Modelling the Global Financial Crisis [*]

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Abstract

This paper models the global financial crisis as a combination of shocks to global housing markets and sharp increases in risk premia of firms, households and international investors in an intertemporal (or DSGE) global model. The model has six sectors of production and trade in 15 major economies and regions. The paper shows that a 'switching' of expectations about risk premia shocks in financial markets can easily generate the severe economic contraction in global trade and production currently being experienced in 2009 and subsequent events. The results show that the future of the global economy depends critically on whether the shocks to risk are expected to be permanent or temporary. The best representation of the crisis may be one where initial long lasting pessimism about risk is unexpectedly revised to a more moderate scenario. This suggests a rapid recovery in countries not experiencing a balance sheet adjustment problem.

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1. Introduction

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The global financial crisis has seen the largest and sharpest drop in global economic activity of the modern era. In 2009, most major developed economies find themselves in a deep recession. The fallout for global trade, both for volumes and the pattern of trade has been dramatic. The OECD predicts world trade volumes could shrink by 13 percent in 2009 from 2008 levels.[1]

In his review of the global banking crisis, Lord Turner said, 'what is unique about this crisis is that severe financial problems have emerged simultaneously in many different countries, and that its economic impact is being felt throughout the world as a result of increased interconnectedness of the global economy'[2]. To understand the quantitative effects of the global financial crisis, a model that incorporates the interconnectedness within and between economies and the linkages between real and financial effects needs to be specified. To do this, a dynamic, intertemporal general equilibrium model that fully integrates the financial and real sectors of the economy is used in this paper to unravel and understand the mechanisms at work. The model incorporates wealth effects, expectations and financial markets for bonds, equities and foreign exchange as well as trade and financial flows. It is a suitable tool to analyse the impact of the crisis and policy responses on global trade and financial flows.

Modelling the global financial crisis has several elements to it. One is the bursting of the housing bubble, particularly in the United States and the primary source of problems at Lehman Brothers which collapsed in September 2008. This was accompanied by changing perceptions of risk by households and by business. Then, monetary and fiscal policies were deployed to offset the decline in activity and keep the financial sector afloat. The downturn in activity is also causing unemployment to rise sharply and, with it, a political response to protect domestic industries through various combinations of domestic subsidies and border protection, although, so far, the effect in aggregate has been small.

One of the main shocks to represent the crisis is the changed perceptions of risk. The collapse of Lehman Brothers sent a wave of fear around world financial markets. Banks virtually stopped lending to each other. The risk premium on interbank borrowing rose sharply to 5 per cent, whereas typically it was close to zero. Although authorities scrambled to inject liquidity into financial markets, the damage was done. The risk premium on corporate bonds shot up even more to over 6 per cent. Large CAPEX projects were shelved, the corporate sector virtually stopped borrowing, trade credit was hard to get and, with falling demand, particularly for investment goods and manufacturing durables like cars, trade volumes collapsed. Since then, risk premia have returned to more normal levels, although remain elevated.

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[1] OECD 2009 http://www.oecd.org/document/12/0,3343,en_2649_37431_42788172_1_1_1_1,00.html

[2] Financial Services Authority 2009, The Turner Review: A regulatory response to the global banking crisis, London

In a previous paper[3] the differences between a sharp rise in global risk that was permanent versus one that is expected to be temporary was explored. The difference was seen to depend on the role of expectations in a dynamic model. Once 'time' is formally included in a dynamic economy-wide model, expectations have to be incorporated. Agents are forward looking and that affects behaviour. How expectations are incorporated in the model is spelt out later, but the problem with a temporary shock to risk premia is that businesses know that risk premia are going to come down and behave accordingly. But, as seen in McKibbin and Stoeckel (2009a), a temporary shock to risk premia, as seems to have happened in hindsight, does not generate the large observed real effects. The question is then, what would happen if business and households initially assumed the worst, that is a long lasting permanent rise in risk premia, but unexpectedly revised their views on risk to that of a temporary scenario one year later whereby things are expected to return to 'normal'?

The objective of this paper is to examine the above question. That is, what are the economic effects of a global financial crisis where businesses and households unexpectedly switch between a pessimistic view on risk and then to a more moderate temporary scenario.

The paper is organised as follows. In the next section, the main features of the G-Cubed model that is used in this analysis are described briefly as the model is documented in full elsewhere.

In section 3, the simulations to represent the financial crisis are described and the justification for the size of the shocks chosen. It turns out five shocks are needed: three for the crisis itself and two for the subsequent policy responses which covers monetary and fiscal stimulus[4].

In section 4, the impact of the crisis, as if it happened in the United States alone in modelled to unpick the mechanisms at work and demonstrate the importance of Lord Turner's remarks on the interconnectedness of economies.

To do this we explore the impact of whether the shock to risk premia is a permanent one, a temporary one or one that is assumed to be permanent but after one year switches back unexpectedly to a temporary scenario. Changing expectations after one year of adjustment leads to different results than the case in which the temporary scenario was always believed to be the most likely outcome because investment decisions are already locked in to the permanent scenario in the first year of the shock.

In section 5 we explore the enormity of the policy response, particularly the extra fiscal response which is in addition to the endogenous response already in the model. It matters a great deal for the subsequent adjustment in the global economy whether the fiscal response is combined with the permanent scenario or the temporary scenario.

Finally, in section 6, some of the main insights are highlighted and discussed.

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[3] McKibbin and Stoeckel (2009a) The Global Financial Crisis: Causes and Consequences, paper prepared for the Asian Economic Panel meeting Tokyo, September 2009.

[4] See McKibbin and Stoeckel (2009b) for an analysis of protectionist responses to the crisis and McKibbin and Chanthapun (2009) for the transmission to Asia under different exchange rate regimes.

2. The model

The G-Cubed model is an intertemporal general equilibrium model of the world economy. The theoretical structure is outlined in McKibbin and Wilcoxen (1998)[5]. A number of studies—summarized in McKibbin and Vines (2000)—show that the G-cubed modelling approach has been useful in assessing a range of issues across a number of countries since the mid-1980s.[6] Some of the principal features of the model are as follows:

▪ The model is based on explicit intertemporal optimization by the agents (consumers and firms) in each economy[7]. In contrast to static CGE models, time and dynamics are of fundamental importance in the G-Cubed model. The MSG-Cubed model is known as a DSGE (Dynamic Stochastic General Equilibrium) model in the macroeconomics literature and a Dynamic Intertemporal General Equilibrium (DIGE) model in the computable general equilibrium literature.

▪ In order to track the macro time series, the behaviour of agents is modified to allow for short run deviations from optimal behaviour either due to myopia or to restrictions on the ability of households and firms to borrow at the risk free bond rate on government debt. For both households and firms, deviations from intertemporal optimizing behaviour take the form of rules-of-thumb, which are consistent with an optimizing agent that does not update predictions based on new information about future events. These rules-of-thumb are chosen to generate the same steady state behaviour as optimizing agents so that in the long run there is only a single intertemporal optimizing equilibrium of the model. In the short run, actual behaviour is assumed to be a weighted average of the optimizing and the rule-of-thumb assumptions. Thus aggregate consumption is a weighted average of consumption based on wealth (current asset valuation and expected future after tax labor income) and consumption based on current disposable income. Similarly, aggregate investment is a weighted average of investment based on Tobin's q (a market valuation of the expected future change in the marginal product of capital relative to the cost) and investment based on a backward looking version of Q. In the model software it is possible to change the information set of forward looing agents after a scenario begins to unfold.

▪ There is an explicit treatment of the holding of financial assets, including money. Money is introduced into the model through a restriction that households require money to purchase goods.

▪ The model also allows for short run nominal wage rigidity (by different degrees in different countries) and therefore allows for significant periods of unemployment depending on the labor market institutions in each country. This assumption, when taken together with the explicit role for money, is what gives the model its "macroeconomic" characteristics. (Here again the model's assumptions differ from the standard market clearing assumption in most CGE models.)

▪ The model distinguishes between the stickiness of physical capital within sectors and within countries and the flexibility of financial capital, which immediately flows to where

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[5] Full details of the model including a list of equations and parameters can be found online at: www.gcubed.com

[6] These issues include: Reaganomics in the 1980s; German Unification in the early 1990s; fiscal consolidation in Europe in the mid-1990s; the formation of NAFTA; the Asian crisis; and the productivity boom in the US.

[7] See Blanchard and Fischer (1989) and Obstfeld and Rogoff (1996).

expected returns are highest. This important distinction leads to a critical difference between the quantity of physical capital that is available at any time to produce goods and services, and the valuation of that capital as a result of decisions about the allocation of financial capital.

As a result of this structure, the G-Cubed model contains rich dynamic behaviour, driven on the one hand by asset accumulation and, on the other by wage adjustment to a neoclassical steady state. It embodies a wide range of assumptions about individual behaviour and empirical regularities in a general equilibrium framework. The interdependencies are solved out using a computer algorithm that solves for the rational expectations equilibrium of the global economy. It is important to stress that the term 'general equilibrium' is used to signify that as many interactions as possible are captured, not that all economies are in a full market clearing equilibrium at each point in time. Although it is assumed that market forces eventually drive the world economy to neoclassical steady state growth equilibrium, unemployment does emerge for long periods due to wage stickiness, to an extent that differs between countries due to differences in labor market institutions.

In the version of the model used here there are 6 sectors (energy, mining, agriculture, manufacturing durables, manufacturing non-durables and services) and 15 countries/regions as set out in Table 2.2.

2.2 **Countries/regions**

United States	China
Japan	India
United Kingdom	Other Asia
Germany	Latin America
Euro Area	Other LDC
Canada	East Europe & Former Soviet Union
Australia	OPEC
Rest of OECD	

3. Simulating the effects of the crisis

Events leading up to the crisis in 2008— the baseline

The focus of this paper is on disentangling the many influences of the financial crisis on the global economy and in particular to see how well the model can explain the macroeconomic and sectoral responses to the crisis in confidence that we model through risk shocks. The 'crisis' is defined here as the bursting of the housing market bubble in late 2007, the ensuing

collapse in the sub-prime mortgage market and related financial markets and the subsequent collapse of Lehman Brothers in 2008 which resulted in a sharp increase in risk premia around the world.

The problem in precisely modelling the crisis is that there are already shocks in the baseline that affect subsequent global dynamics independently of the crisis. Here we are focussing only on the additional shocks from the crisis. The problem is that some of the seeds of the financial crisis were sown in the decade before the crisis. There were a series of large global events, such as the bursting of the dotcom bubble in 2001 and the rapid growth of China, that were already reshaping the pattern and level of world trade before the 2007-2008 financial crisis hit. Some of these events, like the large disparities between savings and investment in China (a surplus) and in the United States (a deficit) led to large differences between exports and imports for each nation so that large current account surpluses were accumulating in China and large deficits in America. Some people[8] attribute these growing global imbalances as contributing causes of the crisis, and there is some truth in that. But the focus of this study is on the impact of the crisis itself on the world economy and not on trying to disentangle the various contributing factors to the crisis, as important as that issue is.

Therefore, besides population and productivity trends shaping the baseline for the world, some of the key events over the last decade influencing the baseline would be:

- First, there was the Asian financial crisis of 1997-98, which saw Asian economies generate large current account surpluses that had to be invested offshore to keep their nominal exchange rates low. Capital flowed out of Asia into US dotcom stocks driving up equity prices.

- Next was the bursting of the dotcom bubble, which saw the booming NASDAQ over 1998–2000 burst in 2001.

- Fearing a downturn and possible deflation, the US Federal Reserve eased monetary policy in 2001 in a series of steps to 2004. Some argue that they eased too much for too long[9].

- But, with easy credit and a rising housing market, a boom in house prices followed and a period of high growth in credit and leveraged loans. Risk premia hit low levels and leveraged deals became common as investors chased yields in an environment of lax regulatory oversight.

- Rising demands from China (and, to some extent, India), plus a booming world economy saw commodity prices rise across oil, minerals and food from late 2004 to late 2007. The shock to the global economy from this commodity price boom was as big as the first oil shock in the 1970s[10].

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[8] For example, see Max Corden, *The world credit crisis: understanding it and what to do,* http://www.melbourneinstitute.com/wp/wp2008n25.pdf and Martin Wolf, *How imbalances led to credit crunch and inflation,* Financial Times, June 17 2008.

[9] Notably John Taylor, see Taylor, J.B. 2008, *The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong.*

[10] The impact of productivity growth in the developing countries, particularly China are considered in McKibbin and Cagliarini (2009)

- Rising prices and inflation caused monetary authorities to tighten policy from mid-2004 to June 2006.

Each of these major events set up their own dynamics for the course of the world economy and helped shape the underlying baseline. Some of these events such as the easing and tightening of monetary policy are endogenous to the model and already incorporated in the baseline. It is important to appreciate that the results reported here are *deviations* from baseline from the financial crisis, as defined here. What is important is the relative contribution of different effects and to disentangle the impacts of the financial crisis on the global economy in the short to medium run.

The five shocks to represent the crisis and the policy responses

The above events have led to the now well known global downturn. All official forecasting agencies, such as the IMF and OECD, have described this downturn and so will not be expanded here. As the IMF notes 'Global GDP is estimated to have fallen by an unprecedented 5 per cent in the fourth quarter (annualized), led by advanced economies, which contracted by around 7 per cent' [11]. Japan has been particularly hard hit with a fourth quarter GDP (2008) plummeting by 13 per cent. Demand for durable goods has been particularly hard hit. With the downturn there has been a sharp upturn in savings by households (and commensurate reduction in consumption), driven by a reappraisal of risk by households and a loss of net worth with falling house prices and equity prices. So shocks need to be devised to account for three things;

- The bursting of the housing bubble and loss in asset prices and household wealth with consumers cutting back on spending and lifting savings.

- A sharp reappraisal of risk with a spike in bond spreads on corporate loans and interbank lending rates with the cost of credit, including trade credit, rising with a commensurate collapse of stock markets around the world.

- A massive policy response including a monetary policy easing, bailouts of financial institutions and fiscal stimulus.

These three outcomes can be represented by five shocks — three for the crisis itself and two for the policy response.

Three main shocks capture the onset of the global financial crisis:

1. The bursting of the housing bubble causing a reallocation of capital and a loss of household wealth and drop in consumption.
2. A sharp rise in the equity risk premium (the risk premium of equities over bonds) causing the cost of capital to rise, private investment to fall and demand for durable goods to collapse.

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[11] IMF 2009, *Group of Twenty, Meeting of the Ministers and Central Bank Governors March 13-14, 2009, London UK,* p. 4.

3. A reappraisal of risk by households causing them to discount their future labor income and increase savings and decrease consumption.

Shock 1: The bursting of the housing bubble

Falling house prices has a major effect on household wealth, spending and defaults on loans held by financial institutions. Events in the United States typify a global phenomenon. From 2000 to 2006, house prices in some areas doubled to subsequently collapse (chart 3.1). These changes in some areas have generated dramatic news headlines but, overall the United States index of house prices has fallen by 6.2 percent in real terms from the 1st quarter 2008 to the same quarter in 2009 [12].

While house prices were rising so strongly, credit was supplied liberally to meet the demand as perceptions of risk fell. The rising wealth boosted confidence and spending. The housing bubble was a global phenomenon centered mainly on the Anglo-Saxon world.

3.1 **US house prices relative to per capita household income**
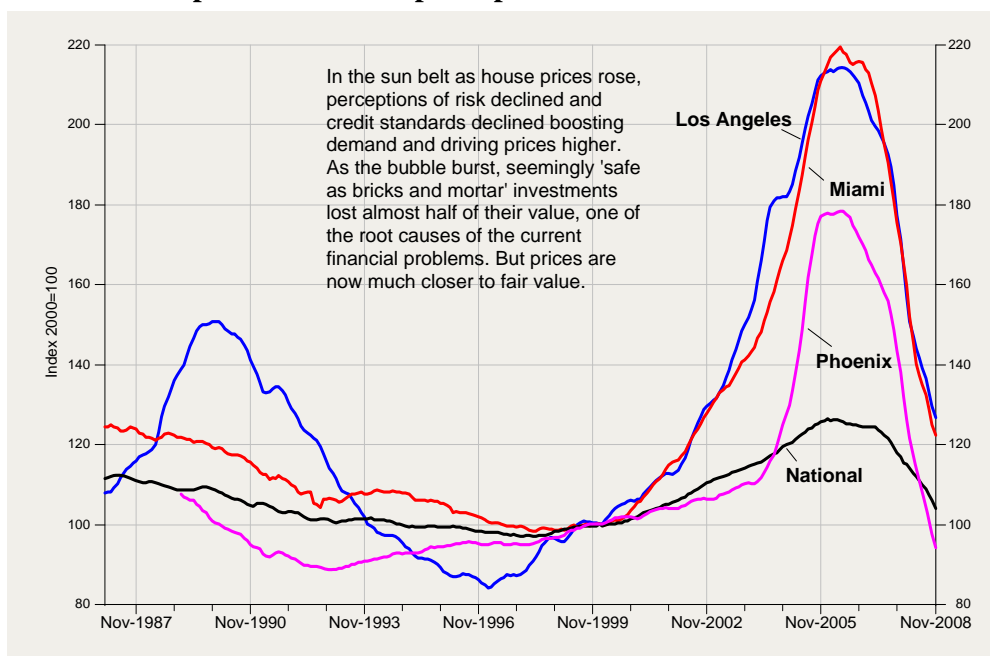
a Notes: Series shown are house prices over per capita household income. For comparison series are indexed to a common base 2000=100. Individual cities are from the S&P Case Schiller index. National prices are from the OFHEO. OFHEO data has a complete coverage of the US while the Case Schiller index only covers the largest 20 cities. OFHEO and Case Schiller data for individual cities indicate similar movements – i.e. differences in the series largely reflect the coverage differences. (The widely reported Case Schiller index shows much larger falls than the OFHEO index.)
Data source: Standard and Poors, Office of Housing Enterprise Oversight, OECD Economic Outlook Database.

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[12] Federal Housing Finance Agency May 2009, http://www.fhfa.gov/webfiles/2406/1q09hpi.pdf

The housing bubble was the result of a long period of low interest rates by the US Federal Reserve. The Federal Reserve cut interest rates by a total of 550 basis points in a series of steps between 2001 and 2004. The easing, subsequent tightening and current easing are shown in chart 3.2. Some believe (for example the 'Austrian school' and John Taylor[13]), that monetary policy was too loose for too long and this is what gave rise to the asset price bubble and commodity price spike. Taylor argues that had the Federal Reserve followed the Taylor rule (actually the Henderson-McKibbin-Taylor rule), interest rates would have risen much sooner and the bubbles not appear to the same extent (chart 3.2).

3.2 **Federal funds rate** Actual and counterfactual
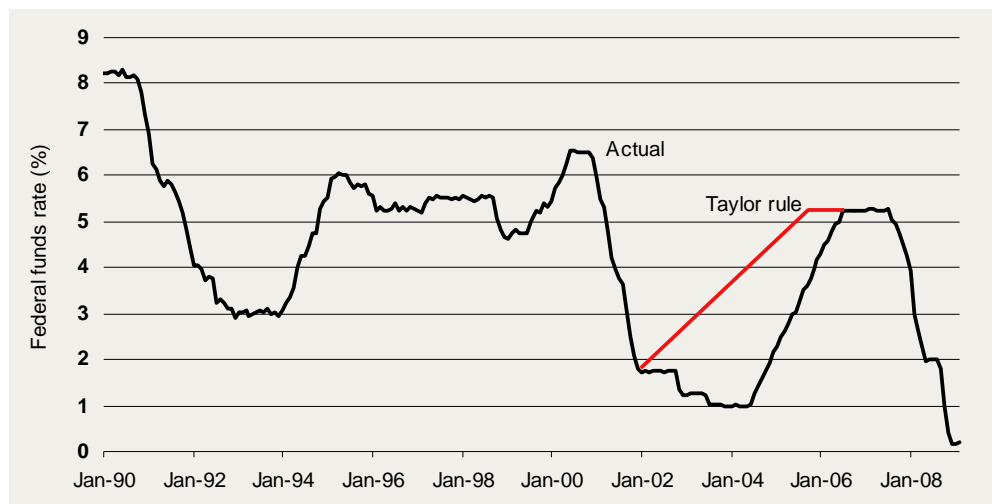
Note: The daily effective federal funds rate is a weighted average of rates on brokered trades. Weekly figures are averages of 7 calendar days ending on Wednesday of the current week; monthly figures include each calendar day in the month. Annualised using a 360-day year or bank interest.
Data source: US Federal Reserve Statistical Release,
http://www.federalreserve.gov/releases/h15/data/Monthly/H15_FF_O.txt, Accessed 5 March 2009.

While low interest rates were due to fears of deflation[14] and led to a boom in US housing, low interest rates were not just the result of the Fed's actions. US bond yields were also low because of low world rates (with Japanese bond yields at a little over 1 per cent and short term interest rates at zero). There was also an international aspect to low US interest rates with Japan and Europe only recovering very slowly from the 2000-01 downturn and in turn placing pressure on the US to keep interest rates low. In Japan there were fears of re-emergent deflation. That is the principal reason why interest rates were kept low in the US for an unusually long term — until mid-2004 when the Fed began a very sharp tightening cycle[15]. The low interest rates through 2003-04 — besides fuelling a boom in bank lending, rising asset prices and rising demand in China and other developing countries — also fuelled a commodity price boom.

[13] Taylor, J.B. 2008, *The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong*, p. 2.

[14] For example, see Alan Greenspan's account in T*he Age of Turbulence,* Allen Lane, 2007, pp228-229.

[15] The sharpest, in fact, since the Volker deflation of the early 1980s.

However, only a part of the dwelling boom and the commodity boom can be attributed to the actions of the Fed. The up-trend in US house prices was evident as early as 2000. As small investors abandoned the stock market in 2001, they dived into the housing market, driving up and sustaining the price rises. Similarly, the surge in commodity prices through 2005 to 2008, which took most analysts by surprise, had as much to do with developments in China, and the lagged response of supply, as they did with an increase in demand in North America. Where the real problem lay was in the combination of the two.

The bursting of the housing bubble is modelled as a surprise fall in the expected flow of services from housing investment – larger in the United States, United Kingdom and Europe but still significant throughout the world. In the model, the household in each economy is modelled as solving an intertemporal consumption problem subject to an intertemporal budget constraint. The result is a time profile for the consumer in each country of consumption of goods from all countries based on expected future income and expected relative goods prices. The household also chooses investment in a capital good. The household capital stock combines housing, and other durable goods. For simplicity of exposition we will refer to this capital good as "housing" from here on.

The investment decision by households is modelled analogously to how we model the investment decisions of firms within an intertemporal framework subject to adjustment costs for capital accumulation. The household invests in housing to maximize consumption from the stream of future service flows that housing provides. This stream of services is analogous to a production function based on inputs of capital and a productivity term. We model the housing part of the crisis as a fall in the productivity of the service flow from the housing stock. This fall in expected future productivity of housing means that the Tobin's q for housing drops when the shock occurs. The drop in housing productivity in the United States is assumed to be 10 per cent lower in 2009 and is calibrated to give, along with the other shocks, a drop in house prices in the US of the order of 6 per cent, roughly what has been observed for the last year[16]. A plausible scenario is where productivity returns to 'normal' by 2013.
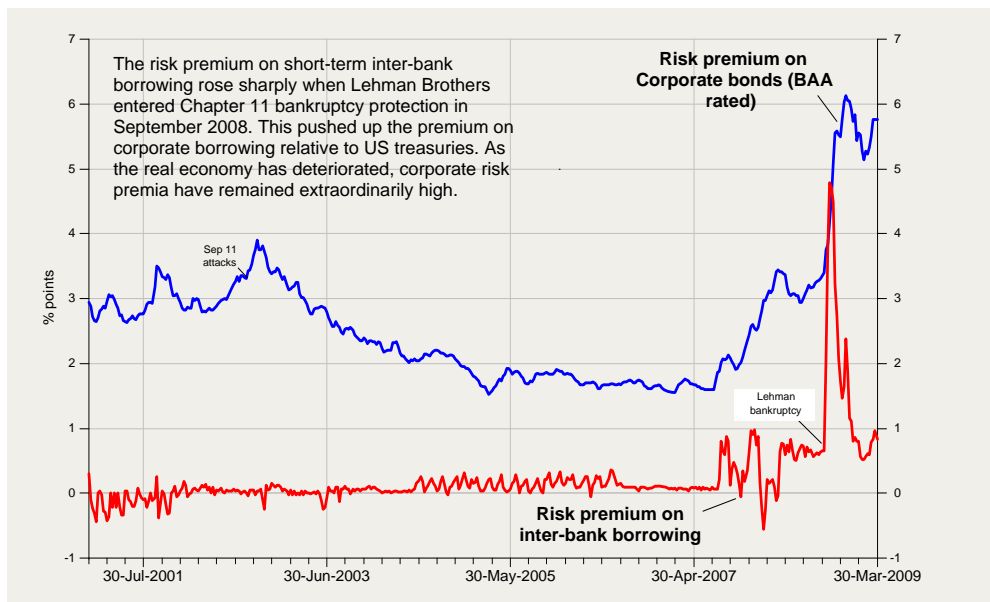
Shock 2: Rising equity risk premia

The surprise up-swing in commodity prices from 2003 but most noticeable during 2006 and 2007 led to concerns about inflation leading to the sharp reversal in monetary policy in the US. This tightening in US policy also implied a tightening of monetary policy in economies that pegged to the US dollar. It was the sharpness of this reversal as much as the fall in US house prices and the failures of financial regulation (for example, the mortgage underwriters Fannie Mae and Freddie Mac) that led to the financial problems for 2008-09[17]. Lehman Brothers' failure was primarily due to the large losses they sustained on the US subprime mortgage market. Lehman's held large positions in the subprime and other lower-rated mortgage markets. But mortgage delinquencies rose after the US housing price bubble burst

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[16] A 10 per cent permanent drop in housing productivity in the United States alone gives a 5.4 per cent drop in housing values one year later. See McKibbin, W and Stoeckel, A, *Bursting of the US housing Bubble*, Economic Scenarios No 14, www.economicscenarios.com.

[17] Similarly, the tightening cycle of the mid-1980s was one factor leading to the Savings and Loan crisis.

3.3 **The Lehman Brothers' bankruptcy and risk premia**

The risk premium on short-term inter-bank borrowing rose sharply when Lehman Brothers entered Chapter 11 bankruptcy protection in September 2008. This pushed up the premium on corporate borrowing relative to US treasuries. As the real economy has deteriorated, corporate risk premia have remained extraordinarily high.

a Notes: Weekly data. Risk premium on inter-bank borrowing approximated by the rate on one month Euro-dollar deposits less the Federal funds rate. Risk premium on corporate bonds measured as the yield on BAA rated corporate bonds less the 10 year Treasury bond yield.
Data source: Federal Reserve Board.

in 2006-07. In the second fiscal quarter 2008, Lehman reported losses of $2.8 billion. It was forced to sell off $6 billion in assets[18]. The failure of Lehman Brothers in September 2008 and effect on risk premiums across markets can be seen clearly on chart 3.3.

– The rise in the equity risk premium since the collapse of Lehman Brothers has been of the order of 8 percentage points. We model three scenarios. One in which the risk premium is permanently higher by 8% compared to a scenario where the risk premium falls by half in year 2 and then is back to baseline by year 3. The third scenario is the case where the risk premium is assume to be permanent in year 1 but in year two expectations are revised to be on the temporary trajectory.

Shock 3: A rise in household risk

The reappraisal of risk by firms as a result of the crisis also applies to households. As households view the future as being more risky, so they discount their future earnings and that affects their savings and spending decisions. The increase in household risk in the United States is assumed to be 3 percentage points in the permanent scenario and returning to zero by year three in the temporary scenario. The revision to expectations occurs in year 2 as for the equity risk scenarios.

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[18] *New York Times*, Thursday, 26 February 2009.

Summary of three crisis shocks and country differences

The three shocks by sector the United States are shown in table 3.4.

3.4 **Equity risk premium, household risk and housing productivity for the United States under the temporary and permanent scenarios**

	2009	*2010*	*2011*	*2012*	*2013*	*2014 on*
Permanent scenario						
Equity risk premium by sector:						
− Energy	8	8	8	8	8	8
− Mining	8	8	8	8	8	8
− Agriculture	8	8	8	8	8	8
− durable manufacturing	8	8	8	8	8	8
− non durable manufacturing	8	8	8	8	8	8
− services	8	8	8	8	8	8
Household risk	3	3	3	3	3	3
Housing productivity	-10	-8	-6	-4	-4	-4
Temporary scenario						
Equity risk premium by sector:						
− Energy	8	4	0	0	0	0
− Mining	8	4	0	0	0	0
− Agriculture	8	4	0	0	0	0
− durable manufacturing	8	4	0	0	0	0
− non durable manufacturing	8	4	0	0	0	0
− services	8	4	0	0	0	0
Household risk	3	1.5	0	0	0	0
Housing productivity	-10	-5	0	0	0	0

Source: authors' calculations.

The shocks in table 3.4 are for the United States — the 'epicentre' of the crisis. But not all countries have been equally affected by the crisis. For example, durable manufacturing in Japan would be hit harder by the risk reappraisal given the collapse of their durable exports (dominated by cars) as a result of the combination of the global downturn and the appreciation of the Yen that resulted from the collapse in commodity prices and improvement in their terms of trade.

Also, Japan had their housing bubble a decade earlier than did the United States, so over the last few years they never experienced a property bubble as in America. So the shock to their economy from the bursting of the housing bubble would be less than for the United States. Therefore the shocks for equity risk, the housing bubble bursting and household risk are scaled off the United States. Taking the United States as 1 a series of weights for other sectors and economies appears in table 3.5.

3.5 Weight for country and sector shocks

	USA	JPN	GBR	DEU	EUR	CAN	AUS	OEC	CHI	IND	OAS	LAM	LDC	EEB	OPC
Equity risk by sector															
− energy	1	1	1	1	1	1	1	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
− mining	1	1	1	1	1	1.2	1.2	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
− agriculture	1	1	1	1	1	1	1	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
− durable manufacturing	1	1.2	1	1.2	1	1	1	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
− non durable manufacturing	1	1	1	1	1	1	1	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
− services	1	1	1.2	1	1	1	1	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Household risk	1	0.3	1	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Household productivity	1	0.1	1	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Two main shocks capture the policy responses

On top of the above three financial crisis shocks there has been an unprecedented policy response comprising two more elements:

4. An easing of monetary policy to near zero official rates of interest in major developed economies.

5. An easing of fiscal policy across countries and large run-up in government deficits.

Shock 4: Monetary easing

There is an endogenous monetary response in the model for each economy where each economy follows a Henderson-McKibbin-Taylor rule as shown in equation (1) with different weights on inflation (π) relative to target, output growth (Δy) relative to potential and the change in the exchange rate (Δe) relative to target.

$$i_t = i_{t-1} + \beta_1 (\pi_t - \pi_t^T) + \beta_2 (\Delta y_t - \Delta y_t^T) + \beta_3 (\Delta e_t - \Delta e_t^T) \qquad (1)$$

The assumed parameter values are set out in Table 3.6. Note that China and most developing economies have a non- zero weight on the change in the $US exchange rate. The monetary easing that has occurred is close to the endogenous monetary policy response already built into the model so any extra monetary stimulus is not required. Of course it is possible that authorities, being fearful of raising interest rates too early and pricking the nascent recovery, could end up easing too much for too long and would be an interesting simulation, especially if different countries chose different amounts of 'over-easing' which would set up capital flow changes and hence trade flow changes.

3.6: **Coefficients in Henderson-McKibbin-Taylor Rules in Each Country**

	inflation ($\beta 1$)	output growth ($\beta 2$)	$US Exchange rate ($\beta 3$)
USA	0.5	0.5	0
JPN	0.5	0.5	0
GBR	0.5	0.5	0
DEU (*)	0.5	0.5	0
EUR (*)	0.5	0.5	0
CAN	0.5	0.5	0
AUS	0.5	0.5	0
OEC	0.5	0.5	0
CHI	0.5	0.5	-1
IND	0.5	0.5	0
OAS	0.5	0.5	-1
LAM	0.5	0.5	-1
LDC	0.5	0.5	-1
EEB	0.5	0.5	-1
OPC	0.5	0.5	-10
(*) Note that Germany (DEU) and the rest of the Eurozone (EUR) have a common interest rate with a weight on European wide inflation and output gap.			

Shock 5: Fiscal easing

There is an endogenous fiscal policy response in the model but the rule is a targeting of fiscal deficits as a percent of GDP. The easing of fiscal policy announced by most economies has been an extra unprecedented stimulus in the modern era and expansion of fiscal deficits and has to be simulated.

The discretionary stimulus packages announced by each country have mainly occurred over 2009 and 2010 and is usefully summarised by the OECD[19]. For the United States the cumulative stimulus is nearly 5 per cent of GDP and for China it is over 11 per cent of GDP. It is unlikely that such a stimulus will suddenly end in 2010 for two reasons: it is hard to crank up government spending on things like infrastructure quickly and governments usually find it hard to reign in spending quickly once programs are announced. Therefore, whilst assuming the same cumulative fiscal response as outlined by the OECD and other studies, the fiscal response has been assumed to taper off quickly after 2010 but finishing in 2012. The assumed fiscal response is outlined in table 3.7.

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[19] OECD 2009, *Fiscal Packages Across OECD Countries: Overview and Country Details*, Paris, 31 March.

3.7 **The assumed fiscal policy response** per cent of GDP

Country/region	2009	2010	2012	2013	Cumulative
United States	2.07	1.55	1.04	0.52	5.18
Japan	1.46	1.10	0.73	0.37	3.65
United Kingdom	1.32	0.99	0.66	0.33	3.29
Germany	1.38	1.04	0.69	0.35	3.45
Euro area	1.30	0.98	0.65	0.33	3.25
Canada	1.68	1.26	0.84	0.42	4.20
Australia	2.48	1.86	1.24	0.62	6.21
Rest of OECD	1.00	0.75	0.50	0.25	2.50
China	4.80	3.60	2.40	1.20	12.00
India	0.50	0.38	0.25	0.13	1.25
Other Asia	2.00	1.50	1.00	0.50	5.00
Latin America	0.50	0.38	0.25	0.13	1.25
Other LDC	0.50	0.38	0.25	0.13	1.25
EEFSU	1.70	1.28	0.85	0.43	4.25
OPEC	3.00	2.25	1.50	0.75	7.50

Source: OECD 2009 and authors' calculations.

4. Effects of crisis without a fiscal policy response

Mechanisms at work

To appreciate the mechanisms at work from the two shocks an illustrative scenario where permanent shocks affect the United States *alone* is shown in chart 4.1. The bursting of the housing bubble has the biggest negative impact on real consumption, which being roughly 70 percent of the domestic economy, has the biggest negative impact on real GDP. The permanent loss in wealth causes consumption to fall sharply and because the housing shock is assumed to be permanent, consumption is permanently lower in all periods as shown on Chart 4.1.

The financial shock has the largest negative impact on stock market values from baseline in 2009 and an equally large impact as the bursting of the housing bubble on investment. The equity risk shock causes a shift out of equities into other domestic assets, such as housing and government bonds as well as to asset purchases overseas. The shift into government bonds drives up their prices and pushes down real interest rates substantially. This surprisingly raises human wealth because expected future after tax income is discounted at a much lower real interest rate. Thus in the US, the equity shock alone is positive rather than negative for consumption in the short run.

Investment on the other hand falls sharply. The equity shock reduces US investment by about 20 percent below baseline. The rise in equity risk implies a sharp sell-off of shares due to a

large rise in the required rate of return to capital. The higher equity risk premium implies that the existing capital stock is too high to generate the marginal product required from the financial arbitrage condition and investment falls and, over time, due to the existence of adjustment costs, the capital stock falls and potential output is permanently reduced.

Under this simulation where the US alone is assumed to be affected by the crisis, there is a large impact on US exports (bottom left hand panel of chart 4.1) because there is a large capital outflow from the US as US savers invest offshore in the household risk shock. The US trade balance improves by 4 per cent of GDP primarily due to a sharp depreciation of the US dollar.

Each of the two shocks has a negative effect on the United States and, combined, has the effect of lowering real GDP by 7 percent below baseline in 2009 and real GDP does not return to baseline until 2017, nearly a decade later. That is sufficient to put the US into recession in 2009 (baseline growth is 3.4 percent) but will allow positive growth in 2010[20].

A key compositional effect also occurs when household discount rates rise and risk premia generally rise. The effect is a much sharper fall in the demand for durable goods relative to other goods in the economy. This is shown clearly in Chart 4.2. Imports and domestic production of durable goods falls by more than non durable goods. The differences are substantial. The high risk adjusted cost leads to a reduction in the flow of services from durables and therefore the demand for these goods drops sharply. This compositional effect is critical for the trade outcomes. Countries that export durable goods are particularly affected by a crisis of the type modelled.

The recession in the United States has two main effects on the world economy. One is the negative knock-on effect from the loss in activity with those economies most dependent on the United States market most affected. The second effect runs counter to the first. As prospects dim in the United States, so the returns on investment look better elsewhere. Money flows out of the United States (or strictly in the case of the US, less inflow than otherwise) and into other economies where it stimulates investment and economic activity. This is illustrated by the effect on China (see chart 4.3). The United States is a large importer from China. As US imports fall, China's exports fall (see bottom left hand panel of 4.3), with a combined effect from the three shocks of a drop in

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[20] Note that all results are presented as deviations from a baseline projection. A fall in GDP of 7% in year 1, relative to baseline, where the baseline growth rate was 3.4% is a new growth rate in the first year of negative 3.6% (i.e. a recession). If the level of GDP remains 7% lower forever, the growth rate of GDP in year 2 is back at baseline growth. Thus in growth rate terms, the crisis is resolved after the first year in many countries although the level of GDP remains below baseline for many years.

4.1 **Impact of a US only Permanent financial crisis on the United States**

US GDP

US Consumption

US Stock Market Value

US Investment

US Trade Balance

US Real Interest Rate

US Exports

US Inflation Rate
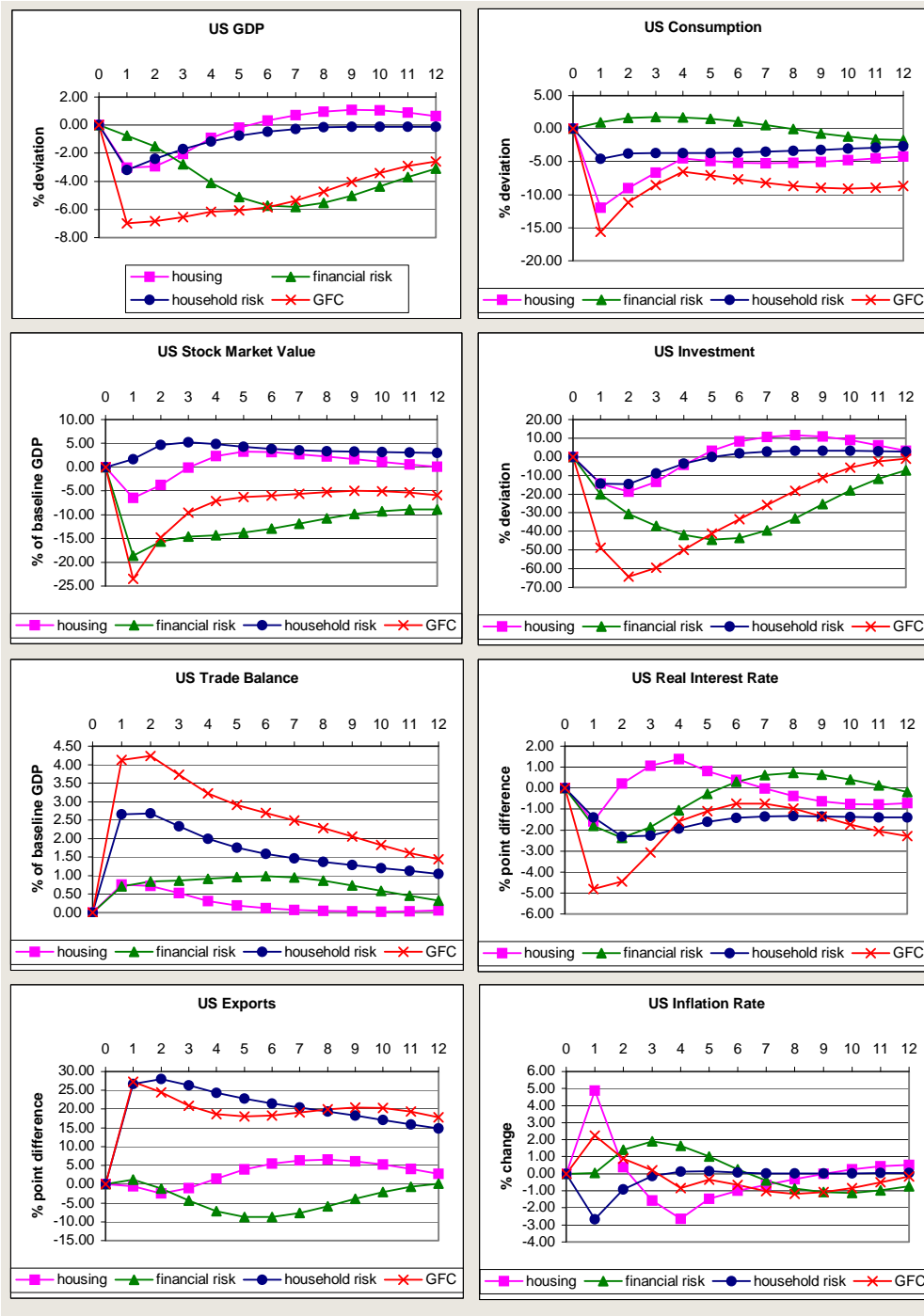
Data source: G-Cubed model simulations

4.2 **Impact of a US only permanent financial crisis on Durables verus Non-Durable goods in the United States**

Production and Imports of Durables and Non-Durables

Data source: G-Cubed model simulations
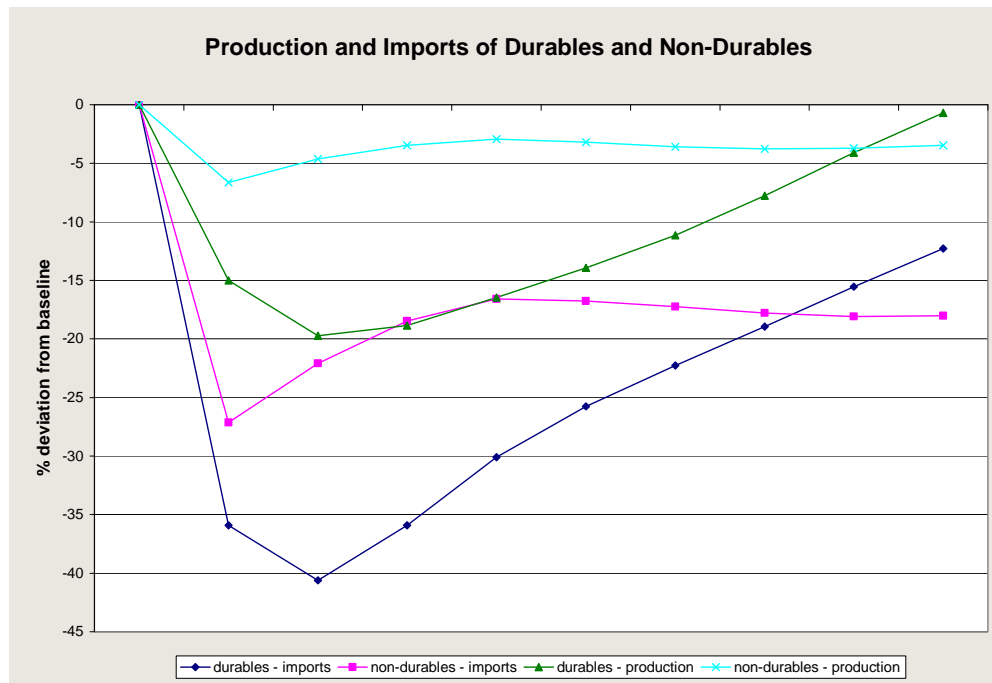
exports of 5 percent below baseline in 2009. China's trade balance worsens, but note how small the effect is: barely 1 percent below baseline (as a percent of GDP).

Note also the net small effect on China's real GDP even though China's exports are a large proportion of their GDP. When the United States alone is affected by the crisis, there is a small combined effect on China of a reduction in real GDP of 0.75 percent below baseline in 2009 and a positive effect from 2011 onwards. Looking at China's real investment provides the answer. Because investment prospects in the United States are now dire under the combined scenario, money flows elsewhere, one recipient of who is China. China's real investment could be 3.5 percent above baseline in 2011 and 2012, in response to the relatively better investment prospects. China gains at the United States' expense. The favourable stimulus from extra investment largely offsets and eventually outweighs the negative effects from the loss of exports to the United States.

The conclusion is that the financial crisis which started in the United States, had it been confined to the US alone, would not have had dire consequences for the world economy. Of course the real story is different. Contagion and rising risk premiums everywhere have caused a different scenario. When everyone is affected the consequences for the United States also depends on who and how other countries are affected.

4.3 **Impact of a US only permanent financial crisis on China**
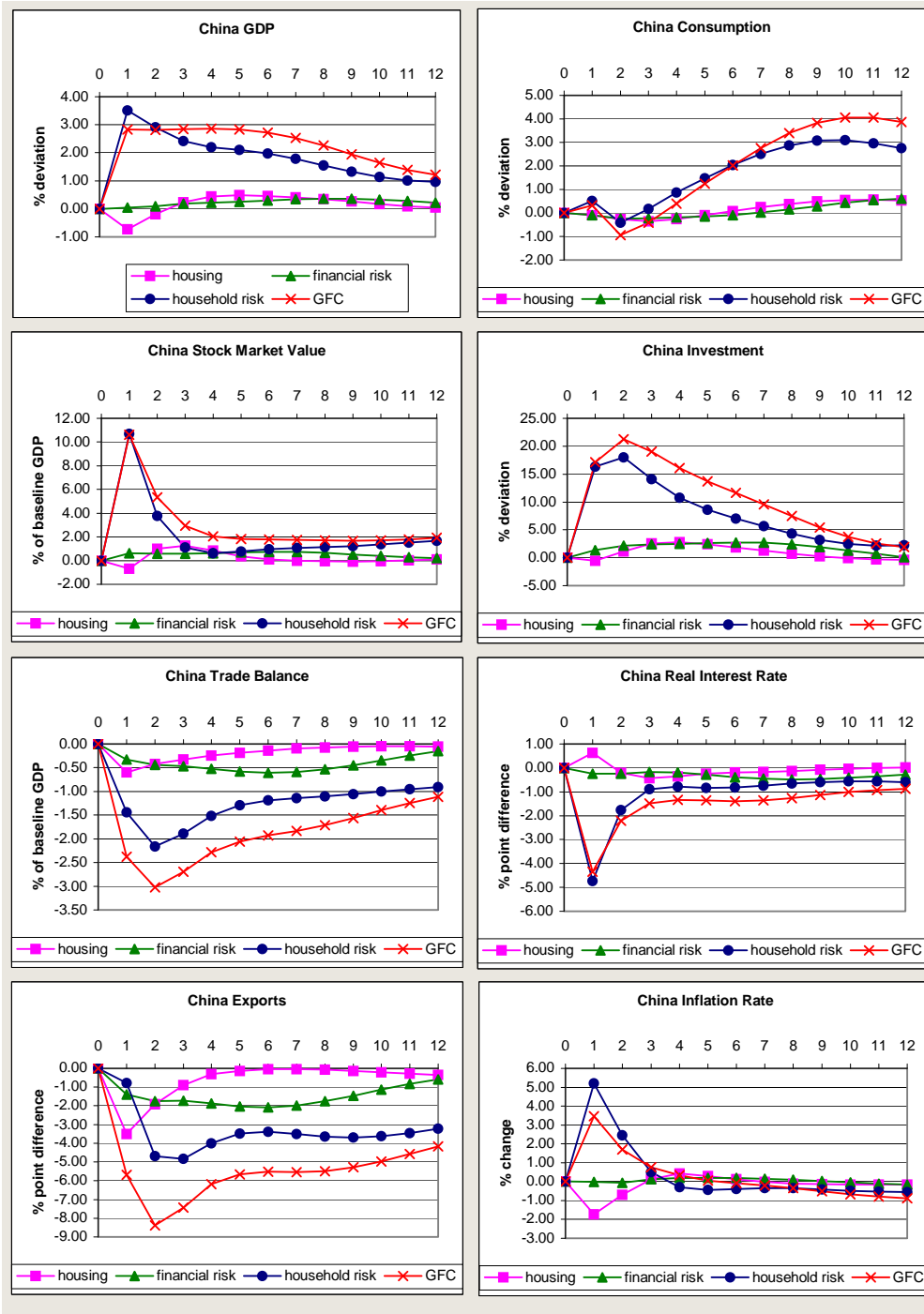
Data source: G-Cubed model simulations

Projected outlook from the global financial crisis without fiscal stimulus

When all economies are affected by the global financial crisis through global changes in risk premia and loss of consumer confidence, other countries like China are adversely affected. The loss of confidence and rise in equity risk premia causes stock markets to fall everywhere

as seen in chart set 4.4. When the rise in equity risk premia is expected to be permanent the decline in stock prices is variously between 15 and 25 per cent in 2009 with a slow recovery over the next few years but never recovering to baseline over the period depicted on the charts.

4.4 **Stock Market Effects of a Permanent, Temporary and Revised GFC**
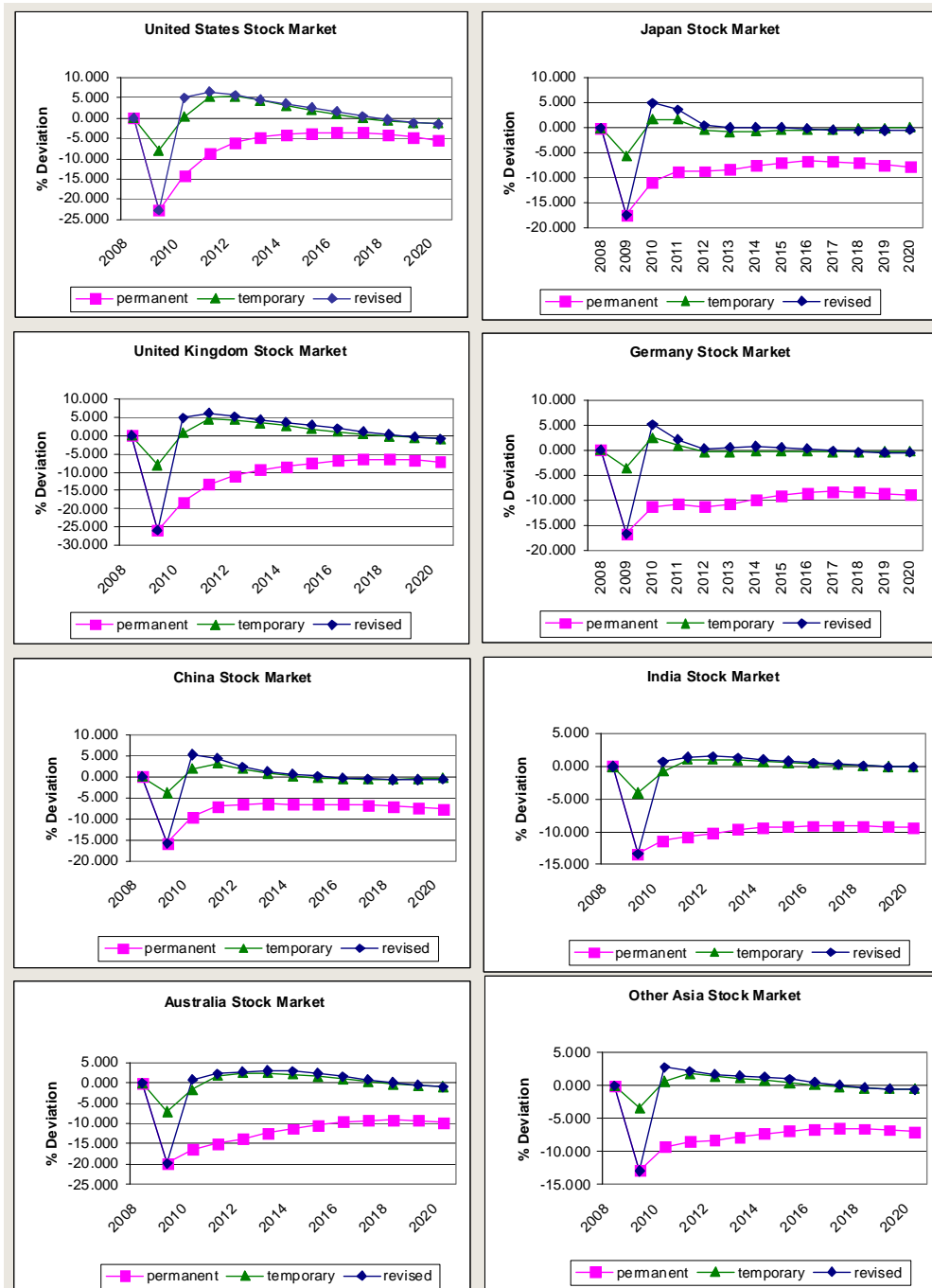
Data source: G-Cubed model simulations

When the rise in equity risk premia is expected to be temporary, the stock market effects are much smaller; stock markets decline by typically around 5 per cent below baseline in 2009. The problem with the temporary scenario where agents expect risk premia to return to 'normal' after two years is that their behaviour reflects that expectation. Since actual events have seen stock markets decline by much more than this, it indicates something like the permanent risk shock occurred. But risk premia have already started to return to more normal levels, more akin to the temporary scenario. Hence one way to reconcile these two observations is the third scenario described earlier whereby business initially expects the permanent rise in equity risk premia but then revise or 'switch' expectations to the temporary scenario. Chart set 4.4 shows that under this revision or switching scenario, stock markets collapse as before under the permanent scenario but recover strongly in 2010. They could be around 5 per cent above baseline in 2010 in major markets. In fact, stock markets could overshoot under such a scenario because the capital stock adjustment in the first year contracts too much so that the return to additional investment to reverse this is subsequent years is higher..

With falling stock markets and the reappraisal of risk, the risk adjusted cost of capital for all countries rises as the return on capital falls and, in effect, causes the existing capital stock to be too large. Therefore investment plummets, but not everywhere because it is relative effects that matter. The impact on investment is shown in chart set 4.5. Whereas Chinese investment rose when just the United States was assumed to be affected by the crisis, now Chinese investment falls to a low of over 10 percent below baseline in 2010. Real interest rates (appendix chart set C.3) fall everywhere by around 400 basis points both reflecting a long run decline in marginal product of capital but also reflecting a response of monetary authorities in lowering nominal interest rates.

Under the assumptions of the smaller rise in risk premia across other economies like India and other Asia, these regions gain relatively from the global reallocation of investment. Investment in other Asia could be over 4 percent higher over baseline in 2010 India and other Asia do not go into recession (see chart set 4.6) as a result of the global financial crisis as represented by the three shocks used in this study. The slight decline in real GDP in these economies below baseline is less than baseline growth. But that does not mean these other economies are not badly affected by the crisis. The effects on exports from India are a decline of around 25 per cent below baseline in 2009 and over 10 per cent for other Asia (see chart set 4.7). Note also from chart set 4.6 that the effects on real GDP in the United States is smaller when everyone is affected by the crisis. Real GDP under the permanent and revision shock is 5 percent below baseline in 2009 whereas it was around 7 per cent when the US alone was affected. The reason is there is not the same exodus of capital and there loss to the US economy when everyone is more or less affected by the crisis.

One of the key features of the crisis in reflected in the results in chart set 4.6 and 4.7. There is a substantially larger contraction in exports relative to the contraction in GDP in all economies. This massive shift in the relationship between trade and GDP is not the result of an assumption about the income elasticity of imports. It reflects some key characteristics of the model. First, imports are modelled on a bilateral basis between countries where imports are partly for final demand by households and government and partly for intermediate inputs across the six sectors. In addition, investment is undertaken by a capital sector that uses

domestic and imported goods from domestic production and imported sources. As consumption and investment collapse more than GDP, imports will contract more than GDP. One country's imports are another country's exports thus exports will contract more than GDP unless there is a change in the trade position of a particular country. The assumption that all risk premia rise and the results that all real interest rates falls everywhere implies small changes in trade balances.

4.5 **Investment effects of a permanent, temporary and revised GFC**
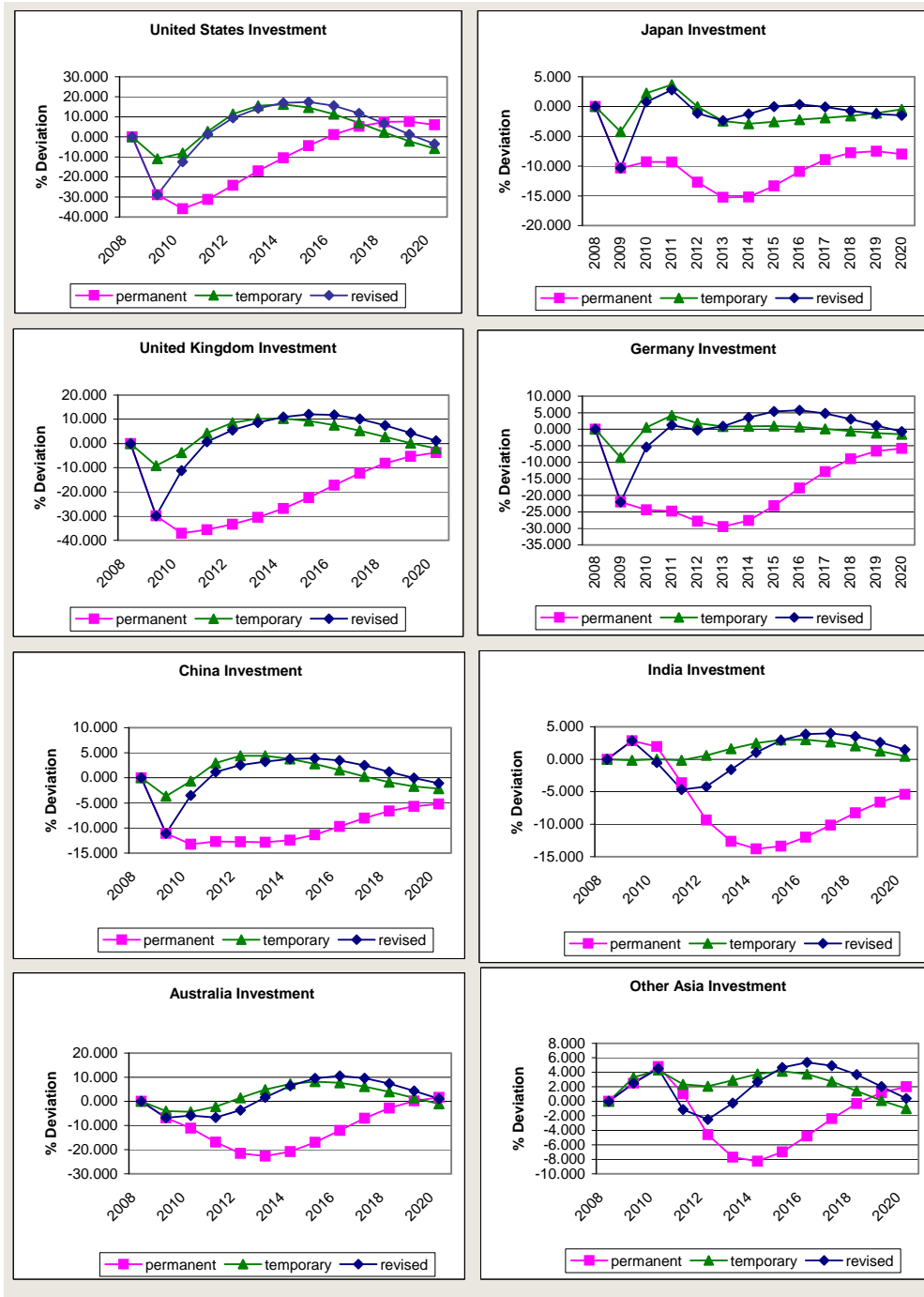
Data source: G-Cubed model simulations

4.6 **GDP effects of a permanent, temporary and revised GFC**
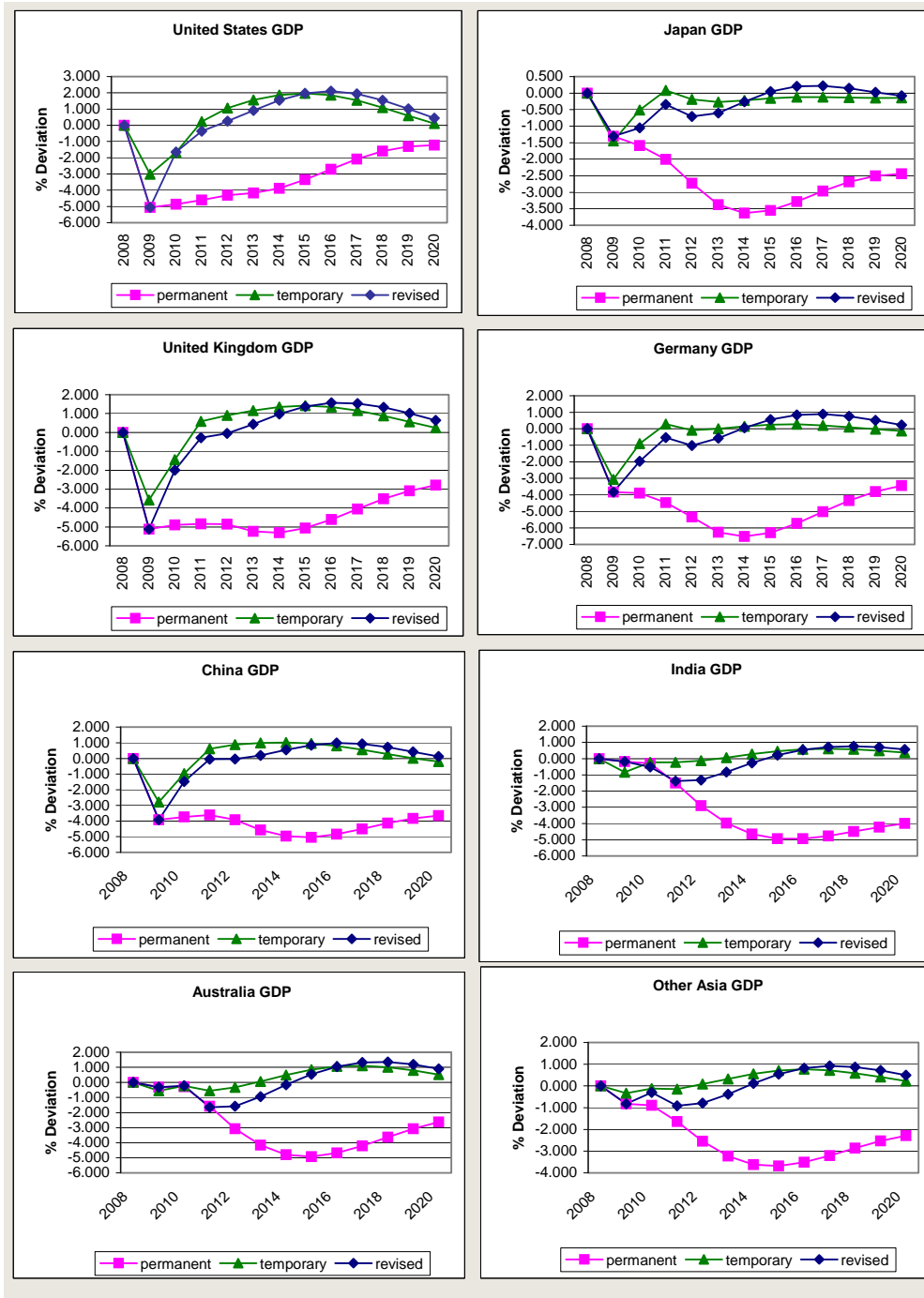
Data source: G-Cubed model simulations

4.7 **Export effects of a permanent, temporary and revised GFC**
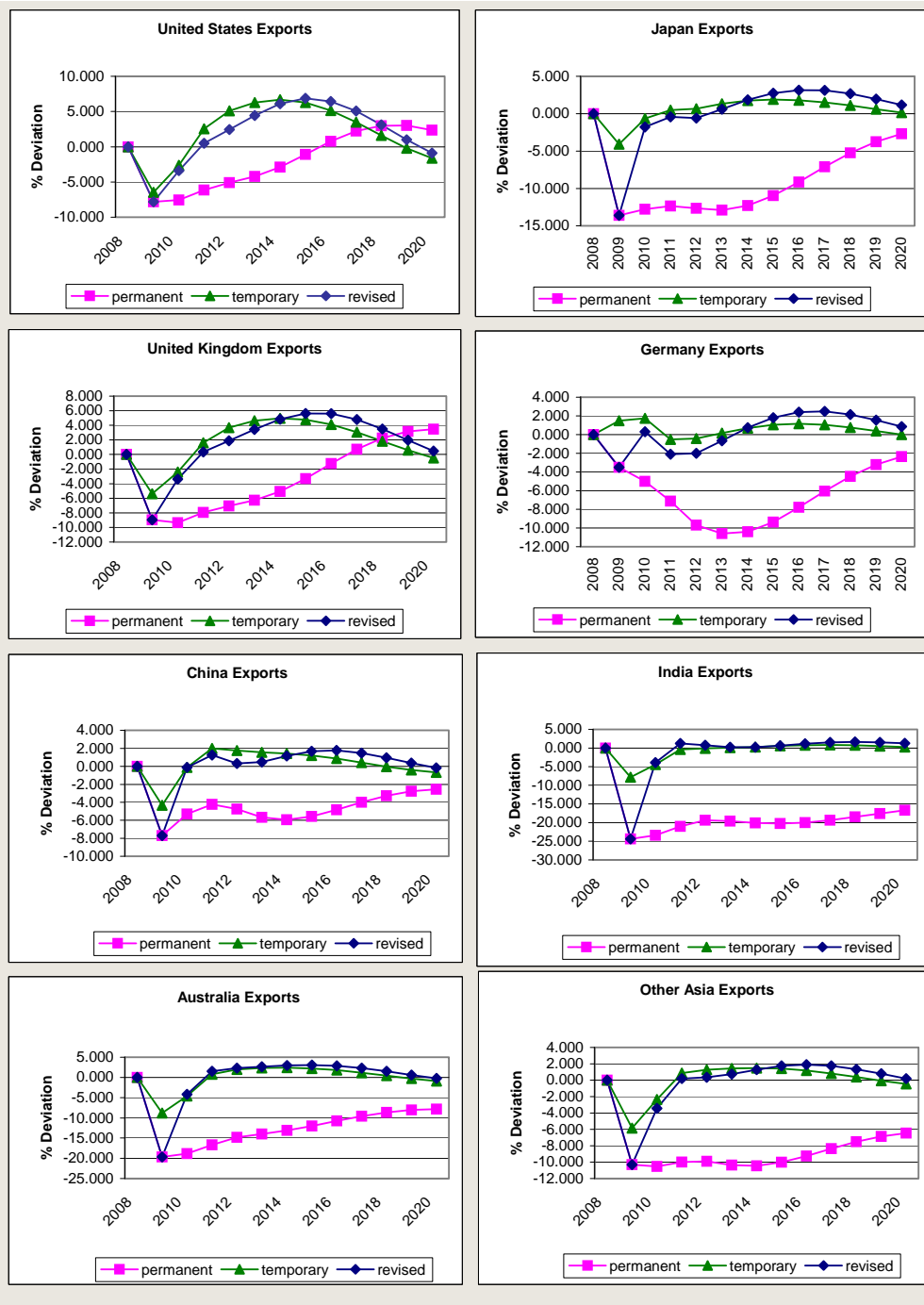
Data source: G-Cubed model simulations

5. *Effects of policy responses*

The results so far have built in a monetary reaction function in the form of a Henderson-McKibbin-Taylor rule for each economy with the short term nominal interest rate adjusting to a variety of factors in each economy. The rules assumed in the model have generated an endogenous monetary response which is similar to that observed so far. The assumption of an unchanged fiscal deficit is very different to what has been observed. In this section we focus on announced fiscal responses. The assumed fiscal policy changes were given earlier in Table 3.7. Note that we do not have infrastructure spending in the model so that the fiscal responses here are assumed to be spending on goods and services and not government investment in physical capital. Expenditure on infrastructure would likely also stimulate medium to long run supply in the model and therefore change the extent to which there is crowding out over time. However to the extent that even infrastructure spending is a demand stimulus for the first few year before the projects begin to deliver medium run supply responses, the initial results in this study can be used to understand the short run impacts of the packages.

Effects of the fiscal stimulus alone

To see the mechanisms at work, the effects of the fiscal stimulus alone are shown in chart set 5.1. These results should be added to the financial crisis results to get a picture of the financial crisis (either permanent or the switch) with fiscal response. In discussing these results we will talk about them relative to baseline which can also be interpreted as relative to what would be seen post crisis.

The fiscal stimulus gives a boost to real GDP above baseline for all major economies and China in 2009, the first year of the fiscal packages. The effects are illustrated by referring to China. China's real GDP could be 1.6 per cent above what otherwise would be the case in 2009, but little different from baseline in 2010. Real GDP would be below baseline in 2011 in China as the effects of higher real interest rates kick in. Real interest rates could be over 3 percentage points above baseline in 2009 and 2010 (see appendix charts) offsetting much of the decline in real interest rates from the global financial shock and monetary policy responses. Real private investment is 9 per cent below baseline in 2010. Considering the massive 11.4 per cent cumulative fiscal stimulus in China, the effect of the fiscal stimulus alone is quite small and transitory.

Note that the fiscal stimulus in the first year raises GDP but for all countries this effect only lasts for a year and is much smaller that many commentators argue. Indeed when added to the results for the full GFC simulation this fiscal stimulus is not sufficient to completely neutralize the crisis in its impact on GDP. The main reason involves the real interest rate implications of the fiscal stimulus as shown in Appendix chart C.6. The global nature of the stimulus implies a spike up in real interest rates which partly offset the spike down in the first year of the shocks. Note however that higher real interest rates persist for up to 6 years after the stimulus. This suggest s some serious problems to be faced by policymakers during the recovery period from 2010 onwards.

The fiscal packages also have significant impacts on global trade. In the model the effect of fiscal policy on trade comes in a number of forms operating both through income and relative

price effects. If an economy increased government spending, private consumption tends to rise and short term income rises. However the increased borrowing tends to increase real interest rates, which reduces private investment[21]. These two responses have opposite effects on trade. In particular, durable goods consumption falls because of the rise in real interest rates, while non-durable goods consumption rises due to the income increase. The effect is that imports of durable goods fall and non-durables rise. In addition the higher real interest rate tends to attract foreign capital which appreciates the real exchange rate and tends to crowd out exports and stimulates income through relative price changes. A country acting alone has a substantial change in the mix of the components of final demand. Hence if there is a global fiscal stimulus, the real exchange rate (or relative price) effects are muted. However because all countries are acting the real interest rate effects are accentuated because the call on global savings is much larger than the outcome of any one country acting alone.

Chart set 5.1 shows an interesting story where exports of the industrial economies tend to fall as a result of the fiscal package. This occurs for several reasons. Firstly, because the OECD economies have relatively larger fiscal packages (apart from China), their real exchange rate will tend to appreciate relative to the non- OECD economies, crowding out exports. Secondly, these economies tend to export more durable goods whose demand is reduced by a rise in global interest rates. This effect was also present in the global financial crisis simulation where the risk adjusted discount rise rose sharply (even though real interest rates fell) and the demand for durable goods collapsed.

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[21] to the extent that there is a substantial supply response through infrastructure, the need for interest rates to rise for a given constrained capacity would be reduced.

5.1 **GDP and export effects of fiscal response**
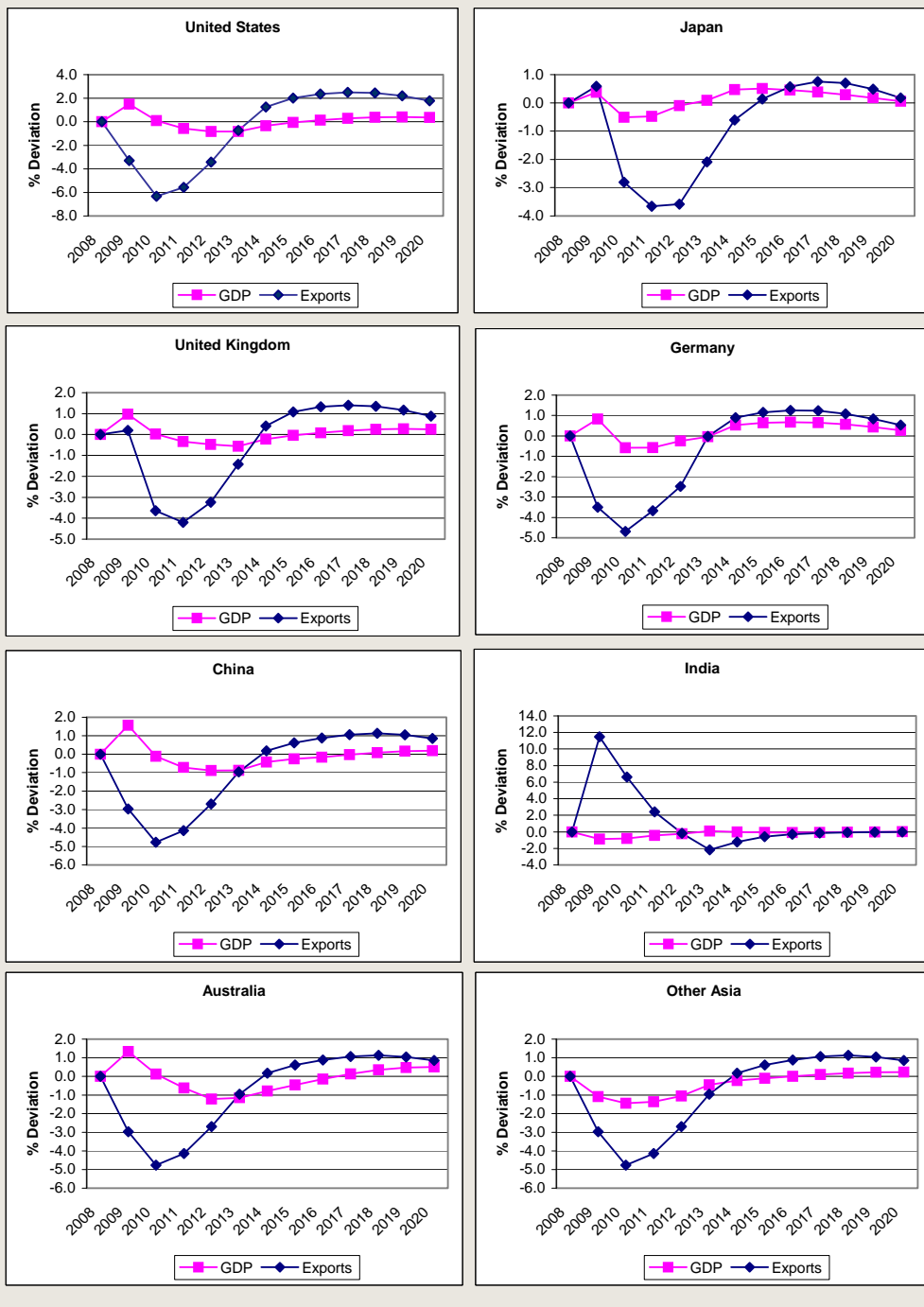
Data source: G-Cubed model simulations

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6. Conclusions

This paper has explored the impact of three major shocks representing the global financial crisis on the global economy. For the crisis itself three shocks are needed to capture the observed drop in asset prices and reduction in demand and trade. It is necessary to simulate the bursting of the housing bubble centred in the United States and Europe, but extending elsewhere, rising perceptions of risk by business as reflected in the equity risk premium over bonds and rising perceptions of risk by households.

The policy response has been dramatic. So the analysis has included an endogenous monetary easing across the globe and an exogenous fiscal stimulus of varying proportions across countries and regions.

Simulating the effect of the crisis itself (that is ignoring the policy responses not already built into the model such as endogenous monetary policy rule) on the United States alone (the 'epicentre' of the crisis) shows several things. Had there not been the contagion across other countries in terms of risk reappraisal, the effects would not have been as dramatic. The adverse trade effects from the United States downturn would have been offset to some degree by positive effects from a global reallocation of capital. Were the US alone affected by the crisis, Chinese investment could have actually risen. The world could have escaped recession. When there is a reappraisal of risk everywhere including China, investment falls sharply – in a sense there is nowhere for the capital to go in a global crisis of confidence. The implication is that if markets, forecasters and policy makers misunderstand the effects of the crisis and mechanisms at work, they can inadvertently fuel fears of a 'meltdown' and make matters far worse.

When there is a global reappraisal of risk there is a large contraction in output and trade. The bursting of the housing bubble has a bigger effect on falling consumption and imports than does the reappraisal of risk, but the reappraisal of risk has the biggest effect on investment. Rising risk causes several effects. The cost of capital is now higher and leads to a contraction in the desired capital stock. Hence there is disinvestment by business and this can go on for several years – a deleveraging in the popular business media. The higher perception of risk by households causes them to discount future labor incomes and leads to higher savings and less consumption, fuelling the disinvestment process by business.

How much disinvestment occurs depends on the scenario chosen. Under a permanent increase in risk premia there is a longer period of disinvestment, typically lasting the best of a decade before returning to baseline. But when agents unexpectedly switch and revise their expectations to a temporary scenario, investment recovers to baseline generally four years earlier.

Mckibbin and Stoeckel (2009a) shows the current and future fall-out from the global crisis depended on the scenario chosen. Although a temporary scenario where risk premia are returning to more normal levels seems to be unfolding, modelling the effects of such a scenario understates the impacts of the crisis in the model used here. The reason is that expectations have to be incorporated once a dynamic model that includes time is specified. Even if a scenario turns out to be temporary what is critical is what households and firms

thought the crisis was going to be. This is what determines the first year results. Under a temporary scenario, which is known to be temporary, businesses 'know' that risk premia are going to come down and behave accordingly, giving muted effects compared to what actually occurred. But a scenario that has businesses initially expecting a pessimistic scenario and then unexpectedly revising expectations to more normal conditions as events unfold better captures the initial downturn more along the lines of what has occurred. In subsequent years the switching scenario tracks the temporary scenario reported in the earlier work quite closely because forward expectations drive the results. As expected asset prices moves very differently in year 2 even thought the shocks in the temporary and revised scenarios are exactly the same from year 2 onwards.

The fiscal policy response initially has the desired effect of increasing domestic demand and hence real GDP. While the boost to domestic demand on its own boosts trade there are other effects going on that have an adverse effect on trade. The fiscal stimulus and accompanying borrowing, causes real interest rates to rise over what they would otherwise be. This effect would be diluted if the global economy remained in recession for a long period. However, the natural recovery from the shocks as shown in the results implies that there will be competition by government and the private sector over scarce funds for either private investment or to finance fiscal deficits. The rise in real interest rates (relative to what they would have been) and fall in investment and durable good demand implies that exports fall and do not get back to baseline for several years. Interestingly if the fiscal responses were designed (and were approximately optimally) when the world was thought to be in a permanent crisis scenario then clearly they are not appropriate if the world moves to a revised scenario that is more temporary. This can be seen by adding the fiscal results to each of the three underlying scenarios.

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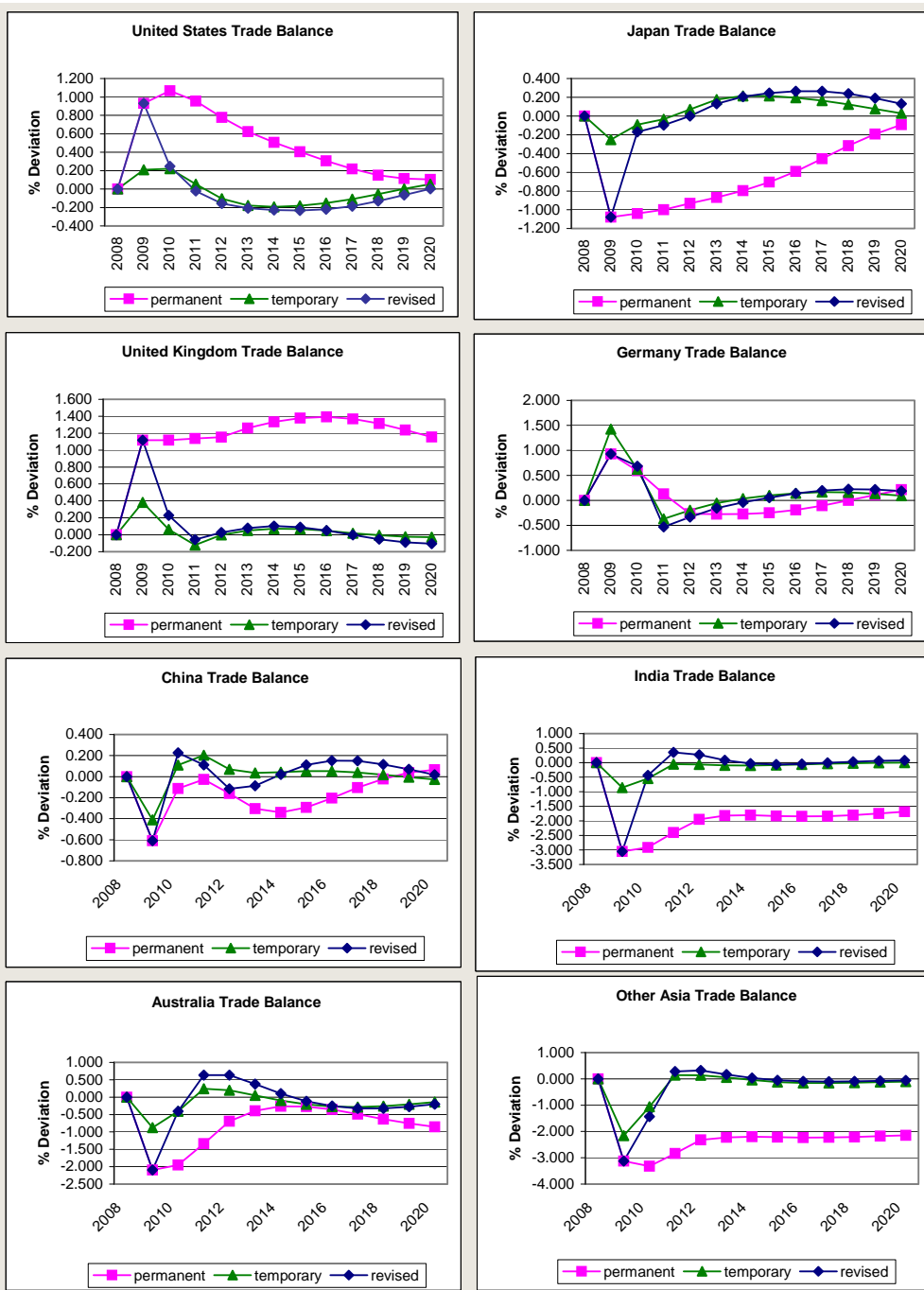
Appendix A. Detailed results

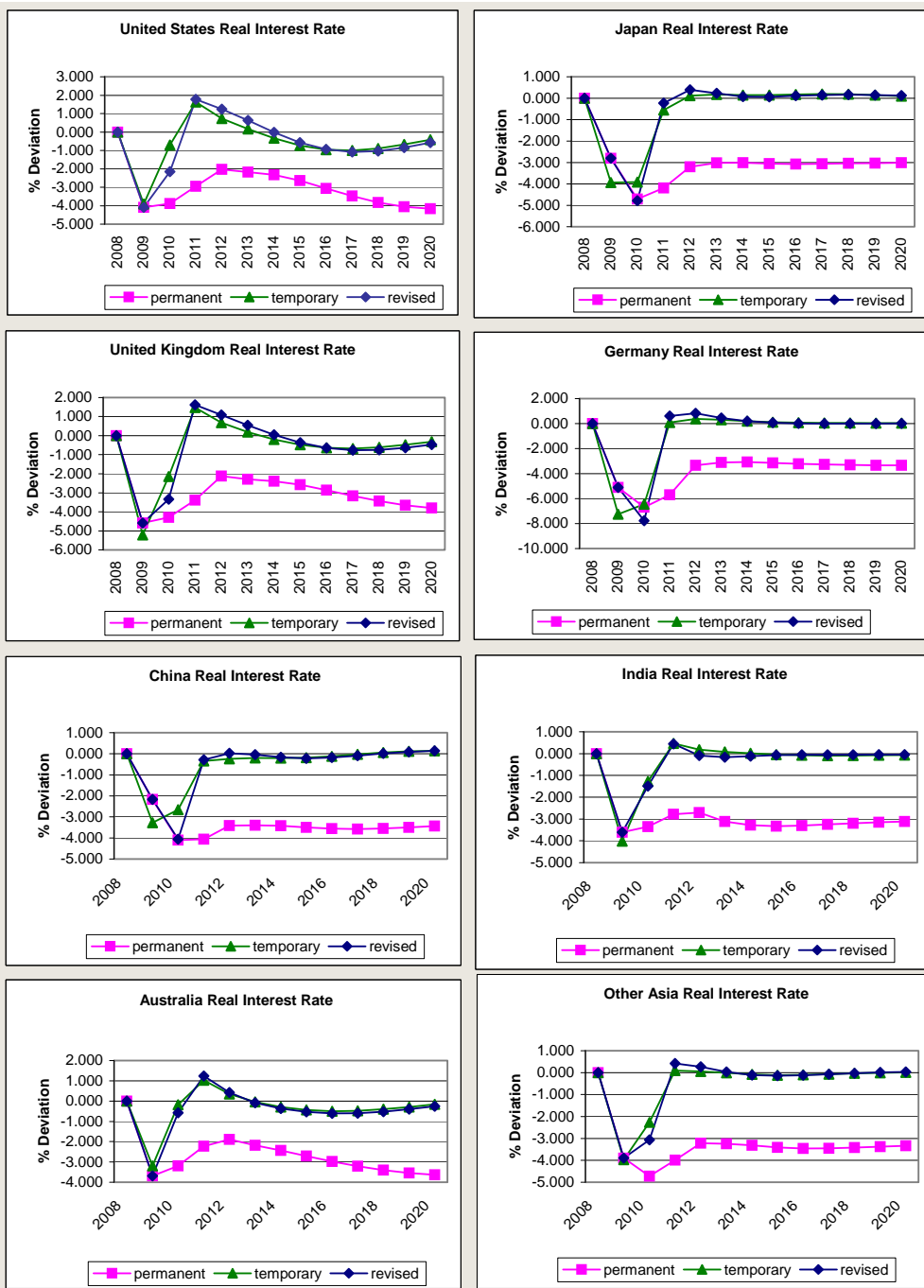A.1 **Consumption effects of a permanent versus temporary GFC**
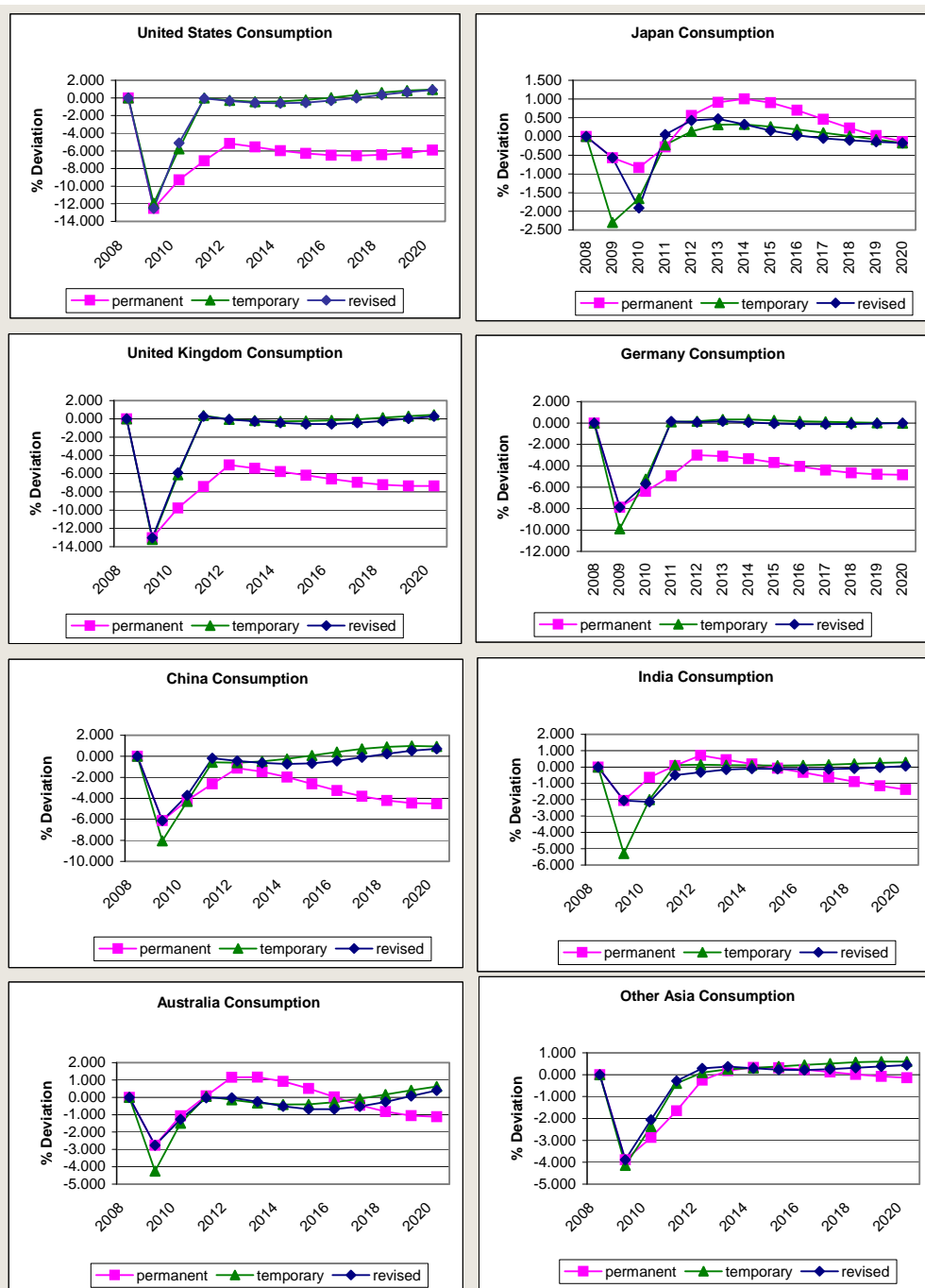
Data source: G-Cubed model simulations

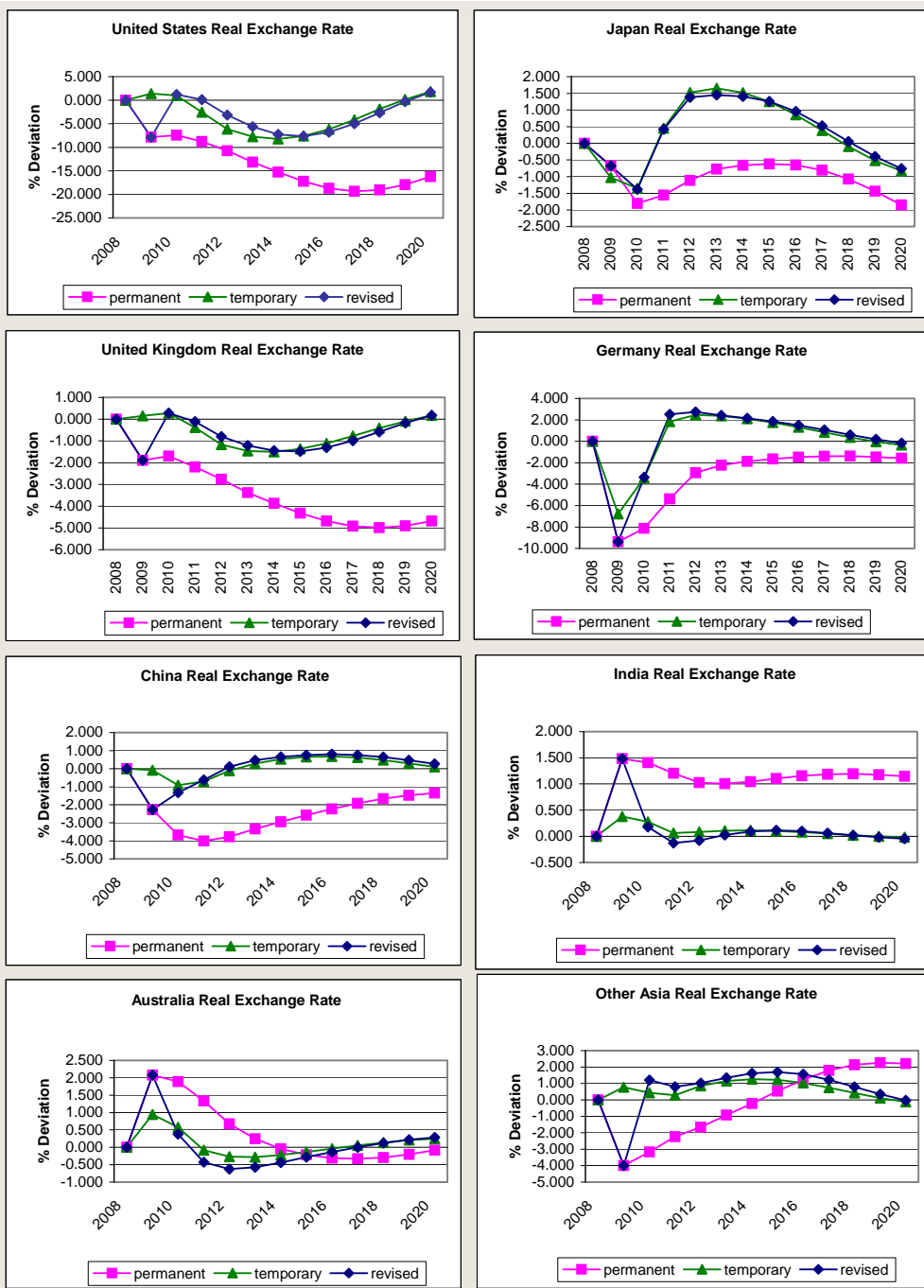C.2 **Trade balance effects of a permanent versus temporary GFC**

Data source: G-Cubed model simulations

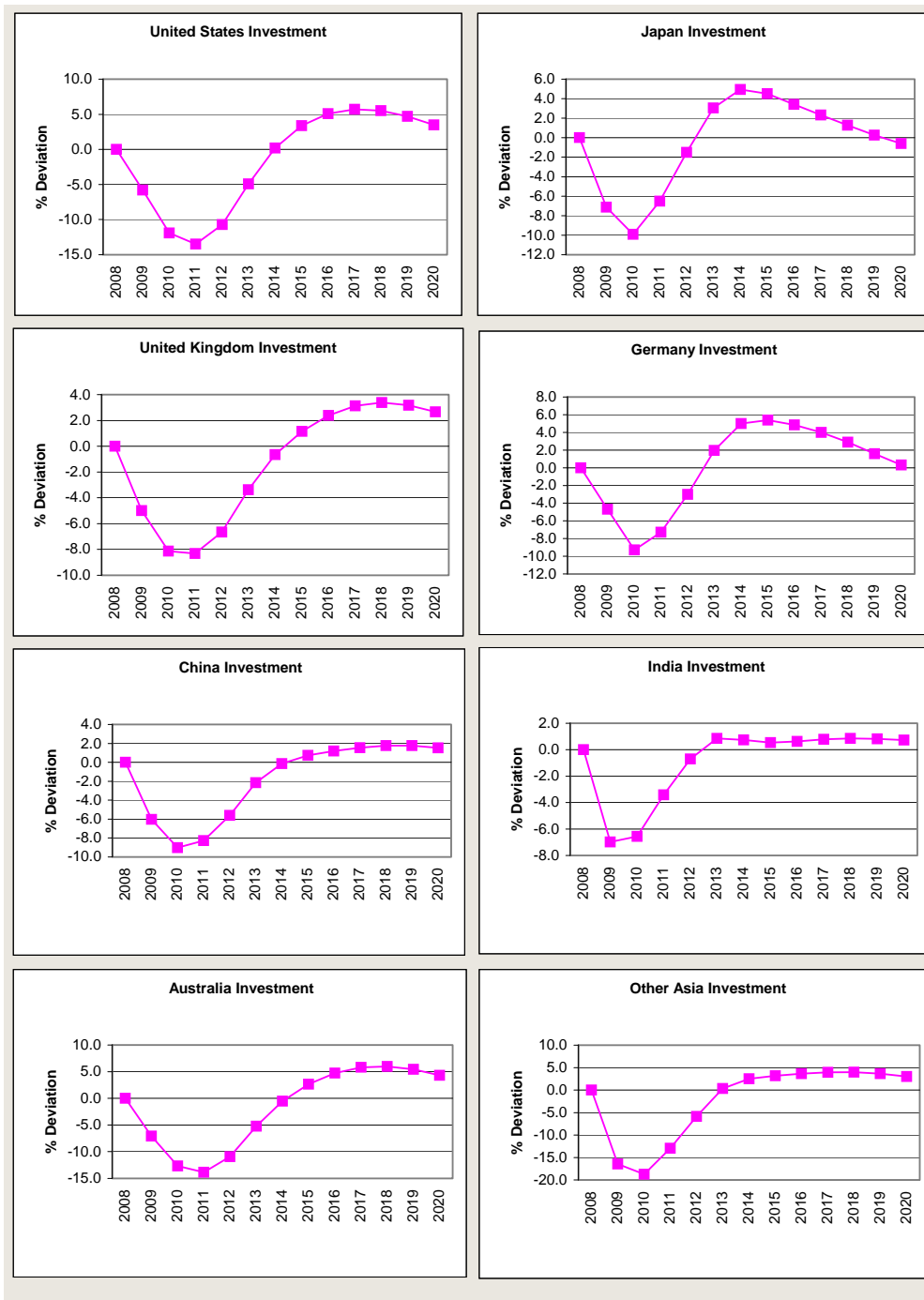C.3 **Real interest rate effects of a permanent versus temporary GFC**

Data source: G-Cubed model simulations

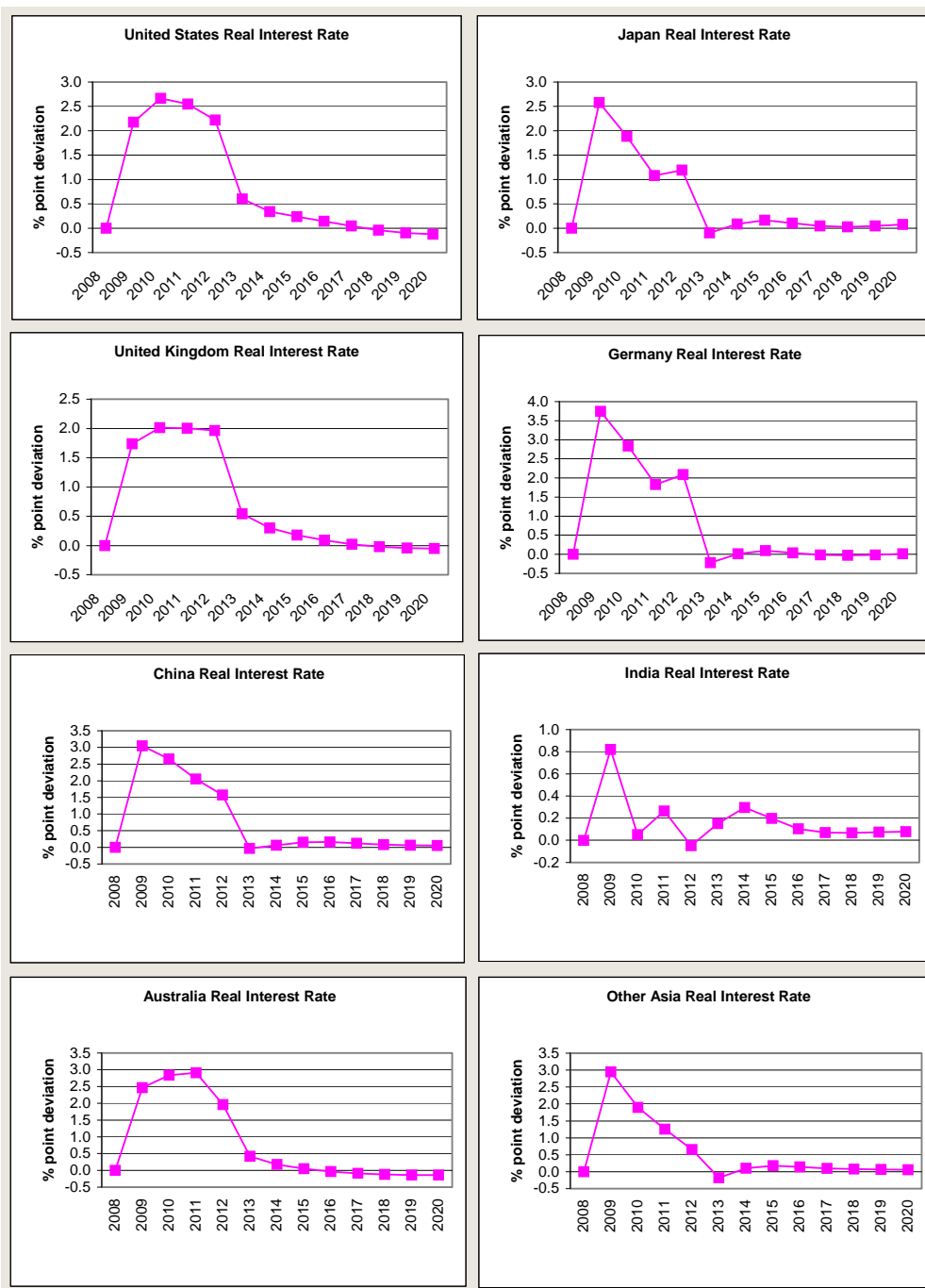C.4 **Real effective exchange rate effects of a permanent versus temporary GFC**

Data source: G-Cubed model simulations
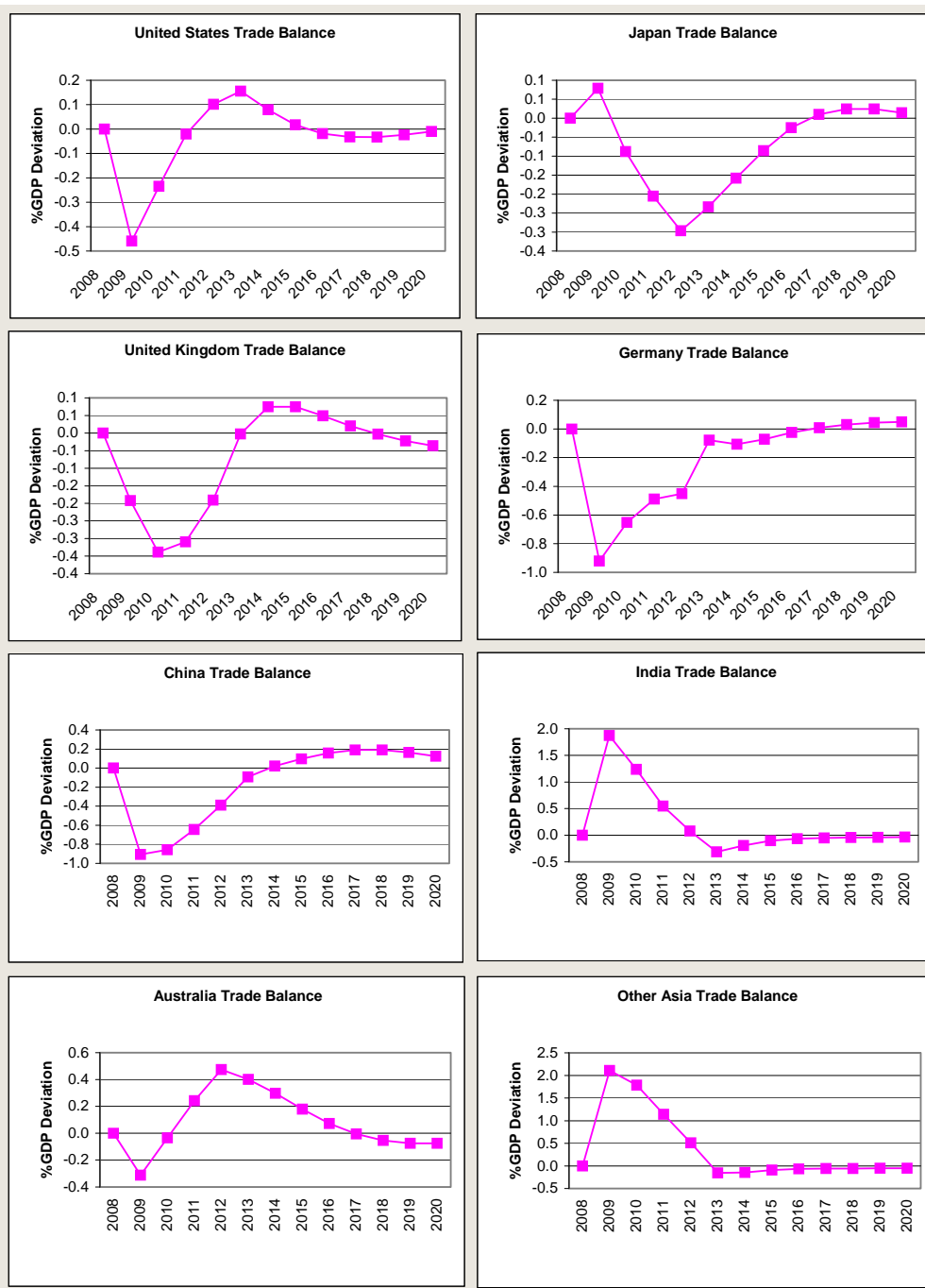
C.5 **Investment effects of fiscal response**

Data source: G-Cubed model simulations

C.6 **Real interest rate effects of fiscal response**

Data source: G-Cubed model simulations

C.7 **Trade balance effects of fiscal response**

Data source: G-Cubed model simulations

C.8 **Real effective exchange rate effects of fiscal response**

Data source: G-Cubed model simulations