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The Global Macroeconomic Costs of Raising Bank Capital Adequacy Requirements

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The Global Macroeconomic Costs of Raising Bank Capital Adequacy Requirements

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Abstract

This paper examines the transitional macroeconomic costs of a synchronized global increase in bank capital adequacy requirements under Basel III, as well as a capital increase covering globally systemically important banks. The analysis, using an estimated multi-country model, contributed to the work of the Macroeconomic Assessment Group analysis, especially in estimating the potential international spillovers associated with a global increase in capital requirements. The magnitude of the effects found in this analysis is relatively modest, especially if monetary policies have scope to ease in response to a widening of interest rate spreads by banks.

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I. Introduction

1. This paper analyzes the transitional macroeconomic costs of strengthening bank capital adequacy requirements, including a general increase in capital requirements as well as an increase specifically for globally systemically important banks (GSIBS). In addition to estimating the impact of introducing higher capital requirements in each of 15 major economies, the analysis also includes estimates of the international spillover effects associated with the simultaneous introduction of higher capital requirements by all 15 countries. The simulations are generated within the framework of an extended and refined version of the multi-country macroeconometric model of the world economy developed and estimated by Vitek (2009).

2. This analysis contributed to the work of the Macroeconomic Assessment Group (MAG), chaired by the Bank for International Settlements (BIS), and the Long-term Economic Impact (LEI) group of the Basel Committee for Banking Stability (BCBS).[1] The MAG participants, including the IMF, used a variety of models to estimate the medium-term macroeconomic costs of strengthening capital and liquidity requirements.[2] The analysis presented in this paper, reflecting the MAG mandate, focuses solely on the short-term to medium-term output costs of the proposed new regulatory measures. Estimates of the net benefits of these regulatory measures can be found in the LEI report (BCBS 2010).

3. The macroeconomic effects of an increase in capital adequacy requirements are assumed in this analysis to be transmitted exclusively via increases in the spread between commercial bank lending rates and the central bank policy rate. We estimate that, in the absence of any monetary policy response, a permanent synchronized global increase in capital requirements for all banks by 1 percentage point, would cause a peak reduction in GDP of around 0.5 percentage points, of which around 0.1 percentage points would result from international spillovers. Losses in emerging market economies are found to be somewhat higher than in advanced economies. If monetary policy is able to respond, however, the adverse impact of higher capital requirements could be largely offset

4. With regard to strengthening capital requirements specifically for GSIBs, we estimate that a 1 percentage point increase in capital requirements for the top 30 GSIBs would cause a

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[1] See MAG (2010a, b), BCBS (2010), and MAG (2011).

[2] One of the DSGE models used in the exercise is described in Roger and Vlcek (2011).

median peak reduction in GDP of around 0.17 percentage points, of which 0.04 percentage points, or 25 percent, results from international spillovers. The aggregate figures conceal a wide range of outcomes, however, and for some countries, international spillovers would be the main source of macroeconomic effects.

5. It is important to bear in mind the limitations of the model and assumptions used in the analysis. In particular, the analysis does not take account of other possible responses by banks or other financial institutions to changes in capital requirements, or non-linearities in the response of financial systems, monetary policy, or the real economy. Nor does the model allow for changes in the macroeconomic steady state associated with very persistent widening of lending spreads. Additionally, the analysis does not take account of the different initial starting points of different countries in raising capital requirements, or differences in the speed of implementation.

II. The MAG Approach and the Role of the Multi-country Analysis

6. As discussed in the MAG Interim and Final reports (MAG 2010a, b), the MAG employed a variety of modeling strategies to estimate the transitional macroeconomic costs of introducing higher bank capital requirements. The most common approach involved a two step procedure. In the first step, countries estimated the impact on interest rate spreads of raising Tier 1 capital requirements on banks by 1 percentage point over several different implementation horizons. In the second step, countries then used standard macroeconomic models to estimate the impact on growth of a widening of credit spreads.[3] In most cases, the macroeconomic simulations considered two alternative policy scenarios: one in which monetary policy did not respond to the macroeconomic effects of the change in capital requirements; while under the alternative scenario monetary policy was allowed to react in a normal fashion.

7. In the follow-up MAG analysis (MAG 2011) of the effects of raising capital requirements for globally systemically important banks (G-SIBs), essentially the same approach was used, but with increases in capital requirements and their effects pro-rated

[3] This approach partly reflected the limitations of most existing mainstream macroeconomic models in analyzing financial or prudential issues, but also reflected a view that, over a relatively lengthy implementation period, banks were most likely to build up capital through some widening of spreads rather than through cutting lending. A number of models used in the MAG exercise, however, were able to consider the impact of tighter credit standards as a means of raising capital asset ratios. See, e.g., Roger and Vlcek (2011).

according to the importance of G-SIBs in national financial systems. Alternative scenarios again allowed for differences in implementation periods and monetary policy responses. In addition, alternative scenarios were constructed for different possible numbers of G-SIBs.

8. The multi-country model reported in this paper contributed importantly to the MAG analyses by providing estimates, on a country by country basis, of the international macroeconomic spillovers associated with the increases in capital requirements, both for a generalized increase in requirements, and for G-SIBs specifically. In the national macroeconomic analyses, the models allowed for an increase in capital requirements domestically, but did not make allowance for the simultaneous increase in capital requirements in other countries. With the multi-country model, however, it was possible to estimate the macroeconomic effects of individual countries raising capital requirements, as well as the effects of all countries raising capital requirements together. The international macroeconomic spillover for each country could then be calculated by subtracting the effects of each country raising capital requirements alone from the effects when all countries raised capital requirements together. As with the national analyses, the multi-country model exercise considered alternative horizons for implementing higher capital requirements, as well as alternative monetary policy scenarios and different numbers of G-SIBs subject to additional requirements.

9. The multi-country model estimates of the macroeconomic effects of increased interest rate spreads were also used as complements to the national model estimates. Instead of relying on single models to estimate these effects, the MAG approach involved aggregating results across models to obtain more robust estimates as well as a sense of a plausible range of outcomes.

III. The Multi-country Macroeconometric Model

10. The macroeconometric model used in this analysis is a panel unobserved components model of 15 major advanced and emerging market economies. This structural macroeconometric model features extensive linkages between the real and financial sectors, both within and across economies. Within each economy, cyclical components are modeled as a multivariate linear rational expectations model of the monetary transmission mechanism, while trend components are modeled as independent random walks. The traditional interest rate and exchange rate channels of monetary transmission are amplified and propagated by a

financial accelerator mechanism linked to the real value of an internationally diversified equity portfolio. For a detailed description of this model, please refer to Appendix A.

11. The multi-country model is estimated with a Bayesian procedure, conditional on prior information concerning the values of parameters, and judgment concerning the paths of trend components. For a detailed description of this estimation procedure, please refer to Appendix B. The data set consists of observations on the levels of a total of 128 macroeconomic and financial market variables observed for 15 economies over the period 1999Q1 through 2011Q1. The economies modeled are Australia, Brazil, Canada, China, France, Germany, Italy, Japan, Korea, Mexico, the Netherlands, Spain, Switzerland, the United Kingdom, and the United States.[4] The macroeconomic variables under consideration are the price of output, the price of consumption, the quantity of output, the quantity of domestic demand, and the prices of energy and non-energy commodities. The financial market variables under consideration are the nominal policy interest rate, the short term nominal market interest rate, the long term nominal market interest rate, the price of equity, and the nominal bilateral exchange rate versus the US dollar. For a detailed description of this data set, please refer to Appendix C.

IV. SIMULATIONS AND RESULTS

12. The multi-country model analysis of the impact of increases in global and G-SIB capital requirements, as with most of the models employed in this exercise, assumes that the primary response of banks to an increase in capital requirements will be a widening of lending spreads (relative to what they would otherwise have been). The widening of spreads would generate larger profit margins which would then be used to build up bank capital. The analysis, therefore, does not take into account other possible responses such as new equity issuance, increases in profit margins through efficiency gains, or through asset disposals or lending cutbacks. The potential impact of these alternative bank responses is discussed in more detail in the MAG reports.

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[4] For the analysis included in the 2010 MAG report, a slightly different sample period and grouping of countries was used. In the earlier analysis the sample period covered 1991Q1-2010Q2. The country grouping differed from the current grouping by omitting the Netherlands and Switzerland, and included India and Russia. As a consequence, the results reported in this paper for a global increase in capital requirements differ somewhat from those reported in the MAG 2010 reports, but the differences are not substantial.

13. The starting point for the analysis are country-by-country estimates of the impact of higher capital requirements on domestic retail interest rate spreads. In the case of an increase in global capital requirements, MAG participants used national models to estimate the impact of a 1 percentage point increase in capital requirements for all banks on bank lending spreads over the central bank policy rate. In the case of an increase in capital requirements applying to G-SIBs, the interest rate effect was scaled by the share of G-SIB lending in total domestic bank lending (see MAG 2011). The results of the national model estimates are reported in Table 1, both for a generalized increase in capital requirements and for increases for different numbers of G-SIBs. Using these spreads, the macroeconomic effects on each country were calculated in various scenarios as described below.

Table 1: Estimated Impact of a 1 Percentage Point Increase in Capital Requirements on Average Bank Lending Spreads (in basis points)

	GDP Weight	All Banks	Global Systemically Important Banks		
			Twenty	Thirty	Forty
Australia	0.02	20.6	1.1	1.5	1.8
Brazil	0.03	25.3	4.3	4.4	4.4
Canada	0.03	14.0	1.0	1.0	3.8
China	0.06	17.7	0.0	1.7	3.9
France	0.06	15.5	3.6	5.2	6.3
Germany	0.08	15.5	3.6	5.2	6.3
Italy	0.05	15.5	3.6	5.2	6.3
Japan	0.13	23.8	3.7	9.6	10.2
Korea	0.02	25.0	0.9	1.0	1.9
Mexico	0.02	20.2	7.4	7.4	12.9
Netherlands	0.02	15.5	3.6	5.2	6.3
Spain	0.03	15.5	3.6	5.2	6.3
Switzerland	0.01	17.7	6.4	6.4	6.4
United Kingdom	0.07	11.8	5.4	8.8	8.9
United States	0.36	12.0	6.1	6.1	6.1
World	1.00	15.9	4.3	5.8	6.6
Advanced Economies	0.86	15.1	4.6	6.3	6.8
Emerging Economies	0.14	20.8	2.2	3.1	5.2

Source: MAG (2010b, 2011)

A. A Global Increase in Capital Requirements

14. The first MAG exercise focused on the short- to medium-term macroeconomic costs of a generalized increase in capital requirements under Basel III. As noted above, the primary

channel of transmission was assumed to be through increases in bank lending spreads.[5] In the initial analysis (MAG 2010a), most estimates of macroeconomic effects were based on a 100 basis point (b.p.) increase in lending spreads, while in the final analysis (MAG 2010b), estimates were based on a 1 percentage point increase in capital adequacy requirements.

15. An important shortcoming of the analyses using national macroeconomic models is that they do not take into account the simultaneous implementation of higher capital requirements on a multi-country basis. If a single country raises its capital requirements while the rest of the world does not, then the contractionary impact on GDP in that country will be cushioned by the sustained strength of foreign demand. That, implicitly, is what national level analyses do. If all countries raise capital requirements simultaneously, however, external demand no longer provides a cushion for GDP. As a consequence, national estimates will typically understate the adverse impact on GDP of a generalized increase in capital requirements.

16. The key contribution of the multi-country model to the MAG exercises has been to take into account the simultaneity of the increases in capital requirements. This is done by comparing two basic scenarios. In the first "baseline" scenario, all countries are assumed to raise capital requirements by the same amount (1 percentage point) over the same period (4 to 8 years). In the "alternative" scenario, each country is assumed to increase its capital requirements, while others do not, equivalent to the national modeling exercises. The difference between these two scenarios amounts to the international spillover effect of the simultaneous change in regulatory requirements.

17. Based on this approach, the model was simulated for a standardized 1 percentage point increase in global capital requirements, resulting in increases in interest rate spreads, as shown under the "all banks" column in Table 1. Within this general scenario, however, two important variations in assumptions were considered. The first was to vary the speed of implementation of the increase in capital requirements, using 4, 6, and 8 year implementation horizons. In each case, the increase in capital requirements was assumed to be implemented in a linear fashion.

18. The second main variation in assumptions concerns the response of monetary policy to the macro-prudential measures. In normal circumstances, central banks in the various countries would adjust policy interest rates to counter the macroeconomic effects of the increase in

[5] As discussed in MAG (2010a, b), many different models were employed in the analysis. Although most models only allowed for transmission via a widening of interest rate spreads, a good number of others allowed for non-price effects through credit rationing.

capital requirements.[6] However, given the very low level of policy interest rates in many countries, the scope for monetary policy easing could be constrained by a zero lower bound on nominal interest rates, at least over part of the implementation horizon. To allow for this possibility, the implementation of the increase was simulated in one set of scenarios with a normal policy response similar to a Taylor Rule, while in the second scenario, the nominal interest rate was held constant.[7]

19. The macroeconomic transmission of the change in capital requirements is as follows. To meet higher capital requirements, banks raise lending spreads over the central bank policy rate. In the absence of a monetary policy response, the real market interest rate rises and real equity wealth falls, inducing a contraction in domestic demand through intertemporal substitution and wealth effects. In the case of a single country raising its capital requirements, the rise in market interest rates also leads to appreciation of the currency in real effective terms, amplifying the contraction in output as real net exports decline and as the real interest rate is further boosted temporarily by lower imported goods prices. If monetary policy is able to respond, however, a lowering of the policy rate can largely offset the impact of the widening of spreads.

20. In the case of a synchronized global increase in capital requirements, the contractionary effects of increases in domestic interest rates are amplified by international trade and financial linkages. Contractions in foreign demand will dampen exports to those countries, while declines in foreign equity values will adversely affect the value of internationally diversified portfolios, with adverse wealth effects on consumption. In addition, movements of exchange rates in response to changes in international interest rate differentials may amplify or moderate the demand and price effects of the shock. Weaker global demand also dampens inflation through downward pressures on commodity prices. As with a single country increase in capital requirements, the effects of a global increase in capital requirements can be substantially offset if countries are able to respond to the rise in capital requirements with an easing of the stance of monetary policy.

21. An important challenge in the modeling exercise faced by all participants including ourselves was how to deal with the very long duration of the shock to interest rate spreads,

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[6] For Euro Area (EA) countries, interest rates are assumed to respond identically to EA (GDP-weighted) averages for inflation and output in the EA countries in the model (Germany, France, Italy, Spain, and the Netherlands).

[7] The constant interest rate assumption was imposed by offsetting deviations from monetary policy rules with monetary policy shocks.

particularly in the scenarios with no monetary policy response. Although, in principle, the widening of spreads would be partly or even largely transitory,[8] they would nonetheless be quite persistent, especially in the scenarios with lengthy phasing in of the requirements. Such persistent shocks are difficult to deal with in "gap" models which take the steady state as given. In the event of very persistent or permanent shocks, however, the steady state equilibrium is likely to be affected. The BCBS (2010) estimated that a 1 percentage point increase in capital requirements would lead to a 0.09 percentage point reduction in the level of potential output. To address the issue of changing potential output in the MAG exercise, a restricted Kalman filter was applied the output paths generated by the model in this paper so that, over the long term, the level of potential would converge towards the model forecast for actual output. The results reported in this paper, however, focus on the actual levels of output, since this is a better indicator of the magnitude of the impact on output than is the estimated output gap.

22. Impulse responses of major variables in the 15 MAG economies in response to country-specific and global increases in capital requirements are shown in Appendix D. Tables 2 and 3 provide a summary view of the peak impact on output in the different countries, implemented over a range of different periods, both when monetary policy is able to respond, and when interest rates are held constant. Key features of the results shown in the tables include:

- In the absence of any monetary policy response, a synchronized global increase in capital requirements by 1 percentage point is estimated to have a peak impact on output of close to 0.5 percentage points (Table 2). Of this, about 0.1 percentage points reflect the international spillover effects of the simultaneous global introduction of higher capital requirements.

- There is substantial variation in the magnitude of output effects across countries, with the lowest estimated impact in the United States (0.4 percentage points), and the highest in China (0.8 percentage points). Differences partly reflect the pattern of interest rate increases associated with higher capital requirements. Countries experiencing higher interest rate increases (as shown in Table 1) tend to have the largest adverse impact on output, as shown in the "alternative" scenarios based on country-specific capital ratio increases. But variations in spillovers also play a role, with more open economies with less flexible exchange rates tending to experience relatively large spillovers.

[8] Once target increases in capital were achieved, banks would then reduce spreads in order to stabilize capital ratios at the required level. A small part of the increase in capital ratios, however, would likely be permanent. See BCBS (2010).

- Shortening the implementation period would accentuate the peak impact on growth and the output gap, but the permanent impact on output would be essentially unaffected.

- The scope for monetary policy to mitigate output losses is potentially large. Assuming that monetary policy is able to take the increase in spreads into account over the 4 to 8 year implementation horizon, the impact of higher capital requirements on output could be substantially offset. In particular, the simulations suggest that the peak impact on output would be reduced to a little over 0.1 percentage points (Table 3).

- In a few cases, the international spillovers may slightly boost growth. This arises in a few cases in the Euro Area where monetary policy is targeted at area-wide inflation and output. In such circumstances, the common monetary policy stance may be a bit too stimulative for some members (France, Italy, and Spain), and insufficiently so for other members (Germany and the Netherlands).

23. These estimates of the macroeconomic costs from raising capital requirements for all banks are broadly consistent with those reported in the existing empirical literature, after accounting for differences in underlying assumptions. Abstracting from monetary policy accommodation, our estimated peak output losses from economy-specific capital requirement increases lie near the top of the distribution of comparable simulation results reported in MAG (2010a, b). This may result from our restriction on the nominal policy interest rate being tighter than in other analyses, in the sense that it also applies after the implementation period. Finally, our estimated contributions from spillovers to these peak output losses are consistent with those reported in Resende, Dib and Perevalov (2010).

Table 2: Peak Impact on GDP from a Global Increase in Capital Requirements with no Monetary Policy Responses[1/]

	Weight	Four Years			Six Years			Eight Years		
		Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers
Australia	0.02	0.60	0.45	0.15	0.60	0.45	0.15	0.60	0.45	0.15
Brazil	0.03	0.74	0.65	0.09	0.74	0.65	0.09	0.74	0.65	0.09
Canada	0.03	0.42	0.25	0.16	0.42	0.25	0.16	0.42	0.25	0.16
China	0.06	0.83	0.61	0.22	0.83	0.61	0.22	0.83	0.61	0.22
France	0.06	0.48	0.38	0.09	0.47	0.38	0.09	0.47	0.38	0.09
Germany	0.08	0.49	0.39	0.10	0.49	0.38	0.10	0.48	0.38	0.10
Italy	0.05	0.48	0.39	0.09	0.47	0.39	0.09	0.47	0.39	0.09
Japan	0.13	0.69	0.59	0.10	0.69	0.59	0.10	0.69	0.59	0.10
Korea	0.02	0.73	0.45	0.28	0.73	0.45	0.28	0.73	0.45	0.28
Mexico	0.02	0.51	0.41	0.10	0.51	0.41	0.10	0.51	0.41	0.10
Netherlands	0.02	0.49	0.39	0.10	0.49	0.39	0.10	0.49	0.38	0.10
Spain	0.03	0.48	0.41	0.07	0.47	0.39	0.08	0.47	0.39	0.08
Switzerland	0.01	0.54	0.28	0.26	0.54	0.28	0.26	0.54	0.28	0.26
United Kingdom	0.07	0.38	0.22	0.15	0.37	0.22	0.15	0.37	0.22	0.15
United States	0.36	0.36	0.29	0.08	0.36	0.29	0.08	0.36	0.29	0.08
Unweighted median	1.00	0.49	0.39	0.10	0.49	0.39	0.10	0.49	0.39	0.10
Unweighted mean	1.00	0.55	0.41	0.13	0.55	0.41	0.14	0.54	0.41	0.14
GDP weighted median	1.00	0.45	0.34	0.09	0.47	0.34	0.09	0.47	0.33	0.09
GDP weighted mean	1.00	0.50	0.39	0.11	0.50	0.39	0.11	0.49	0.39	0.11
Advanced Economies	0.86	0.46	0.36	0.10	0.46	0.36	0.10	0.46	0.36	0.10
Emerging Economies	0.14	0.74	0.56	0.18	0.74	0.56	0.18	0.74	0.56	0.18

Source: Authors
1/ Reports simulated peak output losses (measured in percent) in response to a 1 percentage point increase in regulatory capital adequacy requirements for all banks, phased in at a constant speed over the stated implementation period. The scenarios assume unchanged policy interest rates. The baseline scenario features a global synchronized increase in capital requirements, while the alternative scenarios feature economy specific increases synchronized within the Euro Area. GDP weights are based on 2005 GDP.

Table 3: Peak Impact on GDP from a Global Increase in Capital Requirements with Monetary Policy Responses[1/]

	Weight	Four Years			Six Years			Eight Years		
		Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers
Australia	0.02	0.16	0.15	0.01	0.15	0.14	0.01	0.14	0.13	0.01
Brazil	0.03	0.20	0.19	0.01	0.18	0.18	0.00	0.18	0.17	0.00
Canada	0.03	0.11	0.09	0.01	0.10	0.09	0.01	0.10	0.09	0.01
China	0.06	0.24	0.21	0.02	0.22	0.20	0.02	0.21	0.20	0.02
France	0.06	0.10	0.13	-0.02	0.10	0.11	-0.01	0.10	0.11	-0.01
Germany	0.08	0.15	0.10	0.05	0.13	0.10	0.03	0.12	0.10	0.02
Italy	0.05	0.11	0.14	-0.03	0.11	0.12	-0.01	0.10	0.11	-0.01
Japan	0.13	0.18	0.18	0.01	0.17	0.16	0.01	0.16	0.16	0.00
Korea	0.02	0.19	0.17	0.02	0.18	0.16	0.02	0.17	0.16	0.02
Mexico	0.02	0.15	0.14	0.01	0.14	0.13	0.01	0.14	0.13	0.01
Netherlands	0.02	0.14	0.10	0.05	0.13	0.09	0.03	0.12	0.09	0.02
Spain	0.03	0.11	0.18	-0.07	0.10	0.14	-0.04	0.10	0.13	-0.03
Switzerland	0.01	0.14	0.12	0.02	0.13	0.11	0.02	0.12	0.11	0.02
United Kingdom	0.07	0.09	0.08	0.01	0.09	0.08	0.01	0.08	0.07	0.01
United States	0.36	0.09	0.09	0.01	0.09	0.08	0.01	0.08	0.08	0.01
Unweighted median	1.00	0.14	0.14	0.01	0.13	0.12	0.01	0.12	0.11	0.01
Unweighted mean	1.00	0.14	0.14	0.01	0.13	0.13	0.01	0.13	0.12	0.01
GDP weighted median	1.00	0.11	0.10	0.01	0.10	0.10	0.01	0.10	0.09	0.00
GDP weighted mean	1.00	0.13	0.12	0.01	0.12	0.11	0.01	0.12	0.11	0.01
Advanced Economies	0.86	0.12	0.11	0.00	0.11	0.10	0.01	0.11	0.10	0.01
Emerging Economies	0.14	0.21	0.19	0.02	0.19	0.18	0.01	0.19	0.17	0.01

Source: Authors
1/ Reports simulated peak output losses (measured in percent) in response to a 1 percentage point increase in regulatory capital adequacy requirements for all banks, phased in at a constant speed over the stated implementation period. The scenarios assume endogenous monetary policy responses. The baseline scenario features a global synchronized increase in capital requirements, while the alternative scenarios feature economy specific increases synchronized within the Euro Area. GDP weights are based on 2005 GDP.

B. An Increase in Capital Requirements for Globally Systemically Important Banks

24. In the 2011 MAG exercise, an increase in capital requirements applied to Globally Systemically Important Banks (GSIBs) was assessed using the same methodology as for the global increase in capital requirements for all banks, as described earlier. Simulations were conducted for 4, 6, and 8 year implementation horizons; with and without monetary policy responses; and for country-specific as well as simultaneous global increases in capital requirements for GSIBs.

25. In the GSIB analysis, however, estimates of the increase in spreads in each country reflected the share of GSIBs in total lending in that country. That is, the estimated impact on spreads of an increase in capital requirements for all banks was scaled by the GSIB share of lending in each country.[9] Because the number of banks that would be classified as GSIBs was not known at the time the analysis was undertaken, the MAG examined alternatives based on 20, 30, and 40 GSIBs. The estimated impact on spreads is shown in Table 1. The impact on spreads varies considerably from country to country, partly reflecting large differences in the importance of GSIBs in lending in different countries. In Mexico, for example, even though there are no Mexican GSIBs, foreign GSIBs play a large role in lending, so that the increase in spreads is much larger than average. In contrast, GSIBs have very small lending shares in Australia and Korea, so that spreads are little affected by the increase in capital requirements.

26. The analysis of the macroeconomic impact of the increase in capital requirements for GSIBs reflects the large variations in the importance of GSIBs in the various national banking systems, as well as the importance of taking international spillovers into account. The estimated impact on output of higher GSIB capital requirements for the case of 30 GSIBs (which is closest to the group eventually selected) are shown in Tables 4 and 5, below.

[9] See BCBS (2011).

Table 4: Peak Impact on GDP from an Increase in 30 GSIB Capital Requirements with no Monetary Policy Responses[1/]

	Weight	Four Years			Six Years			Eight Years		
		Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers
Australia	0.02	0.08	0.03	0.04	0.08	0.03	0.04	0.08	0.03	0.04
Brazil	0.03	0.14	0.11	0.03	0.14	0.11	0.03	0.14	0.11	0.03
Canada	0.03	0.09	0.02	0.07	0.09	0.02	0.07	0.09	0.02	0.07
China	0.06	0.14	0.06	0.08	0.14	0.06	0.08	0.14	0.06	0.08
France	0.06	0.17	0.13	0.04	0.17	0.13	0.04	0.16	0.13	0.04
Germany	0.08	0.17	0.13	0.04	0.17	0.13	0.04	0.17	0.13	0.04
Italy	0.05	0.17	0.13	0.04	0.17	0.13	0.04	0.17	0.13	0.04
Japan	0.13	0.26	0.24	0.03	0.26	0.24	0.03	0.26	0.24	0.03
Korea	0.02	0.09	0.02	0.07	0.09	0.02	0.07	0.09	0.02	0.07
Mexico	0.02	0.20	0.15	0.05	0.20	0.15	0.05	0.20	0.15	0.05
Netherlands	0.02	0.18	0.13	0.05	0.18	0.13	0.05	0.18	0.13	0.05
Spain	0.03	0.17	0.14	0.03	0.17	0.13	0.03	0.16	0.13	0.03
Switzerland	0.01	0.19	0.10	0.09	0.19	0.10	0.09	0.19	0.10	0.09
United Kingdom	0.07	0.22	0.17	0.05	0.22	0.17	0.05	0.22	0.17	0.05
United States	0.36	0.17	0.15	0.02	0.17	0.15	0.02	0.17	0.15	0.02
Unweighted median	1.00	0.17	0.13	0.04	0.17	0.13	0.04	0.17	0.13	0.04
Unweighted mean	1.00	0.16	0.11	0.05	0.16	0.11	0.05	0.16	0.11	0.05
GDP weighted median	1.00	0.17	0.14	0.03	0.17	0.14	0.03	0.17	0.14	0.03
GDP weighted mean	1.00	0.18	0.14	0.04	0.18	0.14	0.04	0.18	0.14	0.04
Advanced Economies	0.86	0.18	0.15	0.03	0.18	0.15	0.03	0.18	0.15	0.03
Emerging Economies	0.14	0.14	0.08	0.06	0.14	0.08	0.06	0.14	0.08	0.06

1/ Reports simulated peak output losses (measured in percent) in response to a 1 percentage point increase in regulatory capital adequacy requirements for the 30 most important GSIBs, phased in at a constant speed over the stated implementation period. The scenarios assume unchanged policy interest rates. The baseline scenario features a global synchronized increase in GSIB capital requirements, while the alternative scenarios feature economy specific increases synchronized within the Euro Area. GDP weights are based on 2005 GDP.

Table 5: Peak Impact on GDP from an Increase in 30 GSIB Capital Requirements with Monetary Policy Responses[1/]

	Weight	Four Years			Six Years			Eight Years		
		Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers	Baseline	Alternative	Spillovers
Australia	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
Brazil	0.03	0.03	0.03	0.00	0.03	0.03	0.00	0.03	0.03	0.00
Canada	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
China	0.06	0.03	0.02	0.01	0.03	0.02	0.01	0.02	0.02	0.01
France	0.06	0.04	0.04	-0.01	0.04	0.04	0.00	0.03	0.04	0.00
Germany	0.08	0.05	0.03	0.02	0.05	0.03	0.01	0.04	0.03	0.01
Italy	0.05	0.03	0.05	-0.01	0.03	0.04	-0.01	0.03	0.04	-0.01
Japan	0.13	0.07	0.07	0.00	0.07	0.07	0.00	0.07	0.06	0.00
Korea	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
Mexico	0.02	0.06	0.05	0.00	0.05	0.05	0.00	0.05	0.05	0.00
Netherlands	0.02	0.06	0.03	0.03	0.05	0.03	0.02	0.05	0.03	0.01
Spain	0.03	0.04	0.06	-0.02	0.04	0.05	-0.01	0.04	0.04	-0.01
Switzerland	0.01	0.05	0.04	0.01	0.05	0.04	0.01	0.04	0.04	0.01
United Kingdom	0.07	0.07	0.06	0.00	0.06	0.06	0.00	0.06	0.06	0.00
United States	0.36	0.05	0.04	0.00	0.04	0.04	0.00	0.04	0.04	0.00
Unweighted median	1.00	0.04	0.04	0.00	0.04	0.04	0.00	0.04	0.04	0.00
Unweighted mean	1.00	0.04	0.04	0.00	0.04	0.03	0.00	0.04	0.03	0.00
GDP weighted median	1.00	0.04	0.04	0.00	0.04	0.04	0.00	0.04	0.04	0.00
GDP weighted mean	1.00	0.05	0.04	0.00	0.04	0.04	0.00	0.04	0.04	0.00
Advanced Economies	0.86	0.05	0.05	0.00	0.05	0.04	0.00	0.04	0.04	0.00
Emerging Economies	0.14	0.03	0.03	0.01	0.03	0.02	0.00	0.03	0.02	0.00

1/ Reports simulated peak output losses (measured in percent) in response to a 1 percentage point increase in regulatory capital adequacy requirements for the 30 most important GSIBs, phased in at a constant speed over the stated implementation period. The scenarios assume endogenous monetary policy responses. The baseline scenario features a global synchronized increase in GSIB capital requirements, while the alternative scenarios feature economy specific increases synchronized within the Euro Area. GDP weights are based on 2005 GDP.

27. Notable features of the results include:

- In the absence of any monetary policy response to a 1 percentage point rise in GSIB capital requirements, the median peak adverse impact on GDP is estimated at 0.17 percentage points, of which an average of close to one quarter, or 0.04 percentage points, would stem from international spillovers associated with the simultaneous implementation of higher capital requirements. In the analysis based on 20 GSIBs the median peak output loss was estimated at 0.12 percentage points, while in the case of 40 GSIBs, the loss was estimated at 0.20 percentage points.

- There is a wide dispersion of outcomes, with Australia estimated to experience a peak output loss of just 0.08 percentage points, while Japan's loss is estimated at 0.26 percentage points.

- For several countries, international spillover effects are particularly important. For these countries, including Australia, Canada, China, and Korea, although GSIBs have relatively small direct importance for their banking sectors, their economies are significantly exposed to countries such as Japan and the United States where GSIBs are relatively important. As a consequence, for these countries, spillovers are estimated to account for more than half of the total impact on their GDP.

- As in the case of a global increase in capital requirements, if monetary policies are able to respond to an increase in GSIB capital requirements, the output effects can be substantially reduced.

V. Concluding Comments and Caveats

28. The multi-country macroeconomic model used in this analysis contributed importantly to the MAG assessments of the potential impact over the medium term of a global increase in capital requirements, both for all banks and for a smaller group of GSIBs. The results of the multi-country analysis indicate that international spillovers associated with coordinated policy measures are important—our analysis suggests that spillovers typically account for 20-25 percent of the total impact on output. Moreover, in the case of an increase in capital requirements for GSIBs, international spillovers may be the primary source of macroeconomic effects.

29. At the same time, it is important to recognize the important limitations associated both with the model and with the exercise it was used in. With regard to the model, the main limitations to emphasize are that:

- As discussed earlier, the model is not geared to dealing with changes in the steady state associated with permanent or very persistent shocks. Although the quantitative significance of this does not appear to be large in the context of this exercise, it suggests that the estimated effects of a permanent increase in interest rate spreads should be interpreted with caution, particularly at long horizons.

- The model has only one avenue for the increase in capital requirements to affect the real economy; though a widening of bank lending spreads over the policy rate. As discussed in the MAG reports, there are several ways in which banks can respond to higher capital requirements and some could have much more significant effects on output, while others would be more benign.

30. The exercises themselves have some important limitations that should be borne in mind in assessing the quantitative results and risks surrounding them. These include:

- The implementation of the higher capital requirements is assumed to be linear over the alternative implementation periods. In practice, the speed of implementation is quite likely to be non-linear; indeed, markets may be forcing a front-loading of adjustment.

- The scope for monetary policy responses may well vary over time and differ from one country to another. Not all countries are close to the zero lower bound for interest rates, and even those that are may not remain so over the entire implementation period. Consequently, macroeconomic outcomes and spillovers are bound to differ from those suggested by the model analysis. The analysis should be thought of as showing bounds for potential outcomes associated with different monetary policies.

- The analyses only consider standardized increases in capital requirements by 1 percentage point. However, the effects of increases in requirements may well be non-linear, so that increasing requirements by 2 percentage points may be not be simply twice as much as a 1 percentage point increase, and the degree of non-linearity may not be the same across time or countries. The zero lower bound constraint is one such non-linearity, but there are likely to be others.

- The analysis of the global increase in capital requirements assumed an identical increase in capital requirements in all countries. In reality, banks in some countries will have much further to go in meeting higher capital requirements than banks in other countries. As a consequence, the pace of increases in interest rate spreads will vary across countries. As seen in the exercise with GSIBs, where spreads increased by different amounts in different countries, this would significantly modify the pattern of macroeconomic effects and their spillovers between countries.

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APPENDIX A: THE MACROECONOMETRIC MODEL

1. Our panel unobserved components model of the world economy consists of multiple large open economies connected by trade and financial linkages. Within each economy, cyclical components are modeled as a multivariate linear rational expectations model of the monetary transmission mechanism derived from postulated behavioral relationships. These behavioral relationships approximately nest those associated with a variety of alternative structural macroeconomic models derived from microeconomic foundations, conferring robustness to model misspecification. In the interest of parsimony, cross economy equality restrictions are imposed on the structural parameters of these behavioral relationships, the response coefficients of which vary across economies with their structural characteristics. Trend components are modeled as independent random walks, conferring robustness to intermittent structural breaks.

2. The monetary transmission mechanism in each economy operates via interest rate and exchange rate channels, both of which link a short term nominal interest rate, which serves as the instrument of monetary policy, to consumption price inflation and the output gap, which are generally target variables. Under the interest rate channel, monetary policy affects the output gap and by implication inflation by inducing intertemporal substitution in domestic demand in response to changes in the long term real interest rate. Under the exchange rate channel, monetary policy both directly affects inflation, and indirectly affects the output gap and by implication inflation via intratemporal substitution between domestic and foreign demand, by inducing changes in the real effective exchange rate. A financial accelerator mechanism linked to the real value of an internationally diversified equity portfolio amplifies and propagates both of these channels.

3. In what follows, $\hat{x}_{i,t}$ denotes the cyclical component of variable $x_{i,t}$, while $\overline{x}_{i,t}$ denotes the trend component of variable $x_{i,t}$. Cyclical and trend components are additively separable, that is $x_{i,t} = \hat{x}_{i,t} + \overline{x}_{i,t}$. Furthermore, $\mathrm{E}_t\, x_{i,t+s}$ denotes the rational expectation of variable $x_{i,t+s}$ associated with economy i, conditional on information available at time t. In addition, $x^Z_{i,t}$ denotes the trade weighted average of variable $x_{i,t}$ across the trading partners of economy i, given bilateral weights $w^Z_{i,j}$ based on exports for $Z = X$, imports for $Z = M$, and their average for $Z = T$. Similarly, $x^Z_{i,t}$ denotes the portfolio weighted average of domestic currency denominated variable $x_{i,t}$ across the investment destinations of economy i, given bilateral weights $w^Z_{i,j}$ based on debt for $Z = B$ and equity for $Z = S$. Finally, x^Z_t denotes the weighted average of variable $x_{i,t}$ across all economies, given world weights w^Z_i based on money market

capitalization for $Z = M$, bond market capitalization for $Z = B$, stock market capitalization for $Z = S$, and output for $Z = Y$.

A. Cyclical Components

4. The cyclical component of output price inflation $\hat{\pi}_{i,t}^{Y}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of output according to domestic supply relationship,

$$\hat{\pi}_{i,t}^{Y} = \phi_{1,1}\hat{\pi}_{i,t-1}^{Y} + \phi_{1,2}\,\mathrm{E}_t\,\hat{\pi}_{i,t+1}^{Y} + \theta_{1,1}\ln\hat{Y}_{i,t} + \theta_{1,2}\sum_{z}\frac{Y_i^{COM^z}}{Y_i}\phi_1(L)\Delta\ln\frac{\hat{S}_{i,t}^{USA}\hat{P}_t^{COM^z}}{\hat{P}_{i,t}^{Y}} + \varepsilon_{i,t}^{\hat{P}^Y}, \qquad (1)$$

where domestic supply shock $\varepsilon_{i,t}^{\hat{P}^Y} \sim \text{iid N}(0, \sigma_{\hat{P}^Y,i}^2)$. The cyclical component of output price inflation also depends on contemporaneous, past, and expected future changes in the cyclical components of the relative domestic currency denominated prices of energy and nonenergy commodities, where polynomial in the lag operator $\phi_1(L) = 1 - \phi_{1,1}L - \phi_{1,2}\,\mathrm{E}_t\,L^{-1}$. The response coefficients of this relationship vary across economies with their commodity production intensity, measured by the ratio of commodity production to output $\frac{Y_i^{COM}}{Y_i}$.

5. The cyclical component of consumption price inflation $\hat{\pi}_{i,t}^{C}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of output according to supply relationship,

$$\begin{aligned}\hat{\pi}_{i,t}^{C} &= \phi_{1,1}\hat{\pi}_{i,t-1}^{C} + \phi_{1,2}\,\mathrm{E}_t\,\hat{\pi}_{i,t+1}^{C} + \theta_{1,1}\ln\hat{Y}_{i,t} \\ &\quad + \theta_{2,1}\frac{M_i}{Y_i}\left[\left(1 - \frac{M_i^{COM}}{M_i}\right)\phi_1(L)\Delta\ln\hat{Q}_{i,t}^{M} + \theta_{2,2}\sum_{z}\frac{M_i^{COM^z}}{M_i}\phi_1(L)\Delta\ln\frac{\hat{S}_{i,t}^{USA}\hat{P}_{i,t}^{COM^z}}{\hat{P}_{i,t}^{Y}}\right] + \varepsilon_{i,t}^{\hat{P}^Y} + \phi_1(L)\varepsilon_{i,t}^{\hat{P}^M},\end{aligned} \qquad (2)$$

where foreign supply shock $\varepsilon_{i,t}^{\hat{P}^M} \sim \text{iid N}(0, \sigma_{\hat{P}^M,i}^2)$. The cyclical component of consumption price inflation also depends on contemporaneous, past, and expected future changes in the cyclical components of the import weighted real effective exchange rate and the relative domestic currency denominated prices of energy and nonenergy commodities. The response coefficients of this relationship vary across economies with their import openness, measured by the ratio of imports to output $\frac{M_i}{Y_i}$, as well as their commodity import intensity, measured by the ratio of commodity imports to imports $\frac{M_i^{COM}}{M_i}$.

6. The cyclical component of output $\ln \hat{Y}_{i,t}$ follows a stationary first order autoregressive process driven by a monetary conditions index according to demand relationship,

$$\begin{aligned}\ln \hat{Y}_{i,t} &= \phi_{3,1} \ln \hat{Y}_{i,t-1} + \theta_{3,1}\left(1-\theta_{4,1}\frac{M_i}{Y_i}\right)\left(\hat{r}_{i,t}^{L,C} + \theta_{3,2}\ln\frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^{C}}\right) \\ &+\theta_{4,1}\frac{X_i}{Y_i}\phi_3(L)\ln \hat{D}_{i,t}^{X} + \theta_{4,2}\phi_3(L)\left(\frac{X_i}{Y_i}\ln \hat{Q}_{i,t}^{T,X} - \frac{M_i}{Y_i}\ln \hat{Q}_{i,t}^{T}\right) + \left(1-\theta_{4,1}\frac{M_i}{Y_i}\right)\nu_{i,t}^{\hat{D}} + \frac{X_i}{Y_i}\phi_3(L)\nu_{i,t}^{\hat{X}},\end{aligned} \tag{3}$$

where foreign demand shock $\nu_{i,t}^{\hat{X}} = \rho_{\hat{X}}\nu_{i,t-1}^{\hat{X}} + \varepsilon_{i,t}^{\hat{X}}$ with $\varepsilon_{i,t}^{\hat{X}} \sim \text{iid N}(0,\sigma_{\hat{X},i}^2)$. Reflecting the existence of international trade and financial linkages, this monetary conditions index is defined as a linear combination of a financial conditions index and the contemporaneous and past cyclical components of the trade weighted real effective exchange rate.[10] The cyclical component of output also depends on the contemporaneous and past cyclical components of export weighted foreign demand, where polynomial in the lag operator $\phi_3(L) = 1-\phi_{3,1}L$. The response coefficients of this relationship vary across economies with their trade openness, measured by the ratio of exports to output $\frac{X_i}{Y_i}$ or imports to output $\frac{M_i}{Y_i}$.

7. The cyclical component of domestic demand $\ln \hat{D}_{i,t}$ follows a stationary first order autoregressive process driven by a financial conditions index according to domestic demand relationship,

$$\ln \hat{D}_{i,t} = \phi_{3,1}\ln \hat{D}_{i,t-1} + \theta_{3,1}\left(\hat{r}_{i,t}^{L,C} + \theta_{3,2}\ln\frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^{C}}\right) + \nu_{i,t}^{\hat{D}}, \tag{4}$$

where domestic demand shock $\nu_{i,t}^{\hat{D}} = \rho_{\hat{D}}\nu_{i,t-1}^{\hat{D}} + \varepsilon_{i,t}^{\hat{D}}$ with $\varepsilon_{i,t}^{\hat{D}} \sim \text{iid N}(0,\sigma_{\hat{D},i}^2)$. This financial conditions index is defined as a linear combination of the contemporaneous cyclical components of the long term consumption based real market interest rate and the real value of an internationally diversified equity portfolio.

8. The cyclical component of the nominal policy interest rate $\hat{i}_{i,t}^{P}$ depends on a weighted average of its past and desired cyclical components according to monetary policy rule,

[10] This monetary conditions index $\hat{I}_{i,t}^{MCI}$ is defined as $\hat{I}_{i,t}^{MCI} = \hat{I}_{i,t}^{FCI} + \frac{\theta_{4,2}}{\theta_{3,1}}\left(1-\theta_{4,1}\frac{M_i}{Y_i}\right)^{-1}\phi_3(L)$ $\left(\frac{X_i}{Y_i}\ln \hat{Q}_{i,t}^{T,X} - \frac{M_i}{Y_i}\ln \hat{Q}_{i,t}^{T}\right)$, where financial conditions index $\hat{I}_{i,t}^{FCI}$ satisfies $\hat{I}_{i,t}^{FCI} = \hat{r}_{i,t}^{L,C} + \theta_{3,2}\ln\frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^{C}}$.

$$\hat{i}_{i,t}^{P} = \phi_{5,1}\hat{i}_{i,t-1}^{P} + (1-\phi_{5,1})(\theta_{5,1,j}\hat{\pi}_{i,t}^{C} + \theta_{5,2,j}\ln\hat{Y}_{i,t} + \theta_{5,3,j}\ln\hat{Q}_{i,t}^{T}) + \varepsilon_{i,t}^{\hat{i}^P}, \quad (5)$$

where monetary policy shock $\varepsilon_{i,t}^{\hat{i}^P} \sim \text{iid N}(0,\sigma_{\hat{i}^P,i}^2)$. Under a flexible inflation targeting regime $j=1$ and the desired cyclical component of the nominal policy interest rate responds to the contemporaneous cyclical components of consumption price inflation and output, while under a managed exchange rate regime $j=0$ and it also responds to the contemporaneous cyclical component of the trade weighted real effective exchange rate. For economies belonging to a currency union, the target variables entering into their common monetary policy rule are expressed as output weighted averages across union members. The cyclical component of the real policy interest rate $\hat{r}_{i,t}^{P,Z}$ satisfies $\hat{r}_{i,t}^{P,Z} = \hat{i}_{i,t}^{P} - \text{E}_t\,\hat{\pi}_{i,t+1}^{Z}$, where $Z \in \{C,Y\}$.

9. The cyclical component of the spread between the short term nominal market interest rate $\hat{i}_{i,t}^{S}$ and the nominal policy interest rate follows a stationary first order autoregressive process driven by the contemporaneous cyclical component of the real value of an internationally diversified equity portfolio according to money market relationship,

$$\hat{i}_{i,t}^{S} - \hat{i}_{i,t}^{P} = \phi_{6,1}(\hat{i}_{i,t-1}^{S} - \hat{i}_{i,t-1}^{P}) + \theta_{6,1}\ln\frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^{C}} + \lambda_{6,j}\varepsilon_{t}^{\hat{i}^S,M} + (1-\lambda_{6,j}w_i^M)\varepsilon_{i,t}^{\hat{i}^S}, \quad (6)$$

where credit risk premium shock $\varepsilon_{i,t}^{\hat{i}^S} \sim \text{iid N}(0,\sigma_{\hat{i}^S,i}^2)$. The intensity of international money market contagion varies across economies, with $j=1$ for advanced economies and $j=0$ for emerging economies. The cyclical component of the short term real market interest rate $\hat{r}_{i,t}^{S,Z}$ satisfies $\hat{r}_{i,t}^{S,Z} = \hat{i}_{i,t}^{S} - \text{E}_t\,\hat{\pi}_{i,t+1}^{Z}$.

10. The cyclical component of the long term nominal market interest rate $\hat{i}_{i,t}^{L}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of the short term nominal market interest rate according to bond market relationship,

$$\hat{i}_{i,t}^{L} = \phi_{7,1}\hat{i}_{i,t-1}^{L} + \phi_{7,2}\,\text{E}_t\,\hat{i}_{i,t+1}^{L} + \theta_{7,1}\hat{i}_{i,t}^{S} + \lambda_{7,j}\varepsilon_{t}^{\hat{i}^L,B} + (1-\lambda_{7,j}w_i^B)\varepsilon_{i,t}^{\hat{i}^L}, \quad (7)$$

where duration risk premium shock $\varepsilon_{i,t}^{\hat{i}^L} \sim \text{iid N}(0,\sigma_{\hat{i}^L,i}^2)$. The intensity of international bond market contagion varies across economies, with $j=1$ for advanced economies and $j=0$ for emerging economies. The cyclical component of the long term real market interest rate $\hat{r}_{i,t}^{L,Z}$ satisfies the same bond market relationship, driven by the contemporaneous cyclical component of the corresponding short term real market interest rate.

11. The cyclical component of the relative price of equity $\ln \hat{P}_{i,t}^{STK}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical components of output and the short term output based real market interest rate according to stock market relationship,

$$\ln \frac{\hat{P}_{i,t}^{STK}}{\hat{P}_{i,t}^{Y}} = \phi_{8,1} \ln \frac{\hat{P}_{i,t-1}^{STK}}{\hat{P}_{i,t-1}^{Y}} + \phi_{8,2} \, \mathrm{E}_t \ln \frac{\hat{P}_{i,t+1}^{STK}}{\hat{P}_{i,t+1}^{Y}} + \theta_{8,1} \ln \hat{Y}_{i,t} + \theta_{8,2} \hat{r}_{i,t}^{S,Y} + \lambda_{8,j} \varepsilon_t^{\hat{P}^{STK},S} + (1 - \lambda_{8,j} w_i^S) \varepsilon_{i,t}^{\hat{P}^{STK}}, \quad (8)$$

where equity risk premium shock $\varepsilon_{i,t}^{\hat{P}^{STK}} \sim$ iid $\mathrm{N}(0, \sigma_{\hat{P}^{STK},i}^2)$. The intensity of international stock market contagion varies across economies, with $j = 1$ for advanced economies and $j = 0$ for emerging economies.

12. The cyclical component of the real bilateral exchange rate $\ln \hat{Q}_{i,t}^{USA}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of the short term output based real market interest rate differential according to foreign exchange market relationship,

$$\ln \hat{Q}_{i,t}^{USA} = \phi_{9,1} \ln \hat{Q}_{i,t-1}^{USA} + \phi_{9,2} \, \mathrm{E}_t \ln \hat{Q}_{i,t+1}^{USA} + \theta_{9,1,j} (\hat{r}_{i,t}^{S,Y} - \hat{r}_{USA,t}^{S,Y}) + \varepsilon_{i,t}^{\hat{S}}, \quad (9)$$

where exchange rate risk premium shock $\varepsilon_{i,t}^{\hat{S}} \sim$ iid $\mathrm{N}(0, \sigma_{\hat{S},i}^2)$. The sensitivity of the real bilateral exchange rate to changes in the short term output based real market interest rate differential depends on capital controls, with $j = 1$ in their presence and $j = 0$ in their absence. For economies belonging to a currency union, the variables entering into their common foreign exchange market relationship are expressed as output weighted averages across union members. The cyclical component of the nominal bilateral exchange rate $\ln \hat{S}_{i,t}^{USA}$ satisfies $\ln \hat{Q}_{i,t}^{USA} = \ln \hat{S}_{i,t}^{USA} + \ln \hat{P}_{USA,t}^{Y} - \ln \hat{P}_{i,t}^{Y}$.[11]

13. The cyclical component of the relative price of commodities $\ln \hat{P}_t^{COM^z}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of world output according to commodity market relationship,

[11] It can be shown that the cyclical component of the nominal effective exchange rate $\ln \hat{S}_{i,t}^{Z}$ satisfies $\ln \hat{S}_{i,t}^{Z} = \ln \hat{S}_{i,t}^{USA} - \sum_{j=1}^{N} w_{i,j}^{Z} \ln \hat{S}_{j,t}^{USA}$, while the cyclical component of the real effective exchange rate $\ln \hat{Q}_{i,t}^{Z}$ satisfies $\ln \hat{Q}_{i,t}^{Z} = \ln \hat{Q}_{i,t}^{USA} - \sum_{j=1}^{N} w_{i,j}^{Z} \ln \hat{Q}_{j,t}^{USA}$, where N denotes the number of economies. Note that $\ln \hat{Q}_{i,t}^{Z} = \ln \hat{S}_{i,t}^{Z} + \ln \hat{P}_{i,t}^{C,Z} - \ln \hat{P}_{i,t}^{C}$.

$$\ln \frac{\hat{P}_t^{COM^z}}{\hat{P}_{USA,t}^{Y}} = \phi_{10,1} \ln \frac{\hat{P}_{t-1}^{COM^z}}{\hat{P}_{USA,t-1}^{Y}} + \phi_{10,2}\, \mathrm{E}_t \ln \frac{\hat{P}_{t+1}^{COM^z}}{\hat{P}_{USA,t+1}^{Y}} + \theta_{10,1,j} \ln \hat{Y}_t^{Y} + \varepsilon_t^{\hat{P}^{COM^z}}, \tag{10}$$

where commodity price shock $\varepsilon_t^{\hat{P}^{COM^z}} \sim \text{iid N}(0, \sigma^2_{\hat{P}^{COM},z})$. The sensitivity of the relative price of commodities to changes in world output depends on its type $z \in \{e, n\}$, with $j = 1$ for energy commodities and $j = 0$ for nonenergy commodities. As an identifying restriction, all innovations are assumed to be independent, which combined with our distributional assumptions implies multivariate normality.

B. Trend Components

14. The growth rates of the trend components of the price of output $\ln \overline{P}_{i,t}^{Y}$, the price of consumption $\ln \overline{P}_{i,t}^{C}$, output $\ln \overline{Y}_{i,t}$, domestic demand $\ln \overline{D}_{i,t}$, the price of equity $\ln \overline{P}_{i,t}^{STK}$, and the price of commodities $\ln \overline{P}_{t}^{COM^z}$ follow random walks:

$$\Delta \ln \overline{P}_{i,t}^{Y} = \Delta \ln \overline{P}_{i,t-1}^{Y} + \varepsilon_{i,t}^{\overline{P}^{Y}},\ \varepsilon_{i,t}^{\overline{P}^{Y}} \sim \text{iid N}(0, \sigma^2_{\overline{P}^{Y},i}), \tag{11}$$

$$\Delta \ln \overline{P}_{i,t}^{C} = \Delta \ln \overline{P}_{i,t-1}^{C} + \varepsilon_{i,t}^{\overline{P}^{C}},\ \varepsilon_{i,t}^{\overline{P}^{C}} \sim \text{iid N}(0, \sigma^2_{\overline{P}^{C},i}), \tag{12}$$

$$\Delta \ln \overline{Y}_{i,t} = \Delta \ln \overline{Y}_{i,t-1} + \varepsilon_{i,t}^{\overline{Y}},\ \varepsilon_{i,t}^{\overline{Y}} \sim \text{iid N}(0, \sigma^2_{\overline{Y},i}), \tag{13}$$

$$\Delta \ln \overline{D}_{i,t} = \Delta \ln \overline{D}_{i,t-1} + \varepsilon_{i,t}^{\overline{D}},\ \varepsilon_{i,t}^{\overline{D}} \sim \text{iid N}(0, \sigma^2_{\overline{D},i}), \tag{14}$$

$$\Delta \ln \overline{P}_{i,t}^{STK} = \Delta \ln \overline{P}_{i,t-1}^{STK} + \varepsilon_{i,t}^{\overline{P}^{STK}},\ \varepsilon_{i,t}^{\overline{P}^{STK}} \sim \text{iid N}(0, \sigma^2_{\overline{P}^{STK},i}), \tag{15}$$

$$\Delta \ln \overline{P}_{t}^{COM^z} = \Delta \ln \overline{P}_{t-1}^{COM^z} + \varepsilon_{t}^{\overline{P}^{COM^z}},\ \varepsilon_{t}^{\overline{P}^{COM^z}} \sim \text{iid N}(0, \sigma^2_{\overline{P}^{COM},z}). \tag{16}$$

15. The trend components of the nominal policy interest rate $\overline{i}_{i,t}^{P}$, short term nominal market interest rate $\overline{i}_{i,t}^{S}$, long term nominal market interest rate $\overline{i}_{i,t}^{L}$, and growth rate of the nominal bilateral exchange rate $\ln \overline{S}_{i,t}^{USA}$ also follow random walks:

$$\overline{i}_{i,t}^{P} = \overline{i}_{i,t-1}^{P} + \varepsilon_{i,t}^{\overline{i}^{P}},\ \varepsilon_{i,t}^{\overline{i}^{P}} \sim \text{iid N}(0, \sigma^2_{\overline{i}^{P},i}), \tag{17}$$

$$\overline{i}_{i,t}^{S} = \overline{i}_{i,t-1}^{S} + \varepsilon_{i,t}^{\overline{i}^{S}},\ \varepsilon_{i,t}^{\overline{i}^{S}} \sim \text{iid N}(0, \sigma^2_{\overline{i}^{S},i}), \tag{18}$$

$$\overline{i}_{i,t}^{L} = \overline{i}_{i,t-1}^{L} + \varepsilon_{i,t}^{\overline{i}^{L}},\ \varepsilon_{i,t}^{\overline{i}^{L}} \sim \text{iid N}\ (0, \sigma_{\overline{i}^{L},i}^{2}), \tag{19}$$

$$\Delta \ln \overline{S}_{i,t}^{USA} = \Delta \ln \overline{S}_{i,t-1}^{USA} + \varepsilon_{i,t}^{\overline{S}},\ \varepsilon_{i,t}^{\overline{S}} \sim \text{iid N}\ (0, \sigma_{\overline{S},i}^{2}). \tag{20}$$

16. The trend component of the real policy interest rate $\overline{r}_{i,t}^{P,Z}$ satisfies $\overline{r}_{i,t}^{P,Z} = \overline{i}_{i,t}^{P} - \text{E}_t\, \overline{\pi}_{i,t+1}^{Z}$, the trend component of the short term real market interest rate $\overline{r}_{i,t}^{S,Z}$ satisfies $\overline{r}_{i,t}^{S,Z} = \overline{i}_{i,t}^{S} - \text{E}_t\, \overline{\pi}_{i,t+1}^{Z}$, and the trend component of the long term real market interest rate $\overline{r}_{i,t}^{L,Z}$ satisfies $\overline{r}_{i,t}^{L,Z} = \overline{i}_{i,t}^{L} - \text{E}_t\, \overline{\pi}_{i,t+1}^{Z}$. Finally, the trend component of the real bilateral exchange rate $\ln \overline{Q}_{i,t}^{USA}$ satisfies $\ln \overline{Q}_{i,t}^{USA} = \ln \overline{S}_{i,t}^{USA} + \ln \overline{P}_{USA,t}^{Y} - \ln \overline{P}_{i,t}^{Y}$. As an identifying restriction, all innovations are assumed to be independent.

APPENDIX B: ESTIMATION

17. The traditional econometric interpretation of this panel unobserved components model of the world economy regards it as a representation of the joint probability distribution of the data. We employ a Bayesian estimation procedure which respects this traditional econometric interpretation.

18. Joint estimation of the parameters and unobserved components of our panel unobserved components model is based on the levels of a total of 128 endogenous variables observed for 15 economies over the sample period 1999Q1 through 2011Q1. The economies under consideration are Australia, Brazil, Canada, China, France, Germany, Italy, Japan, Korea, Mexico, the Netherlands, Spain, Switzerland, the United Kingdom, and the United States. The observed endogenous variables under consideration are the price of output, the price of consumption, the quantity of output, the quantity of domestic demand, the nominal policy interest rate, the short term nominal market interest rate, the long term nominal market interest rate, the price of equity, the nominal bilateral exchange rate, and the prices of energy and nonenergy commodities. For a detailed description of this data set, see Appendix C.

A. Estimation Procedure

19. The parameters and unobserved components of our panel unobserved components model are jointly estimated with a Bayesian procedure, conditional on prior information concerning the values of structural parameters, and judgment concerning the paths of trend components. Inference on the parameters is based on an asymptotic normal approximation to the posterior distribution around its mode, which is calculated by numerically maximizing the

logarithm of the posterior density kernel. Following Engle and Watson (1981), we employ an estimator of the Hessian which depends only on first derivatives and is negative semidefinite.

20. Evaluation of the logarithm of the posterior density kernel involves first solving for the unique stationary solution to the multivariate linear rational expectations model governing the evolution of cyclical components with the algorithm due to Klein (2000). The resultant first order vector autoregressive model is then combined with a dynamic factor model governing the evolution of trend components to form a linear state space model expressing the levels of all observed non-predetermined endogenous variables as a function of an unobserved state vector, which in turn evolves according to a first order vector autoregressive process. This linear state space model is then augmented with a set of stochastic restrictions on selected unobserved state variables summarizing judgment concerning the paths of the trend components of all observed non-predetermined endogenous variables. The logarithm of the predictive density function is then evaluated, conditional on the parameters associated with this linear state space model, with the filter presented in Vitek (2009), which adapts the filter due to Kalman (1960) to incorporate judgment. Finally, the logarithm of this conditional density function is combined with the logarithm of a multivariate normal density function summarizing prior information concerning the values of parameters. For a detailed discussion of this estimation procedure, please refer to Vitek (2009).

B. Estimation Results

21. The set of parameters associated with our panel unobserved components model is partitioned into two subsets. Those parameters associated with the conditional mean function are estimated conditional on informative independent priors, while those parameters associated exclusively with the conditional variance function are estimated conditional on diffuse priors.

22. The marginal prior distributions of those parameters associated with the conditional mean function are centered within the range of estimates reported in the existing empirical literature, where available. The conduct of monetary policy is represented by a flexible inflation targeting regime in all economies except for China, where it is represented by a managed exchange rate regime supported by capital controls. Great ratios and bilateral trade and equity portfolio weights entering into the conditional mean function are calibrated to match their observed values in 2005. All world weights and bilateral trade and portfolio weights are normalized to sum to one.

23. Judgment concerning the paths of trend components is generated by passing the levels of all observed endogenous variables through the filter described in Hodrick and Prescott (1997). Stochastic restrictions on the trend components of all observed endogenous variables are derived from these preliminary estimates, with a time varying innovation covariance matrix set equal to that obtained from unrestricted estimation. Initial conditions for the cyclical components of exogenous variables are given by their unconditional means and variances, while the initial values of all other state variables are treated as parameters, and are calibrated to match functions of initial realizations of the levels of observed endogenous variables, or preliminary estimates of their trend components calculated with the filter due to Hodrick and Prescott (1997).

24. The posterior mode is calculated by numerically maximizing the logarithm of the posterior density kernel with a modified steepest ascent algorithm. Parameter estimation results pertaining to the sample period 1999Q3 through 2011Q1 are shown in Table 5, below. The sufficient condition for the existence of a unique stationary rational expectations equilibrium due to Klein (2000) is satisfied in a neighborhood around the posterior mode, while our estimator of the Hessian is not nearly singular at the posterior mode, suggesting that the linear state space representation of our panel unobserved components model is locally identified.

25. The posterior modes of most structural parameters are close to their prior means, reflecting the imposition of tight priors to preserve empirically plausible impulse response dynamics. Nevertheless, the data are quite informative regarding many of these structural parameters, as evidenced by the substantial reduction in standard error from prior to posterior. The estimated variances of innovations driving variation in cyclical components are all well within the range of estimates reported in the existing empirical literature, after accounting for data rescaling. The estimated variances of innovations driving variation in trend components vary considerably across economies and observed endogenous variables.

Table 6: Parameter Estimation Results

	Prior		Posterior																															
			World		Australia		Brazil		Canada		China		France		Germany		Italy		Japan		Korea		Mexico		Netherlands		Spain		Switzerland		United Kingdom		United States	
	Mean	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE
$\phi_{1,1}$	0.490	4.9e–3	0.462	4.3e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{1,2}$	0.490	4.9e–3	0.478	4.7e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{1,1}$	0.013	1.3e–3	0.020	1.1e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{1,2}$	0.250	2.5e–2	0.187	1.2e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{2,1}$	0.100	1.0e–2	0.116	8.9e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{2,2}$	0.250	2.5e–2	0.258	2.5e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{3,1}$	0.750	7.5e–3	0.759	6.8e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3,1}$	–1.500	1.5e–1	–1.548	2.2e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3,2}$	–0.015	1.5e–3	–0.016	4.3e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{4,1}$	1.500	1.5e–1	1.402	2.1e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{4,2}$	–0.150	1.5e–2	–0.113	5.5e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{5,1}$	0.750	7.5e–3	0.752	6.2e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{5,1,0}$	1.250	1.3e–1	...	...	...	...	...	...	...	...	1.391	1.0e–1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{5,1,1}$	1.500	1.5e–1	...	...	1.926	6.6e–2	1.926	6.6e–2	1.926	6.6e–2	...	...	...	...	1.926	6.6e–2	...	...	1.926	6.6e–2	1.926	6.6e–2	1.926	6.6e–2	...	...	...	...	1.926	6.6e–2	1.926	6.6e–2	1.926	6.6e–2
$\theta_{5,2,0}$	0.125	1.3e–2	...	...	...	...	...	...	...	...	0.118	1.2e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{5,2,1}$	0.125	1.3e–2	...	...	0.123	1.1e–2	0.123	1.1e–2	0.123	1.1e–2	...	...	...	...	0.123	1.1e–2	...	...	0.123	1.1e–2	0.123	1.1e–2	0.123	1.1e–2	...	...	...	...	0.123	1.1e–2	0.123	1.1e–2	0.123	1.1e–2
$\theta_{5,3,0}$	0.013	1.3e–3	...	...	...	...	...	...	...	...	0.012	1.2e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{6,1}$	0.250	2.5e–3	0.250	2.5e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{6,1}$	–0.001	1.0e–4	–0.001	7.9e–5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{6,0}$	1.200	1.2e–1	...	...	...	...	1.152	8.1e–2	...	...	1.152	8.1e–2	...	...	...	...	...	...	...	...	1.152	8.1e–2	1.152	8.1e–2	...	...	...	...	...	...	...	...	...	...
$\lambda_{6,1}$	0.800	8.0e–2	...	...	0.890	6.1e–2	...	...	0.890	6.1e–2	...	...	0.890	6.1e–2	0.890	6.1e–2	0.890	6.1e–2	0.890	6.1e–2	...	...	...	...	0.890	6.1e–2	0.890	6.1e–2	0.890	6.1e–2	0.890	6.1e–2	0.890	6.1e–2
$\phi_{7,1}$	0.240	2.4e–3	0.236	2.3e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{7,2}$	0.740	7.4e–3	0.735	5.5e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{7,1}$	0.250	2.5e–2	0.158	7.1e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{7,0}$	1.200	1.2e–1	...	...	...	...	1.195	7.2e–2	...	...	1.195	7.2e–2	...	...	...	...	...	...	...	...	1.195	7.2e–2	1.195	7.2e–2	...	...	...	...	...	...	...	...	...	...
$\lambda_{7,1}$	0.800	8.0e–2	...	...	0.951	4.4e–2	...	...	0.951	4.4e–2	...	...	0.951	4.4e–2	0.951	4.4e–2	0.951	4.4e–2	0.951	4.4e–2	...	...	...	...	0.951	4.4e–2	0.951	4.4e–2	0.951	4.4e–2	0.951	4.4e–2	0.951	4.4e–2
$\phi_{8,1}$	0.240	2.4e–3	0.235	2.4e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{8,2}$	0.740	7.4e–3	0.722	6.5e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{8,1}$	1.000	1.0e–1	0.802	5.7e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{8,2}$	–1.000	1.0e–1	–1.037	9.1e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{8,0}$	1.500	1.5e–1	...	...	...	...	1.623	6.7e–2	...	...	1.623	6.7e–2	...	...	...	...	...	...	...	...	1.623	6.7e–2	1.623	6.7e–2	...	...	...	...	...	...	...	...	...	...
$\lambda_{8,1}$	1.000	1.0e–1	...	...	1.414	4.1e–2	...	...	1.414	4.1e–2	...	...	1.414	4.1e–2	1.414	4.1e–2	1.414	4.1e–2	1.414	4.1e–2	...	...	...	...	1.414	4.1e–2	1.414	4.1e–2	1.414	4.1e–2	1.414	4.1e–2	1.414	4.1e–2
$\phi_{9,1}$	0.240	2.4e–3	0.247	2.3e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{9,2}$	0.740	7.4e–3	0.747	3.4e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{9,1,0}$	–1.000	1.0e–1	...	...	–0.897	3.7e–2	–0.897	3.7e–2	–0.897	3.7e–2	...	...	...	...	–0.897	3.7e–2	...	...	–0.897	3.7e–2	–0.897	3.7e–2	–0.897	3.7e–2	...	...	...	...	–0.897	3.7e–2	–0.897	3.7e–2	...	...
$\theta_{9,1,1}$	–0.250	2.5e–2	...	...	...	...	...	...	...	...	–0.268	1.7e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

	Prior		Posterior																															
			World		Australia		Brazil		Canada		China		France		Germany		Italy		Japan		Korea		Mexico		Netherlands		Spain		Switzerland		United Kingdom		United States	
	Mean	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE
$\phi_{10,1}$	0.490	4.9e–3	0.485	4.2e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{10,2}$	0.490	4.9e–3	0.490	3.9e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{10,1,0}$	0.750	7.5e–2	0.706	4.8e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{10,1,1}$	1.500	1.5e–1	1.502	1.1e–1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{D}}$	0.500	5.0e–2	0.384	2.9e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{M}}$	0.500	5.0e–2	0.685	2.4e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\hat{P}^Y}$	...	∞	...	...	8.5e–1	1.8e–1	3.9e+0	8.1e–1	2.8e–1	5.9e–2	8.0e–1	1.7e–1	2.2e–1	4.6e–2	2.8e–1	5.8e–2	3.2e–1	6.6e–2	1.2e+0	2.5e–1	1.2e+0	2.4e–1	1.3e+0	2.8e–1	2.4e–1	4.9e–2	4.4e–1	9.2e–2	5.5e–1	1.1e–1	7.0e–1	1.5e–1	5.1e+0	1.0e–2
$\sigma^2_{\hat{P}^M}$	...	∞	...	...	2.1e+0	4.3e–1	7.1e+0	5.0e–4	6.4e–1	1.3e–1	1.4e+0	3.0e–1	5.4e–1	1.1e–1	7.6e–1	1.6e–1	7.5e–1	1.5e–1	2.7e+0	5.5e–1	2.7e+0	5.7e–1	2.9e+0	5.9e–1	4.8e–1	9.8e–2	9.2e–1	1.9e–1	1.4e+0	2.8e–1	1.6e+0	3.4e–1	1.1e+1	1.8e–4
$\sigma^2_{\hat{D}}$	...	∞	...	...	6.6e–1	1.4e–1	1.6e+0	3.3e–1	7.2e–1	1.5e–1	7.0e–1	1.4e–1	2.5e–1	5.2e–2	9.3e–1	1.9e–1	2.5e–1	5.1e–2	6.2e–1	1.3e–1	2.2e+0	4.6e–1	1.9e+0	4.0e–1	9.7e–1	2.0e–1	5.8e–1	1.2e–1	1.9e+0	4.0e–1	4.0e–1	8.2e–2	2.1e–1	4.3e–2
$\sigma^2_{\hat{X}}$	...	∞	...	...	1.2e+1	2.6e–5	9.0e+0	3.4e–5	2.2e+0	4.6e–1	2.4e+0	4.8e–1	7.3e–1	1.5e–1	2.2e+0	4.6e–1	1.6e+0	3.2e–1	1.5e+1	2.0e–5	2.2e+0	4.6e–1	2.0e+0	4.1e–1	4.5e–1	9.2e–2	1.4e+0	2.8e–1	1.3e+0	2.7e–1	9.7e–1	2.0e–1	6.9e+0	2.5e–4
$\sigma^2_{\hat{i}^P}$	...	∞	...	...	6.3e–1	1.3e–1	1.4e+0	3.0e–1	3.4e–1	6.9e–2	3.4e–1	7.0e–2	...	...	2.4e–1	4.9e–2	...	...	5.2e–1	1.1e–1	7.5e–1	1.5e–1	6.6e–1	1.4e–1	...	...	...	...	2.3e–1	4.8e–2	6.0e–1	1.2e–1	2.3e+0	4.7e–1
$\sigma^2_{\hat{i}^S}$	...	∞	...	...	1.3e–2	2.8e–3	2.7e–2	5.5e–3	8.2e–3	1.7e–3	4.3e–3	9.1e–4	4.0e–2	8.3e–3	5.6e–2	1.2e–2	3.7e–2	7.6e–3	9.2e–3	1.9e–3	1.7e–2	3.5e–3	5.8e–3	1.9e–3	1.4e–1	2.8e–2	2.5e–2	5.1e–3	4.4e–3	9.1e–4	1.5e–2	3.3e–3	2.3e–2	4.8e–3
$\sigma^2_{\hat{i}^L}$	...	∞	...	...	5.0e–1	1.0e–1	1.5e+0	3.1e–1	6.1e–1	1.3e–1	4.1e–1	8.5e–2	2.9e–1	6.0e–2	3.5e–1	7.1e–2	3.3e–1	6.8e–2	3.1e–1	6.4e–2	1.1e+0	2.2e–1	3.9e–1	8.2e–2	4.7e–1	9.8e–2	3.1e–1	6.3e–2	3.0e–1	6.1e–2	5.2e–1	1.1e–1	1.9e+0	3.9e–1
$\sigma^2_{\hat{P}^{STK}}$	...	∞	...	...	5.9e+2	1.1e–6	1.6e+3	5.2e–7	1.2e+2	6.6e–6	2.4e+2	6.5e–6	3.1e+2	1.4e–6	3.1e+2	1.4e–6	2.9e+2	1.4e–6	3.9e+2	3.1e–6	7.2e+2	1.2e–6	3.3e+2	2.9e–6	4.0e+2	1.1e–6	3.6e+2	1.1e–6	2.9e+2	2.4e–6	5.3e+2	1.6e–6	1.8e+3	1.0e–6
$\sigma^2_{\hat{S}}$	...	∞	...	...	3.6e+1	6.6e–5	5.3e+1	4.1e–5	2.9e+1	1.1e–4	1.2e+0	2.3e–1	...	...	2.6e+1	5.9e–5	...	...	1.7e+1	8.4e–5	3.9e+1	6.6e–5	1.3e+1	2.3e–4	...	...	...	...	2.4e+1	1.3e–4	3.4e+1	6.6e–5	...	...
$\sigma^2_{\hat{P}^{COM},e}$	...	∞	5.3e+1	1.0e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\hat{P}^{COM},n}$	...	∞	6.3e+0	1.1e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\bar{P}^Y}$	...	∞	...	...	1.8e–5	7.7e–6	1.0e–4	4.0e–5	1.8e–5	1.6e–5	9.3e–5	2.0e–5	4.5e–6	4.6e–6	8.4e–7	2.1e–7	5.7e–6	1.8e–6	4.3e–6	1.3e–6	3.1e–5	1.8e–5	2.1e–5	6.4e–6	3.4e–5	7.1e–6	5.3e–5	2.5e–5	1.2e–5	5.6e–6	2.1e–6	6.1e–7	2.1e–5	3.2e–5
$\sigma^2_{\bar{P}^C}$	...	∞	...	...	5.4e–6	1.3e–6	1.9e–4	6.2e–5	4.4e–6	1.1e–6	6.4e–5	1.6e–5	2.4e–6	1.7e–6	3.8e–6	1.6e–6	2.2e–6	6.2e–7	6.5e–6	2.1e–6	1.6e–6	1.3e–6	4.1e–5	9.9e–6	3.0e–5	7.2e–6	1.3e–5	5.8e–6	9.6e–7	8.8e–7	2.1e–5	5.6e–6	1.1e–5	1.4e–5
$\sigma^2_{\bar{Y}}$	...	∞	...	...	1.0e–5	5.9e–6	3.0e–5	1.4e–5	3.8e–5	1.2e–5	7.8e–5	2.5e–5	2.7e–5	1.5e–5	1.3e–5	1.1e–5	4.7e–5	1.8e–5	7.5e–5	4.8e–5	3.0e–5	6.4e–6	7.4e–5	5.9e–5	3.0e–5	3.0e–5	1.1e–4	6.0e–5	3.0e–5	1.0e–5	9.8e–5	4.4e–5	5.3e–5	3.2e–5
$\sigma^2_{\bar{D}}$	...	∞	...	...	7.6e–5	4.1e–5	1.3e–4	4.8e–5	5.8e–5	5.0e–5	6.1e–5	2.1e–5	3.0e–5	1.7e–5	1.7e–5	7.3e–6	4.2e–5	1.5e–5	4.8e–5	2.4e–5	6.0e–5	1.6e–5	1.0e–4	1.2e–4	3.4e–5	4.2e–5	3.7e–4	2.2e–4	5.3e–6	2.3e–6	1.3e–4	5.9e–5	1.0e–4	4.3e–5
$\sigma^2_{\bar{i}^P}$	...	∞	...	...	7.2e–5	4.8e–5	1.8e–4	1.6e–5	5.7e–5	1.1e–5	1.3e–5	6.1e–6	...	...	2.4e–5	4.6e–6	...	...	1.0e–6	3.4e–7	2.6e–5	5.2e–6	2.7e–3	1.2e–3	...	...	...	...	2.1e–5	1.0e–5	2.7e–4	1.1e–4	1.5e–4	3.8e–5
$\sigma^2_{\bar{i}^S}$	...	∞	...	...	6.7e–5	4.4e–5	1.8e–4	1.5e–5	5.1e–5	8.5e–6	8.4e–6	3.3e–6	7.1e–5	2.0e–5	5.9e–5	2.0e–5	3.8e–5	1.2e–5	2.8e–6	1.1e–6	6.7e–5	1.1e–5	3.0e–3	1.3e–3	5.7e–5	1.8e–5	5.7e–5	1.9e–5	2.3e–5	5.7e–6	2.7e–4	1.2e–4	1.2e–4	3.0e–5
$\sigma^2_{\bar{i}^L}$	...	∞	...	...	2.7e–6	4.3e–7	3.3e–5	2.0e–6	4.2e–6	2.7e–7	2.0e–5	8.3e–6	3.6e–6	2.8e–7	4.5e–6	3.7e–7	2.2e–5	5.1e–6	3.5e–6	1.2e–6	1.2e–4	2.6e–5	3.7e–3	8.7e–4	3.6e–6	2.8e–7	5.2e–5	1.6e–5	3.4e–6	3.1e–7	1.0e–5	1.8e–6	9.8e–6	8.8e–7
$\sigma^2_{\bar{P}^{STK}}$	...	∞	...	...	3.0e–3	2.9e–3	6.5e–3	4.5e–3	2.6e–3	1.3e–3	2.0e–2	6.7e–3	4.3e–3	2.0e–3	7.6e–3	2.7e–3	6.1e–3	4.3e–3	9.0e–3	5.9e–3	2.9e–3	1.2e–3	7.2e–3	4.4e–3	4.1e–3	1.6e–3	6.8e–3	2.7e–3	4.2e–3	2.3e–3	2.7e–3	8.0e–4	2.7e–3	1.0e–3
$\sigma^2_{\bar{S}}$	...	∞	...	...	8.2e–4	2.7e–4	5.6e–3	1.4e–3	5.3e–4	2.4e–4	2.2e–4	4.1e–5	...	...	1.1e–3	4.6e–4	...	...	4.3e–4	1.0e–4	1.4e–3	6.4e–4	8.3e–5	5.1e–5	...	...	...	...	2.3e–4	7.9e–5	1.5e–3	6.0e–4	...	...
$\sigma^2_{\bar{P}^{COM},e}$	...	∞	3.0e–3	3.7e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\bar{P}^{COM},n}$	...	∞	9.6e–4	2.6e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Note: All priors are normally distributed, while all posteriors are asymptotically normally distributed. All observed endogenous variables are rescaled by a factor of 100.

Appendix C: Description of the Data Set

26. Estimation is based on quarterly data on several macroeconomic and financial market variables for 15 economies over the sample period 1999Q1 through 2011Q1. The economies under consideration are Australia, Brazil, Canada, China, France, Germany, Italy, Japan, Korea, Mexico, the Netherlands, Spain, Switzerland, the United Kingdom, and the United States. This data was obtained from the GDS database maintained by the International Monetary Fund where available, and from the IFS database compiled by the International Monetary Fund or the CEIC database compiled by Internet Securities Incorporated otherwise.

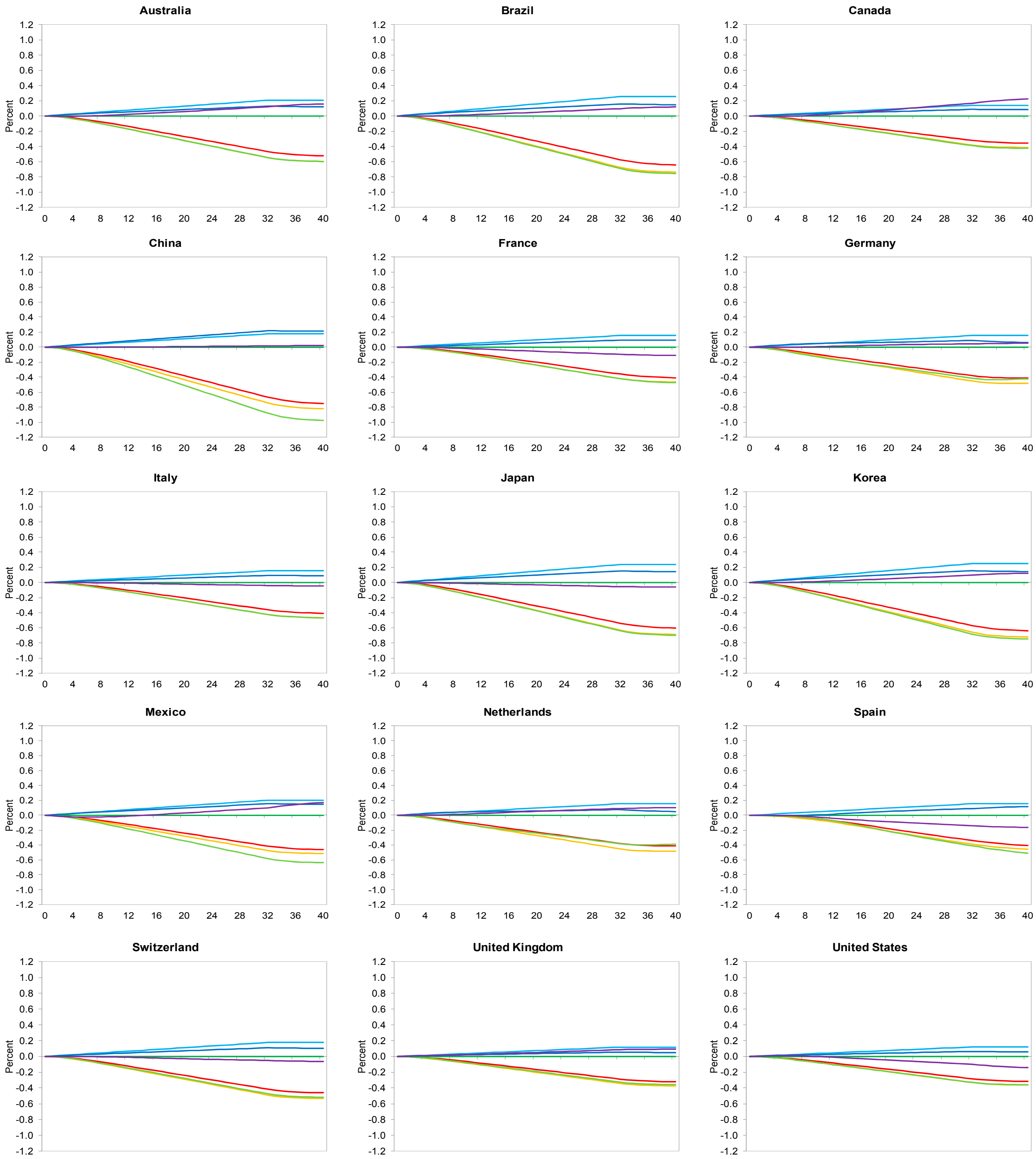
27. The macroeconomic variables under consideration are the price of output, the price of consumption, the quantity of output, the quantity of domestic demand, and the prices of energy and nonenergy commodities. The price of output is measured by the seasonally adjusted gross domestic product price deflator, while the price of consumption is proxied by the seasonally adjusted consumer price index. The quantity of output is measured by seasonally adjusted real gross domestic product, while the quantity of domestic demand is measured by the sum of seasonally adjusted real consumption and investment expenditures. The prices of energy and nonenergy commodities are proxied by broad commodity price indexes denominated in United States dollars.

28. The financial market variables under consideration are the nominal policy interest rate, the short term nominal market interest rate, the long term nominal market interest rate, the price of equity, and the nominal bilateral exchange rate. The nominal policy interest rate is measured by the central bank discount rate, expressed as a period average. The short term nominal market interest rate is measured by a 3 month money market rate, expressed as a period average. The long term nominal market interest rate is measured by the 10 year government bond yield where available, and a 10 year commercial bank lending rate otherwise, expressed as a period average. The price of equity is proxied by a broad stock price index denominated in domestic currency units. The nominal bilateral exchange rate is measured by the domestic currency price of one United States dollar expressed as a period average.

29. Calibration is based on annual data extracted from databases maintained by the International Monetary Fund where available, and from the Bank for International Settlements or the World Bank Group otherwise. Great ratios are derived from the WEO and WDI databases. Bilateral trade weights are derived from the DOTS database. Portfolio weights are derived from the CPIS, BIS, and WDI databases.

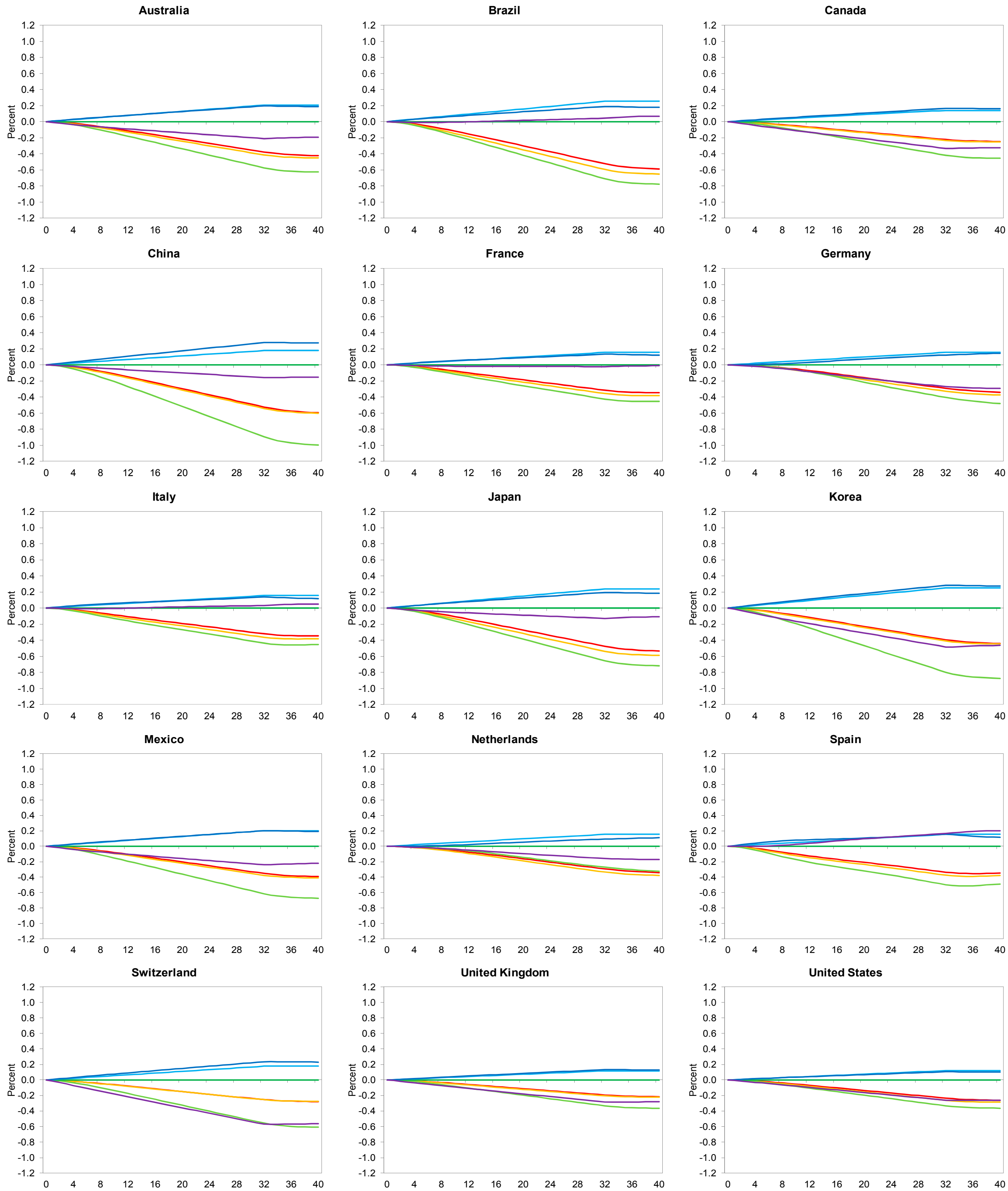
APPENDIX D: IMPULSE RESPONSES

Figure 1: Effects of a Global Increase in Capital Requirements over 8 Years for all Banks with no Change in Policy Interest Rates



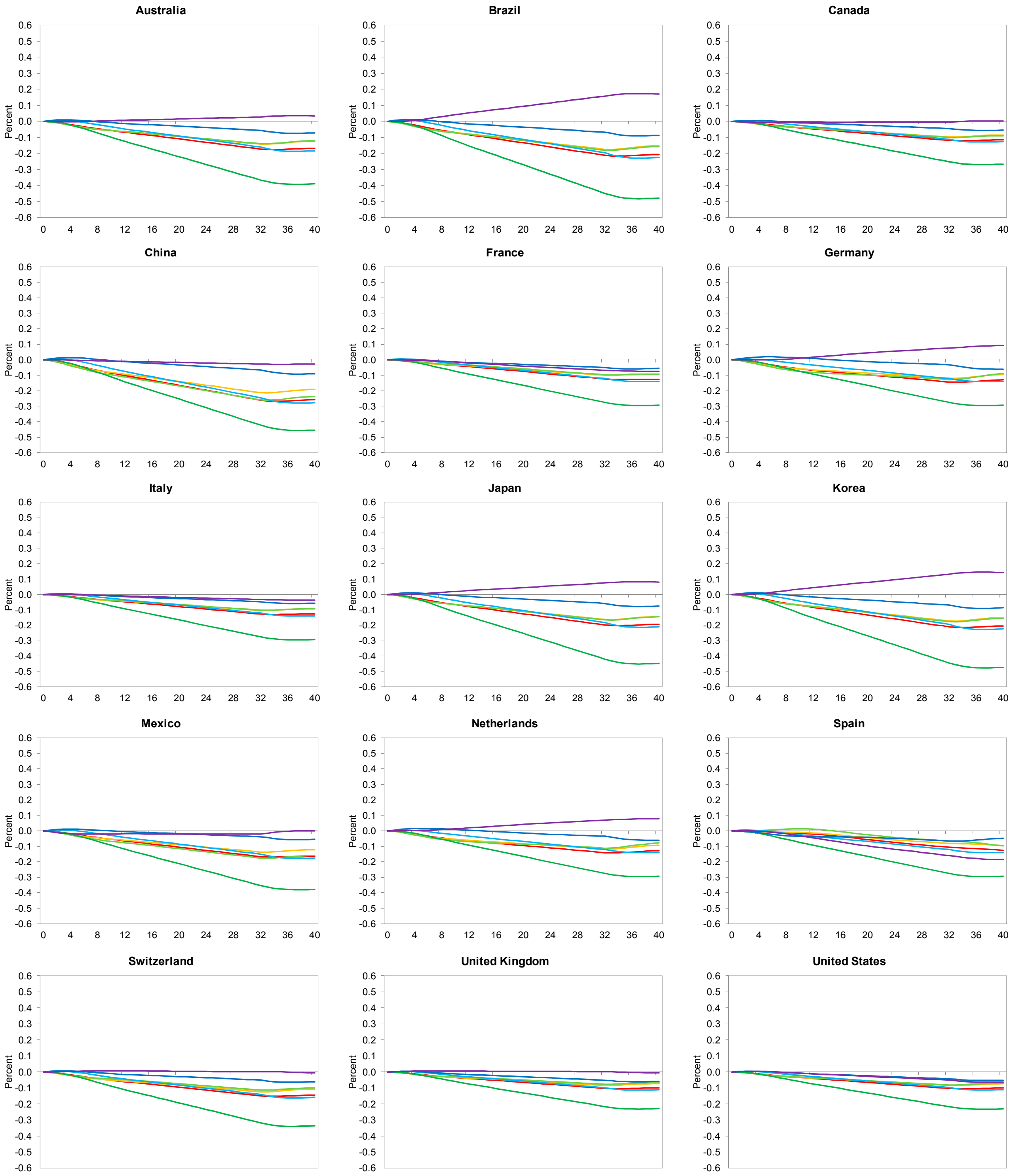
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the short term nominal market interest rate ■, the long term consumption based real market interest rate ■, and the real effective exchange rate ■ to a global synchronized 1 percentage point increase in regulatory capital adequacy requirements phased in at a constant speed over 8 years applicable to all banks, abstracting from monetary policy accommodation. Inflation and interest rates are expressed as annual percentage rates.

Figure 2: Effects of Economy-Specific Increases in Capital Requirements for all Banks over 8 Years with no Change in Policy Interest Rates



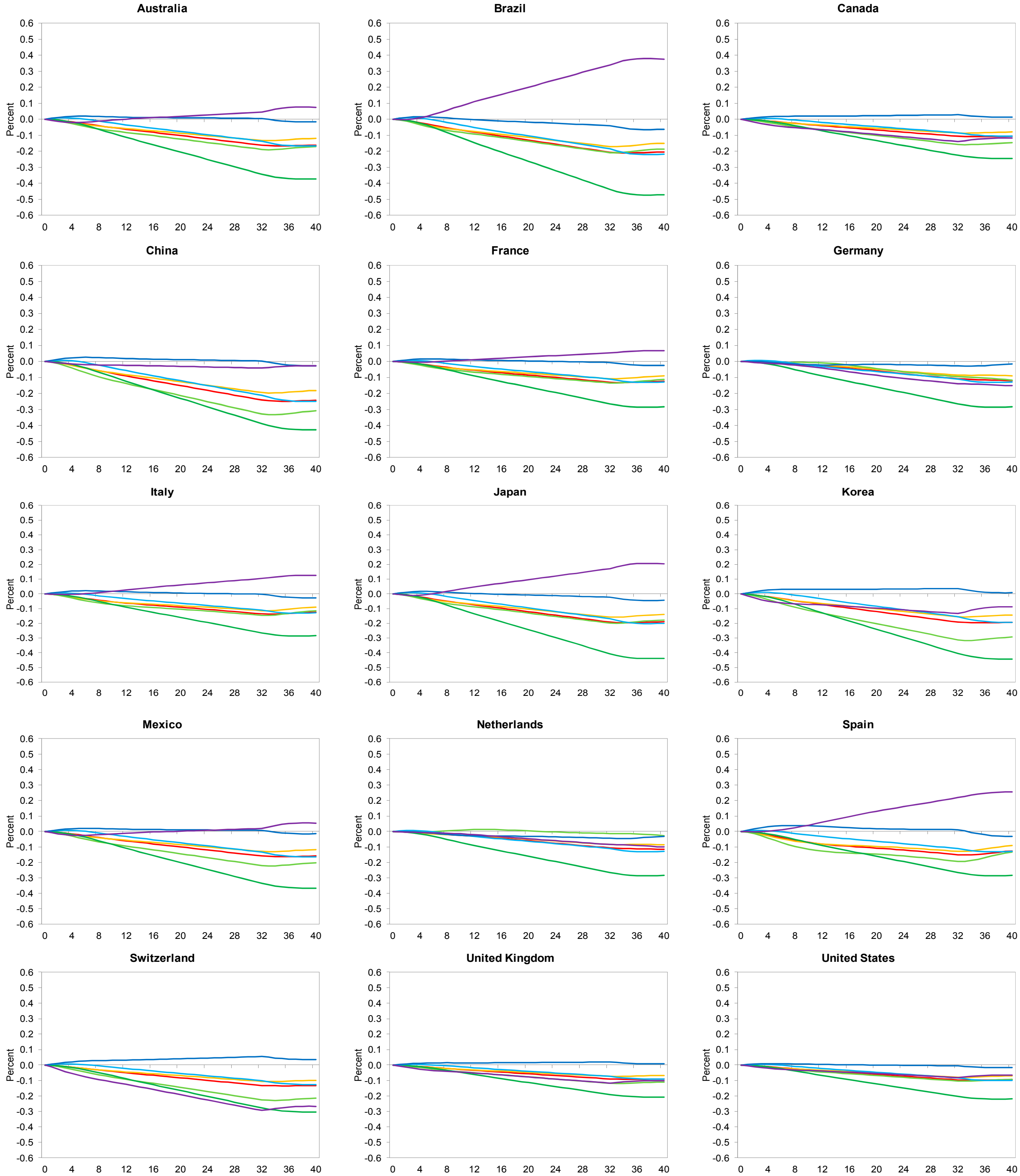
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the short term nominal market interest rate ■, the long term consumption based real market interest rate ■, and the real effective exchange rate ■ to economy specific 1 percentage point increases in regulatory capital adequacy requirements phased in at a constant speed over 8 years applicable to all banks, abstracting from monetary policy accommodation. Inflation and interest rates are expressed as annual percentage rates.

Figure 3: Effects of a Global Increase in Capital Requirements for all Banks over 8 Years with Endogenous Monetary Policy Responses



Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the short term nominal market interest rate ■, the long term consumption based real market interest rate ■, and the real effective exchange rate ■ to a global synchronized 1 percentage point increase in regulatory capital adequacy requirements phased in at a constant speed over 8 years applicable to all banks, accounting for monetary policy accommodation. Inflation and interest rates are expressed as annual percentage rates.

Figure 4: Effects of Economy-Specific Increases in Capital Requirements for all Banks over 8 Years with Endogenous Monetary Policy Responses



Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the short term nominal market interest rate ■, the long term consumption based real market interest rate ■, and the real effective exchange rate ■ to economy specific 1 percentage point increases in regulatory capital adequacy requirements phased in at a constant speed over 8 years applicable to all banks, accounting for monetary policy accommodation. Inflation and interest rates are expressed as annual percentage rates.