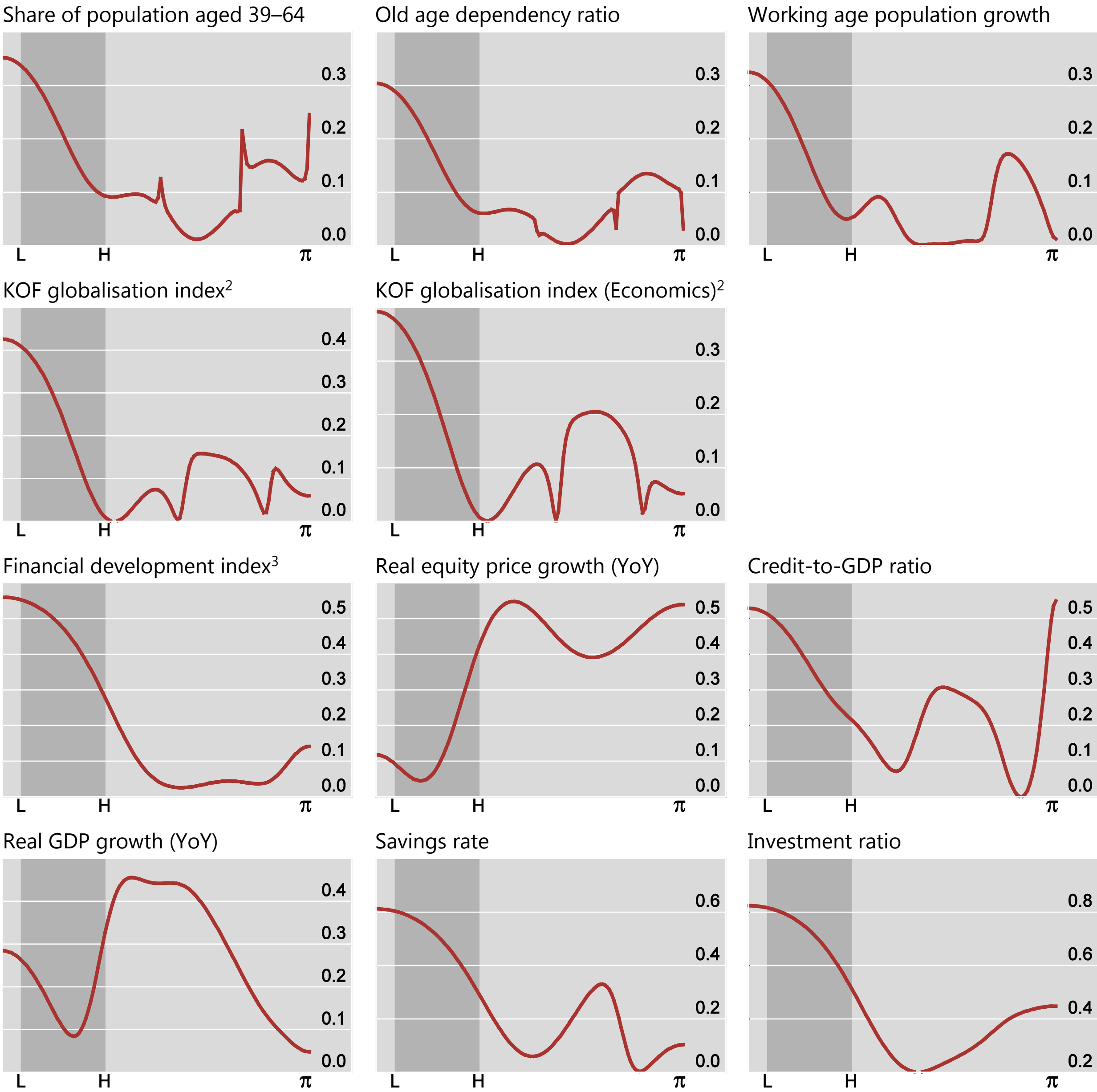
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: Malaysia[1]

With real interest rate

Graph B.3.7.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

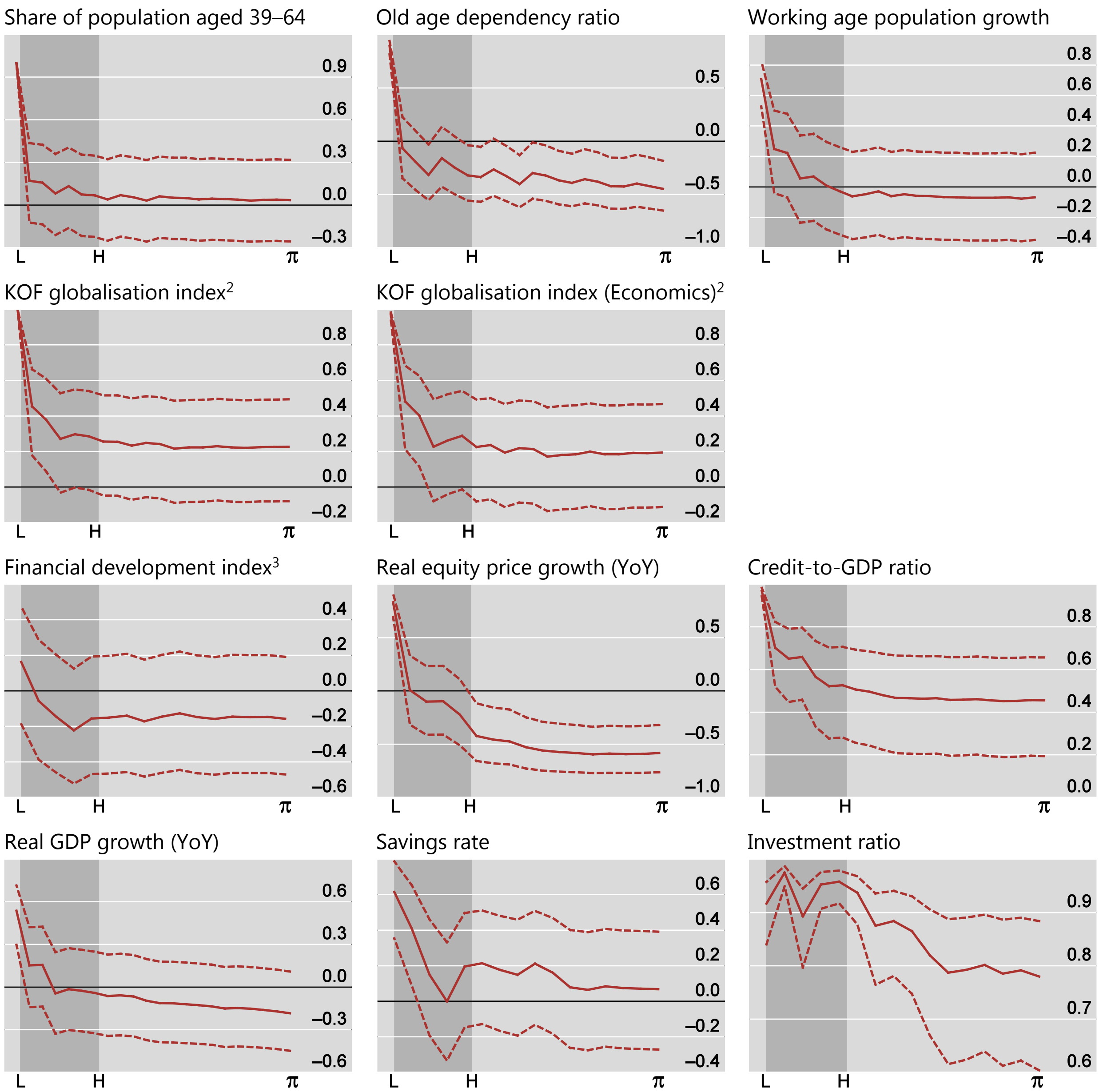
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: Malaysia[1]

With real interest rate

Graph B.3.7.4



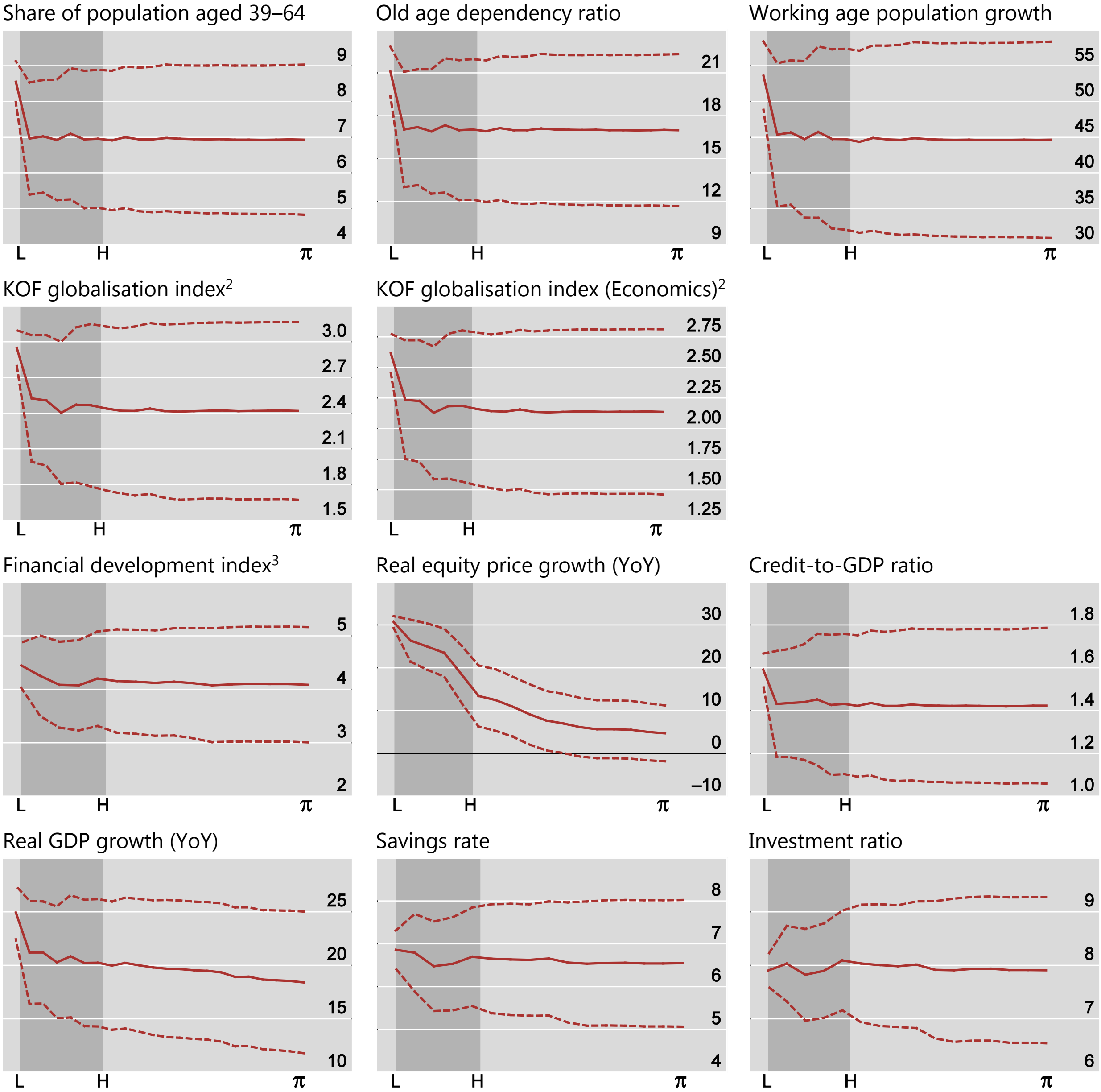
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: Malaysia[1]

Real interest rate as regressand — Graph B.3.7.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

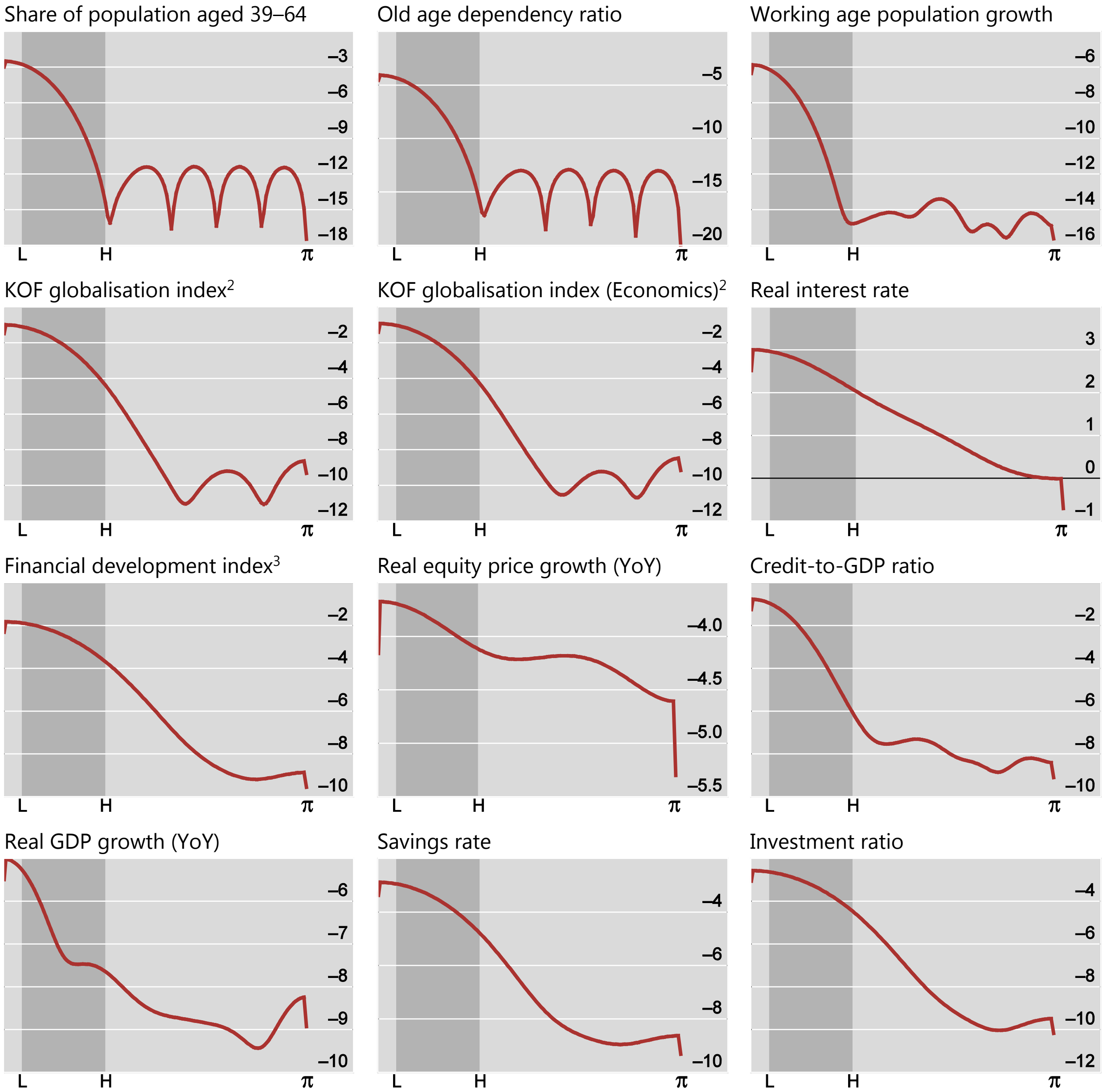
[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

B.3.8. The Philippines

Spectral density estimates: Philippines[1]

In logarithm | Graph B.3.8.1



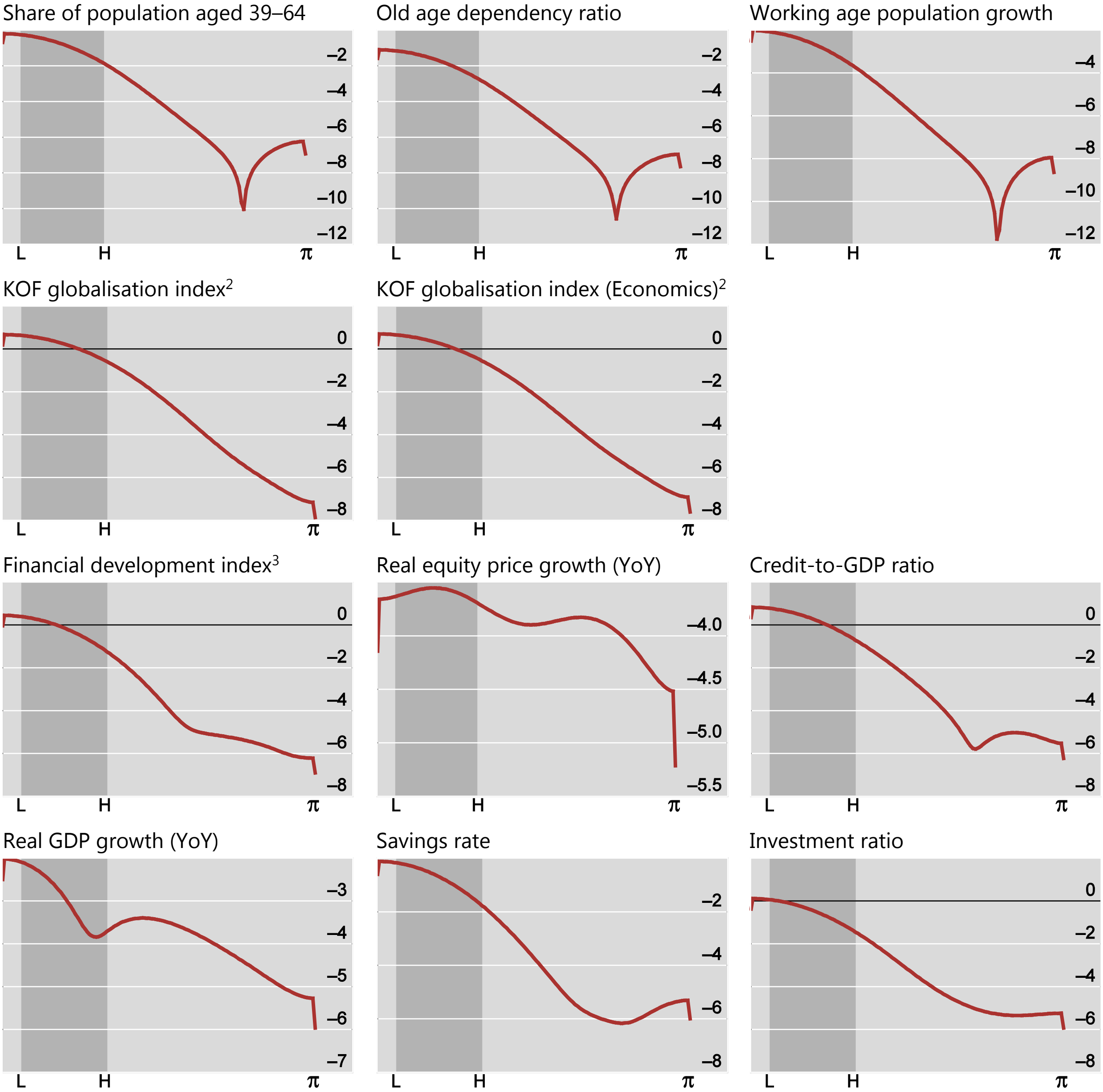
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: Philippines[1]

In logarithm, with real interest rate | Graph B.3.8.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

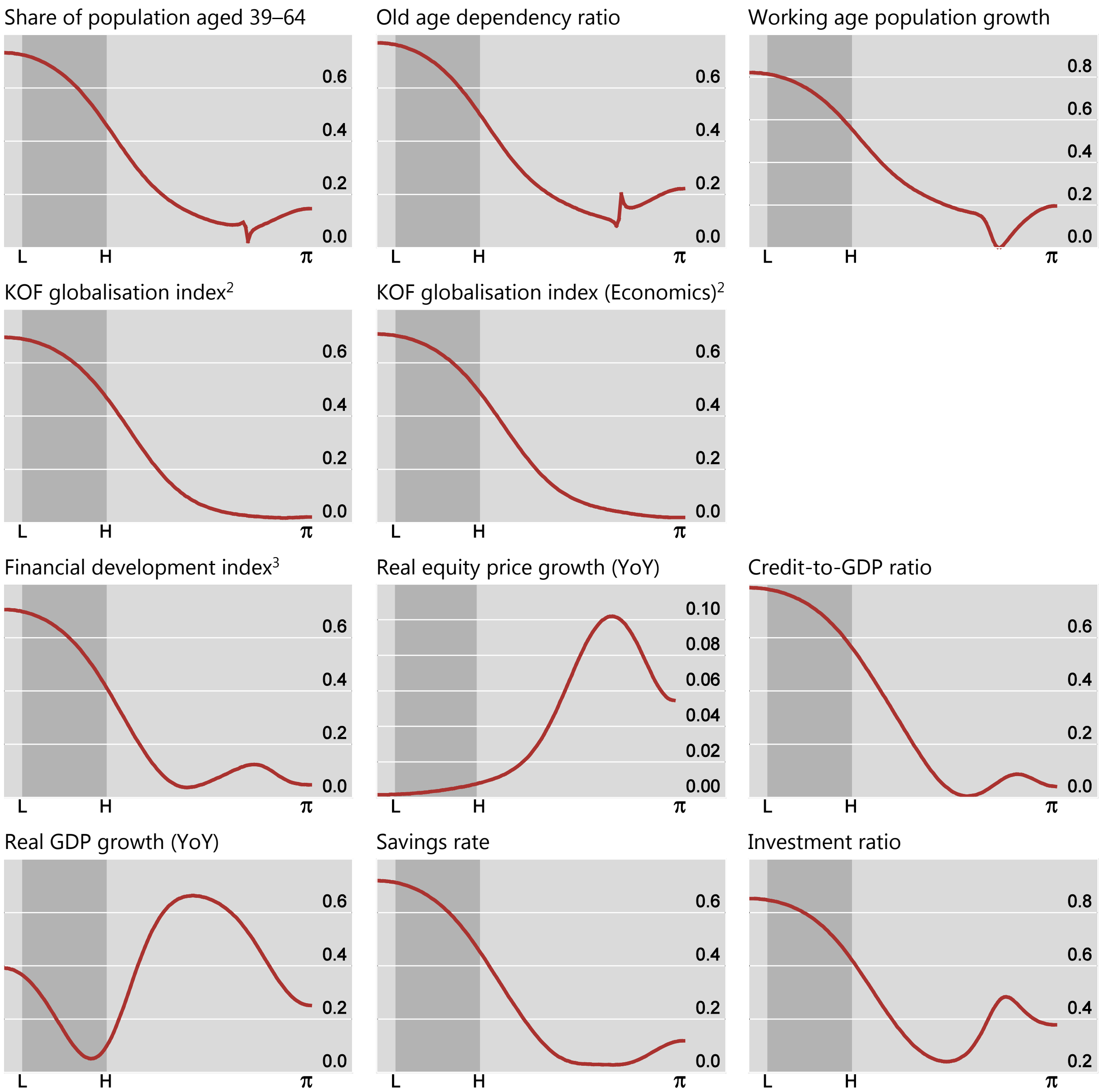
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: Philippines[1]

With real interest rate

Graph B.3.8.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

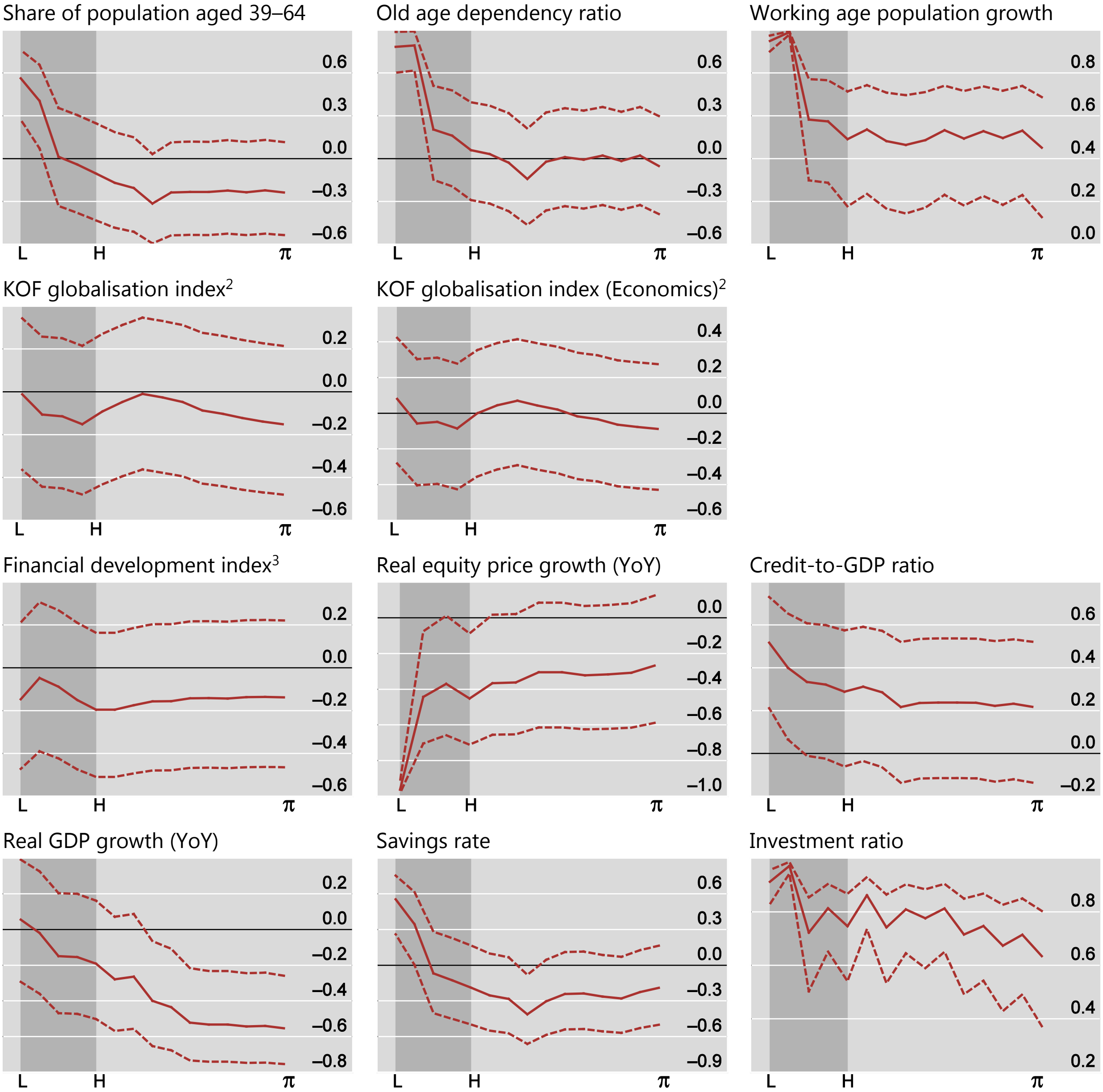
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: Philippines[1]

With real interest rate

Graph B.3.8.4



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

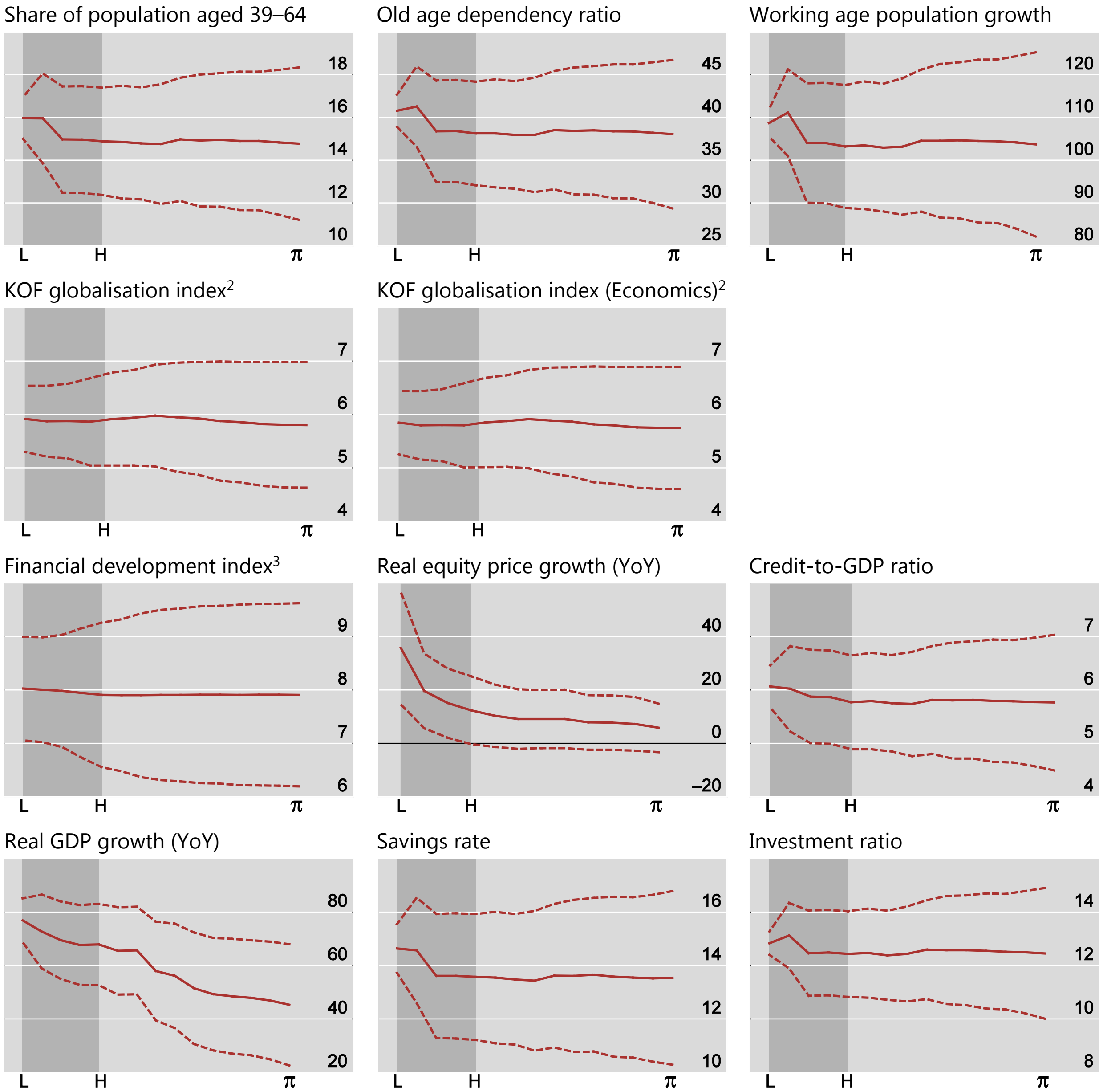
[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: Philippines[1]

Real interest rate as regressand

Graph B.3.8.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

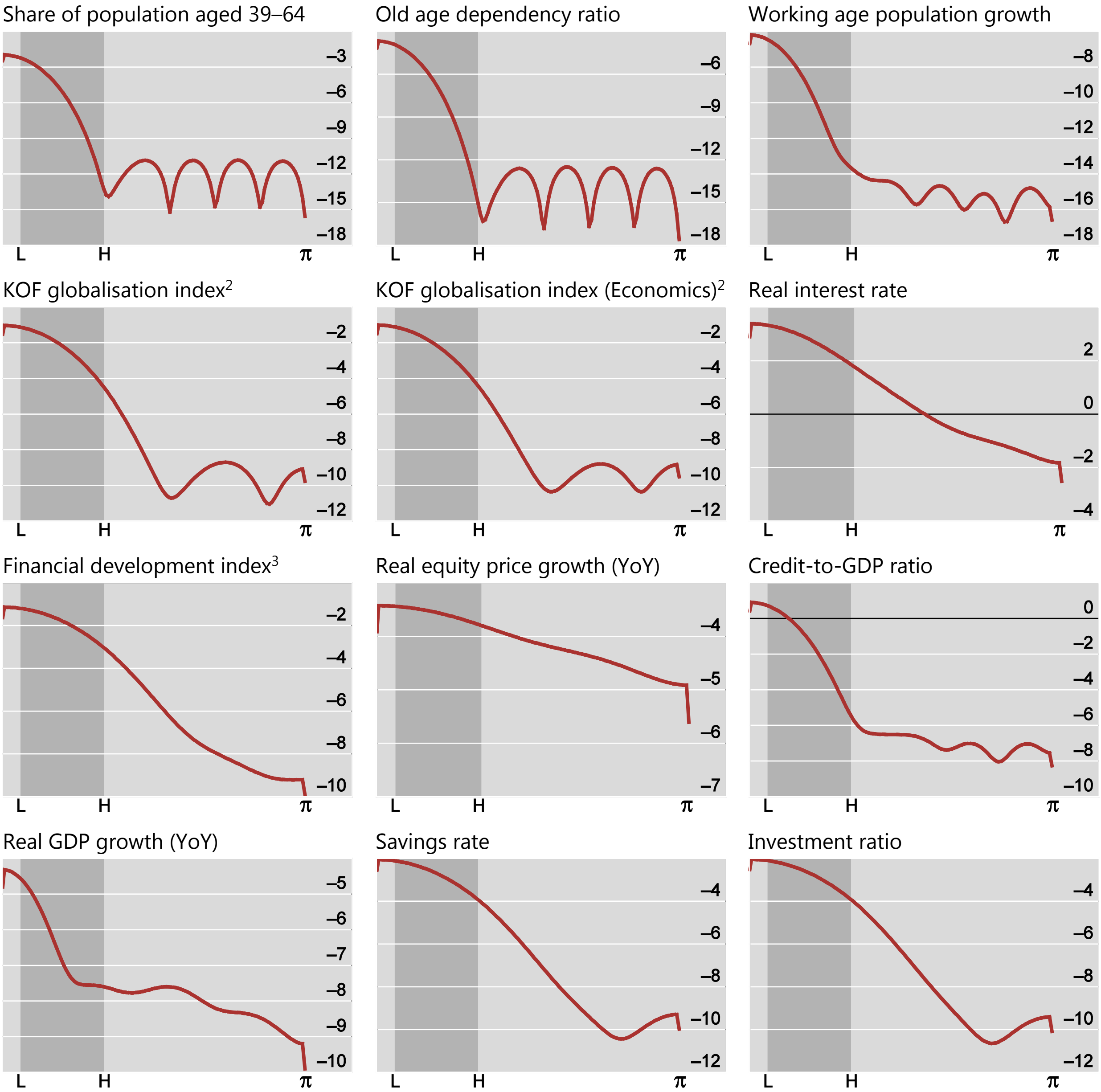
Source: Author’s calculations.

B.3.9. Thailand

Spectral density estimates: Thailand[1]

In logarithm

Graph B.3.9.1



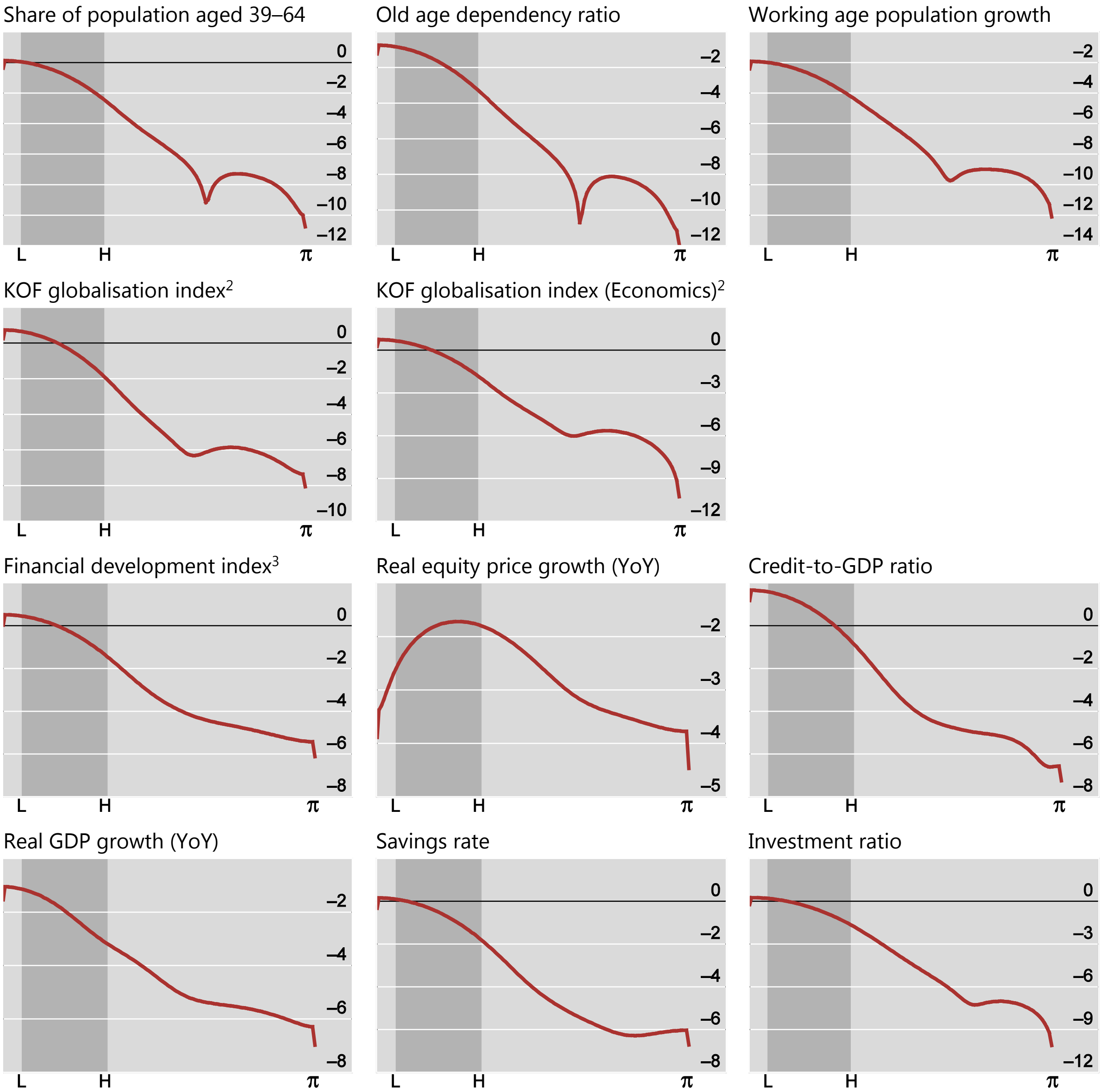
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: Thailand[1]

In logarithm, with real interest rate | Graph B.3.9.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

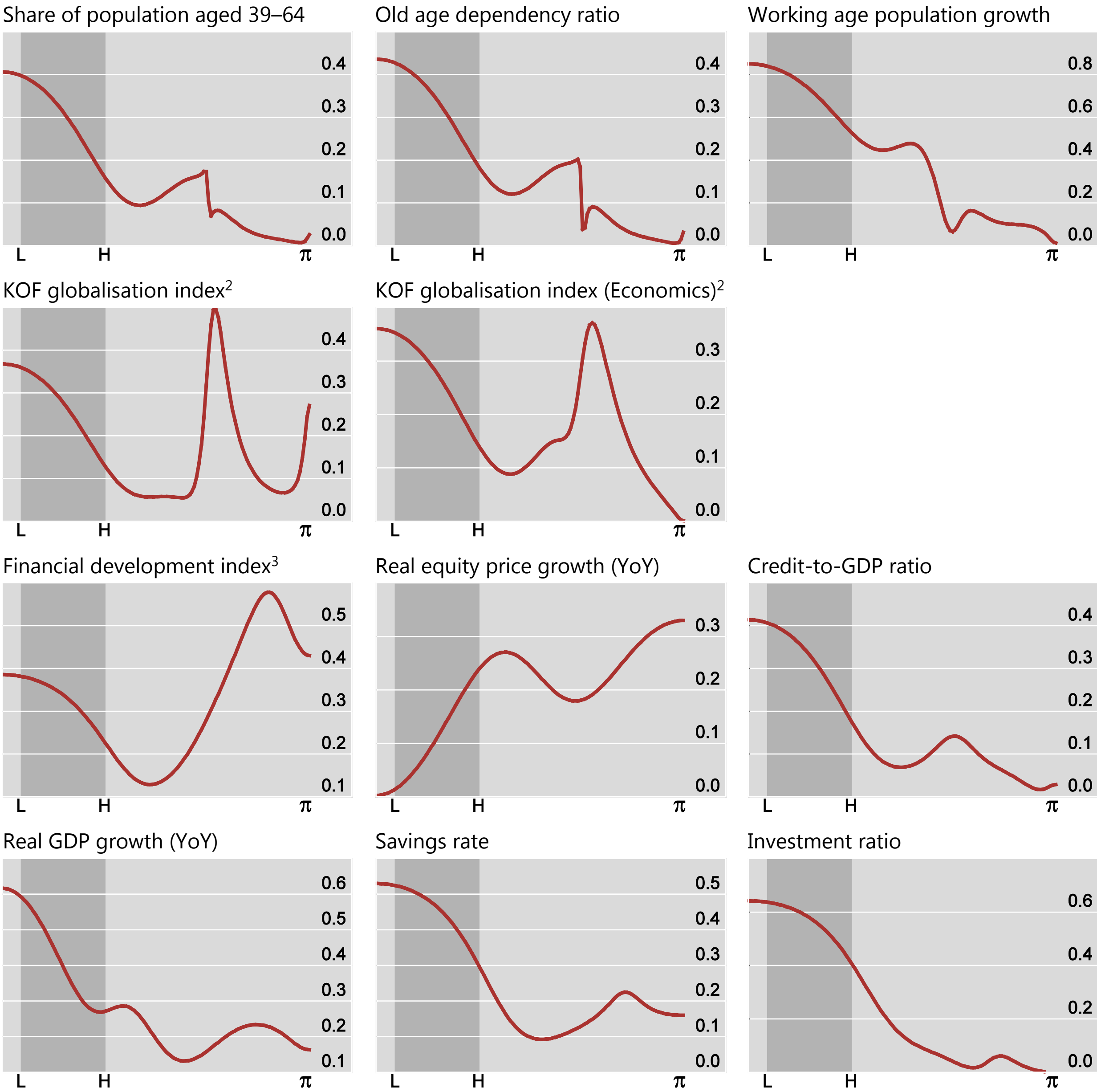
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: Thailand[1]

With real interest rate

Graph B.3.9.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

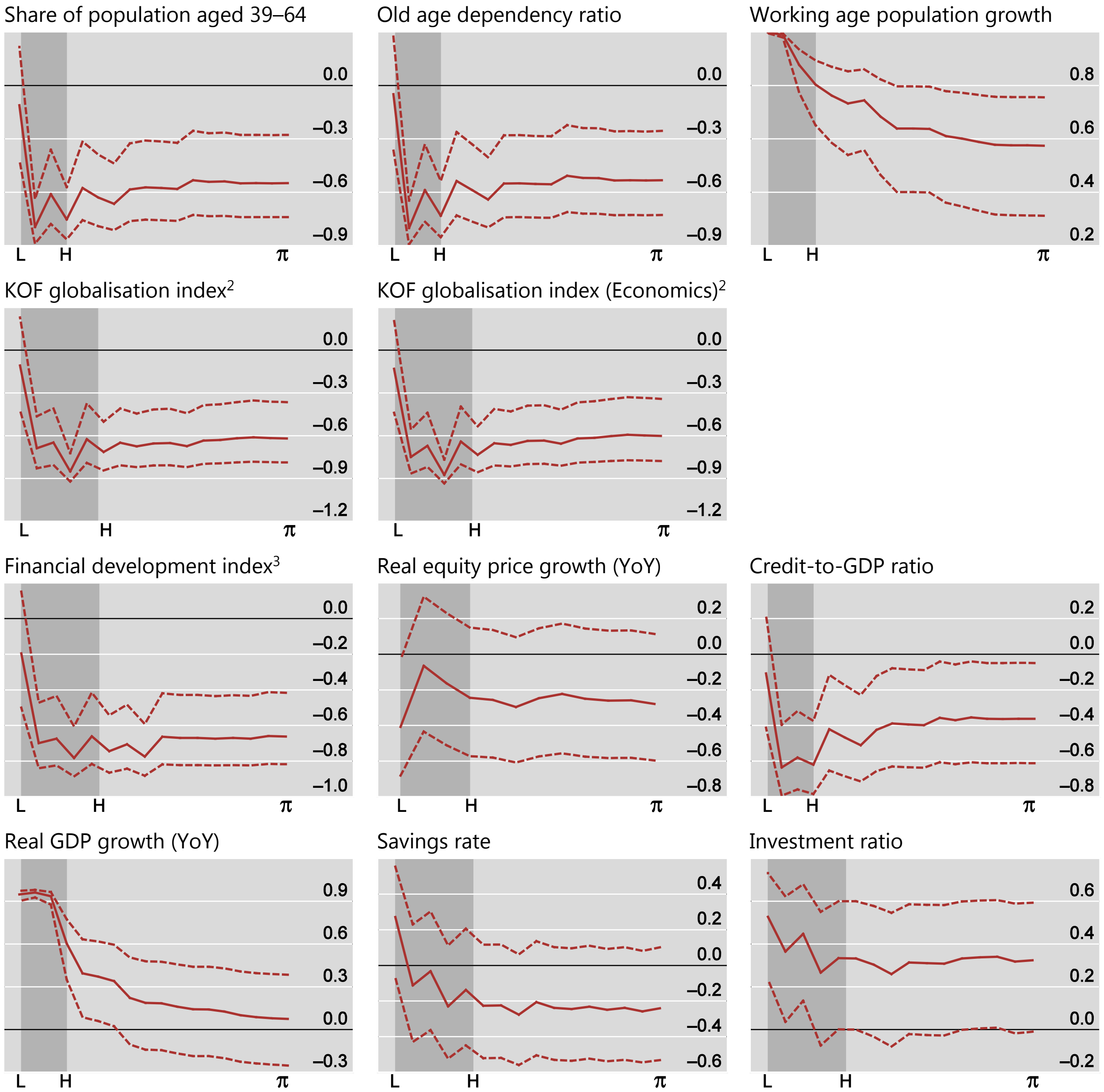
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: Thailand[1]

With real interest rate

Graph B.3.9.4



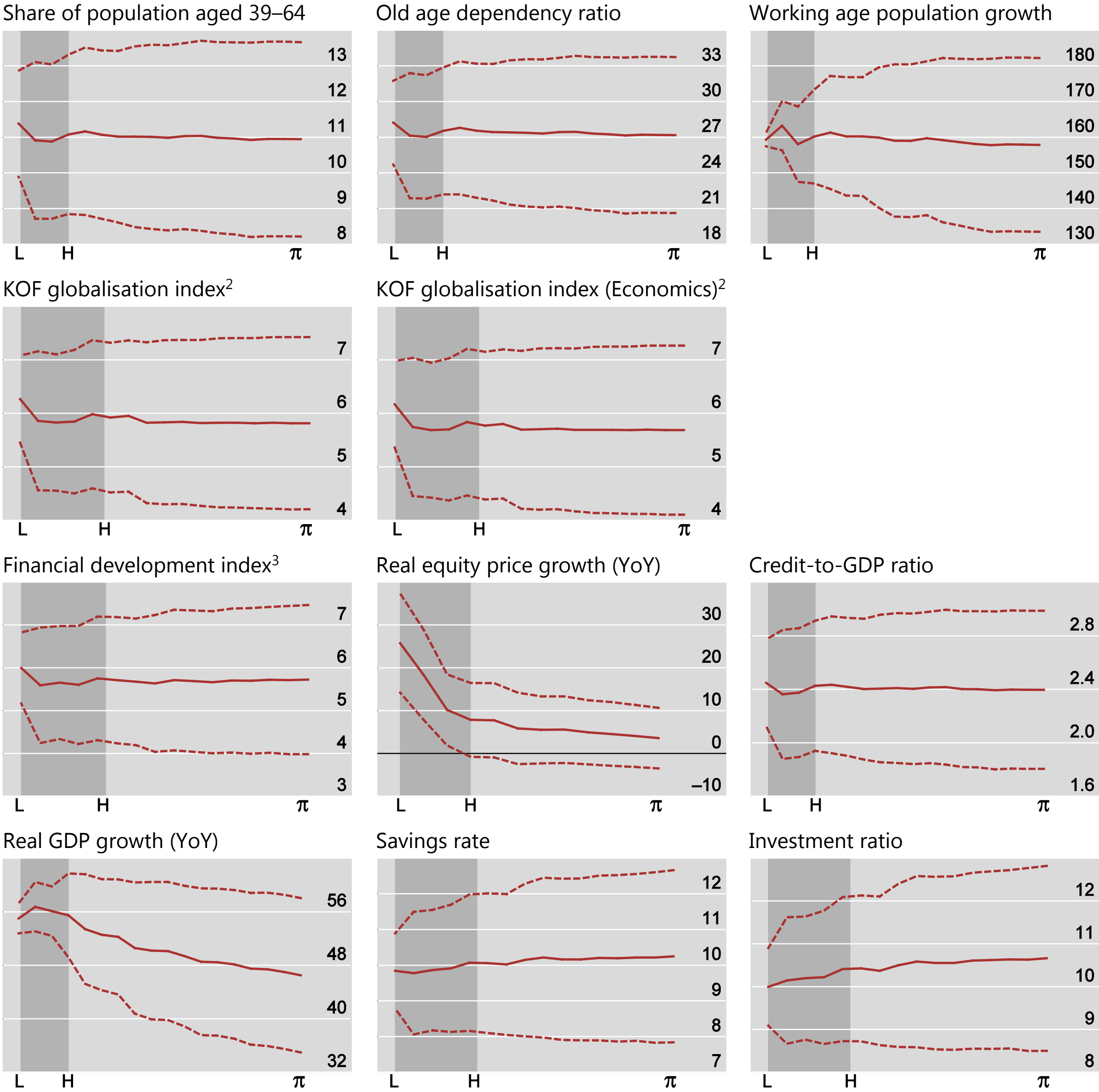
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: Thailand[1]

Real interest rate as regressand | Graph B.3.9.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

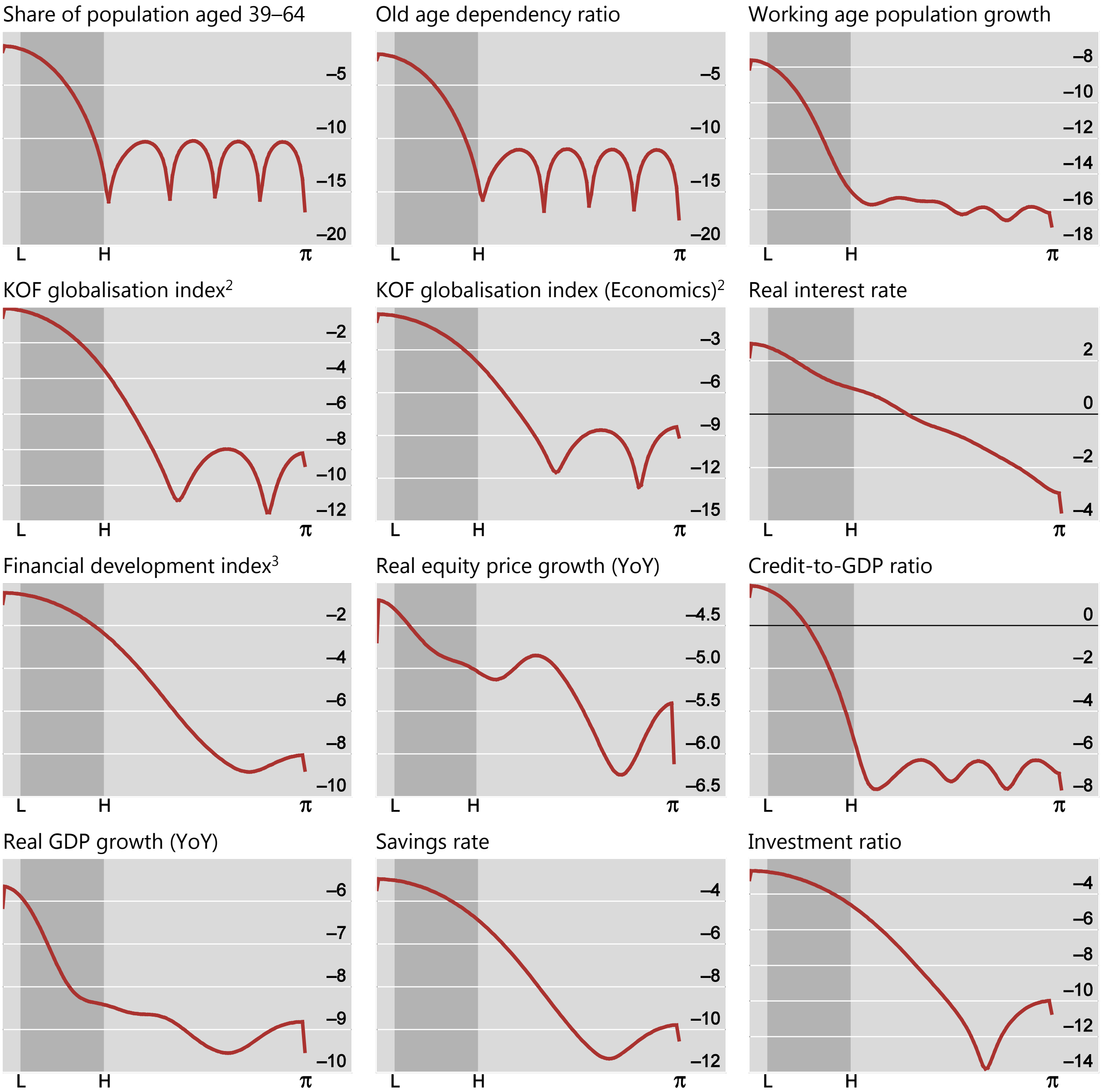
[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

B.3.10. United States

Spectral density estimates: United States[1]

In logarithm | Graph B.3.10.1



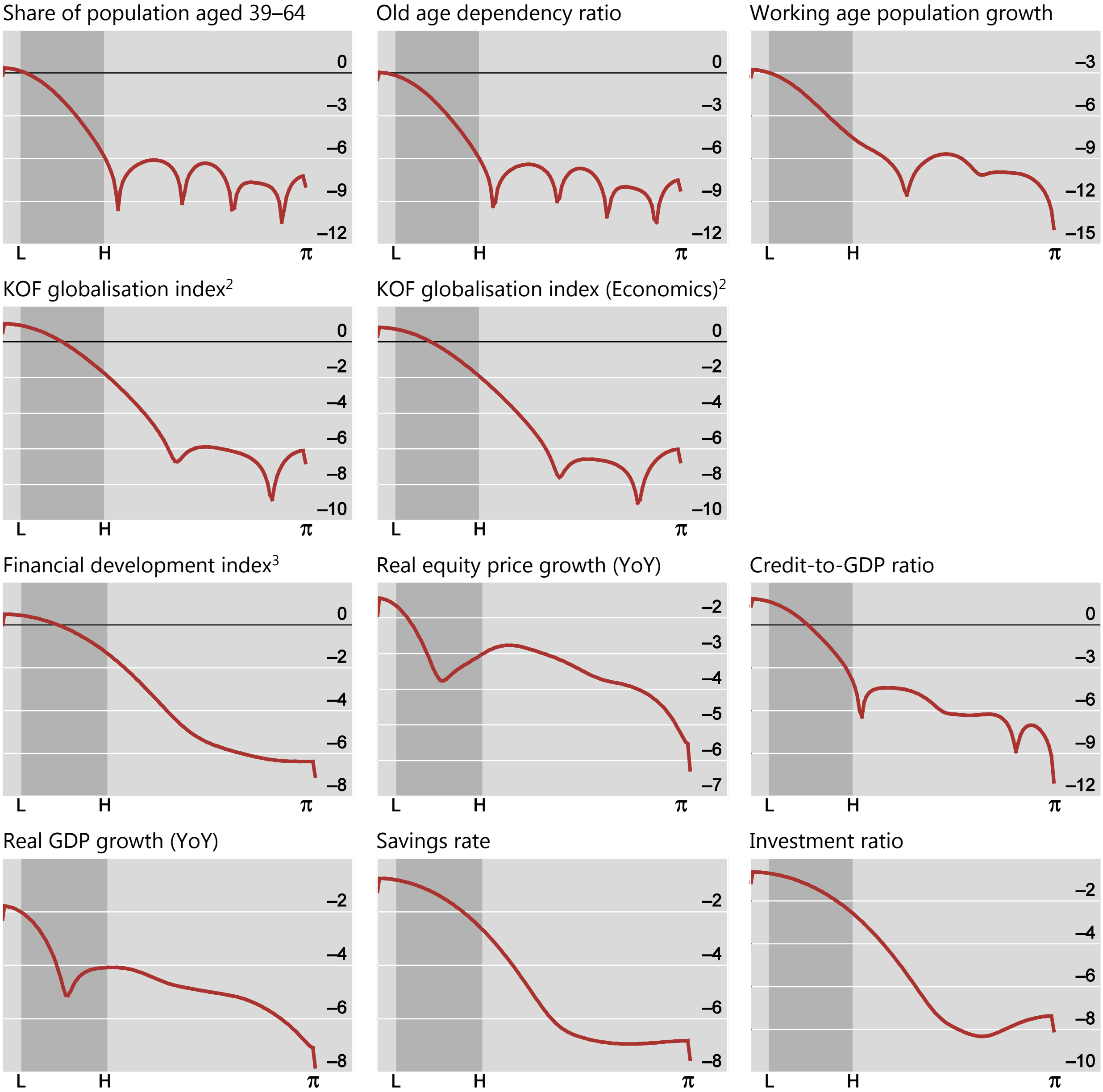
Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] Spectral density, or power spectrum, is estimated using Welch's method. It records the contribution of the component(s) belonging to a specific frequency or frequency band to the total variance of a stochastic process. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Cospectral density estimates: United States[1]

In logarithm, with real interest rate | Graph B.3.10.2



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

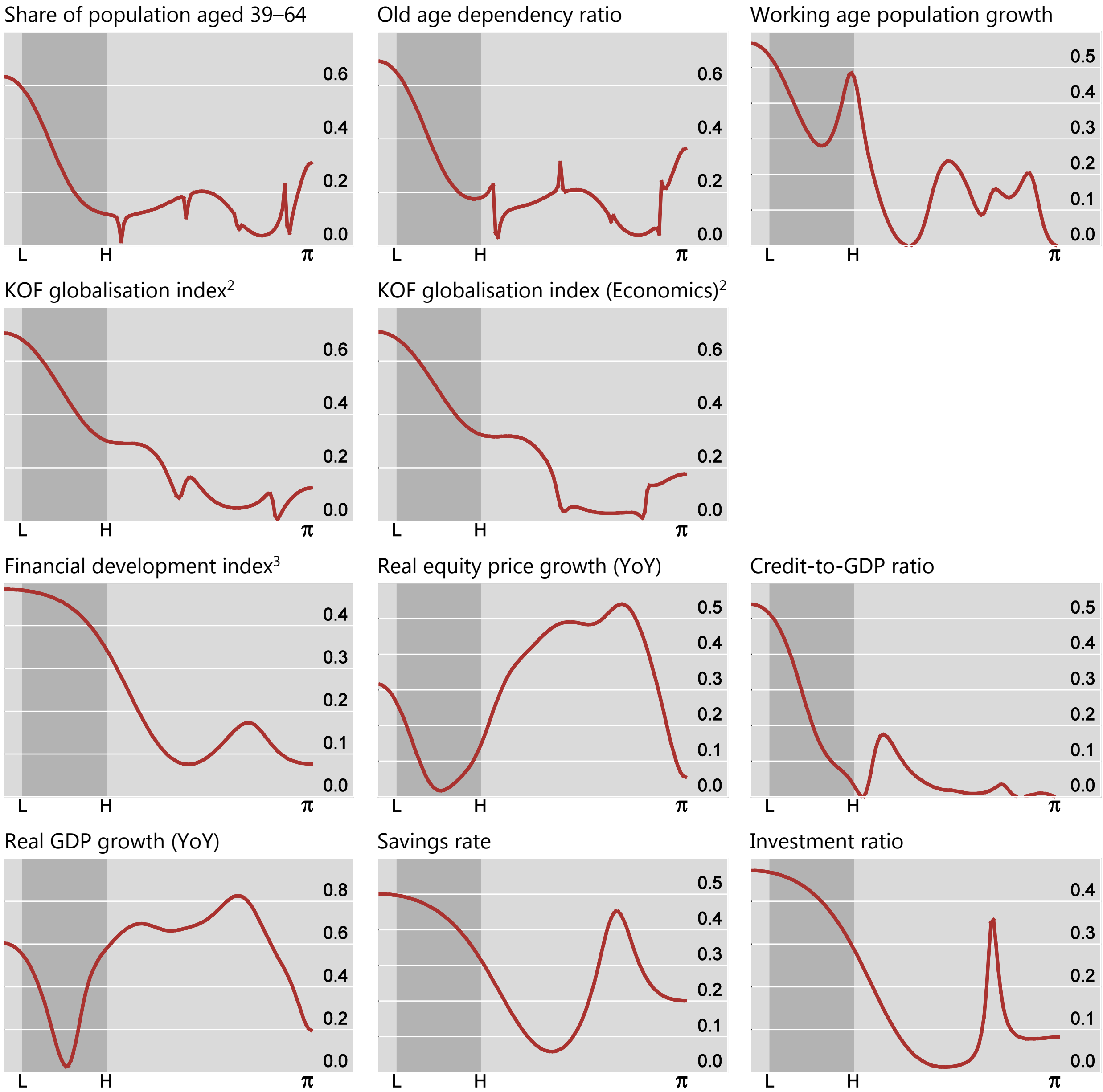
[1] Cospectral density, also known as cross power spectral density or cospectrum, is estimated using Welch's averaged, modified periodogram method. It represents the covariance between the in-phase components of two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Squared coherence estimates: United States[1]

With real interest rate

Graph B.3.10.3



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

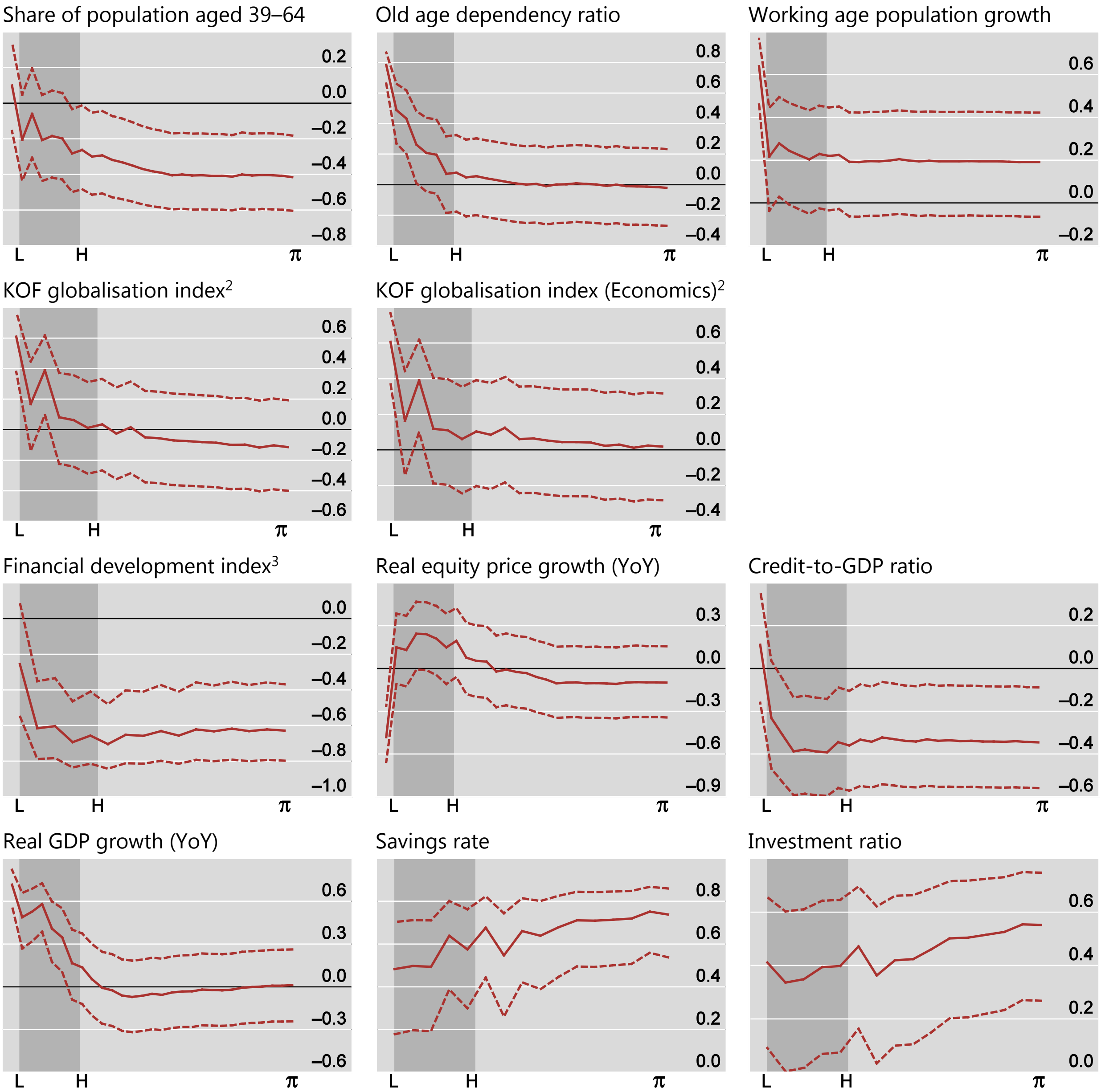
[1] Squared coherence, known as coherency, is estimated using Welch's averaged periodogram method. It is similar to the coefficient of determination R^2, and measures the strength of linear association between two stochastic processes at a specific frequency or frequency band. [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific correlation coefficient estimates: United States[1]

With real interest rate

Graph B.3.10.4



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

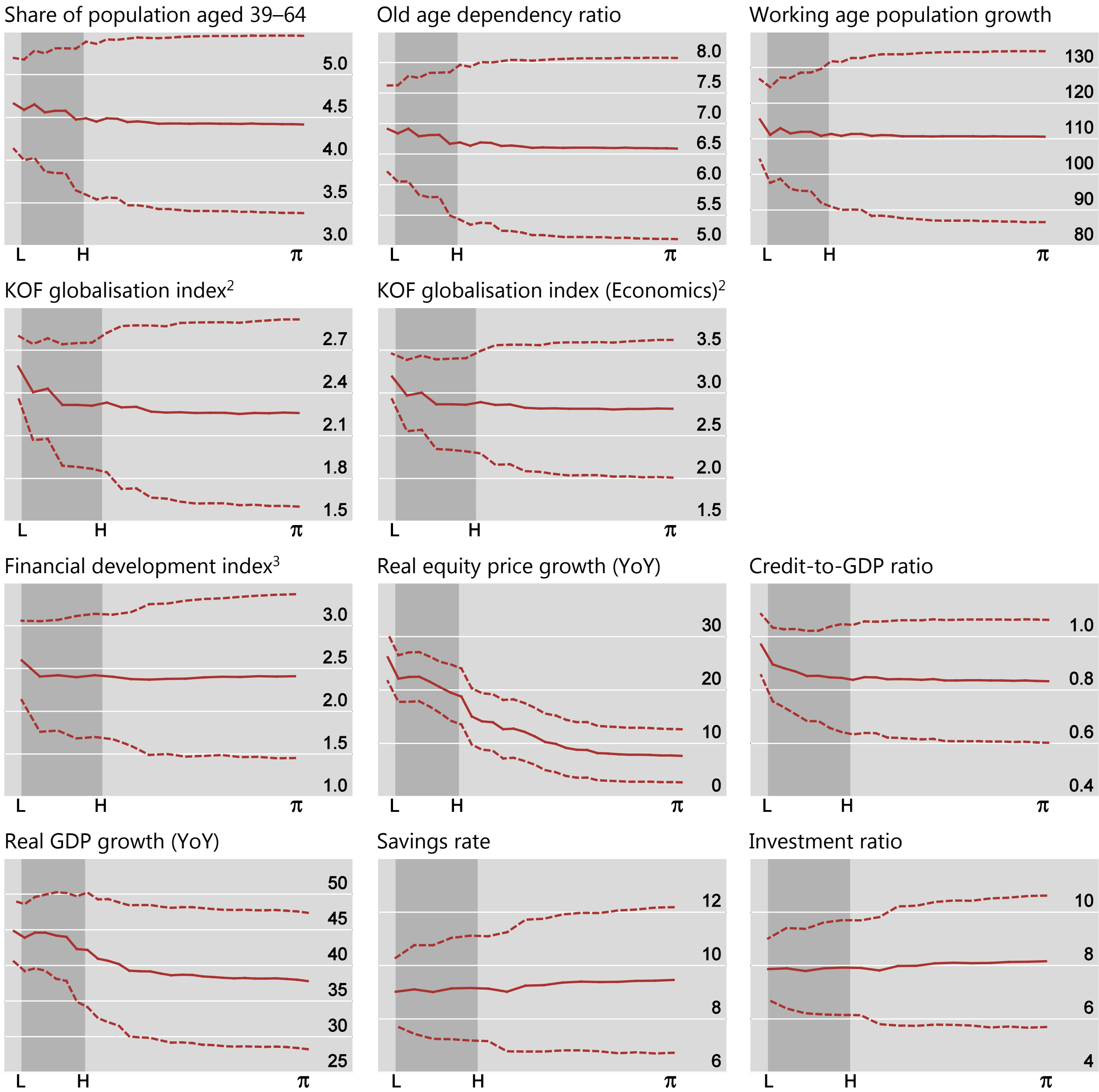
[1] The frequency-specific coefficient of correlation measures the strength of correlation between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Frequency-specific regression coefficient estimates: United States[1]

Real interest rate as regressand

Graph B.3.10.5



Horizontal axis indicates frequency ranging from 0 to π; vertical axis indicates spectral density. The dashed lines indicate 95% confidence intervals. The shaded area indicates the business-cycle frequency, ranging from six quarters (marked by "H") to 32 quarters (marked by "L"). The area between 0 and L corresponds to the low-frequency range which contains the trend component.

[1] The frequency-specific coefficient of regression indicates the degree of linear association between two stochastic processes at a specific frequency or frequency band. See Zhu (2005). [2] The overall KOF Index of Globalisation covers the economic, social and political dimensions of globalisation. For details of the Index and the Economics sub-index, see Dreher (2006) and Dreher, Gaston and Martens (2008). [3] For details of the financial development index, see Sahay et al (2015).

Source: Author's calculations.

Annex C: Data descriptions

This annex provides a detailed description of data used in this paper.

Macro-economy

Table C.1

Variable	Description	Source	Notes
Real GDP	Level in billions of local currencies; year-on-year growth.	IMF IFS, OECD, GFD, national data, BIS.	Different base years in different countries
GDP deflator		IMF IFS, OECD, GFD, national data, BIS.	Rebased with 2005=100.
Consumer price index (CPI)		CEIC, GFD, Datastream, national data.	
Inflation forecasts	current and next year; 6-to-10-year ahead	Consensus Economics ©; BIS calculations	
Savings	Gross national saving.	IMF WEO.	In billions of local currency.
Savings rate	Gross national savings as a percentage of GDP.	IMF WEO.	
Investment	Gross fixed capital formation.	IMF WEO.	In billions of local currency.
Investment ratio	Ratio of nominal investment to nominal GDP.	IMF WEO, BIS calculations.	
Unemployment rate		IMF WEO, OECD, CEIC, Datastream, GFD, national data.	Quarterly data not available for India and Indonesia; annual data available for India.
Employment		Eurostat, IMF IFS, IMF WEO.	in thousands; Quarterly data not available for China and India; annual data not available for India.
Oil price	Crude oil price for spot Brent.	Datastream.	In USD

Financial sector

Table C.2

Variable	Description	Source	Notes
Nominal total credit	Total credit to private non-financial sector.	National data, BIS.	In billions of local currency. Data not available for New Zealand and the Philippines.
Nominal bank credit	Bank credit to private non-financial sector.	National data, BIS.	In billions of local currency.
Domestic credit to GDP ratio	Domestic credit as a percentage of GDP.	World Bank.	
Equity price index		Bloomberg, CEIC, BIS calculations.	
Housing price index		National data.	Rebased with 2010=100
Interest rate	Overnight interest rates.	Bloomberg, Datastream, GFD.	
China's interest rate	Average of overnight, 1-week repo, three-month time deposit, six-month lending and one-year lending rates.	Datastream.	
Three-month government bill rate		Bloomberg, GFD.	Data are not available for Indonesia.
10-year government bond yield		Datastream, GFD.	

Demographics

Table C.3

Variable	Description	Source	Notes
Working age population	Population aged 15–64.	United Nations.	In thousands.
Total population		United Nations.	In thousands.
Ratio of population aged 39–64	Ratio of population aged 39–64 to total population.	United Nations, BIS calculations.	
Ratio of population aged over 64	Ratio of population aged over 64 to total population.	United Nations, BIS calculations.	
Total dependency ratio	Ratio of population aged below 20 and over 64 to population aged 20–64.	United Nations.	
Old-age dependency ratio	Ratio of population aged over 64 to population aged 20–64.	United Nations.	
Birth rate		World Bank.	Per 1000 people.
Life expectancy		World Bank.	In years.

Global economy and external sector

Table C.4

Variable	Description	Source	Notes
Global official liquidity	Total assets of central banks in advanced economies and foreign reserves of emerging economies. [1]	IMF IFS, Datastream, national data, BIS calculations.	In trillions of USD
M3-to-GDP ratio	Weighted averages.	IMF IFS, IMF WEO, Datastream, national data.	Based on rolling GDP and PPP exchange rates.
World interest rate	Weighted (by real GDP) and unweighted world real interest rate.	King and Low (2014).	
Nominal effective exchange rate		BIS.	Index 2010=100.
Real effective exchange rate		BIS.	Index 2010=100.
Globalisation index (Overall)	KOF globalisation index (Overall).	ETH Zurich; Dreher (2006).	Data not available for Hong Kong.
Globalisation index (economics)	KOF Index of Globalisation (Sub-index of economics).	ETH Zurich; Dreher (2006).	
Financial development index		Sahay et al (2015)	

[1] Advanced economies include Canada, Denmark, euro area, Japan, Sweden, Switzerland, Australia and Denmark. Emerging market economies include Brazil, Chile, China, the Czech Republic, Hungary, India, Indonesia, Korea, Mexico, Poland, Russia, South Africa and Turkey.

Comments on "A spectral perspective on natural interest rates in Asia-Pacific: changes and possible drivers"

Solikin M Juhro[1]

The paper by Feng Zhu is a coherent and timely overview of the major policy concerns on the "new neutral" lower equilibrium real interest rates, also known as the natural or neutral interest rate, following a world of "new normal" lower trend growth after the Global Financial Crisis of 2008–09 (GFC). The paper utilises an empirical (statistical) approach to estimate equilibrium real interest rates in Asia-Pacific and their relationship to population characteristics, globalisation, financial variables, and the long-run components of real GDP growth.

The paper provides a lucid overview of several competing theories behind the decline in equilibrium real interest rates and proposes a hypothetical question regarding the relevance of the arguments to Asia-Pacific economies. As has been discussed, the real interest rate is simply a benchmark for measuring the monetary policy stance. Therefore, to use monetary policy rules such as the Taylor rule (Taylor (1993)), a feasible estimate of the equilibrium of real interest rates is required. As there have been, hitherto, very few attempts to estimate and assess the equilibrium real interest rates of emerging economies, and even fewer for emerging Asia, the paper attempts to fill the gap by providing a number of simple estimates and in doing so to shed light on the evolution of equilibrium real interest rates in a number of Asia-Pacific economies.

The paper also elaborates a relevant assessment and its implication for monetary policy implementation across Asia-Pacific countries. In the same spirit as several previous studies (Laubach and Williams (2003); Clark and Kozicki (2005); Canzoneri et al (2013), Hamilton et al (2015)), the paper shows that, in general, the estimates of the equilibrium interest rates in Asia-Pacific vary substantially over time and across economies and further perceives a sizeable degree of imprecision and uncertainty. It simply suggests that the use of the natural rate framework to implement monetary policy poses numerous risks.

Feng Zhu conducts robust empirical exercises and shows that the ageing population, global financial integration, financial sector developments and lower GDP growth potential could potentially lower the equilibrium real interest rate in Asia-Pacific in general. While Feng Zhu humbly concedes one important caveat about the estimates of equilibrium real interest rates, that they are estimated filtered trends rather than true equilibrium values, my discussion will touch more upon the bigger-picture central bank policy issues, rather than the technical aspects of the paper.

1 Bank Indonesia.

To what does "equilibrium" refer?

The first issue that needs to be considered is: to what does "equilibrium" refer? Does equilibrium relate to internal balances, or does it also relate to external balances? Standard theory suggests that it is the rate consistent with full employment and aggregate price stability. The literature that deals with the measurement of equilibrium real interest rates (for example, refer to Laubach and Williams (2003)) has used closed economy models, with large open economies treated as closed economies, and has not addressed the open economy case. Clarida (2009) also pointed out that the neutral equilibrium real interest rate for an open economy could not be defined, modelled or proxied without reference to an explicit global framework.

However, empirical facts from the past decade and lessons of the GFC show that the challenges of future monetary policy, especially in the case of a small open economy that poses structural weaknesses (ie lack of financial deepening), will be more complex. Hence, macroeconomic stability still faces both global and domestic challenges, involving a trade-off between internal and external stabilisation objectives (ie lowering the interest rate to maintain economic growth vs. holding the interest rate to address external vulnerabilities). Amidst widespread global uncertainty, monetary policy should also pay attention to external stability. In this case, lowering the policy rate would likely weaken the domestic currency and exacerbate external vulnerabilities for corporations indebted in foreign currencies and could amplify the impact of external shocks.

Therefore, from a central bank policy perspective, we have to continuously strengthen policy communication in order to manage market confidence and seek an appropriate time to change (shift) the policy stance, as addressing external vulnerabilities also plays a key role in maintaining leeway for monetary policy to pursue macroeconomic stabilisation objectives. Based on these considerations, the question is whether the equilibrium real interest rate that is consistent with internal balances can guarantee accomplishment of the external balance, so that we as central bankers should follow the rate.

A new normal and the implication of the inflation-output nexus

Another issue relates to the monetary policy implication of a change in the behaviour of the inflation-output nexus, namely a flatter Phillips curve, in many emerging economies. Amidst the tendency of the global economy to move towards a lower new normal in the long run, a flatter Phillips curve phenomenon may imply that inflation is less responsive to domestic demand. Rather, it is comparatively affected more by a supply response, such as a temporary cost-push shock related to the exchange rate, commodity price movements or weather anomalies (Bayoumi (2014)). A flatter Phillips curve could imply a lower equilibrium real interest rate. However, as demand management is less effective, the implication of a lower equilibrium real interest rate for monetary policy should be scrutinised. In that regard, policy coordination between the central bank and the government to cope with structural issues is sufficient.

In the case of Indonesia, for instance, an estimation of the NKPC reveals interesting findings on the role of output (Juhro (2015)). While the role of output in determining inflation increased in the early stage of ITF (especially during the GFC), it has subsequently declined in the post-GFC period. Another factor contributing to the flattening of the Phillips curve is also worth noting, namely policy credibility garnered by Bank Indonesia in terms of controlling inflation. One noteworthy point is the success of policy coordination between Bank Indonesia and the government in terms of controlling inflation, especially from the supply side, over the past decade.

Global financial integration and the role of the exchange rate

Feng Zhu, in line with Blanchard and Summers (1984), Barro and Sala-i-Martin (1990), and Bosworth (2014), shows that one potential driver of the decline in equilibrium real interest rates is global economic (trade and financial) integration. By eliminating the barriers to cross-border trade and financial transactions, a country has more space to secure its growth potential and reduce the equilibrium real interest rate. Globalisation, however, including financial integration, has also led to the emergence of an economy's risk exposure in line with the volatility that has beset global financial markets. As one may see, with a domestic financial system that is becoming increasingly integrated with the global financial market, an economy is potentially vulnerable to global volatility, which can put pressure on the exchange rate as well as on inflation as the monetary policy target.

The next question is: how do we incorporate the role of exchange rates in monetary policy formulation?

The prevailing view expressed in the literature on ITF generally suggests that the exchange rate plays only a limited role in the implementation of monetary policy strategy . The arguments are implicitly based on assumptions regarding the role of the exchange rate as an economic shock absorber. However, with the long-run tendency of the global economy to move towards a new normal, it can be construed that the assumption based on the limited role the exchange rate plays in monetary policy strategy is somewhat weak. As such, more volatile short-term capital flows in a more integrated financial system, coupled with a dominant foreign debt structure, have indicated the growing contribution of nominal shocks to shifts in the exchange rate. Concomitantly, high inflation further weakens the role the exchange rate plays as a shock absorber.

What does this imply for monetary policy formulation? While we have recognised that the real interest rate is simply a benchmark for measuring the monetary policy stance, we may ask how to measure the role of the exchange rate using the Taylor rule principle. This slight bending of the rule takes on an interesting format since it takes into account the flexibility of the exchange rate's role. Although doubt may emerge when using such a format, which is considered inconsistent with the basic substance of ITF, several empirical observations of economies characterised by large exchange rate pass-through as well as relatively high and unstable inflation accords merit to this rule-bending (Edwards (2006)). Taking such a standpoint, Bask (2006) also concluded that, technically, for small open economies the addition of an exchange rate variable in the Taylor rule design offers the possibility of achieving system stability, providing that the data used are contemporaneous.

At a more tactical level, it is interesting to explore the nexus between interest rates and the exchange rate and its implication for the equilibrium real interest rate. Several emerging countries indicate that policy orientation in the midst of high global uncertainty is tactically directed not only towards controlling inflation but also at managing the exchange rate through active and measurable intervention on the foreign exchange market. Most recent assessments also provide empirical evidence that there is a tendency for monetary policy strategy to move away from that which is hypothesised by the monetary policy trilemma. Therefore, central banks have choices when maintaining the balance between interest rates and exchange rate management, since it is not only the interest rate that responds to external dynamics; a portion is absorbed by the exchange rate.

Post-GFC monetary policy strategy and the policy instrument mix

The GFC has challenged the existence of monetary policy strategy. Consistent with Feng Zhu's paper, we agree that there are reasons why financial sector developments, along with sustained changes to regulatory policy, such as those we see in the aftermath of the Global Financial Crisis, may matter for the evolution of the equilibrium real interest rate. Feng Zhu also mentions that concerns with financial stability and the impact of regulatory changes may therefore factor into monetary policy considerations. However, the paper does not have more space to discuss the issue.

In fact, there is a great deal of ambiguity about how actual (tactical) central bank behaviour fits into the theoretical literature on monetary regimes, especially the inflation targeting framework (ITF) that uses the interest rate as a key monetary policy instrument to deliver policy signals and manage inflation expectations. The GFC provided a valuable lesson in that the financial sector plays a pivotal role in macroeconomic stability because of its role in triggering excessive procyclicality. Due to its procyclical nature, the financial sector can potentially escalate macroeconomic instability by developing output fluctuations. When an economy moves through an expansionary phase, characterised by macroeconomic stability and escalating growth, investor confidence raises optimism when assessing the economy. This risk-taking behaviour, initially triggered by monetary policy, will eventually push up credit demand and asset prices. Changes in the financial sector, as reflected by adjustments in financial variables (financial stability), influence aggregate outcomes such as economic growth and employment, which are directly linked to monetary stability. The complexity of the problems accompanying procyclicality in financial sector ultimately takes its toll on the workings of the monetary policy transmission mechanism.

From this standpoint, the more complex the challenges facing an economy, the greater number of policy instruments should be utilised by the authorities (within the policy instrument mix). In this regard, it is not just the interest rate that is expected to drive the level of economic activity, a number of unconventional measures could also possibly influence the level of employment and prices. Therefore, when assessing the equilibrium real interest rate, the coordinated implementation of a policy instrument mix is ultimately part of an important strategy in the current climate blighted by ubiquitous uncertainty. Coordination is critical, not only to address sources of external and internal imbalances, but also to optimally manage the impact of monetary policy, while avoiding overkill and mutual exclusivity. Within that policy perspective, the achievement of macroeconomic stability is tied not only to monetary stability (price stability) but also to financial system stability.

Closing notes

In summary, Feng Zhu has delivered sound research on the equilibrium real interest rate and its implication for monetary policy in Asia-Pacific countries. I fully concur that the use of the natural interest rate framework to implement monetary policy poses many risks, given the numerous uncertainties surrounding natural rates. However, we should not only consider the precision of estimation but we should also seek to understand how different factors in different situations influence the equilibrium real interest rate and why this is important for monetary policy formulation. Here, I see some room for enhancement that should be incorporated in the paper. My suggestion is that the paper could discuss a broader scope of the monetary policy domain, especially in the post-GFC era, such as the trade-off between internal-external balances, the role of the exchange rate as well as risk perception/behaviour that could potentially impact the equilibrium real interest rate lift-off, as in the case of Indonesia, Malaysia, and some other emerging countries. This would provide a more rigorous assessment of the strategic role of interest rate policy and thus the practical relevance of equilibrium real interest rates in monetary policy formulation.

Given the practical usefulness of equilibrium real interest rates, I generally support the arguments proffered by Orphanides and Williams (2002) that recommend against relying excessively on these intrinsically noisy indicators when making monetary policy decisions, and Hamilton et al (2015) who inject more inertia into the monetary policy reaction function. To conclude the discussion on this issue and anchor the theme of the conference, namely "expanding the boundaries of monetary policy", we should put a proper weight on interest rate policy along with other instruments under a credible central bank policy mix strategy. This implies that the equilibrium real interest rate estimation should not statistically stand alone, since the determination of equilibrium real interest rates should be consistent with the macroeconomic balance and the related policy mix response. Consequently, while there is no guarantee that structural estimates would fare better, I would prefer to address the issue using a structural approach.

References

Bayoumi, T, G Dell'Ariccia, K Habermeier, T Mancini-Griffoli, F Valencia, and IMF Staff Team (2014): "Monetary policy in the new normal", *IMF Staff Discussion Note*, April.

Barro, R and X Sala-i-Martin (1990): "World real interest rates", in O Blanchard and S Fischer (eds), *NBER Macroeconomics Annual*, MIT Press.

Bask, M (2006): "Should one augment the Taylor rule with an exchange rate term?", Helsinki Center of Economic Research, *Discussion Papers*, no 135, November.

Blanchard, O and L Summers (1984): "Perspectives on high world real interest rates", *Brookings Papers on Economic Activity*, vol 2.

Bosworth, B (2014): "Interest rates and economic growth: are they related?", *Brookings Institution Working Paper*.

Canzoneri, M, R Cumby and B Diba (2015):, "Monetary policy and the natural rate of interest", *Journal of Money, Credit and Banking*, vol 47, no 2-3.

Clarida, R (2009): "Reflections on monetary policy in the open economy", in J Frankel and C Pissarides (eds), *NBER International Seminar on Macroeconomics 2008*, University of Chicago Press.

Clark, T and S Kozicki (2005): "Estimating equilibrium real interest rates in real time", *North American Journal of Economics and Finance*, vol 16.

Edwards, S (2006): "The relationship between exchange rates and inflation targeting: revisited", *NBER Working Paper*, no 12163.

Hamilton, J, E Harris, J Hatzius and K West (2015): "The equilibrium real funds rate: past, present, and future", University of California at San Diego, working paper.

Juhro, S (2015): "The role of the central bank in promoting sustainable growth: perspectives on the implementation of flexible ITF in Indonesia", *Afro Eurasian Studies*, vol 4, no 1.

Laubach, T and J Williams (2003): "Measuring the natural rate of interest", *Review of Economics and Statistics*, vol 85, no 4.

Orphanides, A. and J. Williams (2002): "Robust monetary policy rules with unknown natural rates", *Brookings Papers on Economic Activity*, vol 2.

Taylor, J (1993): "Discretion versus policy rules in practice", *Carnegie-Rochester Conference Series on Public Policy*, vol 39.

Managing monetary and financial stability in a dynamic global environment: Bank Indonesia's policy perspectives

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Abstract

As the Indonesian economy is becoming progressively more integrated with the global economy, the impact of global economic shocks on the domestic economy is becoming more pronounced. Capital inflows, which trigger excessive liquidity and exacerbate the risk of a sudden reversal, pose a serious threat to the Indonesian economy, especially in terms of financial stability. Recent crisis episodes have indicated that monetary policy alone is insufficient to maintain macroeconomic stability; it should be accompanied by macroprudential policy. This paper explores the dynamics of the external and financial sectors as well as the optimal policy mix in order to maintain monetary and financial stability. We use an enhanced or modified small open-economy New Keynesian model to discuss the operation of a flexible inflation targeting framework (ITF). The simulations show that the model's impulse response functions are in line with theoretical and empirical predictions, in which external shocks have significant impacts on both monetary and financial stability. The simulations also show that the adverse macroeconomic and financial effects of external shocks can be mitigated by a mix of monetary and macroprudential policies.

JEL classification: E17, E52, F47.

Keywords: inflation targeting framework, monetary policy, macroprudential policy, policy instrument mix.

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1. Introduction

The Global Financial Crisis (GFC) of 2008–09 showed that keeping inflation in check is not, by itself, sufficient to preserve macroeconomic stability. Several crisis episodes over the past decade have shown that most macroeconomic instability stems from shocks in the financial sector. Financial markets are inherently prone to excessive procyclicality, which ultimately manifests itself in macroeconomic instability. In addition, risk-taking behaviour among economic agents also strengthens financial accelerator mechanisms.

Amidst global economic shocks and more dynamic capital flows, high procyclicality in the financial sector in many emerging markets requires that monetary policy and macroprudential policy be coordinated in order to mitigate excessive economic fluctuations. On the one hand, conventional monetary policy has the potential to bolster financial system stability through its influence on financial conditions and behaviour in financial markets, even if it is focused on financial stability. On the other hand, macroprudential policy is designed to directly ensure financial stability. Given the interactions between them, it is important to adopt a flexible monetary policy regime that can accommodate both monetary and financial system stability. In the case of Indonesia, this takes the form of a flexible inflation targeting framework (ITF), one that is constructed to take account of the wisdom gained from the unconventional monetary policy in the post-GFC era.

In the context of a small open economy, global financial market integration and large capital flows complicate the implementation of monetary policy. There has been a tendency for monetary authorities to shift their preferences from "corner solutions" to "middle solutions" to the classic open economy trilemma, particularly in developing countries. It is widely argued that the policy response should manage exchange rate movements within a certain range (without adopting full flexibility) and restrict capital flows, in addition to targeting domestic inflation. A flexible ITF, incorporating a mix of monetary and macroprudential instruments, can accommodate a compromise between the three intermediate goals of (1) maintaining monetary policy autonomy: (2) stabilising exchange rates; and (3) managing capital flows.

In practice, to optimally support the implementation of flexible ITF in Indonesia, the Bank Indonesia Forecasting and Policy Analysis System (FPAS) uses a model that captures interactions between the financial sector and the real sector as well as the dynamics of the external sector. Bank Indonesia's response to financial and external sector shocks necessitates a mixture of monetary and macroprudential policy tools. To do this requires that we further develop Bank Indonesia's macroeconomic model (ARIMBI).[2] In future, ARIMBI is expected to capture the dynamics of the financial and external sector more fully, thereby improving the accuracy of policy simulations and projections through the FPAS.

This study aims to explore the linkages between monetary and financial stability, especially in the context of a dynamic global environment; to simulate policy and analyse several external shocks to the Indonesian economy and their implication for both monetary and financial stability; and to search for an optimal policy mix in

[2] ARIMBI is a semi-structural New Keynesian model adopted from the IMF's Quarterly Projection Model (QPM), as further developed by Harmanta et al (2013, 2015) and Wimanda et al (2013).

response to global economic dynamics. We use a novel modelling approach, in which the financial sector is highly susceptible to financial accelerators. We consider a number of key variables, including real credit volume growth, the spread between lending rates and deposit rates as well as the banking sector's default risk. The macroprudential policies included in the model are loan-to-value (LTV) policy as well as the reserve requirement (RR). As regards the external sector, we focus on the current account (CA) gap and the capital flow (CF) gap. The model is then used to simulate Bank Indonesia's policy response to a number of shocks and explore the implications for optimal policy.

We find that the flexible ITF is well suited to managing monetary and financial stability in Indonesia. Using the framework, Bank Indonesia can mitigate the impact of external shocks as well as shocks to the exchange rate, current account and capital flows, while simultaneously maintaining both monetary and financial stability. In addition, the integration of monetary and macroprudential policies provides better results in terms of mitigating excessive output and credit fluctuations, as compared with any single policy instrument. We conclude that, for the Indonesian economy, flexible ITF is superior to the standard ITF.

The paper is structured as follows. Section 2 of this paper presents the dynamics and challenges of the post-GFC Indonesian economy. Section 3 discusses Bank Indonesia's policy framework for managing monetary and financial stability, emphasising the flexible ITF. Section 4 concludes.

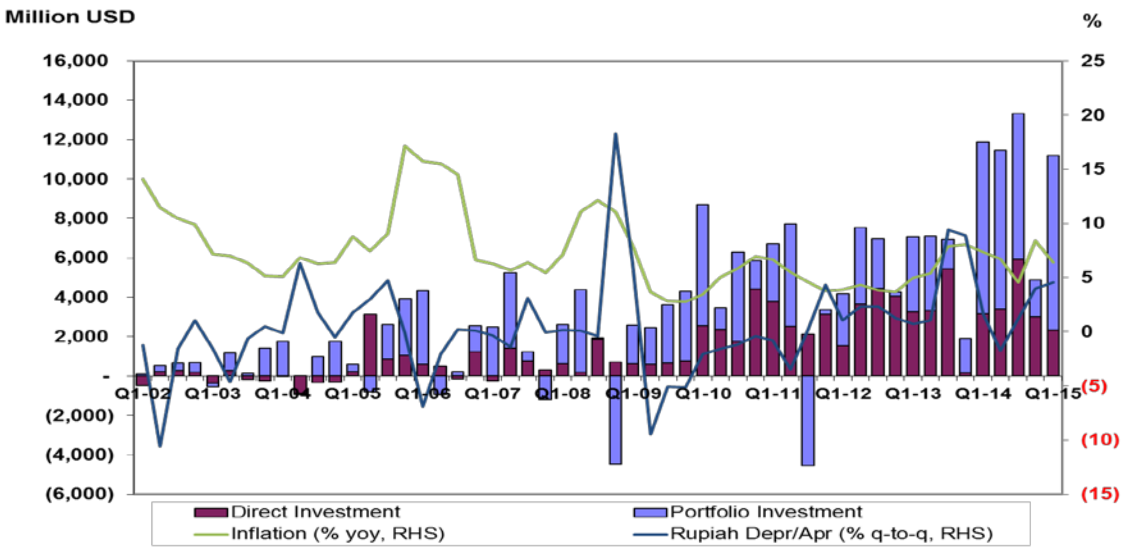
2. Dynamics and challenges of the post-GFC Indonesian economy

The GFC provided a number of valuable lessons, including illustrating that maintaining price stability alone through monetary policy is insufficient. In addition to price stability, financial system stability is also a prerequisite for macroeconomic stability. And, in line with increasing economic openness and integration, the external sector requires considerable attention.

2.1. The post-GFC challenges

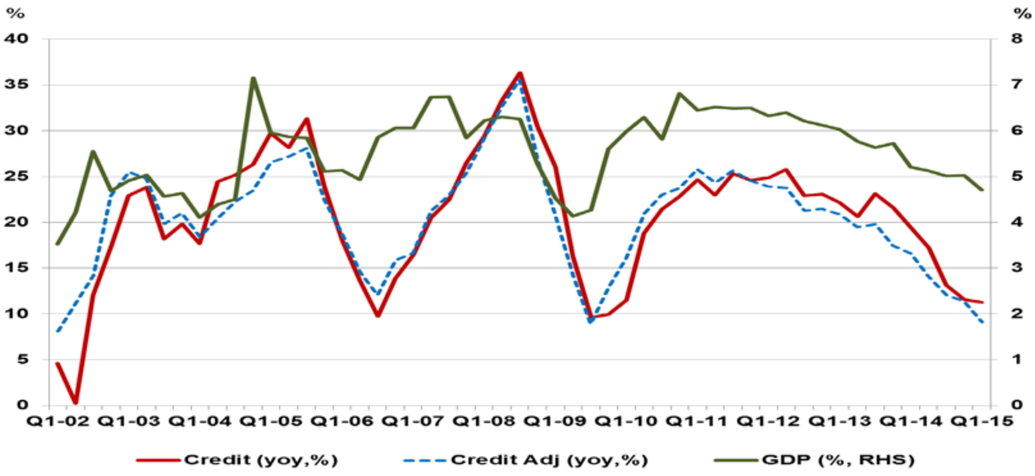
As a small open economy, Indonesia faces a number of challenges in the implementation of monetary policy relating to persistent capital flows arising from quantitative easing (QE) in advanced economies. From Q3 2009 to Q2 2011, these inflows precipitated rupiah appreciation and a widening current account deficit. An open capital account, coupled with an influx of capital flows, ensured that capital flows, rather than the current account, predominantly determined exchange rate behaviour. Accordingly, capital inflows drove nominal rupiah appreciation of 15.9% in 2009 and 4.5% in 2010. In real terms, the value of the rupiah appreciated by 17.8% in 2009 and 11.4% in 2010, even though the currency remained relatively competitive compared with those of some other Asian countries. Combined with the end of the commodity supercycle and a growing middle-income population in Indonesia, rupiah appreciation contributed to a current account (CA) deficit that surpassed 4.27% in the second quarter of 2014.

Capital flows, exchange rate, and inflation | Graph 2.1



Second, capital flow volatility created financial system vulnerability. Capital flows that fluctuated widely, amid ubiquitous herding behaviour, might reverse suddenly if market sentiment changed. They also threatened to increase financial market volatility and, in turn, act as a shock amplifier. Such consequences were further exacerbated by weak infrastructure and a lack of financial deepening, as is often the case in developing countries such as Indonesia. Furthermore, a significant portion of the capital inflows was invested in short-term financial instruments, such as SBIs, government bonds (Surat Utang Negara/SUNs) and stocks, which are particularly vulnerable to sudden reversals. As the Federal Reserve began to "taper" in January 2014, domestic liquidity shrank. Investors withdrew their money from emerging markets, including Indonesia, and switched their investments to US markets.

Credit and GDP growth | Graph 2.2



Third, financial sector procyclicality was amplified by foreign capital inflows. The influx of capital drove more liquidity into the banking system and more credit was channelled to the real sector. Credit growth induced overheating in the economy. As a result, an asset price bubble emerged, especially in housing prices. The financial sector tended to exacerbate economic fluctuations. In Indonesia, procyclicality is reflected in the performance of bank credit during expansionary and contractionary phases. Observing credit growth during periods of expansion and contraction revealed the magnitude of procyclicality in the Indonesian banking system. Risk behaviour also contributed to procyclicality in the financial sector. Optimism about the Indonesian economy and diminishing concerns about the Fed's tapering may have contributed to high portfolio investment in 2014.

2.2. The optimal policy response

Persistent foreign capital inflows undermine the efficacy of monetary management, given that measures to manage liquidity in the economy, such as an interest rate increase, could ultimately be offset by the sheer magnitude of the capital inflows. To manage upward exchange rate pressures, high capital inflows demand intensive intervention, which causes the amount of excess liquidity in the banking system to increase significantly. Such capital flow dynamics could reduce the degree of autonomy in monetary policy and shift its orientation from a sole focus on inflation control towards mitigating rupiah appreciation through intensive intervention.

The orientation of monetary policy in the midst of high global uncertainty is tactically directed towards not only controlling inflation but also to managing exchange rates in line with macroeconomic fundamentals through active intervention in the foreign exchange market. In addition, it simultaneously manages international reserves at a safe level in accordance with best international practice. This has the logical consequence that exchange rate dynamics will not be completely influenced by market forces but also by domestic monetary policy.

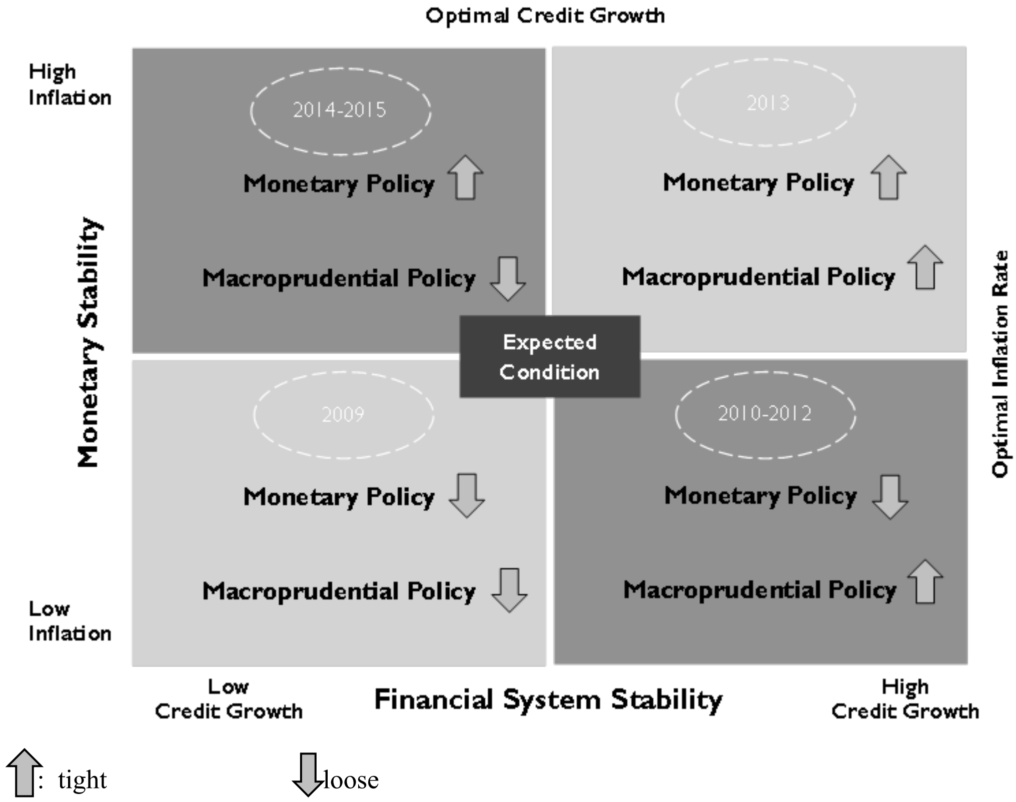
Post-GFC challenges have revealed some valuable lessons for monetary policy implementation in Indonesia. First, the multiple challenges facing monetary policy imply that Bank Indonesia should employ multiple instruments. In the face of capital flows, while the exchange rate should remain flexible, it should also be maintained in such a way that the exchange rate is not misaligned from its fundamental value. Concomitantly, measures are required to accumulate foreign exchange reserves as self-insurance given that short-term capital flows are particularly vulnerable to a sudden stop. In terms of capital flow management, a variety of policy options are available to deal with the excessive procyclicality of capital flows, especially short-term and volatile capital. In terms of monetary management, the dilemmas have been partially resolved by applying a quantitative-based monetary policy to support the standard interest rate policy instrument. In addition, macroprudential policies aimed at maintaining financial system stability should also be adopted to mitigate the risk of asset bubbles in the economy.

Second, while price stability should remain the primary goal of Bank Indonesia, the GFC showed that keeping inflation in check is not, by itself, sufficient to preserve macroeconomic stability. A number of crises in recent decades have also shown that macroeconomic instability is primarily rooted in financial crises. Therefore, the key to managing macroeconomic stability is to manage not only the imbalance of goods (inflation) and externalities (balance of payments) but also imbalances in the financial sector, such as excessive credit growth, asset price bubbles and the cycle of risk-taking behaviour in the financial sector. In this regard, Bank Indonesia would be effective in maintaining macroeconomic stability if also mandated to promote financial system stability. Hence, the monetary policy framework of ITF requires enhancement by including the substantial role of the financial sector.

Third, exchange rate policy should play an important role in the ITF of a small open economy. Under a standard ITF, Bank Indonesia would not attempt to manage the exchange rate. This benign view argues that the exchange rate system should be allowed to float freely, thus acting as a shock absorber for the economy. However, in a small open economy with open capital movements, exchange rate dynamics are largely influenced by investor risk perception, which triggers capital movements. In this environment, there is a case for managing the exchange rate in order to avoid excess volatility that could push the exchange rate beyond a level conducive to achieving the inflation target.

Based on the aforementioned rationale, there is a justification for implementing a less rigid ITF, otherwise known as flexible ITF. Flexible ITF requires monetary and macroprudential policy to be integrated, including capital flow management and exchange rate policy. The policy mix should be an optimal response to tackling multiple challenges in managing monetary and financial stability.

The policy mix under several circumstances Graph 2.3



The formulation of an optimal policy mix in Indonesia depends on what kinds of shocks hit the economy. A fall in world GDP would elicit an accommodative monetary policy response and looser macroprudential measures. An increase in global interest rates would be followed by tighter monetary and macroprudential policy. Meanwhile, a broader current account deficit would require tighter monetary policy and looser macroprudential measures. On the other hand, capital outflows would require raising the policy rate and looser macroprudential measures. As Indonesia faces multiple challenges, for which there are multiple shocks, the formulation of a policy mix is significantly more complex. In Graph 2.3 we describe the policy mix of Bank Indonesia under specific circumstances.

Macroprudential measures in Indonesia

Table 2.1

No	Measure	Objectives
1	Minimum holding period on BI bills	To "put the brake" on short-term and speculative capital inflows and mitigate the risk of a sudden reversal.
2	Lengthen auctions and offer longer maturity of BI bills.	To enhance the effectiveness of domestic liquidity management, including capital inflows, by locking investments into the longer term and helping develop domestic financial markets.
3	Non-tradable rupiah term deposits for banks	To lock domestic liquidity into the longer term and limit the supply of BI bills on the market.
4	Limits on short-term offshore borrowing by banks	• To limit short-term and volatile capital inflows. • To limit FX exposure of the banking system stemming from capital inflows.
5	Mandatory reporting of foreign exchange originating from export earnings	To increase dollar supply.
6	Primary rupiah reserve requirement (checking accounts held at BI)	To help absorb domestic liquidity.
7	Secondary rupiah reserve requirement (checking accounts held at BI, SBI and government bonds)	To absorb liquidity and to strengthen the banking system.
8	FX reserve requirements of the banks	• To strengthen FX liquidity management, and thereby banking system resilience, in the face of increasing FX exposure stemming from capital inflows • To help absorb domestic liquidity.
9	LDR-based reserve requirement	To absorb domestic liquidity and enhance liquidity management at banks without exerting negative impacts on lending that is needed to stimulate growth.
10	Loan-to-value (LTV) ratio for the property sector and downpayments on automotive loans	To control accelerating credit growth in consumer sectors (especially the property and automobile sectors).
11	LTV for second and third properties	To slow the rate of increase of credit risk concentration in the property sector and to foster prudential principles.

As a result of the global financial crisis that hit the global economy in 2008–09, Indonesia's GDP growth dropped to 4.6% in 2009, while nominal credit growth fell to its lowest level, namely 5%. Under such circumstances, it was optimal for Bank Indonesia to lower its policy rate in order to catalyse economic activity, while loosening macroprudential measures (required reserve ratio (RR)). From 2010–12, however, as the economy strengthened and inflation was well managed, Bank Indonesia maintained a low policy rate. Regarding credit growth, which skyrocketed to around 25%, macroprudential measures (loan-to-value ratio (LTV)) were tightened in 2012. Furthermore, rapid credit growth was spurred by an influx of capital into the country as investors regarded Indonesia as a prospective investment destination. To curb credit growth, Bank Indonesia continued to tighten macroprudential measures in 2013 by regulating LTV policy for second and third properties and by raising the secondary RR. Despite decelerating GDP growth, Bank Indonesia raised its policy rate as inflation increased on volatile food and administered prices. From 2014–15, Bank Indonesia maintained a high policy rate in order to control inflation. Simultaneously, Bank Indonesia loosened macroprudential measures (LTV and RR) to stimulate waning credit growth that had sunk to 10%. At the time, the LTV policy was targeted on specific sectors, such as property, so that the divergent stances of macroprudential policy and monetary policy did not confuse the market (by conveying misleading signals). Such conditions are evidence of the advantages of macroprudential tools, which clearly require the support of good policy communication. Table 2.1 presents a number of macroprudential measures implemented by Bank Indonesia, while Appendix 1 presents the same but in chronological order.

3. Framework for managing monetary-financial stability

Bank Indonesia currently implements a de facto flexible inflation targeting framework (ITF) as its policy framework. It is an enhanced framework, given that the Indonesian economy is confronting multiple challenges and that merely achieving the inflation target is insufficient. The framework requires monetary and macroprudential policy to be integrated, which is believed to be the optimal response from a monetary and financial stability viewpoint.

3.1. The framework

Bank Indonesia has operated an inflation targeting framework (ITF) since July 2005. This is a "standard" ITF. Bank Indonesia perceives ITF as a reliable monetary policy strategy, although capable of further enhancement by refining the future ITF implementation strategy. There are two rationales for this enhancement. First, evaluations of ITF implementation in Indonesia have evidenced the requirement for a number of adjustments and refinements, which have been undertaken according to the conventional monetary policy wisdom. In this case, there is justification for implementing a less rigid ITF as an ideal format for the Indonesian economy. Second, Indonesian economic performance during the GFC instilled confidence concerning the aptness of ITF as a reliable monetary policy strategy for Indonesia. However, considering the dynamics and complexity of challenges faced, the framework requires further enhancements.

3.1.1 Integration of monetary and macroprudential policy

The macroeconomic stability attained during the Great Moderation of 1987–2007 did not protect the global economy from the impact of a crisis propagated by financial sector fragility. This experience suggests that monetary policy should anticipate macroeconomic instability risk stemming from the financial system, and that financial system stability is the foundation for a sustainable macroeconomic environment.

Within this policy perspective, the central bank requires flexibility in responding to emerging uncertainties within the economy. Such flexibility is crucial in overcoming the potential conflicts or trade-offs between targeting monetary stability and financial system stability. It can be achieved through, among other means, additional instruments (in this case macroprudential policies) and by extending the horizon for attaining the inflation target in order to accommodate near-term output stabilisation. To overcome potential policy conflict, it is also important to prioritise the policy goal, for example, by setting price stability as the overarching aim.

The pressing need to strengthen the monetary and financial system stability framework requires a strong financial infrastructure coupled with an effective supervisory function. In this regard, Borio (2003) emphasises the need to strengthen the regulatory framework or macroprudential policy, thereby limiting the risk that prolonged financial markets instability would undermine real economic output.

Conceptually, macroprudential policy aims at enforcing financial system stability as a whole, instead of the wellbeing of individual financial institutions. "Macroprudential policy seeks to develop, oversee and deliver an appropriate policy response to the financial system as a whole. It aims to enhance the resilience of the financial system and dampen systemic risks that spread through the financial system" (G30). In maintaining the stability of financial intermediation, macroprudential policy is thus a key factor in backing the monetary policy goal of price and output stability.

Especially after the 2008–09 crisis, many central banks have applied macroprudential policy instruments more broadly. Consequently, several instruments previously considered to be microprudential (such as loan-loss provisioning requirements or loan-to-value) or monetary instruments (such as reserve requirements) have been utilised to curb systemic risk and maintain financial system stability. Rather than focusing on efforts to deal with risk at individual banks, such policy instruments have encompassed a wider macroprudential perspective.

Strengthening the monetary and financial system stability framework requires appropriate monetary and macroprudential policy integration. It is generally accepted that the main goal of monetary policy is to maintain price stability. Accordingly, central banks traditionally use interest rates as their primary instrument to attain that goal. Maintaining price stability, however, is still not sufficient to guarantee macroeconomic stability because the financial system, with its procyclical behaviour, triggers excessive economic fluctuations. Meanwhile, the goal of macroprudential policy is to safeguard overall financial system resilience in a bid to support financial intermediation in the economy as a whole. With its countercyclical role, macroprudential policy supports the goal of monetary policy by preserving price and output stability.

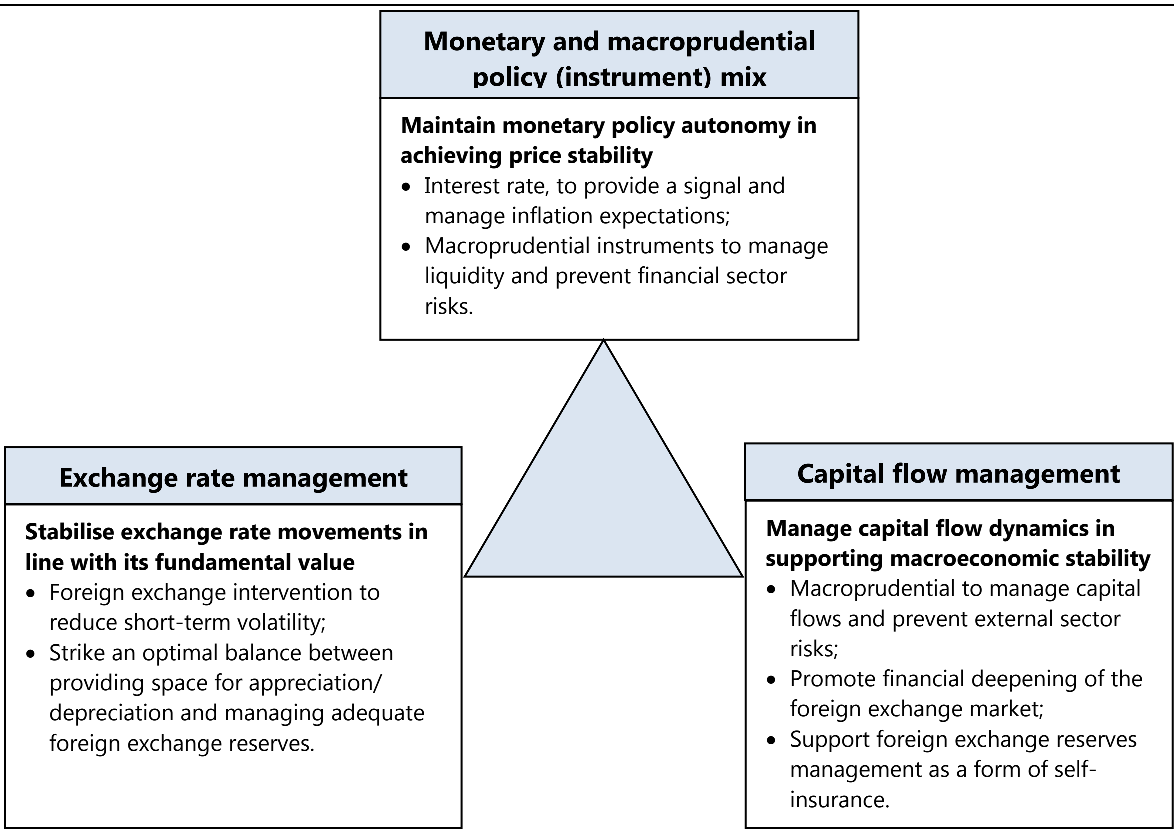
The objectives achieved through monetary and macroprudential policies should be mutually reinforcing. Steps to reinforce financial system resilience will also strengthen monetary policy, by protecting the economy from sharp fluctuations in the financial system. On the other hand, macroeconomic stability will lessen the vulnerability of the financial system, with its procylical characteristics. Therefore, the interest rate may not require adjusting to the extent that would be needed in the absence of policy integration or coordination. Meanwhile, macroprudential policy affects credit supply conditions and, consequently, monetary policy transmission. The efficacy of policy coordination relies on the macroeconomic environment, financial conditions, the intermediation process and the level of capital and assets in the banking system. Hence, it is not realistic to expect the combination of monetary and macroprudential policy to fully eliminate economic cycles. The main goal of such policy integration is to moderate cycles and bolster financial system resilience at a macro level.

Several conditions are required to ensure that monetary and macroprudential policy integration runs smoothly. First, there is a need to understand the framework of linkages amongst monetary, macroprudential and microprudential policies. This is to take into account potential trade-offs when pursuing policy objectives. That is why the use of an instrument mix or adding new instruments can be considered desirable. Second, there is a need to understand the workings of monetary and macroprudential policy transmission in terms of catalysing economic activity. This requires a more integrated analytical framework, especially when evaluating the important role of the financial sector. Third, there is a need to measure appropriate risk behaviour indicators in monitoring system risk. Measuring the risk indicators in addition to supporting the right monitoring system will also strengthen the analysis of transmission mechanisms through the risk-taking channel.

3.1.2. Managing the monetary policy trilemma

The purpose of a flexible ITF is to manage the monetary policy trilemma (as presented in Graph 3.1), namely to achieve three intermediate goals as follows: (1) maintaining monetary policy autonomy in achieving price stability by employing a monetary and macroprudential policy (instrument) mix; (2) stabilising the movement of the exchange rate in line with its fundamental value by employing exchange rate management; and (3) managing capital flow dynamics to support macroeconomic stability by implementing capital flow management.

Bank Indonesia monetary policy trilemma management — Graph 3.1



There are five principles of enhancement, as follows:

a. Continuing the adherence of a policy framework to the inflation target as the overriding objective of monetary policy. The main characteristics of an ITF will remain, ie pre-emptive, independent, transparent and accountable policy implementation.

b. Integrating monetary and macroprudential policy. Appropriate monetary and macroprudential policy integration is required in order to buttress monetary and financial system stability.

c. Managing the dynamics of capital flows and exchange rates. To support macroeconomic stability, coordinated implementation of a policy instrument mix is ultimately part of an important strategy to optimally manage the monetary policy trilemma.

d. Strengthening the policy communication strategy as part of the policy framework. Policy communication is no longer merely for the sake of transparency and accountability but also serves as a monetary policy instrument.

e. Strengthening Bank Indonesia and government policy coordination. Policy coordination is crucial, given that inflation stemming from the supply side creates the majority of inflation volatility.

Monetary policy complexity stemming from the interest rate can be partially resolved through quantitatively tighter monetary policy by raising the reserve requirement. In addition, macroprudential policy aims to avoid financial risks, such as asset bubbles and excessive credit growth, which could trigger potential financial system instability. This type of macroprudential policy is effective if banks intermediate the majority of capital flows. Nevertheless, if the capital flows originate directly from unregulated sectors, such as direct loans from the private sector, measures to control capital inflows are another option, for example, by limiting private loans.

In terms of the exchange rate, the rupiah should be managed to remain flexible, with scope to appreciate/depreciate, but the currency should also be managed so that it avoids misalignment with the economic fundamentals, as this will jeopardise macroeconomic stability. Consequently, Bank Indonesia's presence is required on the foreign exchange market to ensure that the rupiah does not incur excessive volatility. Of course, this option is no longer available if the rupiah becomes overvalued. Simultaneously, efforts to accumulate foreign exchange reserves are vital as a form of self-insurance, given that short-term capital flows are particularly vulnerable to the risk of a sudden reversal.

Regarding capital flows, by continuing to adhere to a free foreign exchange regime, macroprudential measures also consist of policy options designed to reduce excessive short-term capital flows, which could potentially lead to financial risks from the external side. Such measures have been introduced by Bank Indonesia through regulations that require investors to hold Bank Indonesia Certificates (SBI) for a minimum period of one month. This policy has helped diversify foreign portfolio capital flows and extend the duration of SBIs, which consequently nurtured financial deepening, especially of the foreign exchange market.

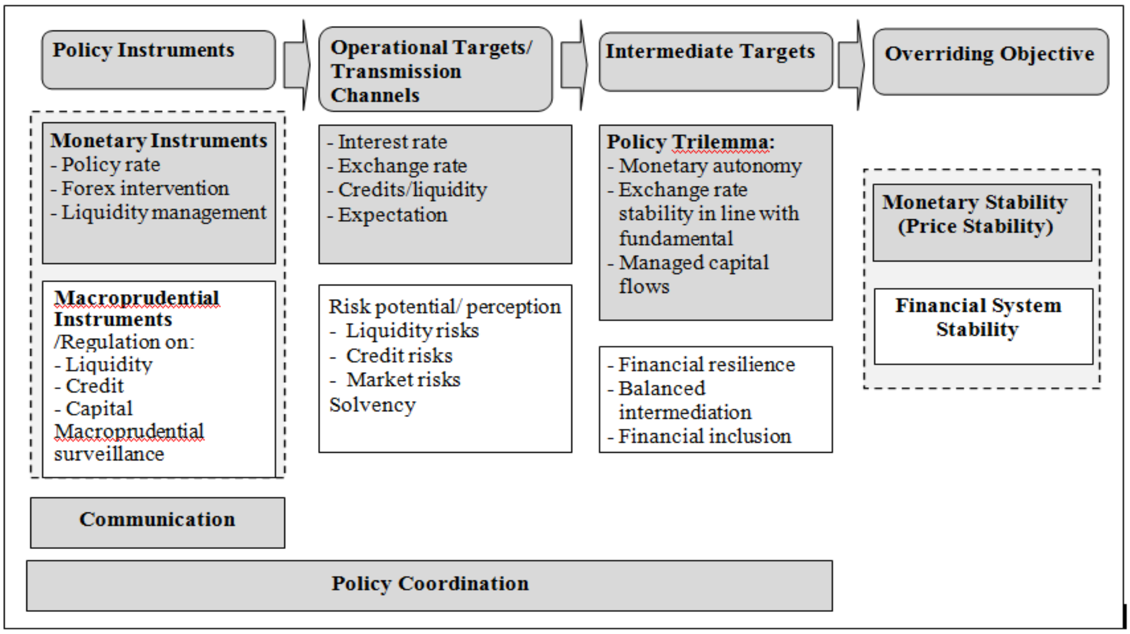
The coordinated implementation of a policy instrument mix is ultimately part of an important strategy to manage the monetary policy trilemma in the current uncertain climate. Coordination is critical, not only to address sources of external and internal imbalances but also to optimally manage the impact of monetary policy.

According to the above policy perspective, the achievement of macroeconomic stability is tied not only to monetary stability (price stability) but also to its interaction with financial system stability. Under a flexible ITF, the flexibility of policy implementation is achieved through macroprudential instruments in addition to monetary instruments that are mutually reinforcing. While monetary instruments are utilised to influence monetary variables, such as the interest rate, exchange rate, credit and expectations, macroprudential instruments are utilised primarily to manage potential risk or risk perception in financial markets. Concerning the measures to overcome potential policy conflict, it is imperative to prioritise policy objectives by setting price stability (inflation) as the overriding objective.

Graph 3.2 shows schematically how the monetary framework under a flexible ITF can be enhanced through a mix of monetary and macroprudential policy instruments.

Monetary policy framework under a flexible ITF

Graph 3.2



In response to the aforementioned challenges, the tasks faced by Bank Indonesia are becoming increasingly complex, particularly in terms of maintaining financial system stability. Consequently, Bank Indonesia strives to consistently implement a flexible ITF. This is achieved in the form of macroprudential policy in addition to monetary policy (interest rate). Concerning macroprudential policy, Agung (2010) recommends monetary and macroprudential policy be conducted within the confines of the same institution considering the close interconnectedness between the two, in this case Bank Indonesia. Furthermore, at the practical level, Agung (2010) recommends several alternative macroprudential instruments for Bank Indonesia, namely countercyclical CAR, forward-looking provisioning (so that when a bank is appropriating reserves, expected losses are also included), the LTV ratio (as an upper limit for credit to asset value that can be offered to a borrower) and the reserve requirement (RR).

Meanwhile, for a small open economy such as Indonesia, the exchange rate plays a central role in the economy. Monetary policy is transmitted partly through its impact on the exchange rate. Changes to the policy rate will influence the rupiah exchange rate through interest rate parity (IRP). Raising the policy rate (which subsequently increases deposit rates) will cause the rupiah to appreciate and vice versa. Furthermore, changes in the value of the rupiah will have direct pass-through and/or indirect pass-through effects on exports, imports, GDP and inflation.

3.2. Modelling a flexible ITF for the Indonesian economy

Here we use an enhanced or modified small open-economy New Keynesian model to explain the flexible ITF and how the policy mix works. We then present policy simulations on the impact of external shocks on the Indonesian economy, especially the impact on monetary and financial stability, and the Bank Indonesia response using monetary and macroprudential policy.

3.2.1. Modelling strategy

Some recent literature explored the integration of monetary and macroprudential policy using quantitative models. Galati and Moessner (2011) state that there is lack of clarification and consensus regarding a definition of financial stability and effective models to explain interactions between the financial system and macroeconomy. A selection of the literature tries to include financial frictions in the corresponding models, in this context relating to credit constraints of loans and non-financial sectors, which are built based on the financial accelerator mechanism of Bernanke et al (1996). Furthermore, efforts have also been taken to include financial frictions relating to financial intermediaries.

Angelini et al (2011) argued that macroprudential policy is expected to have a direct and indirect influence on the monetary policy transmission mechanism. Based on their research, it was found that incorporating macroprudential policy is most beneficial when the economy experiences shocks stemming from the money market or households, where both types of shock affect the supply of credit. As suggested by Gerali et al (2010), banks accumulate capital from retained earnings and strive to maintain a capital-to-assets ratio close to that of the regulated target. According to Angelini et al (2011), using capital requirements as a macroprudential policy tool is based on the argument that systemic crises affect bank capital and the supply of credit. Capital requirements increase when economic conditions are good and, conversely, decrease when economic conditions deteriorate.

Beau et al (2011) identified circumstances where monetary policy and macroprudential policy had a complementary, independent or conflicting effect on price stability. Their findings, amongst others, showed that the best results for price stability were achieved by combining monetary policy focused on price stability with macroprudential policy centred on credit growth. Such a policy mix generates several types of Taylor rule, namely the plain vanilla Taylor rule (using the standard Taylor rule to achieve the overarching goal of price stability) or the augmented Taylor rule (to the original Taylor rule is added the argument that short-term nominal interest rates must be raised in line with stronger credit growth). Independent macroprudential policy can use the augmented Taylor rule accompanied by separate macroprudential policy.

Cúrdia and Woodford (2009) found a need to accommodate the response to variations in aggregate credit in the Taylor rule, with explorations based on a New Keynesian model with financial friction. Monetary policy should be used to help stabilise aggregate private credit by tightening policy during periods of abnormally robust credit growth and, conversely, by loosening policy when credit contracts.

Efforts to model macroprudential policy and incorporate it into monetary policy were also undertaken by Peñaloza (2011), namely by adding a financial block to a standard semi-structural small open-economy Neo Keynesian model. The simulations benefited greatly from the inclusion of macroprudential tools (in this case the CAR rule), enabling the monetary authority to better mitigate output gap shocks, as compared with just using the standard Taylor rule. Therefore, financial shocks could be isolated and their adverse impact on macroeconomic variables alleviated. In this context, the financial block basically represented a set of reduced form equations that facilitate analysis of lending spreads, the delinquency index and credit volume, which can be integrated into the core model. Such a model accommodates the feedback effect from the core model to the financial sector.

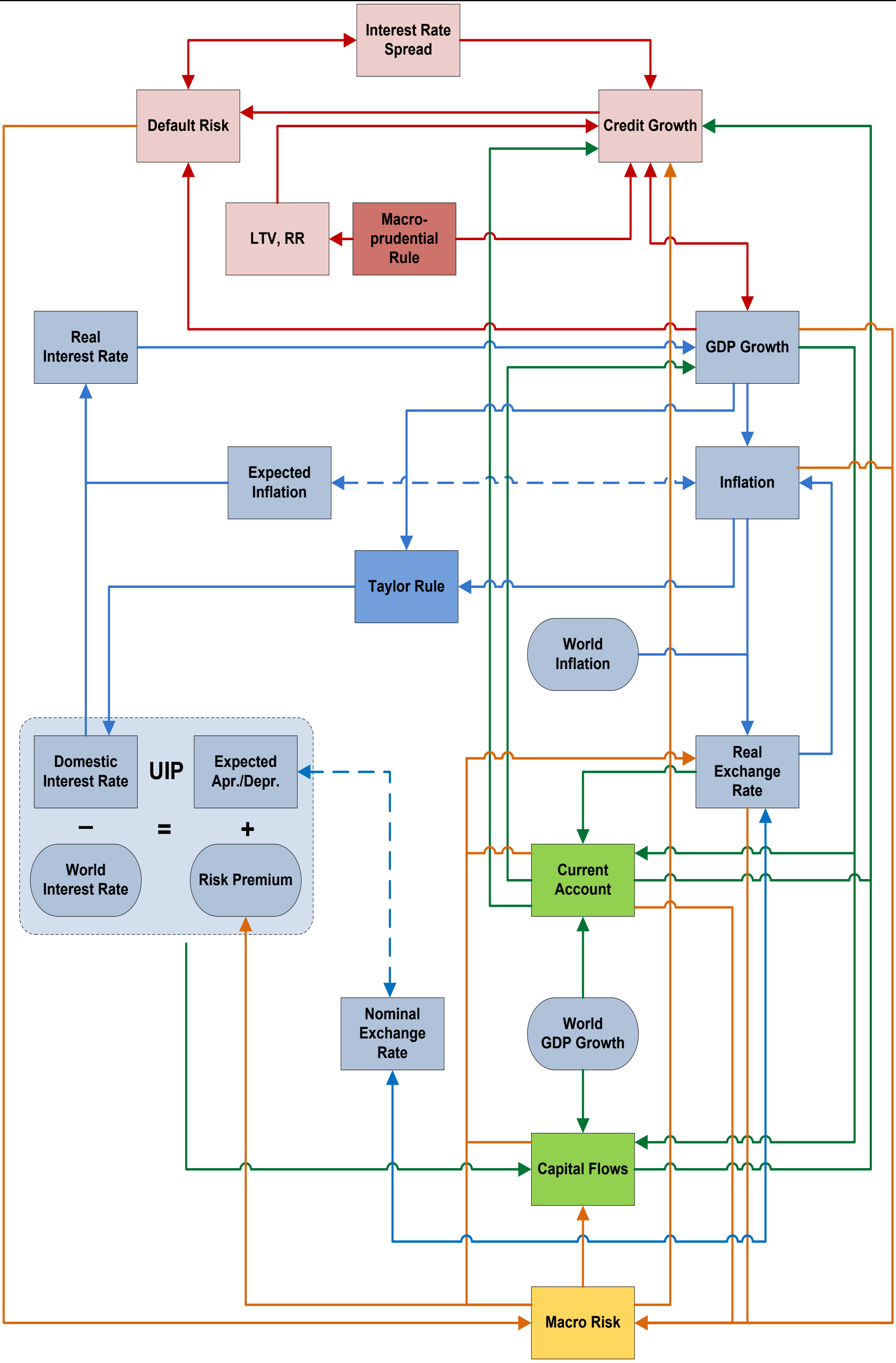
Regarding capital flows, Unsal (2011) states that the challenge to policymakers, concerning the influx of capital flows, is preventing the domestic economy from overheating with implications for inflation, as well as mitigating the risks associated with the impact on financial stability, which would be undermined as credit and financing became more accessible. Monetary policy could be utilised to overcome the effect on inflation; however, macroprudential policy is required to mitigate the impact on financial stability. According to Capistrán et al (2011), emerging economies face the very real threat of a capital flow reversal.

Juhro and Goeltom (2012) state that, in response to capital flow dynamics, amidst inflationary pressures, Bank Indonesia should implement unconventional policy using multiple instruments. The framework applied is a flexible ITF, where the overriding objective is the inflation target. However, a flexible ITF is more flexible than its standard counterpart. The central bank is focused not only on achieving the inflation target but also takes into account a number of other considerations, including financial sector stability, the dynamics of capital flows as well as the exchange rate. With such a policy perspective, the achievement of macroeconomic stability is not only related to monetary stability (price stability) but also to financial system stability.

The importance of balance between the current account and capital flows is highlighted by Ghosh et al (2008), who focus on five cases: (i) conditions where capital inflows respond to the CA financing requirement; (ii) conditions where capital inflows are merely due to higher yields; (iii) conditions where pressures emerge in the balance of payments due to a current account surplus; (iv) conditions where the current account surplus is offset by capital outflows; and (v) pre-crisis and crisis conditions (that transpire due to a current account deficit and/or capital outflows that are not offset by capital inflows and/or a current account surplus). The illustrations developed by Ghosh et al (2008) reveal ideal current account and capital flow conditions, where both are found in a state of equilibrium. According to Lee et al (2008), based on a macroeconomic balance approach, there is a certain level of exchange rate in line with CA norms, known as the equilibrium real exchange rate.

In general, macroeconomic models utilised by countries adhering to an inflation targeting framework tend to institute monetary policy based on the Taylor rule. The basic version stipulates that a central bank only responds to changes in the inflation gap and output gap. Another version specifies that in addition to responding to both

Structure of Bank Indonesia's core model (ARIMBI) Graph 3.3



the aforementioned gaps, a central bank also responds to exchange rate dynamics, marked by the inclusion of a variable for the exchange rate in the Taylor rule. Despite its inclusion in the Taylor rule, the exchange rate is not a policy instrument. In that context, monetary policy is implemented solely through the Taylor rule. As stated by Taylor (2001), there are several research papers dedicated to the inclusion of the exchange rate in the monetary policy rule, including Ball (1999), Svensson (2000) and Taylor (1999).

To support implementation of a flexible ITF, Bank Indonesia developed several macroeconomic models for use in its Forecasting and Policy Analysis System (FPAS). The core model used to make forecast and policy simulations is known as ARIMBI. Besides ARIMBI, there are a number of supporting satellite models, namely SOFIE (short-term forecast of GDP components and inflation by category), MODBI (medium-term forecast of macroeconomic variables), BIMA (short-term forecast of balance of payments) and ISMA (short-term forecast of sectoral GDP). In addition, near-term forecasts of GDP, inflation and exchange rates are also provided based on assessments and anecdotal information.

In the following section, we use equations from the ARIMBI model to explain Bank Indonesia's flexible ITF. Originally, ARIMBI was a standard small open-economy New Keynesian model, consisting of four main equations, namely IS – output gap, inflation – New Keynesian Phillips Curve (NKPC), Uncovered Interest Parity (UIP) and the Taylor rule. When the flexible ITF was introduced, we modified the model to incorporate financial accelerators, as well as procyclicality between the real and financial sectors and the risk-taking channel. We further enriched the model by including the ability to capture the dynamics of the current account and capital flows. In addition, the policy mix of Bank Indonesia is also modelled, including its monetary policy (Taylor rule and optimal exchange rate) and macroprudential policy (LTV rule and RR rule). The structure of the model is presented in Graph 3.3, with further elaboration provided in Appendix 2.

Block 1: The real sector and monetary policy

There are four main equations, namely IS – output gap, inflation – NKPC, the Taylor rule and Uncovered Interest Parity (UIP). The four equations represent a macroeconomy or real sector. The output gap represents the size of the disparity between real GDP and its potential level. The credit growth gap is added to this equation to reinforce the correlation between the macroeconomy and the financial block. Meanwhile the second equation shows that CPI inflation is determined by its expected value, output gap and real exchange rate gap. The Taylor rule is determined by its long-term trend, inflation gap and output gap. The UIP equation shows that it holds when the interest rate differential is the same as the summation of expected nominal exchange rate depreciation/appreciation and risk premium.

Block 2: The financial block and macroprudential policy

There are three equations in the financial block, namely the credit growth gap equation, the interest rate spread gap equation and the default risk gap equation. Three additional equations were included because when an economy experiences a boom/bust episode, real credit growth increases/decreases, accompanied by an increase/decrease in default risk. Meanwhile, the inclusion of the interest rate spread gap equation is required to capture the dynamics of lending rates, given that the core equations do not include the lending rate as a variable. There are two macroprudential tools in the model, namely the LTV and RR ratios, which are modelled together. In the macro model, the macroprudential instrument mechanism of the RR resembles the LTV. The current LTV regulation has a direct effect on mortgages and automotive loans, and ultimately influences total credit. The reserve requirement affects total credit through its impact on loanable funds. In the model, both macroprudential tools respond to total credit.

Block 3: The external block and exchange rate policy

There are three equations in the external block, namely the current account (CA) gap equation, the capital flow (CF) gap equation, and several equations representing the rest of the world. As mentioned previously, the CA gap is the difference between the CA to GDP ratio and CA norms. Meanwhile, the CF gap is the difference between the CF to GDP ratio and the optimum level of CF. The rest-of-the-world equations consist of world IS – output gap, world inflation – NKPC and the world Taylor rule. It is a simple model of the global economy and a representation of what central banks do in response to shocks of world inflation and GDP. Bank Indonesia’s exchange rate policy is basically a combination of responses to current economic conditions and a drift towards gradually bringing the economy to its internal and external balance. If there are no other shocks in the near term (about one to two years ahead), the path of the short-term fundamental exchange rate will be the same as path of the medium-term fundamental exchange rate. The path resembles the concept of permanent equilibrium exchange rate (PEER), in which there are responses to both temporary and permanent shocks.

Block 4: Macro risk and the risk-taking channel

In order to capture the role of risk perception in the model, we endogenise variables of risk, using the International Country Risk Guide (ICRG) index as a proxy. The risk is called macro risk to represent risk at the macro level. A higher output gap would induce lower macro risk, while a higher inflation gap would raise macro risk. On the other hand, real exchange rate depreciation would raise macro risk in a similar way to a deteriorating current account. In the financial sector, higher default risk would escalate macro risk. The determinants of macro risk are basically composed of macroeconomic and financial variables. Furthermore, macro risk influences other variables in the model. Its impact affects not only real exchange rate depreciation/appreciation but also the credit growth gap (or risk-taking channel), default risk gap, risk premium and capital flow gap.

3.2.2. Policy simulation

In this policy simulation, some external shocks are simulated, namely a shock to world GDP, world interest rate, the current account and capital flows. We differentiate two scenarios in the simulations as follows: (i) Bank Indonesia only uses monetary policy in response to the shocks (indicated by the broken red line); and (ii) Bank Indonesia utilises both monetary and macroprudential policy (indicated by the solid dark blue line).

a) A decline in world GDP

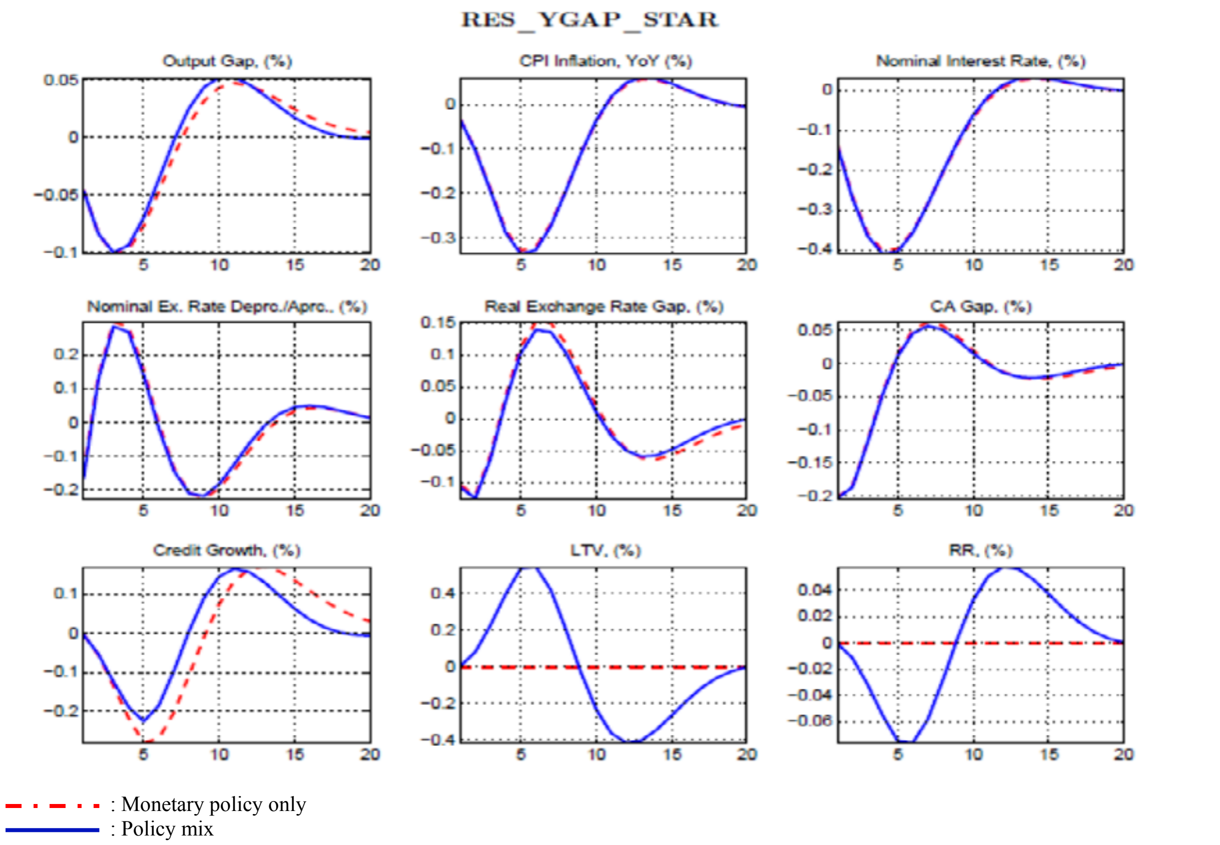
The slowdown in world GDP growth in 2010–13 had a significant impact on the domestic economy. Using the model, we simulate a shock in the form of a 1% drop in the world output gap, accompanied by declines in both world inflation and the world nominal interest rate. Such a shock would precipitate a decrease in the output gap (economic growth) of Indonesia by around 0.10%, followed by a lower rate of inflation, prompting Bank Indonesia to lower its policy rate based on the standard Taylor-type rule mechanism.

A decrease in the world output gap would have a 0.20% impact on the current account deficit due to a larger decline in exports (stemming from the decrease in the world output gap and rupiah real exchange rate appreciation) than imports (because of the decrease in the output gap of Indonesia). Meanwhile, a falling output gap and current account as well as escalating default risk would trigger a limited increase in macro risk and also impact the nominal and real exchange rates as well as other variables.

A more pronounced decline in the world nominal interest rate (in response to a drop in world output gap) compared to the BI rate, coupled with the inherent lag associated with reducing the BI rate, would trigger capital inflows to the domestic economy, thereby increasing the capital flow (CF) gap by around 0.18%. Consequently, the rupiah would appreciate at the onset of the shock but subsequently depreciate as the falling world output gap starts to influence macroeconomic variables, for instance, through domestic economic moderation, a current account deficit and BI rate reductions.

IRF – World output gap shock

Graph 3.4



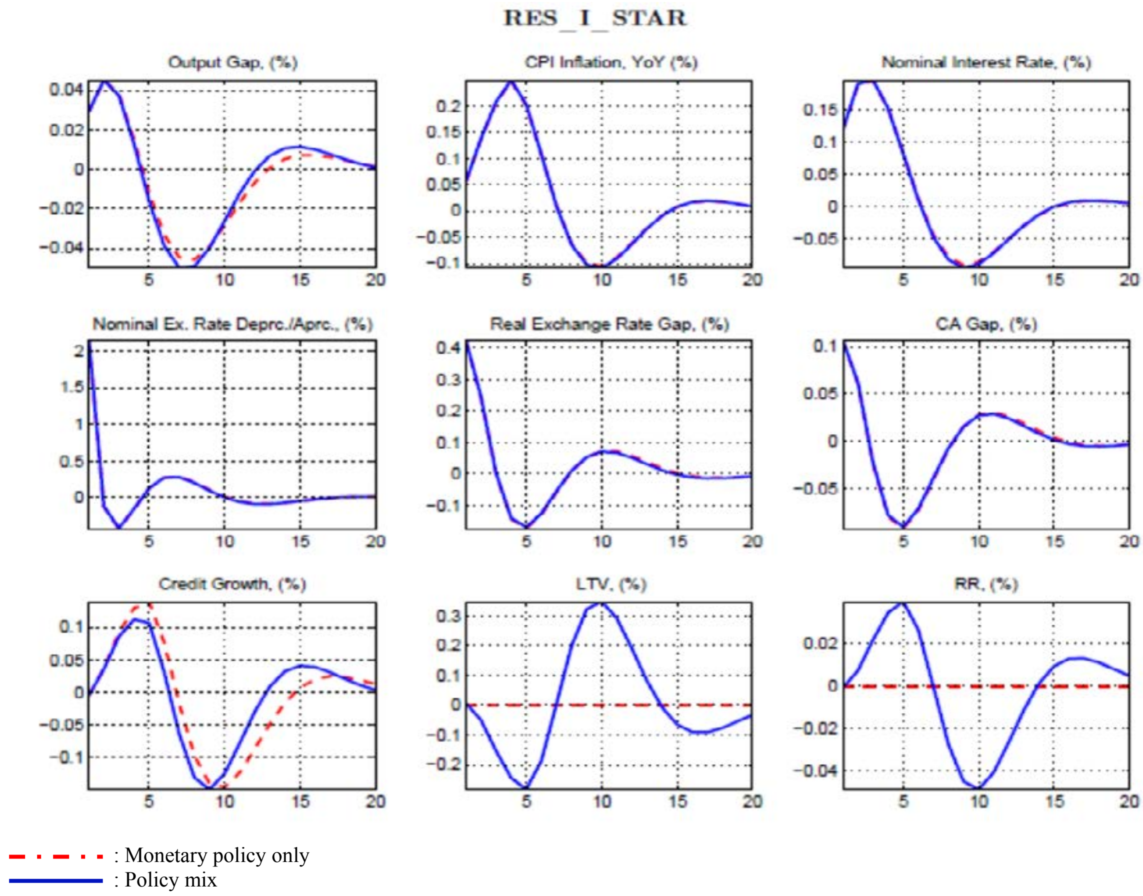
A decline in the output gap would subsequently lead to slower real credit growth due to procyclicality and the presence of a financial accelerator, which could also be attributable to a wider interest rate spread caused by higher default risk, in line with economic moderation. Real credit growth would also be suppressed slightly due to declining liquidity as a result of the ensuing balance of payments (BOP) deficit. In response, Bank Indonesia would need to raise the LTV ratio and lower the RR to maintain financial stability.

It can be observed from the simulation that the integration of monetary and macroprudential policy is superior in terms of slowing the pace of credit growth, as compared with using just one of the policies. It is unnecessary to lower the policy rate dramatically to boost the economy, or even to aggressively raise LTV or lower RR in order to spur credit growth. Implementing the two policies simultaneously necessitates only moderate shifts.

b) World interest rate increase

Normalisation of the Fed's monetary policy stance would compel other central banks to raise their own policy rates. Using the model, we simulated a shock in the form of a 1% increase in the world interest rate. The shock would induce a decline in the world output gap and lower world inflation. The shock would also spur an outflow of capital from Indonesia and cause the rupiah to depreciate, both in nominal and real terms. Nominal rupiah depreciation would bring higher CPI inflation and prompt the central bank to raise its policy rate. On the other hand, real exchange rate depreciation would close the CA gap and subsequently boost the output gap. Furthermore, real credit growth would increase in the first quarter as the output gap increased, causing Bank

IRF – World interest rate shock Graph 3.5



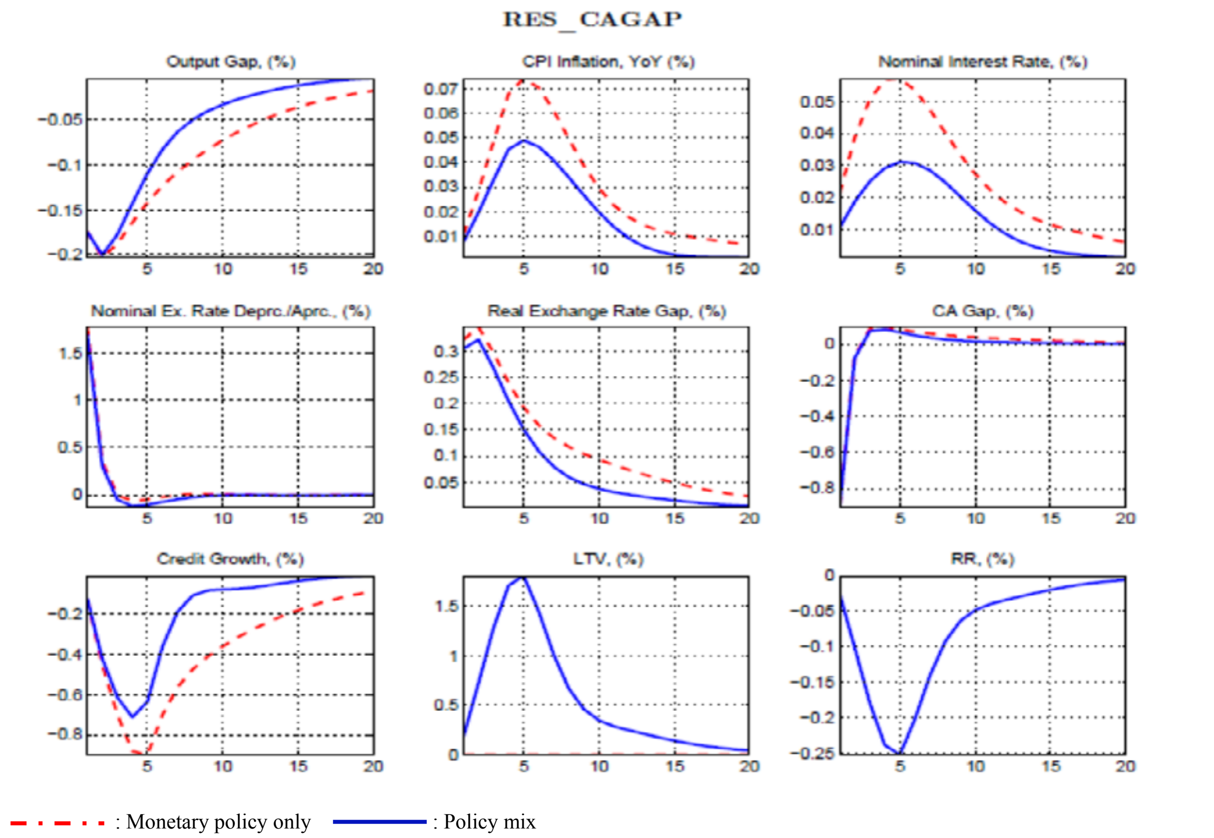
Indonesia to lower the LTV ratio and raise the RR. Here we see that Bank Indonesia responds to the world interest rate shock with an appropriate policy mix. Accordingly, monetary policy is directed towards stabilising domestic inflation, while macroprudential policy would be used to control credit growth. The simulations show that using a policy mix would lessen fluctuations amongst economic and financial variables.

c) *Widening current account deficit*

Bank Indonesia faces the challenge of a large current account (CA) deficit, peaking at more than 4% of GDP in the previous period. A 1% drop in the CA gap (widening CA deficit) would undermine economic growth as the current account (CA) represents net exports, which is a component of GDP. Weaker net exports would clearly undermine GDP and the shock would also slow real credit growth, appearing as an impact of the decline in the CA gap on liquidity and as a result of a lower output gap. Ultimately, a decline in real credit growth would prompt Bank Indonesia to raise the LTV ratio and lower the RR ratio. Meanwhile, mounting macro risk due to the shock would cause the rupiah to depreciate and contribute to higher inflation, prompting Bank Indonesia to raise its policy rate. That combination of outcomes would also precipitate capital outflows. The impact of a drop in the CA gap would demand vigilance, with the balance of payments experiencing reinforcing pressures from both the current account and capital account. A depreciating rupiah constitutes an optimal response to restore the external sector because it would support current account adjustments. The simulations show that it would be better for Bank Indonesia to respond to the multitude of challenges through an appropriate policy mix.

IRF – Current account gap shock

Graph 3.6

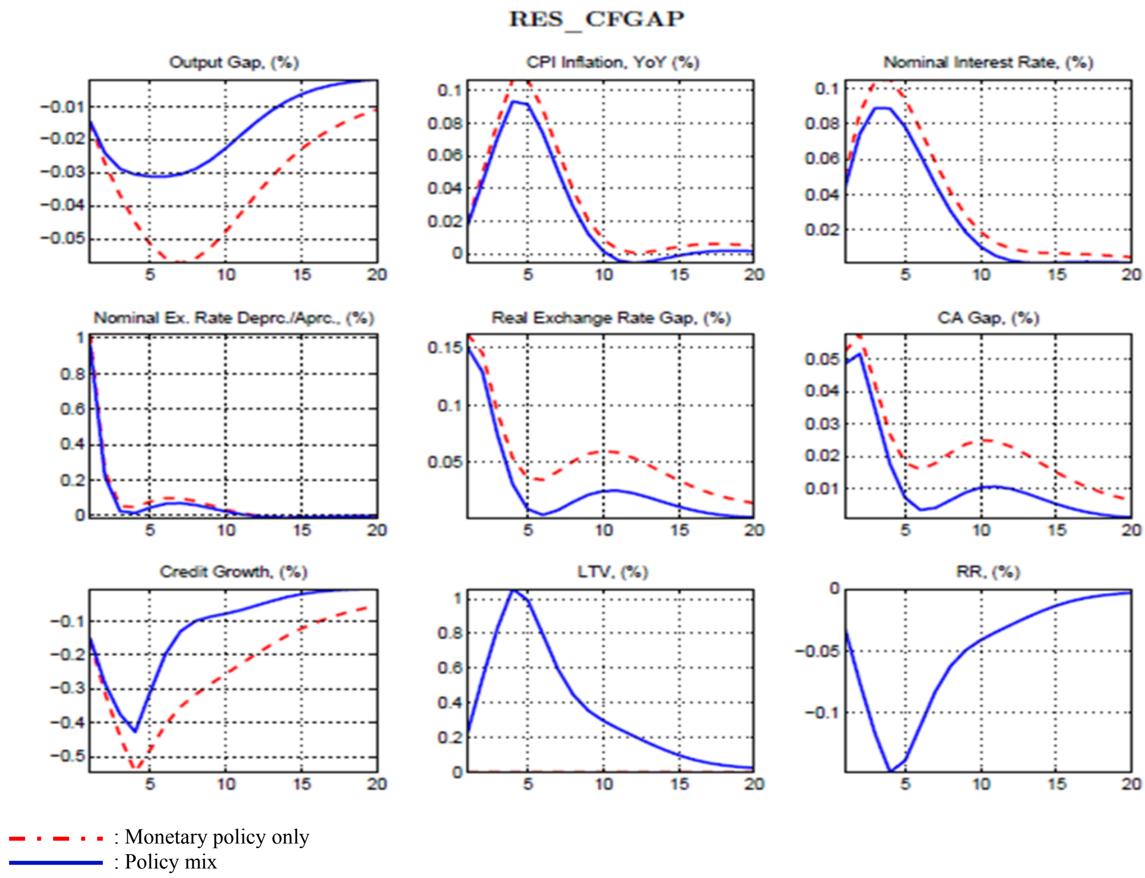


d) Capital outflow

The risk of a sudden reversal following large capital inflows seems to be a serious threat, as experienced by Indonesia due to the 1997–98 crisis. A shock in the form of a 1% drop in the capital flow (CF) gap would reduce real credit growth, following a decline in liquidity flowing into the domestic economy. A substantial deceleration in real credit growth would reduce the output gap due to the presence of a financial accelerator, thus triggering a further decline in real credit growth. Subsequently, the fall in real credit growth would prompt Bank Indonesia to raise the LTV ratio and lower the reserve requirement (RR). The drop in the CF gap would eventually cause the rupiah to depreciate, both in nominal and real terms, inducing higher domestic inflation and compelling the central bank to raise its policy rate. The simulations show that a policy mix is more optimal than monetary policy alone when managing monetary and financial stability.

IRF – Capital flow gap shock

Graph 3.7



4. Conclusion

As the Indonesian economy is becoming progressively more integrated with the world economy, the impact of global shocks on the domestic economy are becoming increasingly pronounced. The influx of capital to the domestic economy, which triggers excessive liquidity and exacerbates the risk of sudden reversal, poses a serious threat to the Indonesian economy, especially in terms of financial stability. Recent crisis episodes have indicated that monetary policy alone is insufficient to maintain macroeconomic stability; it needs to be accompanied by macroprudential policy. Against the backdrop of a dynamic global environment, the multitude of challenges confronting the Indonesian economy demand a policy mix response utilising multiple instruments. To that end, a flexible ITF is considered more suitable than the standard ITF in terms of managing monetary and financial stability in Indonesia as well as dealing with the dynamics of the financial and external sectors. Using the framework, Bank Indonesia could mitigate the impact of external shocks and simultaneously maintain both monetary and financial stability.

This paper finds that the integration of monetary and macroprudential policy provides better results in terms of mitigating excessive macroeconomic (output) and financial sector (credit) fluctuations, as compared with any single policy instrument. By modelling the financial block, the model is better able to capture Indonesian economic dynamics in both the real sector and financial sector, including procyclicality and the presence of a financial accelerator.

More comprehensive external sector modelling provides increasingly accurate analysis of several issues that occur in Indonesia's external sector. External sector dynamics, namely shocks affecting the exchange rate, current account and capital flows, have a significant impact on macroeconomic stability in Indonesia. The model has proved itself useful in helping Bank Indonesia to formulate an appropriate policy mix to mitigate the adverse effects of external shocks.

References

Agung, J (2010): "Integrating monetary and macroprudential policy: towards a new paradigm of monetary policy in Indonesia after the global crisis", *Bank Indonesia Working Paper*, no WP/07/2010.

Altunbas, Y, L Gambacorta and D Marques-Ibanez (2009): "An empirical assessment of the risk-taking channel", Paper presented on the BIS-ECB Workshop on Monetary Policy and Financial Stability, Basel, September.

Angelini, P, S Neri and F Panetta (2011): "Monetary and macroprudential policies", *Bank of Italy Working Papers*, no 801, March.

Ball, L (1999): "Policy rules for open economies", in J Taylor (ed), *Monetary Policy Rules*, University of Chicago Press.

Bank Indonesia (2011): *Strengthening Monetary Policy Framework in Indonesia: Flexible Inflation Targeting Framework*, October.

Beau, D, L Clerc and B Mojon (2011): "Macro-prudential policy and the conduct of monetary policy", *Bank of France Working Paper*, January.

Bernanke, B, M Gertler and S Gilchrist (1996): "The financial accelerator and the flight to quality", *The Review of Economics and Statistics*, vol 78, no 1, February.

Borio, C, C Furfine and P Lowe (2001): "Procyclicality of the financial system and financial stability: issues and policy options", *BIS Papers*, no 1.

Borio, C (2003): "Towards a macroprudential framework for financial supervision and regulation?", *BIS Working Papers*, no 128, December.

Borio, C and H Zhu (2008): "Capital regulation, risk-taking, and monetary policy: a missing link in the transmission mechanism?", *BIS Working Papers*, no 268, December.

Capistrán, C, G Cuadra and M Ramos-Francia (2011): "Policy response to external shocks: lessons from the crisis", *Bank of Mexico Working Papers*, no 2011-14, December.

Cúrdia, V and M Woodford (2009): "Credit spreads and monetary policy", *NBER Working Paper Series*. no 15289, August.

De Nicolò, G, G Dell'Ariccia, L Laeven and F Valencia (2010): "Monetary policy and bank risk taking", *IMF Staff Position Note*, SPN/10/09, July.

Galati, G and R Moessner (2011): "Macroprudential policy – a literature review", *BIS Working Papers*, no 337, February.

Gerali, A, S Neri, L Sessa and F-M Signoretti (2010): "Credit and banking in a DSGE model of the euro area", *Bank of Italy Working Papers*, no 740, January.

Gertler, M and P Karadi (2011): "A model of unconventional monetary policy", *Journal of Monetary Economics*, vol 58.

Ghosh, A, M Goretti, B Joshi, U Ramakrishnan, A Thomas and J Zalduendo (2008): "Capital inflows and balance of payments pressures—tailoring policy responses in emerging market economies", *IMF Policy Discussion Paper*, no PDP/08/2, June.

Harmanta, Tarsidin, M Bathaluddin and Idham (2013): "ARIMBI with macroprudential policy", Revised Edition (not published), *Bank Indonesia Working Paper*, no WP/1/2013, October.

Harmanta, Tarsidin, Idham and A Rachmanto (2015): "ARIMBI 2015", (not published). *Bank Indonesia Research Paper*, no LHP/1/DKEM/2015, June.

Issing, O (2003): "Monetary and financial stability – is there a trade-off?", speech at the BIS Annual Conference on Monetary Stability, Financial Stability and the Business Cycle, Basel.

Juhro, S (2014): "The linkages between monetary and financial stability: some policy perspectives", *Bank Indonesia Occasional Paper*, March 2014.

——— (2015): "The role of the central bank in promoting sustainable growth: perspectives on the implementation of flexible ITF in Indonesia", Paper presented in the CCBS/BoE-Columbia University Joint Seminar on Inflation Targeting, New York, April.

Juhro, S and M Goeltom (2015): "Monetary policy regime in Indonesia", in A Kohsaka (ed), *Macro-Financial Linkages in the Pacific Region*, Routledge.

Lee, J, G Milesi-Ferretti, J Ostry, A Prati and L Ricci (2008): "Exchange rate assessments: CGER methodologies", *IMF Occasional Paper*, no 261.

Peñaloza, D (2011): "In the quest of macroprudential policy tools", *Bank of Mexico Working Paper*, March.

Siregar, R (2011): "The concepts of equilibrium exchange rate: a survey of literature", *SEACEN Staff Paper*, no 81, April.

Svensson, L (1998): "Open-economy inflation targeting", *Journal of International Economics*, no 50, November.

Taylor, J (2001): "The role of the exchange rate in monetary-policy rules", *American Economic Review*, vol 91, no 2, May.

Unsal, D (2011): "Capital flows and financial stability: monetary policy and macroprudential responses", *IMF Working Paper*, no WP/11/189, August.

Wimanda, R, Tarsidin, T Winarno and Idham (2013): "ARIMBI with extended external sector", (not published). *Bank Indonesia Working Paper*, no WP/2/2013, December.

Appendix 1

Macroprudential measures in Indonesia

Period of 2010–15 Table A1

Period	Measures
July 2010	Minimum holding period on BI bills, one-month holding period.
July 2010	Introduce non-tradable rupiah term deposits for banks.
Nov 2010	Increase the primary rupiah reserve requirement from 5% to 8%, effective from June 2011.
Jan 2011	Reinstate limits on short-term offshore borrowing by banks • Maximum of 30% of capital; • Effective end of January 2011 with a three-month transition period.
March 2011	Increase the FX reserve requirements on banks from 1% of FX deposits to 5%, effective from March 2011.
March 2011	Impose the LDR-based reserve requirement.
Jan 2011	Lengthen (from weekly to monthly) auctions and offer longer maturity (three, six and nine months) for BI bills.
May 2011	Introduce a six-month holding period for BI bills.
June 2011	Increase the FX reserve requirement from 5% to 8%.
Sept 2011	Mandatory reporting of foreign exchange originating from export earnings.
March 2012	Loan-to-value (LTV) ratio for the property sector (max 70%)
Dec 2012	Mandatory reporting of foreign exchange originating from export earnings. • Adjustment of the deadline for receipt; • Limiting the difference between the report and the value based on the declaration of exported goods
Sept 2013	• LTV for second property 60%; • LTV for third property 50%.
Sept 2013	Secondary reserve requirement raised from 2.5%: • to 3% from 1 to October 31, 2013. • to 3.5% of from November 1 to December 1, 2013 • to 4% from December 2, 2013.
Sept 2013	Adjustments of LDR-based reserve requirement • The upper limit of the LDR-based RR was reduced from 100% to 92%; • The lower limit remained at 78%; • Disincentives imposed on banks with an LDR ratio above 92% and CAR of less than 14% • Disincentives is also imposed on banks that have LDR less than 78%
June 2015	LTV ratio for property sector: • LTV for first property 80%; • LTV for second property 70%; • LTV for third property 60%. Down payments (DP) for automobiles (min 25%), for commercial vehicles (min 20%) and for motorcycles (min 20%).
June 2015	Adjustments to LDR-based reserve requirement: • Redefinition: to include bank securities in the calculation. LDR to be renamed to Loan-to-Funding Ratio (LFR); • Commencing August 2015, the upper limit of LFR permitted at 94% if the bank fulfils an NPL ratio < 5%.

Appendix 2

Bank Indonesia's Core Model (ARIMBI)

Block 1: The real sector and monetary policy

There are four main equations, namely IS – output gap, inflation – NKPC, the Taylor rule and Uncovered Interest Parity (UIP). The four equations represent a macroeconomy or real sector.

IS – Output gap

$$\hat{y}_t = \beta_1 \hat{y}_{t-1} + \beta_2 \hat{y}_{t+1} - \beta_3 \hat{r}_t + \beta_6 \widehat{dcr}_t + \beta_7 \widehat{ca}_t + e_t^{\hat{y}} \quad \text{A2.1}$$

The output gap ($\hat{y}$) represents the size of the disparity between real GDP and its potential level. It is determined by the output gap in the previous period, its value in the next period, real interest rate gap ($\hat{r}$), credit growth gap ($\widehat{dcr}$) and current account (CA) gap ($\widehat{ca}$). The credit growth gap ($\widehat{dcr}$) is added to reinforce the correlation between the macroeconomy and the financial block. The addition of this variable is necessary considering that the dynamics of real credit volume growth (that subsequently affect the output gap) cannot be fully represented by real interest rate gap ($\hat{r}$). Other factors also influence real credit volume growth. Therefore, it would be more appropriate to directly input the impact of real credit volume growth into the output gap equation. On the other hand, investment not only stems from or is financed through credit but also through direct investment, the magnitude of which is determined by the real interest rate gap. Meanwhile, the CA gap represents the level of exports and imports, which is modelled in detail in the external sector. A positive CA gap increases the output gap.

Inflation – NKPC

$$\pi_t^{CPI} = w^{adm} \pi_t^{adm} + (1 - w^{adm}) \pi_t^{net} + e_t^{\pi^{CPI}} \quad \text{A2.2}$$

$$\pi_t^{net} = \lambda_1 \pi_{t-1}^{net} + (1 - \lambda_1) E_t \pi_{t+1}^{net} + \lambda_3 \hat{y}_t + \lambda_4 \hat{z}_t + e_t^{\pi^{net}} \quad \text{A2.3}$$

The first equation represents CPI inflation and its components, while the second is NKPC. The CPI inflation (π^{CPI}) is formed by two components, ie administered price inflation (π^{adm}) and core inflation (π^{net}), including volatile food inflation. The NKPC shows that inflation is determined by its value in the previous period, its expected value, output gap ($\hat{y}$), and real exchange rate gap ($\hat{z}$). We can see that it is a forward-looking specification of inflation and shows the significance of inflation expectation. Meanwhile, the output gap represents the level of inflation pressure in which a higher output gap indicates more intense inflationary pressures. The variable of the real exchange rate gap represents sources of inflation from abroad, ie exchange rate pass-through to inflation from imported goods.

Monetary policy – Taylor rule

$$i_t = \gamma_1 i_{t-1} + (1 - \gamma_1)(\bar{\imath}_t + \gamma_2 \hat{\pi}_t^{CPI} + \gamma_3 \hat{y}_t) + e_t^i \quad \text{A2.4}$$

The Taylor rule is determined by value of the policy rate in the previous period, its long-term trend ($\bar{\imath}$), inflation gap ($\hat{\pi}^{CPI}$) and output gap ($\hat{y}$). It is a standard Taylor rule. Bank Indonesia responds to the inflation gap (deviation of inflation expectation from its target) and output gap. There is no real exchange rate variable in the equation, in line with ITF, where the exchange rate is free-floating in nature.

Uncovered interest parity

$$i_t - i_t^* = E_t DS_t + prem_t \tag{A2.5}$$

The UIP equation shows that it holds when the interest rate differential ($i - i^*$) is the same as the summation of expected nominal exchange rate depreciation/appreciation (EDS) and risk premium ($prem$). The expected nominal exchange rate appreciation/depreciation is calculated by comparing the expected nominal exchange rate level (S^e) and the actual current nominal exchange rate level (S). The expected nominal exchange rate level is calculated based on the exchange rate level in the period t + 1 and t – 1, with the addition of a drift that is twice the nominal exchange rate appreciation/depreciation trend. Meanwhile, risk premium represents the amount of premium asked by investors to invest in domestic assets.

Block 2: The financial block and macroprudential policy

There are three equations in the financial block, namely the credit growth gap equation, the interest rate spread gap equation and the default risk gap equation. Three additional equations were included because when an economy experiences a boom/bust episode, real credit growth increases/decreases, accompanied by an increase/decrease in default risk. Meanwhile, inclusion of the interest rate spread gap equation is required to capture the dynamics of lending rates, considering that the core equations does not include lending rate as its variable. The equations refer to Peñaloza (2011), with some modification.

Credit growth gap

$$\widehat{dcr}_t = \delta_1 \widehat{dcr}_{t-1} + (1 - \delta_1)\big(-\delta_2 \hat{r}_t - \delta_3 \widehat{spread}_t + \delta_4 \hat{y}_t + \delta_5 \widehat{ltv}_t - \delta_6 \widehat{rr}_t + \delta_7 \widehat{ca}_{t-1} + \delta_8 \widehat{cf}_t - \delta_9 \widehat{\Upsilon}_t\big) + e_t^{dcr} \tag{A2.6}$$

The credit growth gap ($\widehat{dcr}$) indicates the size of disparity between real credit volume growth and potential real credit volume growth. The credit growth gap is determined by the credit growth gap in the previous period as well as by the real interest rate gap ($\hat{r}$), the interest rate spread gap ($\widehat{spread}$) and output gap ($\hat{y}$). A wider real interest rate gap implies a correspondingly narrower credit growth gap, and a wider spread gap leads to a narrower credit growth gap. On the other hand, a larger output gap will exacerbate the credit growth gap. Meanwhile, a narrow credit growth gap is also the result of macroprudential variables, in this instance LTV and RR. Moreover, a wider LTV gap ($\widehat{ltv}$) will broaden the credit growth gap. Conversely, a wider RR gap reduces loanable funds and thereby narrows the credit growth gap. Escalating default risk will also precipitate a narrower credit growth gap as banks opt to hold their credit allocation. However, considering that default risk is already implicitly represented by spread (which indicates that higher lending rates tend to escalate default risk) and output gap (which denotes that a larger output gap leads to lower default risk), default risk no longer appears in the credit growth gap equation.

A balance of payments (BOP) surplus/deficit is added to the credit growth gap equation, represented by the total of the CA gap and CF gap. The inclusion of the BOP variables intends to capture the impact of more/less liquidity in the economy stemming from the external sector. The combination of the variables, CA gap and CF gap, in the credit growth gap equation can be expressed as a single variable, namely the BOP surplus/deficit. However, in order to accommodate differences between the characteristics of the current account and capital flows with regards to their impact on liquidity, a lag is applied to the CA gap, while the CF gap has no lag.

Interest rate spread gap

$$\widehat{spread}_t = \nu_1 \widehat{spread}_{t-1} + (1-\nu_1)\nu_2 \widehat{def}_t + e_t^{spread} \qquad \text{A2.7}$$

The interest rate spread gap equation ($\widehat{spread}$) shows that the gap between the lending rate and deposit rate is not only determined by the spread gap in the previous period but also by the default risk gap ($\widehat{def}$) faced by the banks. In addition to the range of variables previously mentioned, the interest rate spread gap is also affected by the bank market structure. This, for instance, is observable based on the fact that the wide spread in Indonesia, amongst others, is attributable to monopolistic competition in terms of market structure. However, considering that the bank market structure has remained relatively unchanged in the near term (one to two years), the variable of bank market structure is omitted from the model.

Default risk gap

$$\widehat{def}_t = \theta_1 \widehat{def}_{t-1} + (1-\theta_1)\left(\theta_2 \widehat{spread}_t + \theta_3 \widehat{dcr}_{t-1} - \theta_4 \hat{y}_t + \theta_5 \hat{\Upsilon}_t\right) + e_t^{def} \qquad \text{A2.8}$$

The default risk gap equation ($\widehat{def}$) indicates that the default risk gap is determined by the default risk gap in the previous period, the interest rate spread gap ($\widehat{spread}$), credit growth gap ($\widehat{dcr}$) in the previous period and the output gap ($\hat{y}$). A wider spread gap leads to greater pressures on the cost of capital faced by the customer, which will clearly intensify default risk. Meanwhile, a higher credit growth gap increases the likelihood of default. Conversely, a larger output gap ameliorates business conditions and eases default risk as the economy experiences robust growth. Gross non-performing loans (NPL) data are used as a proxy for default risk gap, which reveals the level of risk faced by the bank (and the requested premium).

Macroprudential rule

Macroprudential policy can constitute a separate policy, in other words macroprudential policy and monetary policy are independent. Notwithstanding, macroprudential policy can be incorporated into monetary policy, explicitly using the augmented Taylor rule or implicitly through variables in the Taylor rule. Interaction between macroprudential policy and monetary policy must be modelled accurately, considering that the effect of such interaction can be complementary, neutral/independent or indeed conflicting. In this case, modelling macroprudential policy and monetary policy falls under the auspices of Bank Indonesia.

There are two macroprudential tools in the model, namely the LTV ratio and the reserve requirement (RR), which are modelled together. In the macro model, the macroprudential instrument mechanism of the RR resembles the LTV. The current LTV regulation has a direct effect on mortgages and automotive loans, and ultimately influences total credit. The reserve requirement affects total credit through its impact on loanable funds. In the model, both macroprudential tools respond to total credit.

LTV rule

LTV policy intends to limit the provision of credit/financing by banks when an economy is experiencing boom conditions and, conversely, expand the allocation of credit/financing when an economy is in recession. Limits are placed on credit availability, where banks are only permitted to extend credit up to the specified LTV ratio, and, on the other hand, households and the corporate sector are only allowed to borrow up to the prevailing LTV ratio. Thus, LTV ratio intends to control the pace of credit growth. If the credit growth gap widens, LTV will need to be lowered in order to curb credit growth. To this end, an LTV rule is required as follows:

$$\widehat{ltv}_t = \mu_1 \widehat{ltv}_{t-1} + (1-\mu_1)\left(-\mu_2 \widehat{dcr}4_t\right) + e_t^{ltv} \qquad \text{A2.9}$$

RR rule

The reserve requirement ratio (RR) is fundamentally designed to manage the amount of loanable funds. This can be achieved, for example, by raising/lowering the reserve requirement at times when the economy is facing excess/insufficient liquidity. The reserve requirement is countercyclical in nature and helps control procyclicality in the financial sector, thereby avoiding excessive credit growth. The dynamic reserve requirement refers to the following rule:

$$\widehat{rr}_t = \kappa_1 \widehat{rr}_{t-1} + (1-\kappa_1)\kappa_2 \widehat{dcr}4_t + e_t^{rr} \qquad \text{A2.10}$$

Block 3: The external block and exchange rate policy

There are three equations in the external block, namely the current account (CA) gap equation, the capital flow (CF) gap equation and several equations representing the rest of the world. As mentioned previously, the CA gap is the difference between the CA to GDP ratio and CA norms. Meanwhile, the CF gap is the difference between the CF to GDP ratio and the optimum level of CF. CA norms are calculated by regressing the variable CA to GDP ratio against the fundamental variables of an economy, applying the Macroeconomic Balance Approach cited by Lee et al. (2008). In contrast, an approach to calculate the optimal level of capital flows is yet to be determined. There are only depictions of an optimal CF to GDP ratio in relation to the CA to GDP ratio, as quoted by Ghosh et al (2008).

Current account gap

$$\widehat{ca}_t = \vartheta_1 \widehat{ca}_{t-1} + (1-\vartheta_1)(\vartheta_2 \hat{z}_t - \vartheta_3 \hat{y}_t + \vartheta_4 \hat{y}_t^*) + e_t^{\widehat{ca}} \qquad \text{A2.11}$$

The equation of the current account gap ($\widehat{ca}$) shows the size of the gap between the CA to GDP ratio and CA norms. This variable is influenced by the previous current account gap, real exchange rate gap ($\hat{z}$), output gap ($\hat{y}$) and global output gap ($\hat{y}^*$). As the real exchange rate gap increases (depreciates), the current account gap also increases, while a higher output gap will result in a lower current account gap (considering its impact on higher imports). On the other hand, a larger global output gap (representing external/foreign demand) will exacerbate the current account gap (considering its impact on higher exports).

Capital flow gap

$$\widehat{cf}_t = \phi_1 \widehat{cf}_{t-1} + (1-\phi_1)\left(\phi_3(i_t - i_t^* - (\phi_2 EDS_{t-1} + (1-\phi_2)EDS_t) - prem_t) + \phi_4 \hat{y}_t - \phi_5 \hat{y}_t^* - \phi_6 \hat{\Upsilon}_t\right) + e_t^{\widehat{cf}} \qquad \text{A2.12}$$

The capital flow gap equation ($\widehat{cf}$) indicates the magnitude of the gap between the CF to GDP ratio and the optimum level of CF. This variable is driven by the previous capital flow gap, uncovered interest rate parity (UIP), output gap ($\hat{y}$) and global output gap ($\hat{y}^*$). A higher domestic nominal interest rate will attract capital flows (increasing the capital flow gap), while a higher global nominal interest rate will trigger foreign capital outflows (reducing the capital flow gap), and higher expected exchange rate depreciation will also lead to foreign capital outflows (reducing the capital flow gap). Conversely, a greater level of risk in Indonesia will prompt foreign capital outflows (lowering the capital flow gap). In this case, it is assumed that UIP will not hold because of a lag in the formation of expected nominal exchange rate appreciation/depreciation.

An increase in the output gap represents improvements in the economy of Indonesia and will attract foreign capital (increasing the capital flow gap). Meanwhile, a larger global output gap denotes improvements in the global economy, thereby diverting foreign capital from Indonesia (reducing the capital flow gap). Considering the Indonesian economy is affected by improvements in the global economy, the impact on capital flows is sometimes mixed, depending on the most dominant factor.

It should be emphasised here that the CA gap and CF gap were brought back to their optimal path (where the gap is zero) through appreciation/depreciation of the nominal and real exchange rates and adjustments to other influencing variables. Furthermore, there is no policy to control capital flow in this model. The CF gap equation shows that capital moves freely depending on its determinants. However, some shocks can be added to the model to capture the impact of BI regulations on capital movements.

Rest of the world

$$\hat{y}_t^* = \beta f_1 \hat{y}_{t-1}^* + \beta f_2 \hat{y}_{t+1}^* - \beta f_3 (r_t^* - \overline{r_t^*}) + e_t^{\hat{y}*} \quad \text{A2.13}$$

$$\pi_t^* = \lambda f_1 \pi_{t-1}^* + (1 - \lambda f_1) E_t \pi_{t+1}^* + \lambda f_3 \hat{y}_t^* + e_t^{\pi^*} \quad \text{A2.14}$$

$$i_t^* = \gamma f_1 i_{t-1}^* + \left(1 - \gamma_{f1}\right)\left(\bar{r}_t^* + \pi 4_{t+3}^* + \gamma f_2 (\pi 4_{t+4}^* - \pi_{ss}^*) + \gamma_{f3} \hat{y}_t^*\right) + e_t^{i*} \quad \text{A2.15}$$

The rest of the world equations consist of world IS – output gap, world inflation – NKPC and the world Taylor rule. It is a simple model of the world economy and a representation of what central banks do in response to shocks of world inflation and GDP. In addition, there is a residual in each equation to represent an external shock. As required, covariance shocks could be added to ensure a more appropriate magnitude of external shocks.

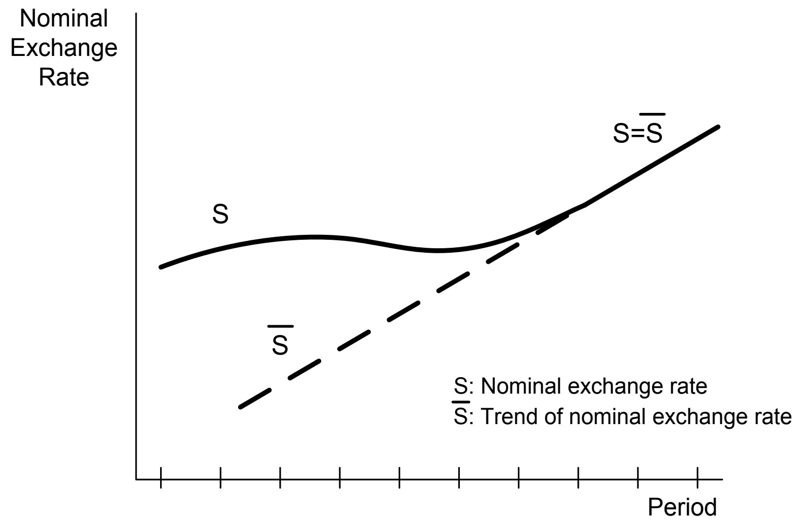
Bank Indonesia actively responds to external sector dynamics, such as through foreign exchange market intervention and capital flow management. Even though Bank Indonesia's exchange rate regime is free floating, the rupiah exchange rate is actually managed in line with economic fundamentals and to be less volatile. By intervening on the foreign exchange market, Bank Indonesia adheres to the exchange rate policy framework, which is continuously developed in line with the current issues and challenges.

The Indonesian economy is not currently at an external balance, as indicated by a current account (CA) deficit that surpassed 4.27% in second quarter of 2014. On the other hand, the Indonesian economy is nearly close to its internal balance, which is demonstrated by the low level of unemployment (around 5.7% in February 2014) as well as low and stable inflation (3.99% in August 2014, in line with the inflation target of 4.5%$\pm$ 1%). Internal and external balance cannot be achieved with rapidity, it should be achieved gradually over a sufficiently long horizon, for example five years. In the near term, however, Bank Indonesia should seek to achieve favourable economic conditions, while simultaneously pursuing the internal and external balance.

Bank Indonesia policy does not aim to achieve internal and external balance immediately but to achieve it optimally, which requires a rupiah exchange rate path that responds favourably to current economic conditions and concomitantly seeks the internal and external balance. This is not a medium-term fundamental exchange rate path (ie an exchange rate path that is consistent with the internal and external balance). If Bank Indonesia sticks to the medium-term fundamental exchange rate path; the economy would be forced to adjust drastically to the internal and external balance, which could trigger macroeconomic instability as the exchange rate is distorted from its optimal level. An optimal exchange rate level must be consistent with macroeconomic and financial variables at their fundamental value. Therefore, Bank Indonesia should maintain the rupiah exchange rate in line with short-term fundamentals, while simultaneously aiming for the medium-term fundamental exchange rate path. The optimal exchange rate path is consistent with attaining the inflation target as outlined by the flexible ITF.

Bank Indonesia's exchange rate policy is basically a combination of responding to current economic conditions while gradually shifting the economy back to its internal and external balance. If no other shocks occur in the near term (about one to two years), the short-term fundamental exchange rate path will be the same as the medium-term fundamental exchange rate path, resembling the concept of permanent equilibrium exchange rate (PEER), in which there are responses to both temporary and permanent shocks. The path is depicted in Graph A2.1, in which there are two exchange rate paths, ie nominal exchange rate trend values ($\bar{S}$, broken straight line) and Bank Indonesia's exchange rate policy path (S, solid curve line).

Path of exchange rate policy Graph A2.1



In the ARIMBI model, dz represents short-term fundamental (real) exchange rate depreciation/appreciation, while $\overline{dz}$ represents medium-term fundamental (real) exchange rate depreciation/appreciation. Meanwhile, in nominal terms it is represented by DS and $\overline{DS}$. In the model, the exchange rate is modelled as it depreciates/appreciates over time. In the model, the nominal and real exchange rates are determined based on the uncovered interest parity (UIP) and purchasing power parity (PPP) equations as follows:

Uncovered interest parity

$$i_t - i_t^* = EDS_t + prem_t \qquad \text{A2.16}$$

Purchasing power parity

$$dz_t = (DS_t + \pi_t^*) \quad - \pi_t \qquad \text{A2.17}$$

where:

trend of real exchange rate depreciation/appreciation:

$$\overline{dz_t} = \overline{dzgrowth_t} + \iota_1 \widehat{\Upsilon}_t - \iota_2\left(\widehat{ca}_{t-1} + \widehat{cf}_t\right) + e_t^{\overline{dz}} \qquad \text{A2.18}$$

From both the UIP and PPP equations, several determinants of nominal and real exchange rates are observed in the model, ie (i) interest rate differential (considering expected nominal exchange rate depreciation/appreciation and risk premium), (ii) terms of trade (represented by domestic and world inflation), (iii) risk (Υ), and (iv) net foreign assets represented by current account gap ($\widehat{ca}$) and capital flows gap ($\widehat{cf}$). Higher risk leads to greater exchange rate depreciation. On the other hand, larger net foreign assets would lead to exchange rate appreciation.

Block 4: Macro risk and the risk-taking channel

In the model, we endogenise variables of risk in order to capture the role of risk perception, using the International Country Risk Guide (ICRG) index as a proxy. The risk is called macro risk to represent risk at the macro level and modelled as follows:

$$\widehat{\Upsilon}_t = \eta_1 \widehat{\Upsilon}_{t-1} + (1 - \eta_1)\left(-\eta_2 \hat{y}_t + \eta_3 \hat{\pi}_t^{CPI} + \eta_4 \hat{z}_t - \eta_5 \widehat{ca}_t + \eta_6 \widehat{def}_t\right) + e_t^{\widehat{\Upsilon}} \qquad \text{A2.19}$$

From the equation, we notice that the level of macro risk in the previous period determines macro risk along with the output gap ($\hat{y}$), inflation gap ($\hat{\pi}^{CPI}$), real exchange rate gap ($\hat{z}$), current account gap ($\widehat{ca}$) and default risk gap ($\widehat{def}$). A higher output gap would induce lower macro risk, while a higher inflation gap would raise macro risk. On the other hand, real exchange rate depreciation would raise macro risk in a similar way to a deteriorating current account. In the financial sector, higher default risk would escalate macro risk.

The determinants of macro risk are basically composed of macroeconomic and financial variables. Furthermore, macro risk influences other variables in the model. Its impact not only affects real exchange rate depreciation/appreciation but also the credit growth gap (called the risk-taking channel), default risk gap, risk premium and capital flow gap.

Comments on "Managing monetary and financial stability in a dynamic global environment: Bank Indonesia's policy perspectives"

Iikka Korhonen[1]

Summary

The paper comprises two distinct parts. The first provides an overview of the interaction between traditional monetary policy and various macroprudential policy measures. The second discusses the impact of such policies on the basis of results obtained from Bank Indonesia's macroeconomic model. The paper contains a clearly defined motivation, and the overview segues very well into several applications discussed in the second part of the paper. Indonesia's example is certainly interesting to many other emerging market economies (EMEs) with a relatively free movement of capital.

Comments

Overall, the paper arrives at a relatively optimistic conclusion. With the right mix of monetary policy (broadly speaking) and macroprudential policy measures, it is possible to achieve both low and stable inflation as well as a stable financial system (see Graph 2.3 for an overview of different policy mixes).

The authors are, of course, not alone in reaching such a conclusion. Much of the recent literature points to the same direction, even if it may be too soon to declare the issue settled. For example, Maddaloni and Peydró (2013) review the situation in the euro area after the Great Financial Crisis of 2008–2009 and find that interest rate and macroprudential policies can enhance each other's effects. More specifically, if central banks lean against the wind in their interest rate policy, more active use of macroprudential measures may allow them to keep interest rates lower than they otherwise would need to be. The IMF (2013) arrives at similar conclusions at a more general level.

However, most of the existing literature (with significant exceptions in the current volume, of course) deals with issues of macroprudential policy in advanced economies (AEs). Therefore, potential policy conclusions for EMEs with different institutional arrangements may be limited. I think that the authors could have put greater emphasis on this aspect in their excellent contribution. For example, it is not clear whether the current literature places sufficient emphasis on the effects of exchange rate movements and capital flows on financial stability. In this connection, the paper would benefit from discussing the relative importance of measures relating to domestic lending versus measures of a macroprudential nature relating to the

1 Bank of Finland.

foreign exchange operations of banks. Moreover, it would be interesting for a reader, who may not be so familiar with the situation in Indonesia, to know how often macroprudential measures were changed or implemented by Bank Indonesia, and how those measures were communicated. The latter point is all the more significant given the emphasis placed on communication in current discussions of monetary policy.

In the second part of the paper, the authors discuss the macroeconomic model used to assess effects of monetary policy and macroprudential measures on a vector of outcome variables. As such, the theoretical framework is relatively standard (even if the model is quite complex), and Graph 3.3 provides a good summary of the interrelations within the model. However, a number of issues remain somewhat unclear, and more detailed information would benefit the reader and make the authors' argument more convincing.

First, the definition of the credit gap is somewhat unclear. How is it actually measured? Second, the LTV ratio has a clear effect on mortgage and car lending, but how large is the share of those components on overall bank lending? Third, I would have reservations regarding the quantification of macroeconomic risks. The International Country Risk Guide (ICRG) is well-known, but by no means the only provider of such risk metrics. How often do their risk measures change, for example? If the authors used a different risk metric in their estimation work, would the results change?

Moreover, some aspects of the paper would warrant deeper discussion. First, when there is a shock to the world output gap or the world interest rate, there is almost no difference in the estimated outcomes of whether just monetary policy or monetary policy and macroprudential measures are used together. It would be useful to read why this is so, as this could give us an idea of the limits of macroprudential policy. Second, it is not exactly clear what the current account shock is. Is it the same thing as an exogenous shock to the real exchange rate? Interestingly, in this case a carefully balanced use of monetary policy and macroprudential measures seems to work very well. Third, in the case of a capital account shock an appropriate policy mix works well. However, since the current and capital accounts are basically just two sides of the same coin, it would be beneficial to try to disentangle these two effects.

In a related comment, are there other market-based measures that would help deal with such external shocks? For example, if borrowing in foreign currency provides tax advantages, could policy action be undertaken directly to manage this source of distortion? Can the private sector insure itself better with various derivatives etc?

Concluding remarks

The current paper provides an excellent overview of the recent literature on the interaction between traditional monetary policy and macroprudential measures. It is especially valuable that such an exercise has been done for an EME. It is comforting that most of the conclusions carry over from the literature devoted to more advanced economies. At the same time, the current paper leaves a number of open questions relating to macroprudential policies in EMEs, especially when the banking sector is vulnerable to exchange rate movements.

References

International Monetary Fund (2013): "Key aspects of macroprudential policy", *IMF Policy Papers*, no 13, June.

Maddaloni, A and J-L Peydró (2013): "Monetary policy, macroprudential policy, and banking stability: evidence from the euro area", *International Journal of Central Banking*, vol 12, no 3, pp 121–167.

Monetary independence in a financially integrated world: what do measures of interest rate co-movement tell us?

Enisse Kharroubi and Fabrizio Zampolli*

Abstract

Does global financial integration reduce the independence of monetary policy or its effectiveness? Do flexible exchange rates offer sufficient insulation from foreign monetary and financial developments? To provide an answer to these questions, this paper summarises the outcome of ongoing research conducted at the BIS on the measurement of co-movements in short- and long-term interest rates across countries. The sensitivities of domestic short-term interest rates to their foreign counterparts are found to be increasing in financial openness and exchange rate stability, as predicted by Mundell's trilemma hypothesis. By contrast, long-term yield sensitivities are increasing in financial openness, but their relationship with exchange rate stability is non-monotonic. Excluding pegged exchange rates or very stable currencies, which display a high degree of sensitivity, the relationship for other currencies is negative: that is, a more volatile exchange rate is associated with larger long-term interest rate spillovers from core countries. Estimates of domestic short- to long-run interest rate pass-through also show that greater exchange rate flexibility does not necessarily translate into stronger control of the long end of the yield curve.

Keywords: Mundell's trilemma, international monetary and financial system, government bond yields, interest rate spillovers, interest rate pass-through

JEL classification: E52; F42; G15; O57.

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1. Introduction

With the global financial system becoming more complex and integrated than ever,[1] doubts have emerged concerning the ability of central banks to control domestic monetary and financial conditions by running an independent monetary policy. This paper asks whether these concerns are legitimate.

The issue of policy independence can be seen through the lenses of Mundell's trilemma hypothesis (Mundell (1963)).[2] Absent restrictions on capital movement, monetary policy can be independent only if exchange rates are flexible: that is, the more flexible the exchange rate, the larger the scope for a central bank to set its policy rate independently from those prevailing abroad. Alternatively, a country that wants to run an independent monetary policy, but dislikes exchange rate flexibility cannot allow unrestricted capital movements.

That said, greater leeway in setting policy rates does not necessarily amount to greater monetary policy effectiveness. As a result of financial globalisation, domestic monetary and financial conditions may have become more responsive to external financial conditions, even when exchange rates are free to float. Consistent with this view, Rey (2013), and Miranda-Agrippino and Rey (2015) find the existence of a strong global financial cycle, driven largely by monetary policy in the United States and investors' risk aversion (as proxied by a common index of US option-implied stock market volatility, the VIX). Rey (2016) also shows that US monetary policy shocks have a strong influence on credit spreads, output and inflation in a number of AEs operating under floating exchange rate regimes.

While flexible exchange rates have never offered perfect insulation from external developments, greater financial integration may have further diminished their capacity to act as a buffer. For instance, in the presence of significant inflows of foreign currency credit (especially in dollar), currency appreciation may contribute to improve lenders and borrowers' balance sheets, and, through this channel, compress risk premia and boost credit supply (Bruno and Shin (2015), and Hoffman et al (2016)).[3] Such an effect may thus offset any negative impact of appreciation on trade and output.

The influence of external financial conditions may have become so prominent that the trilemma has morphed into a dilemma. In a provocative paper, Rey (2013) argues that without capital controls countries may have very little or no room for setting monetary policy independently. This pessimistic view, however, does not appear to be fully warranted by existing evidence. The finding of a strong global financial cycle is likely to reflect interdependence and common shocks. By itself, it does not tell much about how the autonomy and the effects of monetary policy on

1 For an overview of how the global monetary and financial system has evolved, see Bank for International Settlements (2015).

2 In its simplest formulation, the trilemma hypothesis posits that a country can choose only two of the following three elements of policy: 1) capital mobility; 2) monetary policy independence; or 3) fixed exchange rates. In reality, countries do not face binary choices but trade-offs. For example, without restrictions on capital movements, a country may face a trade-off between exchange rate stability and monetary policy independence. Such a trade-off may improve if a country imposes restrictions on capital movements (see Aizenman (2010) and Aizenman et al (2015)).

3 On the risk-taking channel of monetary policy more broadly, see Borio and Zhu (2012).

domestic financial conditions vary with the degree of the exchange rate flexibility. This is still an open question empirically.

This paper summarises ongoing research bearing on this question. Kharroubi and Zampolli (forthcoming) provide estimates of short- and long-term interest rates co-movements across countries and of short- to long-term rate pass-throughs. They also examine how these estimates vary with the volatility of the exchange rate and measures of capital account openness.

The key findings from Kharroubi and Zampolli (forthcoming) lend support to the view that more flexible exchange rate regimes buy greater monetary independence as predicted by the trilemma hypothesis, but at the potential cost of weaker effectiveness in controlling the longer end of the yield curve. Specifically, country-specific short-term rate sensitivities to core countries are found to be positively related to both financial openness and exchange rate stability, thus confirming results from a number of other recent studies (Shambaugh (2004), Klein and Shambaugh (2013), Obstfeld et al (2005), Obstfeld (2015) and Aizenman et al (2015)).

By contrast, while long-term interest rate sensitivities are increasing in financial openness, their relationship with exchange rate stability is *non-monotonic*: excluding pegged exchange rates or very stable currencies, which display high sensitivity, the relationship for other currencies (including for most EMEs) is negative. That is, a more volatile exchange rate is associated with larger interest rate spillovers from core countries. This is, to the best of our knowledge, a novel finding.[4] A possible interpretation is that the volatility of the exchange rate tends to amplify the response of (local currency) sovereign risk premia to changes in core countries' interest rates. This finding is also confirmed by estimates of domestic short- to long-term rate pass-through: central banks seem to have greater influence on long-term interest rates only at intermediate levels of exchange rate volatility. That is, the pass-through is lower not only for pegged or very stable currencies, but also for the very volatile ones.

The rest of the paper is organised as follows. Section 2 reviews recent studies that have examined interest rate co-movements in an attempt to shed light on the trilemma. Section 3 describes in greater detail the method used in ongoing research (Kharroubi and Zampolli (forthcoming)). Section 4 presents the key results of this research. Section 5 concludes.

2. A glimpse on the recent empirical literature on the trilemma

Monetary policy independence is often identified with the freedom to set policy rates independently of those of other countries. Hence, the most obvious way to test the trilemma assumption is to estimate how strongly short-term interest rates co-move across countries and how the strength of this relationship varies with the degree of exchange rate volatility and capital account openness.

[4] While Obstfeld (2015) finds that the co-movement of long-term interest rates is high regardless of whether a country adopts a pegged or non-pegged exchange rate, he does not show how long-term interest rate sensitivities for non-pegging countries affect the volatility of the exchange rate.

In the recent empirical literature on the trilemma (Shambaugh (2004), Obstfeld et al (2005), Klein and Shambaugh (2013), and Obstfeld (2015)), co-movement is usually measured by an estimate of coefficient β in a panel regression of changes in countries' interest rates Δr_{jt} on those of a base or dominant currency Δr_{bt}:

$$\Delta r_{jt} = \beta \Delta r_{bt} + \gamma' x_{jt} + \varepsilon_{jt} \tag{1}$$

where j indicates a generic country and x_{jt} other possible determinants. The latter could also include variables that capture common global influences, such as the VIX index of US stock market volatility. The coefficient β is assumed to vary with an indicator of the exchange rate regime adopted by country j, an indicator of capital account openness and other structural indicators, as summarised by z_{jt}: [5]

$$\beta = \beta_1 + \beta_2 z_{jt} \tag{2}$$

The literature finds support for the trilemma hypothesis. Shambaugh (2004) uses a measure of de facto exchange rate regime – based on the actual volatility of the exchange rate vis-à-vis that of a base country – and finds for a large sample of both AEs and EMEs over the period 1973–2000 that countries which do not peg their exchange rates display significantly less interest rate sensitivity than counties that let their exchange rates float. This finding is robust to controlling for capital account openness. Moreover, controlling for time effects or trade shares does not suggest that trade interdependence or common shocks are important, although common influences may not be fully captured by such variables.

The post-2000 environment of very rapid financial globalisation has not invalidated these earlier findings. Using a more recent sample, Klein and Shambaugh (2013) find that, in the absence of capital restrictions, interest rate sensitivity continues to be larger for peggers than for floaters, with soft pegs providing an intermediate degree of monetary autonomy.[6] They also find that mild restrictions on capital flows do not raise monetary independence much: walls rather than gates may be needed. Furthermore, controlling explicitly for the globalisation of banking does not alter these conclusions. As shown by Goldberg (2013), the exchange rate regime remains by far the most important variable in determining interest rate sensitivity, despite the fact that the share of foreign bank lending in domestic credit supply tends to raise interest rate sensitivity slightly for peggers and floaters.

The analysis of interest rate co-movements within the context of the trilemma literature has been recently extended to long-term yields. Obstfeld (2015) finds that the co-movement of long-term rates under floating exchange rates is quite high and statistically not different from that under pegged exchange rates, whereas the co-movement of short-term interest rates continues to be dependent on the exchange rate regime. This means that central banks may have less control over the long end of the yield curve. Hence, to the extent that the long-term interest rate matters in the monetary transmission mechanism or in reducing financial stability risks, greater financial integration may have worsened the trade-offs currently faced by central banks in small open economies or EMEs.

5 This amounts to estimating a panel regression (1) augmented with interactive terms such as $x_{jt} z_{jt}$. Alternatively, if z_{jt} is an indicator variable, one can assume that all coefficients in (1) vary with z_{jt}.

6 Soft peggers include countries that manage their exchange rate vis-à-vis major countries but keep their exchange rate within a larger band than peggers. See Klein and Shambaugh (2013) for a precise definition.

The method typically used in the cited literature, and summarised by specifications (1) and (2), has at least two potential drawbacks. One concerns the treatment of common factors or shocks. For example, a rise in oil prices and global inflation may lead to a wave of policy rate increases in many oil-importing countries. Similarly, tight trade linkages and other factors may make business cycles more highly synchronised across countries. Failure to control for these common factors may lead to a higher estimate of interest rate co-movements. But this estimate should not be taken as evidence of lack of monetary independence: authorities may choose similar policies because they face similar conditions rather than because they are compelled to do so. Global investors' risk aversion, as captured by the VIX index, is also another important common factor, although it is unclear a priori whether it leads to over- or under-estimating interest rate spillovers (Obstfeld (2015)).

Common influences can be controlled for in regressions such as (1) and (2) by adding time fixed effects or variables known to have a common influence such as the VIX index. Yet, in fixed-coefficient panel regressions, this amounts to assuming that common factors have the same influence on every countries. This is clearly unrealistic and may therefore not be a good approximation in all applications.

Another potential limitation is that these studies do not allow for sufficient country heterogeneity. Their purpose is to compare mean effects among country groups such as peggers versus non-peggers. That is, β in (2) is assumed to be homogeneous across individual countries even if it can hypothetically be significantly different within the same group. If sample size is too small, there may be no alternative. Otherwise, not explicitly allowing for country heterogeneity within similar groups in the analysis may make it more difficult or impossible to uncover economically relevant relationships between the effects of interest rate and country characteristics – for example, when several factors can simultaneously determine the cross-sectional distribution and/or when the relationship is non-linear or of unknown shape. Furthermore, if the effect is sufficiently heterogeneous across countries, using fixed-coefficient panel regressions may lead to econometrically inconsistent estimates (Pesaran and Smith (1995)).

Hence, a natural alternative to estimating a panel regression (1) with interactive terms (2) is to estimate:

$$\Delta r_{jt} = \beta_j \Delta r_{bt} + \gamma_j{}' x_{jt} + \delta_j f_t + \varepsilon_{jt} \tag{3}$$

where the coefficients are allowed to vary by country *j=1,2,…,N*; and f_t is a vector of variables representing common factors (some or all of which may be unobserved).[7] Another advantage is that the common factors are allowed to have a different influence on countries. Provided there are enough countries and sufficiently long time series, (3) can be estimated by running individual regressions for each country *j*. The average of the estimated coefficients would measure the mean effect, similarly to the β estimated in (1)–(2). Most importantly, in a second step the distribution of estimates from (3) can be analysed by running cross-country regressions such as:

$$\beta_j = \varphi_0 + \varphi_1 \bar{z}_j + u_j \tag{4}$$

where $\bar{z}_j$ indicates the set of country characteristics (usually the average of z_{jt} in (2)).

7 In applications, regressions such as (3) may also involve lags of the dependent and independent variables, which are excluded here for presentational simplicity.

In the context of the recent trilemma literature (Aizenman et al (2015)) follow a similar two-step procedure and find that the trilemma is alive and well: not only do policy rates co-move in the direction predicted by the trilemma, but so do equity prices and real effective exchange rates. However, they are not able to draw any firm conclusion on term spreads (ie the difference between the 10-year long-term rate and the policy rate) "because of the consistent lack of robust results". Instead, the findings presented in this paper concern the long-term interest rate.

3. Research method and data

Our ongoing research (Kharroubi and Zampolli (forthcoming)) is closely related to Obstfeld (2015) and Aizenman et al (2015). Like in Obstfeld (2015), the analysis uses a similar reduced-form econometric specification and focuses on both short- and long-term interest rates. There are, however, a few key differences. First, the analysis controls more extensively for common factors. Second, it does not use a fixed coefficient panel regression but estimates country-specific interest rate sensitivities through regressions such as (3). It then runs cross-section regressions such as (4) of the betas on indicators of the exchange rate regime, capital account regime and other controls. Third, unlike Obstfeld (2015), the analysis estimates the pass-through from domestic short- to long-term interest rates. In this case, it controls for the full set of observed and unobserved common factors by adding to the original regression cross-section averages of the dependent and independent variables (Pesaran (2006)). Similarly to Aizenman et al (2015), the analysis adopts a two-step procedure such as the one discussed above, but it is able to draw conclusions on the behaviour of long-term interest rates.

The sample consists of an unbalanced panel of monthly observations over the period M1 1999 to M12 2014 for 49 countries, including both AEs[8] and EMEs.[9] The main variables in the analysis are the short- and the long-term interest rate. The former is a three-month treasury bill rate, if available, or a proximate money market rate. The latter is a 10-year government bond yield. Both are sourced from Global Financial Data (GFD) or, in the absence of GFD data, from Datastream.

In the first step, three types of regression such as (3) are run. The first regresses the domestic *short-term interest rate* on the base country's short-term rate, while the second regresses the domestic *long-term rate* on the base country's long-term rate. Both regressions include as control variables changes in domestic consumer price inflation, in real GDP and in the log of the VIX index.[10] Given the monthly frequency, real GDP is interpolated. Common factors other than the VIX index are controlled for by using changes in oil (or commodity) price inflation, global inflation and global

[8] Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

[9] Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Hong Kong (SAR China), Hungary, India, Indonesia, Israel, Latvia, Mexico, Philippines, Poland, Romania, Russia, Singapore, Slovakia, Slovenia, South Africa, Korea, Thailand, Turkey, Malaysia and New Zealand.

[10] In Obstfeld (2015) control variables include the change in real GDP (rather than the change in GDP growth) and the change in inflation.

output. The third is a regression of the domestic long-term rate on the domestic short-term rate (*pass-through*). This regression uses the same set of domestic variables as controls with the exception of the variables proxying common factors. Instead, following Pesaran (2006), common factors are proxied by adding cross-section averages of the dependent variable as well as of all the regressors.[11] All regressions are specified as autoregressive distributed lag models (Chudik and Pesaran (2015)). Local projections methods (LPs) are then employed to compute impulse response functions directly (Jorda (2005)).

In the second step, the trilemma hypothesis is tested by running a set of *cross-sectional regressions* of the estimated interest rate sensitivities of two indicators. The first is the *Chinn-Ito index of financial openness*, which is compiled on the basis of information provided by the IMF (see Chinn and Ito (2006) and (2008) for details). This is a de jure index that takes on continuous values between 0 and 1 (from perfectly closed to perfectly open, respectively). The second is a de facto *index of exchange rate stability*, also normalised between 0 and 1. It equals 1 if a country is a pegger – that is, if the country keeps its exchange rate vis-à-vis its base country within a band of –/+2%. Alternatively, if the country is not a pegger, the index is inversely related to the annual standard deviation of the monthly change in the country's nominal exchange rate (see Aizenman et al (2010) for details).

Control variables include indicators of macroeconomic performance and stability, such as the average inflation rate, average output growth and the respective volatility of those variables. Additional variables are the average interest rate differential vis-à-vis the base country and its volatility. Intuition suggests that when the interest rate falls in a core country and perceived risk is low, capital may flow more strongly into higher-yielding currencies, putting relatively more pressure on interest rates to decline in such currencies than in lower-yield currencies, other things equal.[12] This process should work in reverse when core countries' interest rates rise. At the same time, a higher volatility of interest rate differentials would act to dampen capital flows and hence create depreciating pressures on receiving countries' asset prices.

11 Pesaran's (2006) method for proxying common factors cannot be applied directly to the first two types of regression. The presence on the right-hand side of a base country's rate makes the country-specific betas, β_j ($j = 1,2,\dots,N$), semi-identified. That is, these coefficients are identified only if the average beta, $\beta = E(\beta_i)$, is known but the latter cannot be estimated directly (see Kharroubi and Zampolli (forthcoming) for details). This problem, instead, does not arise when estimating the domestic short- to long-term interest rate pass-through. In this case the cross-sectional information can be fully exploited to obtain estimates of pass-through that are robust to both observed and unobserved common factors (Pesaran (2006)).

12 High interest rate currencies typically earn a larger excess returns than low interest rate currencies (not explained by expectations of future currency depreciation). Foreign currency assets are riskier from the viewpoint of an investor based in the United States or other major economy, for they tend to depreciate when consumption growth is low and risk aversion is high in the country from which the assets originate (Lustig and Verdelhan (2007) and Lustig et al (2011)).

4. Main findings

The main findings from the ongoing research of Kharroubi and Zampolli (forthcoming) can be summarised as follows.[13]

First, *the sensitivity of short-term interest rates behaves as predicted by the trilemma*. Table 1 shows the outcome of cross-sectional regressions of estimated short-run betas on financial openness and exchange rate stability using regression methods robust to the presence of outliers. These betas are increasing with financial openness and exchange rate stability. This result does not change if the sample is restricted to the pre-crisis period (M1 1999 to M8 2008). The positive association with exchange rate stability is particularly robust to the inclusion of control variables.

Short-run interest rate sensitivity: cross-section regressions

Table 1

	Full period sample:				Pre-crisis period:			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Financial openness	0.9274***	0.3926	1.0980***	0.3932	1.3770***	1.9408***	1.2041**	0.8564
	(0.329)	(0.474)	(0.350)	(0.535)	(0.465)	(0.619)	(0.490)	(0.562)
Exchange rate stability	1.2859***	1.3892***	1.4361***	1.5219***	1.5414***	1.6514***	1.3106**	1.0726**
	(0.316)	(0.320)	(0.329)	(0.352)	(0.472)	(0.504)	(0.502)	(0.495)
Inflation		0.0204		-0.0207		0.2077**		0.0612
		(0.087)		(0.142)		(0.088)		(0.106)
Inflation volatility		-0.0364		-0.0261		-0.1478*		0.0017
		(0.073)		(0.138)		(0.086)		(0.088)
GDP growth		-0.1199*		-0.1343*		0.0152		-0.1254
		(0.068)		(0.080)		(0.120)		(0.103)
Output growth volatility		0.0131		0.0057		-0.0191		0.1435
		(0.088)		(0.104)		(0.198)		(0.171)
Average differentials			0.0404	0.0047			0.0264	0.0324
			(0.049)	(0.080)			(0.064)	(0.073)
Differential volatility			-0.0044	0.0850			-0.1733	-0.3627*
			(0.077)	(0.103)			(0.154)	(0.187)
Observations	49	49	48	47	49	48	47	47
R-squared	0.460	0.562	0.482	0.545	0.398	0.451	0.487	0.567

Regressions are robust to outliers. Standard errors in parentheses. ***, ** and * denote statistical significance at 1%, 5% and 10% respectively.

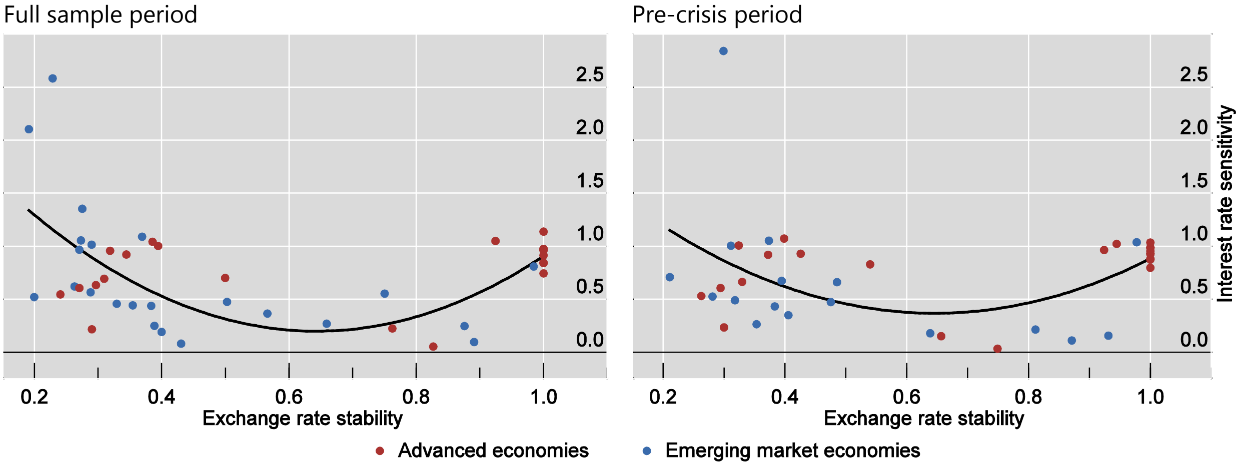
Source: Kharroubi and Zampolli (forthcoming)

Second, *the sensitivity of long-term interest rates conforms to the trade-offs highlighted by the trilemma*: while it increases with financial openness, *its relationship with exchange rate stability is non-monotonic*. A simple scatter plot (Graph 1) illustrates this point. The sensitivity tends to be larger at the limits of the distribution. At the right-hand limit of the horizontal scale are countries that belong to the euro zone or are hard pegs such as Hong Kong SAR and Denmark (1 indicates a hard peggers). This group of countries comprises mostly AEs and displays relatively high betas that are mostly concentrated in a narrow range (0.75–1). At the opposite extreme are countries exhibiting very volatile exchange rates vis-à-vis their base country and displaying on average similarly high, albeit more disperse, sensitivities than peggers. By contrast, countries in the intermediate range display lower sensitivities. Hence, excluding hard pegs, the relationship tends to be negative: the less stable the exchange rate, the stronger is the co-movement of long-term interest rates with those of the base country. And this remains true even if the sample is

[13] These findings come with a health warning: they are still preliminary and may change numerically and be refined as the research is finalised. However, they are not expected to change qualitatively.

restricted to the pre-crisis period. The existence of such a non-linear relationship may explain why fixed-coefficient panel regressions such as those used by Obstfeld (2015) find a relatively similar long-term yield co-movement between pegging and non-pegging countries, but that an analysis of cross-sectional estimates based on linear specification do not find a robust relationship (eg Aizenman et al (2015)).

Long-term yields sensitivity varies non-monotonically with exchange rate stability[1] Graph 1



[1] Negative estimates of interest sensitivity, which are statistically insignificant, are dropped from the scatter plots. The black line is a quadratic function fitted to the plotted observations.

Source: Kharroubi and Zampolli (forthcoming).

Table 2 shows that this non-monotonic relationship is robust to controlling for capital openness, which has a strong positive effect on long-term yield co-movements, as well as to controlling for other variables. The non-monotonic relationship with exchange rate stability is modelled using a quadratic specification, which turns out to be statistically significant. As an aside, a potentially interesting result is that long-term yield sensitivities tends to be higher, other things equal, in countries that experience a larger average interest rate differential and a lower volatility.

Third, *the pass-through from domestic short- to long-run interest rates also varies non-monotonically with exchange rate stability*. Table 3 shows that, while the size of the pass-through is linearly and positively related to financial openness, it has an inverted U-shaped relationship with exchange rate stability. Again, this reflects the finding that in countries that have a hard peg or a very stable currency the domestic pass-through tends to be relatively low, similarly to countries that have highly volatile currencies. Yet, excluding hard pegs, the pass-through tends to increase as the volatility of the exchange rate diminishes.

Long-run interest rate sensitivity: cross section regressions

Table 2

	Full sample: (1)	(2)	(3)	(4)	Pre-crisis: (1)	(2)	(3)	(4)
Financial openness	0.5752***	0.6784**	0.6128**	0.7242**	0.7044***	0.7576***	0.8417***	0.5702***
	(0.175)	(0.310)	(0.229)	(0.299)	(0.164)	(0.203)	(0.197)	(0.172)
Exchange rate stability	-4.0334***	-4.1625**	-3.3575**	-2.9582*	-4.0723***	-4.1112***	-3.9847***	-2.3112**
	(1.182)	(1.628)	(1.450)	(1.627)	(1.307)	(1.436)	(1.412)	(1.128)
Exchange rate stability (squared)	3.1206***	3.2912**	2.7191**	2.4446*	3.1809***	3.2083***	3.1473***	1.7291*
	(0.935)	(1.271)	(1.119)	(1.260)	(1.007)	(1.089)	(1.081)	(0.858)
Inflation		0.0491		-0.0896		-0.0266		-0.0665**
		(0.060)		(0.085)		(0.034)		(0.031)
Inflation volatility		-0.0271		0.0810		0.0700		0.1701***
		(0.048)		(0.062)		(0.051)		(0.058)
GDP growth		0.0431		0.0221		-0.0274		-0.0159
		(0.045)		(0.041)		(0.039)		(0.030)
Output growth volatility		-0.1293**		-0.0729		0.0063		0.0138
		(0.061)		(0.059)		(0.068)		(0.053)
Interest rate differential			0.1130***	0.1560**			0.0157	0.1368***
			(0.035)	(0.058)			(0.031)	(0.030)
Volatility of interest rate differential			-0.1868***	-0.2110***			0.0491	-0.5702***
			(0.048)	(0.061)			(0.052)	(0.082)
Observations	49	48	49	48	43	42	42	41
R-squared	0.352	0.390	0.510	0.557	0.487	0.592	0.510	0.830

Regressions are robust to outliers. Standard errors in parentheses. ***, ** and * denote statistical significance at 1%, 5% and 10% respectively.

Source: Kharroubi and Zampolli (forthcoming)

Domestic short- to-long-term yields pass-through: cross-section regressions

Table 3

	Full sample: (1)	(2)	(3)	(4)	Pre-crisis: (1)	(2)	(3)	(4)
Financial openness	-0.1184	0.0027	-0.0078	0.0139	-0.3395***	-0.3489***	-0.3728***	-0.4658***
	(0.102)	(0.144)	(0.130)	(0.159)	(0.087)	(0.111)	(0.094)	(0.119)
Exchange rate stability	0.3397	1.1773	0.9820	1.2279	1.7937**	2.3293***	2.4389***	2.7391***
	(0.692)	(0.733)	(0.816)	(0.848)	(0.696)	(0.781)	(0.674)	(0.783)
Exchange rate stability (squared)	-0.3151	-0.9392	-0.7706	-0.9744	-1.4318**	-1.8112***	-1.9577***	-2.1831***
	(0.547)	(0.572)	(0.630)	(0.656)	(0.537)	(0.592)	(0.517)	(0.595)
Inflation		0.0608**		0.0549		0.0077		0.0004
		(0.027)		(0.044)		(0.018)		(0.022)
Inflation volatility		-0.0459**		-0.0416		0.0195		0.0093
		(0.022)		(0.033)		(0.028)		(0.026)
GDP growth		-0.0091		-0.0085		-0.0222		-0.0303
		(0.020)		(0.022)		(0.021)		(0.020)
Output growth volatility		-0.0306		-0.0320		-0.0228		0.0298
		(0.027)		(0.031)		(0.037)		(0.037)
Interest rate differential			0.0324	0.0055			0.0422***	0.0371*
			(0.020)	(0.030)			(0.014)	(0.021)
Volatility of interest rate differential			-0.0381	-0.0032			-0.1300***	-0.1403***
			(0.027)	(0.032)			(0.025)	(0.050)
Observations	48	48	48	48	43	42	43	42
R-squared	0.065	0.208	0.117	0.198	0.440	0.473	0.597	0.595

Regressions are robust to outliers. Standard errors in parentheses. ***, ** and * denote statistical significance at 1%, 5% and 10% respectively.

Source: Kharroubi and Zampolli (forthcoming)

5. Conclusion

Does global financial integration reduce the independence of monetary policy or its effectiveness? Do flexible exchange rates offer sufficient insulation from foreign monetary and financial developments? Based on the ongoing research summarised in this paper (Kharroubi and Zampolli (forthcoming)), the answers to these questions are affirmative. Evidence based on short-term interest rate co-movements suggests that central banks retain some degree of monetary independence, which depends inversely on the degree of exchange rate stability they are prepared to accept.

Short-term interest rate correlations, however, do not tell the whole story. The finding of a negative relationship between long-term yield co-movements for non-pegging countries indicates that central banks may have significantly less control on the long end of their yield curve than on their short end. Not only do flexible exchange rates not provide sufficient insulation from external conditions, but they could also amplify their effects on the domestic economy. Hence, to the extent that long-term interest rates are sufficiently important for the monetary transmission mechanism or for financial stability,[14] the independence allowed by flexible exchange rates does not necessarily translate into greater policy effectiveness.

Our findings raises at least two issues warranting further research. The first is to understand the theoretical mechanisms behind the stylised facts uncovered in the empirical analysis. For example, does the positive link between long-term yield spillovers and exchange rate volatility reflect higher term premia or exchange rate risk premia or both? The second is to extend the empirical analysis to variables other than government bond interest rates (eg equity prices, credit growth, etc) and see how the co-movement of these variables with their foreign counterparts varies with the exchange rate regime and the degree of capital account openness.

[14] For example, Turner (2014) argues that EMEs may have become more sensitive to the long-term interest rate.

References

Aizenman, J (2010): "The impossible trinity (aka the policy trilemma)", *Working Paper*, University of California, Santa Cruz, May.

Aizenman, J, M Chinn and H Ito (2010): "The emerging global financial architecture: tracing and evaluating new patterns of the trilemma configuration", *Journal of International Money and Finance*, vol 29, no 4, pp 615–641.

Aizenman, J, M Chinn and H Ito (2015): "Monetary policy spillovers and the trilemma in the new normal: periphery country sensitivity to core country conditions", *NBER Working Paper*, no 21128, April.

Bank for International Settlements (2015): *85th Annual Report*.

Bruno, V and H S Shin (2015): "Capital flows and the risk-taking channel of monetary policy", *Journal of Monetary Economics*, vol 71, pp 119–132.

Borio, C and H Zhu (2012): "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?", *Journal of Financial Stability*, vol 8, pp 236–51.

Chinn, M and H Ito (2006): "What matters for financial development? Capital controls, institutions, and interactions", *Journal of Development Economics*, vol 81, no 1, pp 163–192.

Chinn, M and H Ito (2008): "A new measure of financial openness", *Journal of Comparative Policy Analysis*, vol 10, no 3, pp 309–322.

Chudik, A and M Pesaran (2015): "Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors", *Journal of Econometrics*, vol 188, no 2, pp 393–420.

Hofmann, B, I Shim and H S Shin (2016): "Sovereign yields and the risk-taking channel of currency appreciation", *BIS Working Papers*, no 538, January

Goldberg, L (2013): "Banking globalization, transmission, and monetary policy autonomy", *Sveriges Riksbank Economic Review*, no 3, pp 161–193.

Kharroubi, E and F Zampolli: "Interest rate pass-through and co-movement in the global financial system: what drives country heterogeneity?", *BIS Working Papers*, forthcoming.

Klein, M and J C Shambaugh (2013): "Rounding the corners of the policy trilemma: sources of monetary policy autonomy", *NBER Working Paper*, no 19461, September.

Jorda (2005): "Estimation and inference of impulse responses by local projections", *American Economic Review*, vol 95, no 1, pp 161–182.

Lustig, H and A Verdelhan (2007): "The cross section of foreign currency risk premia and consumption growth risk", *American Economic Review*, vol 97, no 1, pp 89–117.

Lustig, H, N Roussanov and A Verdelhan (2011): "Common risk factors in currency markets", *Review of Financial Studies*, vol 24, no 11, pp 3731–3777.

Miranda-Agrippino, S and H Rey (2015): "World asset markets and the global financial cycle", *Working Paper*, London Business School, October.

Mundell, R (1963): "Capital mobility and stabilization policy under fixed and flexible exchange rates", *Canadian Journal of Economics and Political Science*, vol 29, no 4, pp 475–485.

Obstfeld, M (2015): "Trilemmas and tradeoffs: living with financial globalization", *BIS Working Paper*s, no 480, January.

Obstfeld, M, J Shambaugh and A Taylor (2005): "The trilemma in history: tradeoffs among exchange rates, monetary policies, and capital mobility", *Review of Economics and Statistics*, vol 87, no 3, pp 423–438.

Pesaran, M (2006): "Estimation and inference in large heterogeneous panels with a multifactor error structure", *Econometrica*, vol 74, no 4, pp 967–1012.

Pesaran, M and R Smith (1995): "Estimating long-run relationships from dynamic heterogeneous panels", *Journal of econometrics*, vol 68, no 1, pp 79–113.

Rey, H (2013): "Dilemma not trilemma: the global cycle and monetary policy independence", paper presented at the Jackson Hole Economic Policy Symposium, hosted by the Federal Reserve Bank of Kansas City, in *Proceedings, Economic Policy Symposium, Jackson Hole*, pp 285–333..

Rey, H (2016): "International channels of transmission of monetary policy and the Mundellian trilemma", *IMF Economic Review*, vol 64, no 1, pp 6–35.

Shambaugh, J (2004): "The effect of fixed exchange rates on monetary policy", *Quarterly Journal of Economics*, vol 119, no 1, pp 301–352.

Turner, P (2014): "The global long-term interest rate, financial risks and policy choices in EMEs, *BIS Working Papers*, no 441, February.

Comments on "Monetary independence in a financially integrated world: what do measures of interest rate co-movement tell us?"

Mardi Dungey[1]

The nub of the current debate about whether macroeconomic policy faces the traditional Mundell trilemma or the more recently proposed dilemma of Rey (2013) rests on whether the benefits of open financial markets are overwhelmed by the constraint that international financial flows impose on the domestic economy. If an important channel of monetary policy impact is via the domestic long-term interest rate, then accepting that international conditions can have an impact on that rate creates a key constraint for domestic policy makers. Rey (2013) goes as far as to say that it requires capital control measures in order to cope with the problems that financial openness induce for the economy. Obstfeld (2015), however, argues that in all probability the reality is that economies lie somewhere on the spectrum between the trilemma and the dilemma.

The paper by Kharroubi and Zampolli (2016) examines the empirical evidence relating to whether there are high degrees of interest rate pass-through along a number of dimensions. They examine not only the issue of the differential rates of international pass-through at short and long maturities, as undertaken in Obstfeld (2015), but also the classic question of pass-through along the term structure, in the tradition of Cook and Hahn (1989), Kuttner (2001) and Thornton (2014), for example. In combining these three mechanisms they are able to present a triangulation of the empirical evidence on the trilemma versus the dilemma.

The role of exchange rate volatility and financial openness

The focus of this paper is whether there are observable variables that would explain the range of sensitivities to the transmission of interest rate shocks, either internationally or along the domestic term structure. Taking the first-stage estimates of betas for each country, they regress these against a range of explanatory variables. The ones of primary interest here are the exchange rate volatility index and the financial openness index. In general, the results seem to support the importance of these explanatory variables, but it is not easy to get a ready interpretation. Table 1, for example, summarises the signs of the significant explanatory variables in the most general and the second most general specifications of these regressions, drawn from Tables 2 to 4 in Kharroubi and Zampolli (omitting the non-linear term which will be discussed later).

Table 1 makes clear how difficult it is to draw general conclusions from their empirical work. Comparing the results in columns (1-3) with the corresponding columns in (4-6) and columns (7-9) with (10-12) in Table 1, the first observation is that

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there seems to be strong differentiation between the results for the pre-crisis period and for the whole sample. The only consistency that seems to be maintained is for the first specification looking at the long rates – that is columns (2) and (5) of Table 1 have a similar pattern of signs in the significant variables. In this case, this means that the international transmission of long rates is consistently statistically affected positively by the financial openness index, negatively by exchange rate stability, positively by a higher average interest rate differential and negatively by volatility in the interest rate differential. These results seem sensible.

In the other cases, there are sometimes dramatic changes between the pre-crisis and full-sample outcomes. It would be informative to test a nested specification to see whether the loss of significance is due to an additional, offsetting effect which would begin to play only in the post-crisis period, perhaps due to a regime shift as posited for global liquidity by Shin (2013), or a permanent change in the transmission mechanisms between different markets as demonstrated in a different context by Dungey et al (2010). If two regimes are conflated, then the full sample results do not reveal the significant changes between regimes, instead these are masked.

Table 1

	Specification of column (4) in tables 2-4						Specification of column (5) in tables 2-4					
	Pre-crisis			Full sample			Pre-crisis			Full-sample		
	short (1)	long (2)	term (3)	short (4)	long (5)	term (6)	short (7)	long (8)	term (9)	short (10)	long (11)	term (12)
Financial openness		+	-		+		+		-	+		
Ex rate stability	+	-	+	+	-		+		+	+		
Inflation		-					+			-	-	+
Inflation volatility		+	+				-		+		+	-
GDP growth				-				-		-	-	
Output growth volatility									-		-	
Irate diff	-	+	+		+							
Irate diff volatility		-	-		-							
CB assets							-				-	+
Debt issuance							-			+		
FX reserves									+		+	
Liabilities							-		+		+	
Assets							+		-	-		

The second issue, shown in Table 1, is the rather dramatic shift in what is important in explaining these betas between the two specifications of the paper. The specification in columns (1-6) includes interest rate differentials and interest rate differential volatility, but not the remaining greyed out variables. The specification in columns (7-12) removes these interest rate variables and replaces them with a number of alternative variables mainly related to the stocks and flows of financial assets (consistent with the view that these should be included to understand the determination of domestic economic conditions, as put forward by Rey (2013), and Godley and Izurieta (2004, for an example of the earlier literature in this vein). Notably again, there is little correspondence between the statistically significant explanatory elements of the betas for each of the three cases (short- and long-term interest rates, and the term structure) between the pre-crisis sample and the full sample in this specification either.

More importantly, there is a considerable difference between the significance of financial openness between the two specifications in the left- and right-hand panels of Table 1. In the pre-crisis period, the first and second specifications agree only that financial openness has a significantly negative effect on term structure pass-through. In the full sample period, the two specifications agree only that there is no impact of financial openness on term structure pass-through. That is, the only evidence here is that financial openness has a consistent relationship with term structure pass-through but that this relationship seems to have altered between pre-crisis and post-crisis periods. Pinning this down further would seem useful. Prior to the crisis, term structure pass-through was being negatively affected by financial openness; that this relationship disappeared seems to run counter to the arguments that the dilemma would restrict the effectiveness of monetary policy. What precisely has happened to this term in the post-crisis period? Respecifying the model to use interaction dummies could allow for a more formal exploration of this question.

In terms of the relationship with exchange rate stability, there is agreement that the pass-through of international short rates is positively affected by increased exchange rate stability in all specifications, both pre-crisis and for the full sample. The crisis does not seem to have affected this aspect of the international transmission process. The beta on the term structure pass-through is consistently positive in the pre-crisis period. This suggests that a higher beta is obtained with a more flexible exchange rate regime, which might work against the argument of the dilemma. However, in the full sample period this has become insignificant. If we could determine that there was a significant change in direction in the second part of the sample, perhaps through an interactive dummy specification, then this might provide some support for the dilemma hypothesis as binding in the post-crisis period.

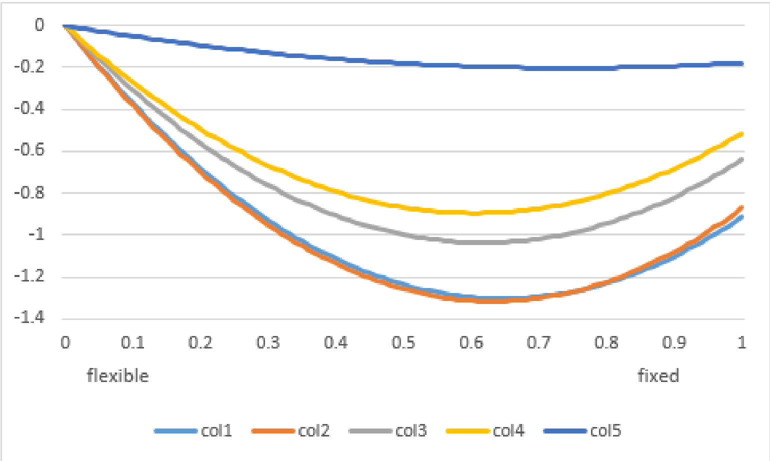
The beta on the transmission of long rates has different signs for the two specifications. In the first specification, the long rate pass-through beta is negatively affected by exchange rate stability, but in the second it is unaffected. This result is consistent across both sample periods. That increased exchange rate stability would negatively affect the transmission of the long rate seems rather unusual and is addressed by the addition of a volatility term. The addition of the squared exchange rate stability term to the long interest rate and term structure pass-through specifications in Tables 3 and 4 in Kharroubi and Zampolli provide a non-monotonic element to the analysis. In the long term specifications, this has a consistently significantly positive coefficient, and in the term structure pass-through it has a consistently statistically significant impact only during the pre-crisis period – for the whole sample it is insignificant.

The form of the non-monotonicity of these specifications is rather less straightforward than may at first appear. Figure 1 plots the non-linearities estimated in Tables 3 and 4 for the five different specifications used in the paper (labelled with the corresponding columns for each table in Kharroubi and Zampolli (2016)). It is clearly evident that the degree of estimated non-linearity varies considerably for the long rates, so that drawing conclusions about how important this effect is requires some certainty about the appropriate functional form. With this degree of uncertainty about the impact of non-linearity, it would be very easy to overstate the gains from adopting a moderately flexible exchange rate regime.

Non-linear form of exchange rate stability – pre-crisis period

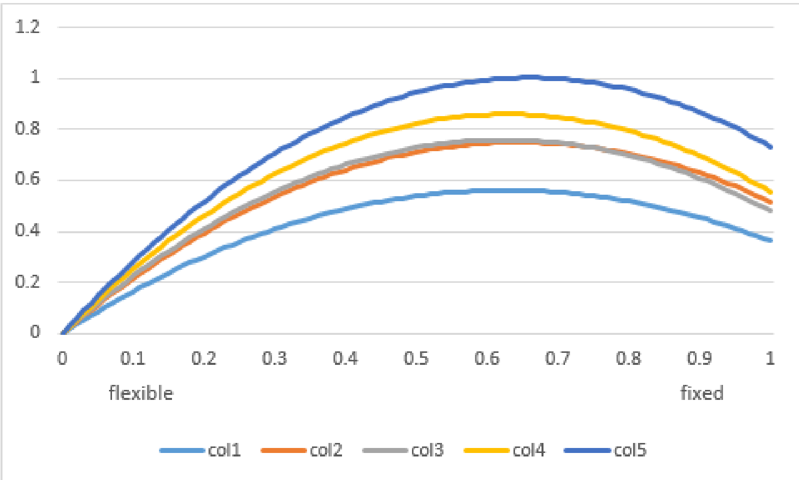
Figure 1

A. Long rate equations in Table 3 from KZ



The beta for long rates is negatively related to exchange rate stability

B. Term structure equations in Table 4 from KZ



The beta for the term structure is positively related to exchange rates overall

Returning to the issue of whether one should prefer the specification (4) in Kharroubi and Zampolli (given in the left-hand panel of Table 1) or specification (5) (given in the right-hand panel of Table 1), there are a number of important considerations. First, specification (5) looks more general at first, and has in most cases a higher R-squared explanatory power. The parameter estimates on these statistically significant additional variables are very small and seem unlikely to be economically meaningful. However, they are contributing to a specification that often no longer finds the financial openness variable to be significant, and this is important to investigating the dilemma versus trilemma debate. One fairly likely explanation lies in the bounded nature of the financial openness and exchange rate stability indices. These two indices are both bounded (0,1) and are being used as determinants of a continuously variable beta (it would be interesting for the paper to report the range of betas estimated). Specification (5) adds a range of further continuous variables to the estimation, providing the potential to match the variance in the dependent variable more easily. This may be spurious and simply an artefact of the properties of the data, rather than implying that the financial openness and exchange rate stability results are less evident.

Empirically the paper demonstrates that short rates are more independent than long rates, that the short rate pass-through to long rates is not perhaps as strong as one would like, and that variation in the pass-through can be linked to financial openness and exchange rate stability (non-monotonically). These technically challenging questions are addressed in Kharroubi and Zampolli with a nice contribution to controlling for commonality.

Links to theory

Resolving the problems posed in this paper calls for a link to some underlying theoretical specification. The main variables involved in the specifications, inflation, growth, and exchange rate and interest rate volatility are not uncommon in macroeconomic models of monetary policy making. Kharroubi and Zampolli find that the beta decreases when markets are more financially open and more volatile, but additional insights from other works of the literature could help refine the arguments; first, Thornton (2014) shows that beta is overestimated unless controls for ambient news are included, and, second, Ellingsen and Soderstrom (2001) show that the beta decreases when central banks are more averse to inflation.

Ellingsen and Soderstrom (2001) posit a model that changes in monetary policy affect the term structure in two distinct ways. The first suggests that the central bank has new information on the state of the economy which it relays to the market via its policy actions. The second puts forward that the central bank could reveal a change in preference weightings on its target variables – empirical evidence as to the validity of this model is available in Claus and Dungey (2012) and (2015). An alternative model would be to consider whether the networks of firms and financial institutions processing and absorbing information about the success of firms' real investment decisions constitute a major source of transmission of policy shocks, as in Acemoglu et al (2015). These two exemplar models would have quite different implications with respect to whether the policy problem concerns the connectivity structure of global financial institutions or is a direct result of domestic monetary authorities taking account of foreign policy changes. Either way, a theoretical framework is clearly needed to reconcile the empirically more tightly connected long rates with the less tightly connected short rates, and the role that monetary policy plays in the economy and encompasses the stylised facts revealed in Kharroubi and Zampolli. Their evidence for the changing nature of the empirical relationships amongst rates, alongside the results in Shin (2013), suggests a steepening of yield curves for emerging market economies post-2010. It also raises the question of the desirable degree of pass-through from short- to long-term rates for momentary policy effectiveness. Is there an optimal level of pass-through across the term structure, or is it simply necessary to be clear about what degree of pass-through exists at any point in time?

References

Acemoglu, D, A Ozdaglar and A Tahbaz-Salehi (2015): "Systemic risk and stability in financial networks", *American Economic Review*, vol 105, no 2, pp 564–608.

Claus, E and M Dungey (2015): "Can monetary policy surprises affect the term structure?", *Journal of Macroeconomics*, vol 47, part A, pp 68–83.

Claus, E and M Dungey (2012): "U.S. monetary policy surprises: identification with shifts and rotations in the term structure", *Journal of Money, Credit and Banking*, vol 44, no 7, pp 1443–1453.

Cook, T and T Hahn (1989): "The effect of changes in the federal funds rate target on market interest rates in the 1970s", *Journal of Monetary Economics*, vol 24, no 3, pp 331–351.

Dungey, M, G Milunovich and S Thorp (2010): "Unobservable shocks as carriers of contagion: a dynamic analysis using identified structural GARCH", *Journal of Banking and Finance*, vol 34, pp 1008–1021.

Ellingsen, T and U Soderstrom (2001): "Monetary policy and market interest rates", *American Economic Review*, vol 91, no 5, pp 1594–1607.

Godley, W and A Izurieta (2004): "The US economy: weaknesses of the 'strong' recovery", *Banca Nazionale del Lavoro Quarterly Review*, no 229, pp 131–139.

Kharroubi, E and F Zampolli (2016): "Monetary independence in a financially integrated world: what do measures of interest rate co-movement tell us?", this volume.

Kuttner, K (2001): "Monetary policy surprises and interest rates: evidence from the Fed funds futures markets", *Journal of Monetary Economics*, vol 47, no 3, pp 523–544.

Obstfeld, M (2015): "Trilemmas and trade-offs: living with financial globalisation", *BIS Working Papers*, no 480, January.

Rey, H (2013): "Dilemma not trilemma: the global financial cycle and monetary policy independence", paper presented at the Jackson Hole Economic Policy Symposium, hosted by the Federal Reserve Bank of Kansas City, in *Proceedings, Economic Policy Symposium, Jackson Hole*, pp 285–333.

Shin, H. (2013) "The second phase of global liquidity and its impact on emerging economies", speech given at the Federal Reserve Bank of San Francisco, 7 November.

Thornton, D (2014): "The identification of the response of interest rates to monetary policy actions using market based measures of monetary policy shocks", *Oxford Economic Papers*, vol 66, no 1, pp 67–87.

Financial globalisation and monetary independence[1]

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Abstract

Has financial globalisation compromised central banks' ability to manage domestic financial conditions? This paper summarises the results from our recent research, which tackles this question from the bond market perspective for both advanced and emerging market economies. Using an asset pricing framework, we isolate co-movements of bond return risk premia unrelated to economic fundamentals to identify spillovers driven by exogenous global shifts in risk preference or appetite. Based on co-movements in bond yields, the analysis reaches several conclusions that run counter to popular presumptions. In particular, emerging market economies appear less susceptible to external financial conditions than advanced economies.

JEL classification: E40, E43, E44, E50, E52, F30, F41, G15.

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1. Introduction

Increased financial globalisation has renewed the debate on monetary policy and frameworks in open economies. The rising sensitivity of domestic credit and asset prices to external influences has heightened concerns about central banks' ability to manage domestic financial conditions. Some even argue that without the imposition of capital controls, monetary autonomy is largely lost.

This paper examines this issue from a bond market perspective covering 10 advanced and 21 emerging market economies. We propose an organising principle that delineates external influences on domestic financial conditions along three dimensions. *Monetary autonomy* is the ability of central banks to achieve desired targets with their instruments, regardless of how those targets are set as well as the factors that may influence them. *Monetary dependence* is the extent to which the actual setting of policy, as well as monetary conditions more generally, are influenced by external financial developments. Finally, *financial contagion* represents changes in domestic financial conditions unrelated to domestic fundamentals, which may be driven by external shifts in risk appetites or investor preferences.

Absent clear distinctions along these dimensions, discussions of how greater financial integration affects policy have often become muddled. Some recent renditions of the classic Mundell-Fleming trilemma, for example, conflate the notions of monetary autonomy and monetary dependence. Under this view, "monetary autonomy" has sometimes been associated with the degree to which local interest rates vary with foreign ones. But this makes no distinction between the *ability* to set monetary policy independently and the *willingness* to do so. Observed interest rate co-movements say less about the ability of central banks to set rates independently than they do about how external developments enter their policy reaction functions, and the extent to which responding to such developments is deemed appropriate given local mandates.

At the same time, "monetary autonomy" under the trilemma has also been interpreted as the complete insulation of domestic financial conditions from external factors. Rey (2013) prominently argued that, even with flexible exchange rates, so that central banks can set interest rates independently, the trilemma breaks down because broader financial conditions are still affected by external influences. We argue that this is again an overly broad interpretation of monetary autonomy under the trilemma.

In Disyatat and Rungcahroenkitkul (2015), we add to the literature that examines co-movements in global bond yields along two main dimensions. First, in contrast to the bulk of the literature that focuses exclusively on advanced economies, our sample encompasses most emerging market economies, where much of the focus on spillovers has been directed. Secondly, we make the critical distinction between *monetary dependence* and *financial contagion* as outlined above.

With trade and financial integration, it is inevitable that external developments will impinge on local economic and financial conditions. In this context, co-movements in yields, and asset prices more generally, are part and parcel of monetary dependence. From a policy perspective, however, whether co-movement in yields reflects reactions to common fundamentals and uncertainty about those fundamentals, or reactions to exogenous changes in risk appetite and preferences has vastly different implications. In the former, the bond market is acting simply as a messenger about expected future economic developments whereas in the latter case, they are a conduit of exogenous financial shocks unrelated to domestic fundamentals. Such global financial contagion may warrant offsetting policy actions.

The starting point for our measure of global financial contagion is the bond return risk premium, namely the expected excess return from investing in a long-term bond over a short one (throughout the paper, "risk premium" and "term premium" will be used interchangeably in reference to such expected excess return). By looking at the bond risk premium, we purge the direct influence of the expected path of monetary policy on bond price movements. Thus any incidental co-movement in monetary policy across countries, which could result in correlated bond prices yet be fully consistent with individual monetary autonomy, is removed from our measure of global financial contagion.

Term premia may still be affected by fundamentals, not least monetary policy through the risk-taking channel. We therefore proceed to refine the term premia by controlling for these influences. In the final step, we then extract the common component from these "cleansed" term premia to obtain our measure of global financial contagion. This measure essentially captures co-movements in bond returns unrelated to the expected path of monetary policy and economic fundamentals. This is the component that arguably matters most for policy traction as it represents an external shock that interferes with the transmission mechanism. In reacting to it, policy may need to deviate from what would have been justified purely based on domestic fundamentals.

Our analysis yields some novel results. First, our estimate of global financial contagion contains significant information not present in other popular global risk appetite measures such as the VIX. We argue that our measure is a more accurate metric for gauging the extent of policy traction. Second, emerging market economies are much less susceptible to global financial contagion than are advanced economies, contrary to popular presumptions. Third, for all country groups, it is far from obvious that the sensitivity to global financial contagion has increased after the global financial crisis, despite oft-cited concerns about the spillover effects of quantitative easing policies. Fourth, the analysis confirms that the simple correlation of bond yields can be misleading, as it could be influenced by correlation in monetary policies and fundamentals. Finally, the results shed some light on the interactions of term premia and exchange rate movements and point to the prevalence of nominal shocks, such as portfolio rebalancing, in emerging economies but not so in advanced countries.

Overall, our analysis suggests that the impact of financial globalisation on domestic policy traction appears to be less severe than sometimes portrayed. In particular, the spillovers that directly impinge on policy are substantially lower than those indicated by statistical co-movements in bond yields. In addition to its importance in underpinning expected short rates, monetary policy exerts significant influence on term premia via the risk-taking channel. We conclude that the domestic credit cycle remains very much the domain of central banks and local financial regulators.

The paper is organised as follows. In Section 2, we discuss the conceptual distinction between monetary autonomy, monetary independence and financial contagion. Section 3 explains the empirical approach for isolating the influence of financial contagion and sets out the main results. The final section concludes.

2. Financial globalisation and monetary control

In a provocative paper, Rey (2013) argued that the emergence of a global financial cycle has meant that, for small open economies, "...independent monetary policies are possible if and only if the capital account is managed, directly or indirectly via macroprudential policies." (Rey (2013), p 287) This view suggests that the conventional monetary "trilemma" has morphed into a "dilemma" between monetary autonomy on the one hand and capital mobility on the other. This is in stark contrast to Woodford (2010), who argued that central banks' control over inflation has not diminished, and has in some respects been strengthened, by globalisation. Obstfeld (2015) and Kamin (2010) meanwhile take the middle road by acknowledging that spillovers complicate the task of monetary policy but that independent monetary policy remains feasible for financially open emerging economies with relatively flexible exchange rates.

At the same time, many studies such as Fratzscher (2012), Miranda-Agrippino and Rey (2014), Bruno and Shin (2013), and Cerutti et al (2014) highlight the important role for "push factors" such as the VIX in driving financial flows. This is collaborated by a growing literature documenting the presence of a global factor driving co-movement in bond yields and other asset prices across countries (eg Aizenman et al (2015), Diebold et al (2008), Bauer and de los Rios (2012), Abbritti et al (2013) and Jotikasthira et al (2015)). Taken at face value, this suggests that the traction that monetary policy has over domestic monetary conditions has diminished.

An important shortcoming of the extant literature, however, is the tendency to conflate different definitions of monetary independence. As a result, interpretations of empirical results and the policy implications drawn are often muddled. We therefore begin by establishing a clear distinction between three notions of external linkages.

First, we define *monetary autonomy* as central banks' ability to achieve the desired targets of their instruments, whatever those instruments and targets may be. This is the narrow sense of policy autonomy that focuses only on the technical capability to attain a given target setting of the monetary instrument, abstracting from the reasons behind those targets. Second, *monetary dependence* is the extent to which the actual setting of policy, as well as monetary conditions more broadly, are influenced by external financial developments. Observed monetary conditions embed the trade-offs weighed by policymakers implicitly in their reaction functions in response to foreign shocks, as well as financial market reactions to those shocks. Finally, the third notion is *financial contagion*, identified as changes in domestic financial conditions driven by shifts in global risk appetites or preferences unrelated to domestic fundamentals.

2.1 Monetary autonomy versus monetary dependence: revisiting the trilemma

Discussions of monetary policy autonomy in the context of open economies have invariably been framed around the classic Mundell-Fleming trilemma, which states that countries can simultaneously attain no more than two objectives out of the possible combination among capital mobility, a fixed exchange rate, and an independent ability to set interest rates. The last of these has been treated as synonymous with monetary policy autonomy. To assess the degree of autonomy, most existing studies seek to gauge the extent to which domestic interest rates are related to world/base-country interest rates (eg Frankel et al (2004), Obstfeld et al (2005), Bluedorn and Bowdler (2010), Klein and Shambaugh (2013), Obstfeld (2015), Edwards (2015) and Aizenman et al (2015)).

When it comes to assessing monetary policy traction, however, a focus on simple correlations of short-term or long-term interest rates may result in misleading inferences. At the most basic level, the approach makes no distinction between the *ability* to set monetary policy independently and the *willingness* to do so, given central banks' goals and mandates. Flexible exchange rates do give central banks the technical ability to set short-term interest rates at some arbitrary level. But the actual conduct of policy will be governed by central bank mandates and goals. Hence any inference based on observed *outcomes* of policy setting will embody *both* the technical ability to set short rates independently and the normative choice of a policy setting deemed appropriate for the domestic economy. The approach, in other words, conflates the notions of monetary autonomy and monetary dependence as defined above.

Another way to see the point is to consider that countries with flexible exchange rates might just as easily choose to peg interest rates to another country, entailing no less a degree of dependence on foreign monetary policy than a fixed exchange rate would. Conversely, countries that choose to peg exchange rates are able to vary their monetary stance by adjusting the peg or adopt frameworks that send monetary policy signals through future prospective paths of the exchange rate. The Monetary Authority of Singapore is the leading example of this latter approach.

The real issue posed by greater financial integration is not so much monetary autonomy but monetary dependence. The question is how much of this dependence arises naturally from common fundamentals among economically and financially integrated economies, and how much of it reflects exposure to unpredictable swings in global risk appetite and preferences, which will now be discussed.

2.2 Monetary dependence versus financial contagion

With trade and financial integration, co-movements in yields, and asset prices more generally, are part and parcel of monetary dependence. From a policy perspective, however, it is important to ascertain the underlying shocks driving such co-movements. These can be divided into two broad categories.

In the first category, co-movements in asset prices may result from the normal interdependence among market economies due to real and financial linkages. Such "fundamentals-based co-movement" can be due to common global factors, such as a major economic shift in advanced countries or commodity price shocks, that trigger capital flows and portfolio readjustments. Here, asset price adjustments reflect the natural outcome of markets internalising news about expected fundamentals. A priori, there may be no need for policy to counteract such movements as they reflect the normal working of markets. Indeed, a substantial part of the price adjustment already reflects anticipated policy reactions to changing fundamentals.

The second category of asset price co-movement is one that cannot necessarily be linked to changes in macroeconomic or other fundamentals but arises as a result of arbitrary changes in the behaviour of investors. Such *financial contagion* is often linked to shifts in investors' risk appetites and preferences and may be characterised by herd behaviour or financial panic. Here, asset prices are acting as conduits of exogenous financial shocks unrelated to domestic fundamentals and, as such, may warrant offsetting policy actions.

Our focus is on applying this distinction to bond yields, where the role of monetary policy looms large. The strong co-movement in government bond yields has been well documented, especially among advanced economies since the late 1980s. An obvious explanation for this stylised fact is that economic activity and inflation co-move across countries, entailing short-term policy rates that move in tandem. Indeed, there is ample evidence in the literature that points to the existence of a world business cycle (eg Kose et al (2003)) as well as the influence of global factors on inflation (eg Borio and Filardo (2007) and Ciccarelli and Mojon (2010)).[4] Clearly, we need to move beyond simple correlation in bond yields to get a handle on the contagion component.

Our underlying premise is that externally driven changes in domestic financial conditions unrelated to domestic economic developments may give rise to adverse policy trade-offs. These trade-offs arise because they may necessitate monetary policy actions that, given the pervasiveness of their impacts, result in undesirable outcomes or side-effects along other dimensions.[5] From this perspective, "policy traction" refers to the degree to which domestic monetary conditions are influenced by global financial factors unrelated to current and expected future fundamentals. The greater the influence, the lower is the degree of traction and the more policy may need to offset these movements.

To be clear, fundamental-based changes in financial conditions are not always benign. Capital flows linked to fundamental developments can create real challenges. For example, capital flows to emerging markets tend to be procyclical, reinforcing booms and exacerbating downturns. Indeed, we find that term premia in emerging markets are substantially larger and much more volatile than those in advanced economies. This reflects both lower market liquidity as well as the greater prevalence of economic shocks in these countries. By analysing changes in term premia unrelated to fundamentals, we are focusing more narrowly on externally driven variations in financial conditions that are exogenous to the domestic economy.

3. Contagion in bond premia

Our starting point for measuring financial contagion is term premia in government bond yields. By abstracting from short-rate expectations, variations in bond yields related to anticipated fundamental economic developments are, to a large extent, controlled for. That said, term premia themselves may also be related to fundamentals

4 Henrisksen et al (2013) show that interest rate co-movements are part of a more general pattern of greater synchronisation of nominal variables across countries than fluctuations in real activity, even at medium-term business-cycle frequencies. This can be rationalised as the outcome of expected monetary policy reaction to anticipated co-movements in real variables in response to positive productivity shock spillovers.

5 The analogy with exchange rate movements is useful here (Engel (2011)). As long as nominal exchange rate movements reflect changes in underlying resource costs across countries, there is no case for policy concern. Only when movements are not related to fundamentals and cause international prices to deviate from underlying relative costs do they pose a concern.

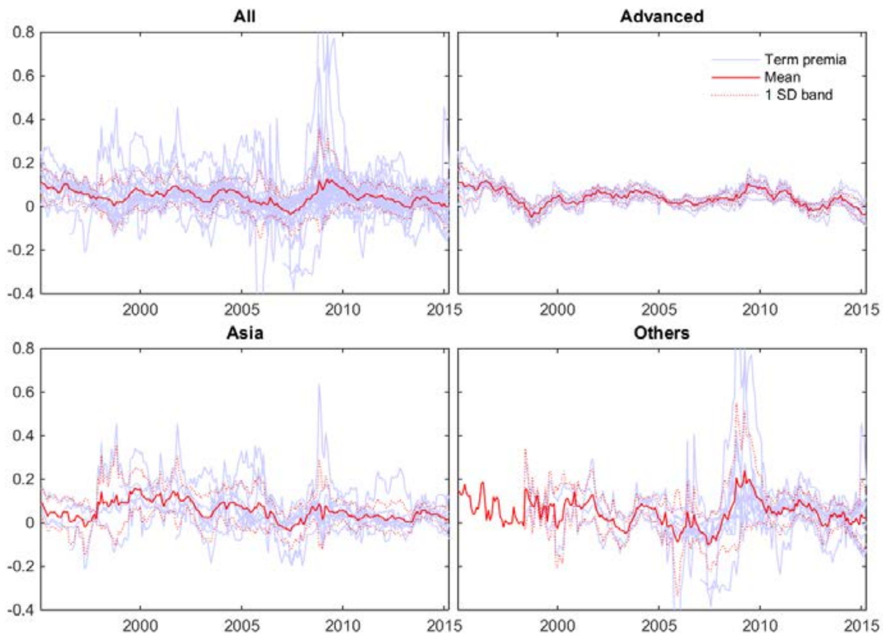
and hence external developments. To the extent that global macroeconomic risks are correlated with domestic ones, for example, it is natural to expect co-movements in risk premia. Indeed, Diebold et al (2008) and Jotikasthira et al (2015) document the importance of global factors in driving co-variation in risk compensation for long-term bonds across countries.

The empirical exercise covers 31 countries comprising 10 advanced economies, 10 emerging economies in Asia and 11 other emerging market economies. This rough division into three groups provides a convenient way to organise and interpret the empirical results. Data used are monthly zero-coupon yields from Bloomberg, and consensus forecasts of GDP and inflation obtained from Consensus Economics.

3.1 Empirical strategy

We adopt a three-step empirical procedure to identify financial contagion. In step 1, we estimate the term premia of long-term government bonds through a linear excess return regression (thus removing monetary policy expectations). In addition to the standard term structure factors, namely first five principal components, an "unspanned global factor" related to the level of global yields is found to help forecast excess returns for all countries. The extended model is used to calculate estimated term premia for all countries, whose individual time-series and regional averages are shown in Graph 1.

Term premia: all regions Graph 1



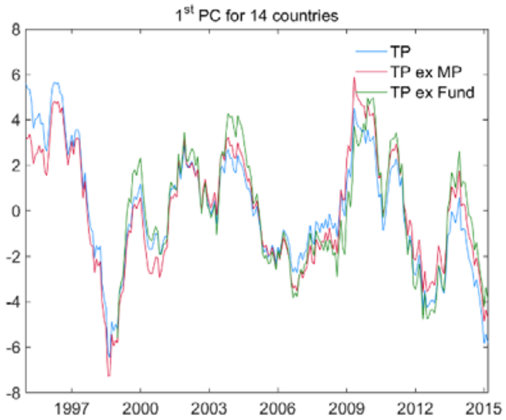
In step 2, we filter out the influence of domestic monetary policy and macroeconomic fundamentals from the estimated term premia. This is done by (i) regressing each factor in the excess return model on a set of controls related to monetary policy and fundamentals, (ii) recovering the residuals, and (iii) recomputing "restricted" term premia by substituting the residuals into the previously estimated excess return model. The restricted or "cleansed" term premia are now free from the influence of domestic variables but are still subject to external spillovers or contagion effects. Two sets of controls are considered separately, namely a monetary policy variable (one-year bond yield) and a broader set of fundamentals (one-year bond yield and consensus forecasts of GDP growth as well as inflation 12-months ahead).

In the final step, we recover the global financial contagion index as the common component of term premia. For comparison, we calculate the contagion index separately for each of the three models of term premia, (i) original term premia, (ii) restricted term premia cleansed of monetary policy, and (iii) restricted term premia cleansed of fundamentals. The global financial contagion indices are common factors positively correlated with the underlying term premia, so that a higher financial contagion index suggests higher term premia on average, and vice versa.

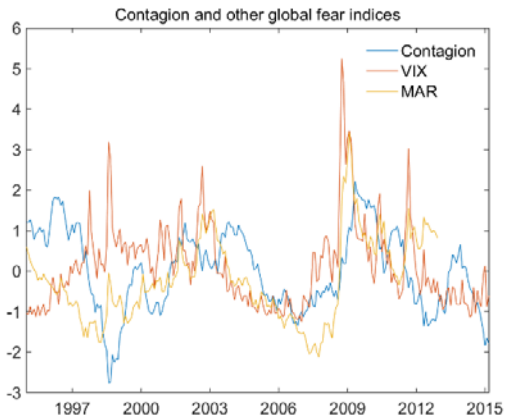
The global financial contagion indices are quite robust to the choice of models. As Graph 2 (left-hand panel) shows, the three versions produce very similar contagion series. The result supports the notion that the core common driver of international term premia is not due to correlated fundamentals and may be more related to financial contagion.

Global financial contagion indices Graph 2

(a) Contagion by models



(b) Contagion and global risk appetite indices



In Graph 2 (right-hand panel), we plot our contagion index (using the model that controls for monetary policy) against the VIX and the global common factor in Miranda-Agrippino and Rey (2014) (MAR index, in short), which is calculated from a broad range of risky asset returns. The correlation between our contagion index and the MAR index is 0.38, suggesting some relations between the global driver of the bond term premia and global risk appetite. But one could argue that this is not a strong correlation. On the other hand, our contagion factor is almost uncorrelated with the VIX (correlation = 0.01). Our index therefore seems to contain additional information about the nature of financial spillovers not captured by other measures. In particular, since government bonds are under greater influence from monetary policy compared to other risky assets, our global financial contagion index may be a more relevant metric to gauge policy traction in the context of financial globalisation.

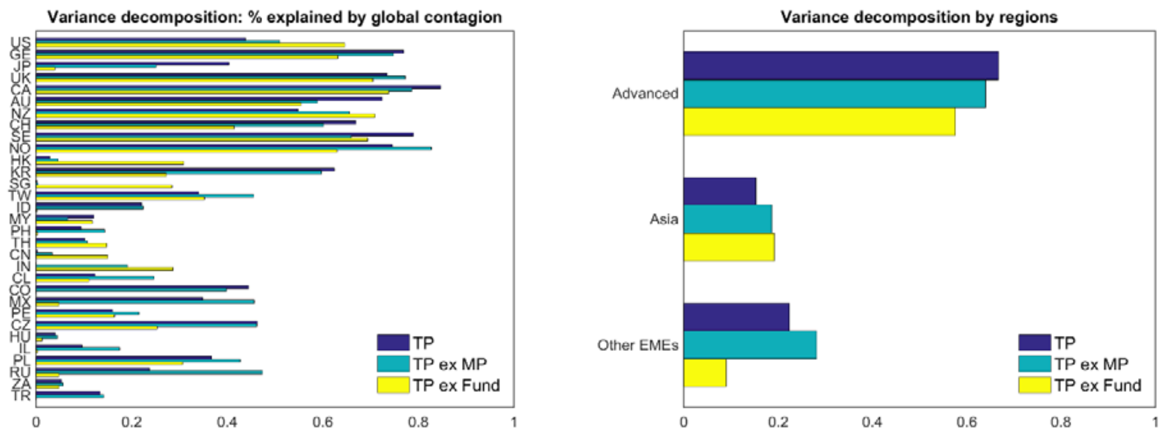
3.2 Reassessing the implications of global financial contagion

Armed with this new estimate of financial contagion, we can now reassess various issues regarding financial contagion. How much policy traction do countries have? Or equivalently, how sensitive are economies to swings in the financial contagion factor? How to compare/contrast our results with a high correlation in long-term yields? Has financial contagion become stronger in recent years, because of extraordinary monetary policies in advanced economies? How do term premia move with exchange rate changes? We now take up these questions in turn.

The sensitivity to contagion can be measured as the proportion of term premium variation that can be explained by financial contagion. This variance decomposition is shown in Graph 3 in detailed country breakdown, and in terms of regional averages. There is a striking differentiation across regions. In particular, the sensitivity to contagion is notably higher for advanced countries than emerging markets. Without step-2 conditioning, the contagion factor explains nearly 70% of variations in advanced economies' term premia on average, but only 15% and 22% in emerging Asia and other emerging market economies respectively. The order of magnitude is relatively robust to filtering out monetary policy and macro fundamentals. The inter-regional differences remain large whichever model is considered.

Variation of term premia explained by global contagion — Graph 3

(a) By country — (b) Regional averages

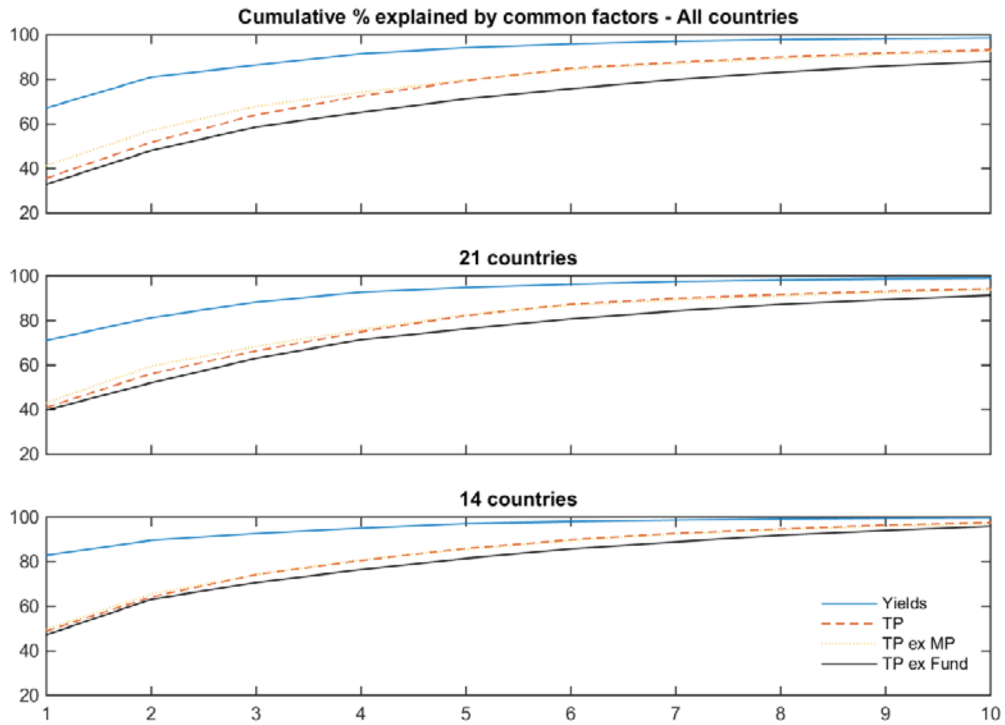


Note that this does *not* imply that emerging markets are subject to fewer external shocks, simply that these shocks are more idiosyncratic. Part of this may be due to greater liquidity shocks, given the less developed state of bond markets in these countries. Moreover, even as emerging markets are less subject to common shocks, the types of external shock that they face may pose more challenges for policy. Another possible explanation for greater susceptibility to common movements in term premia among advanced economies is the generally higher degree of financial openness and integration in these countries.[6]

[6] In principle, greater financial integration can entail both costs and benefits, the latter of which include higher growth and better international risk-sharing. See Rungcharoenkitkul (2012) for a discussion of the trade-off and a measure of risk-sharing in the context of an affine term structure models.

High correlation in long-term yields is often associated with strong contagion (see Turner (2014) for example). The degree of such correlation can be seen in Graph 4, which plots cumulative percentage of cross-country variations in 10-year yields that can be explained by their principal components. The first factor alone can account for 70–80% of the total yield variations, depending on the set of countries included. Adding the second principal component lifts the percentage explained to 80–90%. It is tempting to conclude from this that financial contagion is the dominant single driver of international long-term yields.

Percentage of term premium variations explained by principal components Graph 4



Note: Graph shows the percentage variations in 10-year yields and three definitions of term premia as a function of the top n principal components used, where n is on the horizontal axis.

Our results help quantify how misleading a high correlation of yields is. In Graph 4, we also plot the variations in the three versions of term premia that can be explained by their common factors. The first principal component, namely our global contagion factor, explains only 30–50% of the total variations in term premia. To explain 80% of all term premia variations, five or more principal components are required. The relevance of a single contagion factor in driving term premia is thus much weaker than suggested by yield correlation. Once fundamentals are accounted for, the influence of contagion weakens even further.

Conclusion

Has monetary policy lost traction in an era of increased financial globalisation? Our short answer is no. Central banks, by and large, do retain substantial influence over local financial conditions. In addition to their impact on the path of expected short rates, monetary policy appears to also have a significant influence on term premia. This conclusion does not preclude the possibility that the degree of *monetary dependence* may be large. Increased economic and financial linkages across economies do imply greater co-movement in asset prices and more rapid transmission of shocks. But a sizeable component of such co-movements reflects common fundamentals. We have argued that stripping these out yields a measure of spillovers that is more relevant for the assessment of how policy trade-offs are affected. At the end of the day, though, what matters is how financial globalisation has altered such trade-offs, and hence, the set of attainable outcomes. Going forward, research is needed that focuses directly on the link between financial globalisation and outcomes of goal variables such as inflation, output and financial stability. This will provide a basis for evaluating the appropriateness of policy regimes and to investigate possible adjustments.

References

Abbritti, M, S Dell'Erba, S Moreno and S Sola (2013): "Global factors in the term structure of interest rates", *IMF Working Paper*, no WP/13/223.

Aizenman, J, M Chinn and H Ito (2015): "Monetary policy spillovers and the trilemma in the new normal: periphery country sensitivity to core country conditions", *NBER Working Paper*, no 21128.

Bauer, G and A de los Rios (2012): "Global risk premiums and the transmission of monetary policy", *Bank of Canada Review*.

Bluedorn, J and C Bowdler (2010): "The empirics of international monetary transmission: identification and the impossible trinity", *Journal of Money, Credit and Banking*, vol 42, pp 679–713.

Borio, C and A Filardo (2007): "Globalisation and inflation: new cross-country evidence on the global determinants of domestic inflation", *BIS Working Papers*, no 227.

Borio, C and H Zhu (2012): "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?", *Journal of Financial Stability*, vol 8, pp 236–51.

Bruno, V and H S Shin (2013): "Capital flows and the risk-taking channel of monetary policy", *NBER Working Paper*, no 18942.

Cerutti, E, S Claessens and L Retnovski (2014): "Global liquidity and drivers of cross-border bank flows", *IMF Working Paper*, no WP/14/69.

Ciccarelli, M and B Mojon (2010): "Global inflation", *Review of Economics and Statistics*, vol 92, pp 524–35.

Cochrane, J and M Piazzesi (2005): "Bond risk premia", *American Economic Review*, vol 95, pp 138–60.

Dahlquist, M and H Hasseltoft (2013): "International bond risk premia", *Journal of International Economics*, vol 90, pp 17–32.

Diebold, F, C Li and V Yue (2008): "Global yield curve dynamics and interactions: a dynamic Nelson-Siegel approach", *Journal of Econometrics*, vol 146, pp 351–63.

Disyatat, P and P Rungcharoenkitkul (2015): "Monetary policy and financial spillovers: losing traction?", *BIS Working Papers*, no 518.

Edwards, S (2015): "Monetary policy independence under flexible exchange rates: an illusion?", *NBER Working Paper*, no 20893.

Engel, C (2011): "Currency misalignments and optimal monetary policy: a re-examination", *American Economic Review*, vol 101, pp 2796–822.

Fama, E and R Bliss (1987): "The information in long-maturity forward rates", *American Economic Review*, vol 77, pp 680–92.

Frankel, J, S Schmukler and L Servèn (2004): "Global transmission of interest rates: monetary independence and currency regime", *Journal of International Money and Finance*, vol 23, pp 701–33.

Fratzscher, M (2012): "Capital flows, push versus pull factors and the global financial crisis", *Journal of International Economics*, vol 88, pp 341–56.

Hellerstein, R (2011): "Global bond risk premiums,", *Federal Reserve Bank of New York Staff Papers*, no 499.

Henrisksen, E, F Kydland and R Šustekd (2013): "Globally correlated nominal fluctuations", *Journal of Monetary Economics*, vol 60, pp 613–31.

Jotikasthira, C, A Le and C Lundblad (2015): "Why do term structures in different currencies co-move?", *Journal of Financial Economics*, vol 115, pp 58–83.

Kamin, S (2010): "Financial globalization and monetary policy", Board of Governors of the Federal Reserve System, *International Finance Discussion Papers*, no 1002.

Klein, M and J Shambaugh (2013): "Rounding the corners of the policy trilemma: sources of monetary policy autonomy", *NBER Working Paper*, no 19461.

Kose, M, C Otrok and C Whiteman (2003): "International business cycles: world, region, and country-specific factors", *American Economic Review*, vol 93, pp 1216–39.

McCauley, R, P McGuire and V Sushko (2015): "Global dollar credit: links to US monetary policy and leverage", *BIS Working Papers*, no 483.

Miranda-Agrippino, S and H Rey (2014): "World asset markets and the global financial cycle", mimeo.

Obstfeld, M (2015): "Trilemmas and trade-offs: living with financial globalisation", *BIS Working Papers*, no 480.

Obstfeld, M, J C Shambaugh and A M Taylor (2005): "The trilemma in history: tradeoffs among exchange rates, monetary policies and capital mobility", *Review of Economics and Statistics*, vol 87, pp 423–38.

Rey, H (2013): "Dilemma not trilemma: the global financial cycle and monetary policy independence", proceedings of the Federal Reserve Bank of Kansas City Jackson Hole symposium, August 2013.

Rungcharoenkitkul, P (2012): "Risk sharing versus financial contagion in Asia: an asset price perspective", *Review of Development Finance*, vol 2, pp 101–17.

Shin, H S (2013): "The second phase of global liquidity and its impact on emerging economies", speech at the Federal Reserve Bank of San Francisco.

Turner, P (2014): "The global long-term interest rate, financial risks and policy choices in EMEs", *BIS Working Papers*, no 441.

Woodford, M (2010): "Globalization and monetary control", in J Galí and M Gertler (eds), *International Dimensions of Monetary Policy*, University of Chicago Press.

Wright, J (2011): "Term premia and inflation uncertainty: empirical evidence from an international panel dataset", *American Economic Review*, vol 101, pp 1514–34.

Comments on "Financial globalisation and monetary independence"

Paul Mizen[1]

This paper addresses some important issues. There are few central bankers or monetary economists around the world who are disinterested in the traction of monetary policy, and all would pay close attention if traction were to be lost. And there are papers suggesting that we are indeed losing traction. Helene Rey's 2013 Jackson Hole paper has argued that the pre-Great Financial Crisis (GFC) view that countries face a trilemma of policy choices between monetary policy independence, exchange rate stability and interdependence of financial markets has collapsed to a dilemma since monetary policy independence is no longer a feasible option. Much of this debate is connected with the observations of other papers that highlight the convergence of long-term interest rates (Turner (2013, 2014)), the pro-cyclical movement of exchange rates (Bruno and Shin (2015b)) and the compelling evidence that phases of global cross-border banking liquidity ((Schularick and Taylor (2012) and Bruno and Shin (2015a)) tie together advanced economies (AEs) and emerging market economies (EMEs). Rey's view is that there is a global credit cycle through which the risk-taking channel of monetary policy is driven by loose US policy (both through low short-term rates and the use of QE that lowers long-term rates). The risk appetite of investors rises as the risk premium falls, amplifying the credit cycle externally. This implies that a flexible exchange rate does not insulate the domestic economy from external shocks, reducing the trilemma to a dilemma.[2] According to Borio and Zhu (2012), and Ahmed and Zlate (2014), risk appetite is the linchpin in the transmission process, linking countries through portfolio flows. Moreover, leverage and bank-to-bank credit play key roles in propagating capital flows to EMEs (Bruno and Shin (2015a)).

There are, however, detractors from this view. Aizenman et al (2015) argue that it is necessary to control for trade linkages, financial development and gross national debt as those factors imply a greater baseline sensitivity of peripheral to centre countries. This being the case, we may overstate the loss of monetary independence, which may always have been constrained by trade, finance and debt linkages. Aizenman et al (2015) seem to be more tentative about drawing strong conclusions from greater monetary interdependence or loss of traction. But, at a minimum, it appears that we should control for the baseline sensitivity of these links between peripheral and centre countries.

I would like to address three main points with respect to this paper. First, I summarise the insights of the paper itself – the advantages of this particular decomposition exercise. Second, I consider other decompositions and ask whether

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[2] Miyajima, Mohanty and Yetman (2014) use a model with an open economy user cost of capital concept to explore these channels. They find that the exchange rate moves countercyclically after an external shock. An exchange rate appreciation can induce looser domestic monetary policy, easing credit conditions. It can affect the balance sheet of firms, allowing them to borrow more domestically and internationally.

we have focused on the right one. This is a matter of the choice of fundamentals used to decompose the term premium. Finally, I consider what these tell us about financial conditions more generally and how else can they be modelled.

The paper offers important insights into the definition of terms. It differentiates between monetary autonomy, monetary dependence and financial contagion. It is also about distinguishing monetary dependence from financial contagion, and distinguishing changes due to risk appetite from those resulting from fundamentals. The authors do a fine job of removing the parts of the long-term bond yield related to expected monetary policy to focus on the term premium. The common component in the residuals determines the extent of monetary policy dependence. The paper shows that co-movements in the residuals have different dynamics compared with "off-the-shelf" measures of global risk such as the VIX index of US stock market volatility. EMEs are shown to be less exposed than AEs to global contagion (contrary to popular opinion), and the sensitivity of EMEs to global risk did not increase after the GFC (again contrary to popular opinion). The extent of co-movements from the decompositions in this paper differ from the co-movements apparent from long-term bond yields. But this is not entirely surprising since expectations of future short-term rates, and the fundamentals driving the term premium, have been removed before the co-movement of residuals is considered. Under this decomposition, monetary policy does not appear to be losing as much traction as some might have feared – we can all breathe more easily.

So what should we conclude? Either EMEs are more independent or they are affected by the global credit channel. We are not able to determine which of these two elements is true from the correlations of residuals. Potentially these results reveal that EMEs are more idiosyncratic than AEs. This may be due to the relatively large shocks they experience and the low correlation between those shocks across countries. The decompositions used here focus on shocks that are proportionally large for the EMEs concerned, but may not be large in an absolute sense, and are most likely to be much smaller than the shocks affecting AEs. Nevertheless, being relatively large, they may appear to give EMEs greater independence due to the dissimilarity of the residuals from the decomposition. Further exploration of the differences between EMEs – as opposed to their independence from global shocks – could be revealing. Could certain characteristics determine the extent to which EMEs' policy responses converge at points of stress? An analysis of the response of Asia-Pacific currencies to the US dollar around the time of the 2013 "taper tantrum" suggests that EMEs with more liquid currencies are more exposed to global volatility risk (Levich and Packer (2015)).

The conclusions are of course dependent on the type of decomposition that has been implemented. This raises several questions: How can we be sure about the reliability of the decomposition? How do we determine the "correct" fundamentals? Should we allow for announcements and news? How does the decomposition relate to financial conditions more generally?

This decomposition exercise would be more convincing if the authors could establish the "usefulness", quality of signal and robustness of their carefully extracted residual series. What makes this decomposition useful, high quality and robust for monetary policymakers? How much has to be taken on trust in the exclusion of fundamentals? Can we verify that the process has been conducted for maximum benefit?

A critical issue in extracting the residuals is the definition of fundamentals. In the paper, this is based on principal components (most significant common factors). We need to be convinced that the use of local yield curve and forward rate information and global information (such as yields on core country assets, lags of unexpected returns and the VIX index) is sufficient to control for fundamentals. We also need to be sure that by using this particular decomposition exercise we do not get results that are at variance with decompositions based on other fundamentals. For example, if we control for market depth and liquidity, bond characteristics (term to maturity, duration, amounts outstanding and coupon) and expected default frequency (along the lines suggested by Gilchrist and Zakrajsek (2012), and Bleaney et al (2016)), can we draw similar conclusions from the co-movement of residuals from this decomposition? We might also consider the use of a broader range of macroeconomic and financial factors, following Faust et al (2013), who used 15 macro and 110 financial variables. Term structure decompositions are to some degree model-specific, but the findings would be more robust if the co-movements between residuals under a range of alternative definitions of fundamentals were similar.

What about announcements and news? Monetary policy in AEs has been conducted unconventionally through announcements as much as through changes to policy instruments. There is considerable evidence that monetary policy announcements lead to changes in the term premium component of bond yields, as reported by Giannone et al (2011) and Altavilla et al (2014). We might also ask whether news has an impact on long-term yields and term premia. Brazys and Martens (2015) find that economic news can explain 20% of the total daily variation in US Treasury returns. Moreover, they indicate that some news items have temporary effects (manufacturing surveys and retail sales) while others have permanent effects (GDP advance/preliminary announcements). This suggest that we should first examine whether measures of fundamentals should be supplemented with news, and then allow for the possibility that some of these effects could be temporary and others more permanent.

Finally, how do the empirical results of the paper relate to financial conditions more generally? Financial condition indices have come back into favour as the recent paper by Hatzius et al (2010) illustrates. If there is a signal from the residuals, can this be related to EME financial conditions? Or is it related to real economic activity? The results from corporate bond markets in Gilchrist and Zakrajsek (2012), and Bleaney et al (2016) show that, for the US and European economies, the residuals from a decomposed bond spread index offer a useful forewarning of downturns in real activity. Could the same be true of the decomposition of sovereign bond yields? If so, could it be used to anticipate recessions due to changes in global risk appetite? Is any forward-looking information contained in the residuals or is it essentially contemporaneous?

This is a well-executed and insightful paper. I enjoyed reading it. It makes its main point very clearly: we are not losing traction. Further investigation would help in convincing the reader that the results are robust and that important variables have not been left out. It may also extend the usefulness of the decomposition to other uses such as monetary policy responses to changes in risk appetite.

References

Ahmed, S and A Zlate (2014): "Capital flows to emerging market economies: a brave new world?", *Journal of International Money and Finance,* vol 48, part B, pp 221–248.

Aizenman, J, M Chinn and H Ito (2015): "Monetary policy spillovers and the trilemma in the new normal: periphery country sensitivity to core country conditions", *NBER Working Paper*, no 21128, April.

Altavilla, C, D Giannone and M Lenza (2014): "The financial and macroeconomic effects of OMT announcements", *ECB Working Paper Series*, no 1707, August.

Borio, C and H Zhu (2012): "Capital Regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?", *Journal of Financial Stability*, vol 8, no 4, pp 236–251.

Bleaney, M, P Mizen and V Veleanu (2016): "Bond spreads and economic activity in eight European economies", *Economic Journal*, doi:10.1111/ecoj.12288.

Brazys, J and M Martens (2015): "How important is economic news for bond markets?", https://www.aeaweb.org/aea/2015conference/ program/retrieve.php?

Bruno, V and H S Shin (2015a): "Cross-border banking and global liquidity", *Review of Economic Studies*, vol 82, no 2, pp 535–564.

Bruno, V and H S Shin (2015b): "Capital flows and the risk-taking channel of monetary policy", *Journal of Monetary Economics*, vol 71, pp 119–132.

Faust, J, S Gilchrist, J Wright and E Zakrajšek (2013): "Bond spreads as predictors of real-time economic activity: a bayesian model-averaging approach", *Review of Economics and Statistics*, vol 95, no 5, pp 1501–1519.

Giannone, D, M Lenza, H Pill and L Reichlin (2011): "Non-standard monetary policy measures and monetary developments," *ECB Working Papers Series*, no 1290, January.

Gilchrist, S and E Zakrajšek (2012): "Credit spreads and business cycle fluctuations", *American Economic Review*, vol 102, no 4, pp 1692–1720.

Hatzius, J, P Hooper, F Mishkin, K Schoenholtz and M Watson (2010): "Financial conditions indexes: a fresh look after the financial crisis", *NBER Working Paper*, no 16150, July.

Levich, R, and F Packer (2015): "Development and functioning of FX markets in Asia and the Pacific", *BIS Papers*, no 82, October.

Miyajima, K, M Mohanty and J Yetman (2014): "Spillovers of US unconventional monetary policy to Asia: the role of long-term interest rates", *BIS Working Papers*, no 478, December.

Schularick, M and A Taylor (2012): "Credit booms gone bust: monetary policy, leverage cycles, and financial crises, 1870–2008", *American Economic Review*, vol 102, no 2, pp 1029–61.

Turner, P (2013) "Benign neglect of the long-term interest rate", *BIS Working Papers*, no 403, February.

Turner, P (2014): "The global long-term interest rate, financial risks and policy choices in EMEs", *BIS Working Papers*, no 441, February.

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