Oxford Review of Economic Policy, Volume 34, Numbers 1–2, 2018, pp. 329–347

Modelling a complex world: improving macro-models

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Abstract: Macro models have come under criticism for their ability to understand or predict major economic events such as the global financial crisis and its aftermath. Some of that criticism is warranted; but, in our view, much is not. This paper contributes to the debate over the adequacy of benchmark DSGE models by showing how three extensions, which are features that have characterized the global economy since the early 2000s, are necessary to improve our understanding of global shocks and policy insights. The three extensions are to acknowledge and model the entire global economy and the linkage through trade and capital flows; to allow for a wider range of relative price variability by moving to multiple-sector models rather than a single good model; and to allow for changes in risk perceptions which propagate through financial markets and adjustments in the real economy. These extensions add some complexity to large-scale macro-models, but without them policy models can oversimplify things, allowing misinterpretations of shocks and therefore costly policy mistakes to occur. Using over-simplified models to explain a complex world makes it more likely there will be 'puzzles'. The usefulness of these extensions is demonstrated in two ways: first, by briefly revisiting some historical shocks to show how outcomes can be interpreted that make sense within a more complex DSGE framework; then, by making a contemporary assessment of the implications from the proposed large fiscal stimulus and the bans on immigration by the Trump administration which have both sectoral and macroeconomic implications that interact.

Keywords: macroeconomics, models, risk, relative prices, DSGE

JEL classification: C02, C5, C68, D58, D9, E17, E62, F4

> 'Everything should be made as simple as possible, but no simpler.' (attributed to Albert Einstein)

I. Introduction

The debate over how to make macro-models useful is not new.[1] One contribution to that debate was made by this journal 17 years ago (*Oxford Review of Economic Policy*,

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We would like to thank David Vines for very helpful guidance and Adrian Pagan for excellent comments. The views expressed in the paper are those of the authors and should not be interpreted as reflecting the views of any of the above collaborators or of the institutions with which the authors are affiliated, including the trustees, officers, or other staff of the ANU or The Brookings Institution.

[1] A useful summary of the long history of model development and new directions for research in macroeconometric models can be found in Hall *et al.* (2013).

doi:10.1093/oxrep/grx056

vol. 16, no. 4, 2000). Then, as now, the debate had many dimensions; one paper by McKibbin and Vines (2000) argued that, for real-world policy analysis, large structural models that incorporated both inter-temporal optimization and stickiness were required. Inter-temporal budget constraints and their role in determining asset prices were needed, along with short-term stickiness in wages, adjustment costs in investment, and rule-of thumb behaviour by consumers and producers. The authors went on to show how several macroeconomic 'puzzles' raised at the time by Obstfeld and Rogoff (2000) could be explained once these features were included in a large structural macro-model. The model they used, incorporating these two features that they focused on, was the G-Cubed model.

Inter-temporal optimization and stickiness are now routinely included in the class of DSGE models used today that seek to analyse actual policy issues. But three other features included in the G-Cubed model, namely, global linkages in capital and trade, the role of relative prices in transmitting shocks across countries, and changes in financial risk, tend to be omitted from benchmark DSGE models that deal with real-world policy. That omission turns out to be important. In this paper we show why these three aspects are important to explain some of the macroeconomic puzzles that have arisen during the past 18 years, but particularly with the emergence of large developing economies as key parts of the global economy and with the onset of the global financial crisis and its aftermath.

Our view is that there need not be such a clear distinction between large policy models and the ideas at the foundation of the DSGE models. There is much that the discipline of DSGE models can contribute to improving larger-scale policy models. The G-Cubed model of McKibbin and Wilcoxen (2009, 2013) and the MSG2 model of McKibbin and Sachs (1991) show how to build policy models with DSGE microfoundations but enough nominal and real frictions to better understand recent experience. We are closer to the arguments of Lindé (2018) that the approach of the DSGE framework is useful in many respects. We also agree with Wren-Lewis (2018) that large-scale models are useful, although we find the DSGE framework is a useful guide to improving large-scale models. We disagree with the Hendry and Muellbauer (2018) view that there is little to be gained from the DSGE approach. The G-Cubed model is an example of a model that is consistent with the benchmark DSGE model as set out in section III of the Vines and Wills paper (2018), but also incorporates short-run rigidities, less than fully rational behaviour, and heterogeneous firms in many sectors.

(i) What are we trying to understand?

To make better policy decisions implies better understanding of the economic system and consequences of any disruptions that occur. Understanding any economy in the world, including the US, requires an acknowledgement that the world is highly integrated. The fact that a number of US macroeconomic models still assume a closed US economy without exchange rates is a major puzzle and a major problem for most questions of macroeconomic policy. Understanding large complex systems, like the global economy, requires large-scale models. But what features to include, what to leave out, and for what purpose? Blanchard (2017) makes a useful contribution here and distinguishes five types of macro model—each with a different aim in mind. One of those classes of models, which G-Cubed falls into, is policy models. Their purpose, as

Blanchard describes it, is 'to help design policy, to study the dynamic effects of specific shocks, to allow for the exploration of alternative policies'. These models should fit the data and capture actual dynamics and have 'enough theoretical structure that the model can be used to trace the effects of shocks and policies'.

Two examples Blanchard gives of such use are: 'If China slows down, what will be the effect on Latin America?' and 'If the Trump administration embarks on a fiscal expansion, what will be the effects on other countries?' There are plenty more examples one could give. What does Brexit do for the UK, Europe, and the rest of the world? What could happen to economies if rising protection in the US leads to a trade war? How does the emergence of a billion people into the global economy as producers and consumers change the propagation of global shocks? The potential list is a long one. Notice something in all of these examples—the interest is in how a shock in one economy might affect other world economies and what the implications are for policy. That is, not only are we interested in how a shock in one economy affects that economy, but in a highly globalized world, understanding how these shocks spill over into other economies is also crucial. In addition, it is critical to understand how shocks then reverberate back into the originating country from the rest of the world. Shocks are transmitted by trade and financial linkages. We have to be able to understand the basis of trade and capital flows and how various events affect these.

The level, direction, and composition of trade depend on transaction costs (tariffs, subsidies, transport cost, other taxes) and comparative advantage. So relative differences between countries—whether from natural endowments (think energy, agriculture, and mining), from physical and human capital (and how specific and fixed that is), or from relative productivity differences—all matter for trade. It follows that we need a minimum set of countries and sectors to reflect these relative differences. This is particularly important in a world economy that has experienced extremely large changes in relative prices of food versus energy versus manufactured goods versus services over the past 15 years since the large emerging economies of China, India, and Brazil have been transforming the world economy. Nearly every shock of interest that can be imagined will affect sectors differentially, generate changes in relative prices, and cause differences in trade flows that contribute to the overall macroeconomic outcome for an economy. The same is true for financial assets and capital flows—and, of course, these financial aspects are linked to the real sectors.

Capital flows are affected by asset market arbitrage conditions. Important considerations here are: the substitutability between financial assets; satisfying inter-temporal constraints on international debt (besides all the domestic constraints); and the arbitrage conditions linking the rate of exchange-rate change to the difference between home and foreign interest rates and risk premia. It is this role of risk, how it is modelled in G-Cubed, and what insights we gain from including this aspect, along with the role of relative price changes, that is the focus of this paper. We now expand on the role of risk and relative prices.

(ii) What can be important and is largely missing from the usual macro story

Three key features of the world economy since 2000 have been: the emergence of large developing countries such as China and India as well as ASEAN economies and other emerging regions into global production and consumption chains; large shifts in risk premia in different markets and large swings in the relative prices of manufactured goods, energy, mining, agriculture, and services. These must have had macroeconomic implications, yet they are largely missing in most macroeconomic models of advanced economies.

Figure 1 shows one measure of risk from 2001 to 2009. Clearly large spikes in risk occur during the Dot-Com crisis starting in 2000 and leading up to the financial crisis in 2008.

Figure 2 shows the price of energy, mining, agriculture, durable and non-durable manufacturing, and services from 2000 to 2008, just before the global financial crisis.

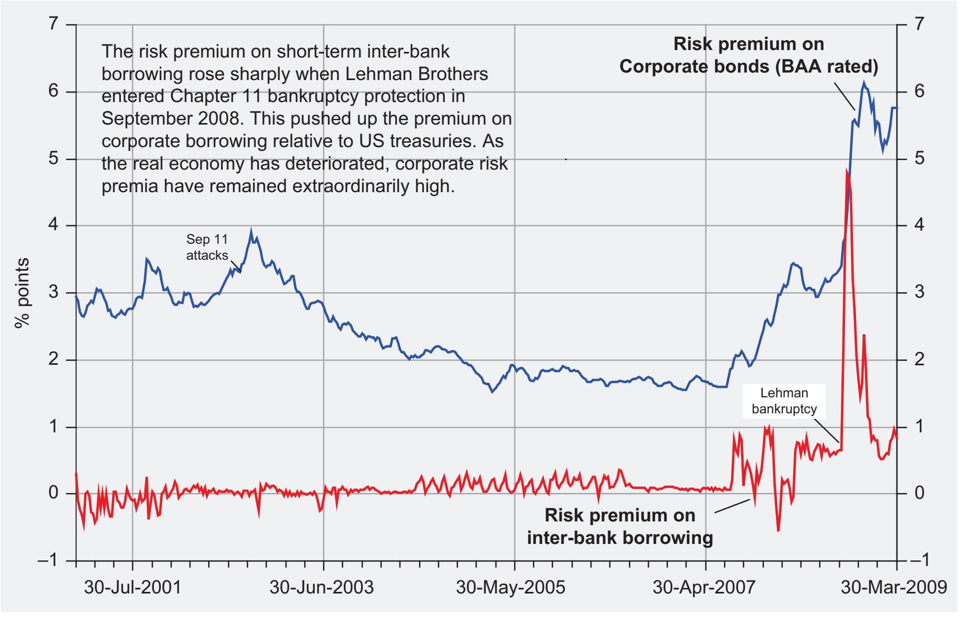
This paper summarizes applications of the G-Cubed multi-country model that incorporate these relative prices and risk shocks that are relevant for understanding macroeconomic adjustment and considering contemporary macroeconomic policy.

II. The approach of G-Cubed

(i) Brief summary of the general approach and key features

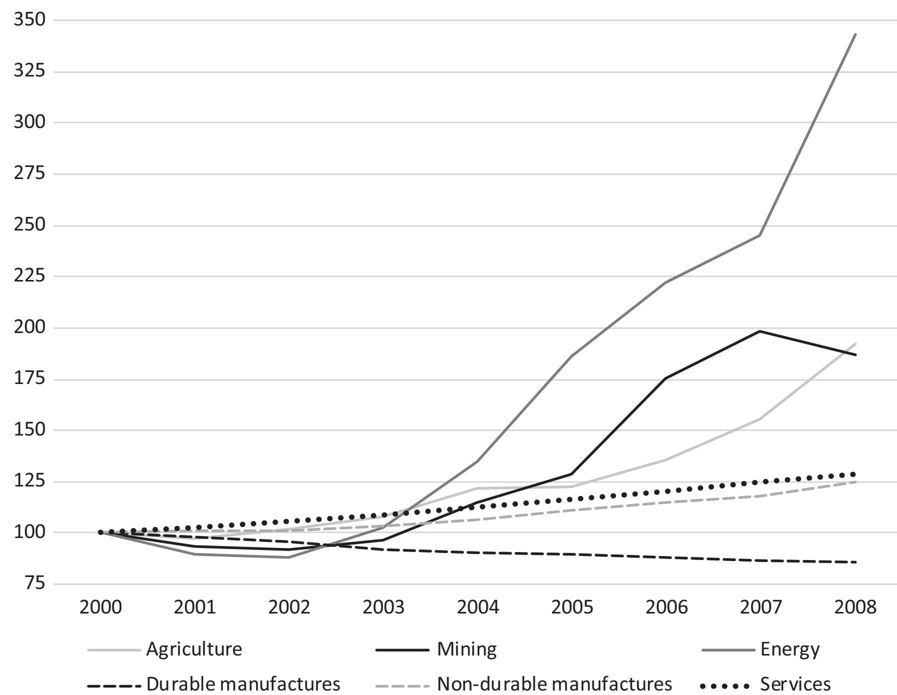
The features of the benchmark DSGE model described by Vines and Wills (2018) in the introduction to this volume are all incorporated in the G-Cubed model used here.

Figure 1: The Lehman Brothers' bankruptcy and risk premia



Notes: From McKibbin and Stoeckel (2009). Weekly data. Risk premium on inter-bank borrowing approximated by the rate on 1 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.

Figure 2: Commodity, manufacturing, and services prices, US$, 2000=100



Source: McKibbin and Cagliarini (2009).

At the core of the model is a real model of the process of capital accumulation and growth, one that has been taken over from a multiple-sector version of the Solow–Swan growth model, and from the work of real business-cycle (RBC) theorists. Capital accumulation is driven by the decision to invest by the firms that exist in each sector of the model. But unlike in the RBC model, what is saved is not automatically invested. Instead, there is an explicit investment function; the investment decision is forward looking, depending on the expected future need for capital. The extent of investment is governed by the costs of adjustment of capital. The long-run equilibrium Ramsey growth path for this model is one in which the capital accumulation caused by investment exactly keeps pace with population growth and technical progress. In the short run there is a distinction between the optimizing firms and rule-of-thumb firms in each sector of each economy. In the long run both firms follow the same decision rules.

The representative consumer is based on a forward-looking Euler equation but with a probability of death included, as in Yaari (1965), Blanchard (1985), and Weil (1989). This means that the model approximates an overlapping generations (OLG) model and deviates from the standard infinitely lived agent models. Along the equilibrium growth path consumers hold the equity created by investment. Financial intermediation ensures that this happens, although the existence of non-Ricardian equivalence caused by the positive probability of death means that the real interest rate can deviate from the sum of the pure rate of time preference plus the long-run growth of productivity. In the short run, shocks to the level of technology, and to its expected rate of change, disturb this growth path; so do shocks to the desire to save, and to the financial intermediation process. There is an endogenous 'neutral' real rate of interest which can ensure that—despite such shocks—resources eventually become fully employed. The model can be used to study the effects of technology shocks, of the kind studied by RBC theorists, but also demand shocks.

The addition of nominal rigidities to this model creates the possibility of an output gap in which output, driven by changes in aggregate demand, is different from aggregate supply, so that inflation can emerge. This leads to a role for monetary policy, in the form of a central bank setting the nominal (and short-term real) interest rate; such policy can pin down the rate of inflation. The Henderson–McKibbin–Taylor rule is one way of representing policy. Subject to inflation being controlled, such a policy can also ensure that demand is just sufficient for resources to be fully utilized.

The G-Cubed model importantly joins all countries in the world together through both trade and asset-market arbitrage.

Fiscal policy can stabilize demand, but over time government deficits lead to public debts which, to ensure fiscal solvency, require higher levels of taxes to pay the higher debt interest. Public debt can also crowd out capital because of the Approximate OLG feature of the model. This was explored at great length in McKibbin (2006) in a version of the G-Cubed model that incorporated annual cohorts of agents to demonstrate the impact of global demographic change on the real rate of interest and global growth.

Extensive detail of that model's features is in McKibbin and Vines (2000) and is not necessary to repeat here, except for the key features of the model (amended for the version of G-Cubed used here) so there is some context in which to interpret the dynamics and the insights described later. The key features are:

- specification of the demand and supply sides of economies;
- the real side of the model is disaggregated to allow for the production of six types of goods and services;
- international trade in goods and services produced by the six sectors, and in financial assets;
- integration of real and financial markets of economies with explicit arbitrage linking real and financial rates of return adjusted for equity risk premia for domestic assets and country risk premia for international arbitrage through uncovered interest parity conditions;
- inter-temporal accounting of stocks and flows of real resources and financial assets;
- imposition of inter-temporal budget constraints so that agents and countries cannot forever borrow or lend without undertaking the required resource transfers necessary to service outstanding liabilities;
- short-run behaviour is a weighted average of neoclassical optimizing behaviour based on future income streams and Keynesian current income;
- full short-run and long-run macroeconomic closure with macro dynamics at an annual frequency around a long-run Solow/Swan/Ramsey neoclassical growth model;
- the model is solved for a full rational-expectations equilibrium at an annual frequency over 100 years;
- fiscal and monetary policy adjustments are made in response to shocks to meet domestic objectives for activity, employment, and target inflation, with rules varying across countries.

The version of the model used here has six sectors: energy, mining, agriculture, manufacturing durables, manufacturing non-durables, and services. The first three sectors are important for their links to resource endowments that vary widely across the globe. Separating manufacturing into durables and non-durables is important because interest rate changes have differential effects. Also, there is a capital goods producing sector in each economy but it is not traded.

In the current version there are 17 countries/regions as set out in Table 1. More aggregation to make the model smaller is possible, but the grouping below has proved to be optimal to appreciate most shocks of interest from a macro perspective.

Important for policy DSGE models noted by Blanchard earlier is the need to fit the data and capture the actual dynamics. The G-Cubed model is calibrated to the data using a mix of time series econometrics and calibration of parameters following the approach common in computable general equilibrium (CGE) models.[2]

III. Some lessons from the model for understanding history

(i) Asian and global financial crisis

In McKibbin (1998) the crisis in Asia was modelled as a rise in country risk in the crisis economies. That is, foreign investors suddenly needed a high rate of return to hold assets in the crisis economies. The rise in country risk immediately caused a capital outflow and sharp real and nominal exchange rate depreciation and a collapse in private consumption and investment. A sharp recession in the crisis economies resulted.

The analysis was undertaken at the start of the crisis so two possible scenarios were modelled. The first looked at a permanent rise in risk; the second a temporary rise in risk. In the permanent case, the recovery was weak, investment flat, and the capital stock eventually fell to new lower levels. The temporary risk shock led to a deep recession but a 'V-shaped' recovery. The actual outcome was a flatter V-shaped recovery with a permanently lower capital stock and an investment rate at half of the pre-crisis levels. This outcome was in between the temporary and the permanent risk shock scenarios, but the model simulations did a good job in stylizing the adjustment to the

Table 1: G-Cubed model countries/regions (version 140V)

United States	China
Japan	India
United Kingdom	Indonesia
Germany	Other Asia
Rest of euro area	Latin America
Canada	Other emerging economies
Australia	East Europe and Former Soviet Union
Korea	Organization of the Petroleum Exporting Countries (OPEC)
Rest of advanced economies	

[2] See McKibbin and Wilcoxen (2013) for more details.

shocks during and after the crisis. As argued by Corbett and Vines (1999), the results for changes in expected productivity had a similar effect as the risk shocks. The existing capital stocks across the economy were too large and had to be reduced, but this was expensive given real rigidities in changing capital stocks and highly flexible financial flows.

The same methodology was used by McKibbin and Stoeckel (2009) to model the global financial crisis (GFC), although a larger range of shocks was needed because the actual shocks were different to those experienced by crisis economies in the Asian financial crisis. At the time of analysis, which was in the midst of the crisis, it was clear what the shocks were (although the persistence was unknown) and the announced policy responses. The shocks were a bursting of the housing bubble in the US market; a sharp rise in global risk premia in equity markets and in risk assessments by households and firms; and the rise in risk was larger in the crisis economies of the United States and United Kingdom. The policy responses were large changes in interest rates and bailouts of banks by central banks in the US and UK and a global but asymmetric response of fiscal expansions. The actual crisis was a combination of shocks in the US and UK and global changes in risk as well as direct spillovers through trade and capital flows adjustment.

The lessons from that modelling exercise were that the recessions were large, particularly in the US and UK, but the global fiscal stimulus and monetary reactions offset the severity of the risk shocks and the bursting of the housing bubble. The recovery, particularly in housing, would be slow because there was an excess of housing capital that needed to be run down over time.

Another interesting insight was that the sectoral effects of the crisis were very different. The distinction between durable and non-durable manufacturing in each economy was important. The demand for non-durable goods is driven by income, wealth, and relative prices of these goods. The demand for durable goods was largely for building the capital stock in the production sectors and the household's capital stock in the household sector. A large rise in risk in the model meant that the expected value of buying a durable good yielding a return over many years collapsed in present value terms. The rise in risk meant a rise in the rate at which future income would be discounted and therefore there was a collapse in the demand for durable goods. The durable goods sector in the model experienced the largest fall in output. This was true in all countries. It meant that countries that exported durable goods (such as Japan and Germany) experienced a large trade shock as part of the financial crisis, relative to countries with a different composition of trade and a different source of income generation.

One of the side effects was that the model predicted that global trade would contract by more than global GDP and the impact across countries would reflect both the financial risk shocks but also the composition of the production of each economy. When decomposing global production versus global trade it is clear that the share of durable goods in global trade is higher than the share of durable goods in global production. There are some countries which have a comparative advantage in durable goods production for investment purposes. Because of the disaggregation of manufacturing into durable and non-durable goods, the shift in the ratio of global trade to GDP was well captured by the model.

While in both cases the authors did not claim they could predict the movement of risk premia, the modelling showed the important consequences of changes in risk in various markets and the usefulness of the model in evaluating outcomes and the implications of alternative policy responses.

(ii) Growth and relative price shocks from emerging economies

In McKibbin and Cagliarini (2009), the authors explore the impact of growth in the emerging world, particularly China and India, on relative prices in the global economy from 2000 and on the macroeconomic adjustments in the global economy. They considered a sharp rise in productivity growth in China but focusing on the relatively larger rise in productivity in China in the manufacturing sector. The productivity shocks were particularly interesting because they captured the rise in Chinese productivity growth relative to other countries, as well as the rise in manufacturing productivity that reduced the relative price of manufactured goods to other sectors. The second shock was a fall in the risk of investing in emerging economies, particularly in China. The third shock was a relaxation of global monetary policy with a focus on the relative shifts across countries.

One interesting result was that the shocks in overall productivity in China led to changes in the global allocation of capital and trade flows. The shifts in relative productivity growth within China led to a large change in the relative price of manufactured goods relative to energy, agriculture, and services in China. This relative price change also spilled over into a similar relative price change in all economies. The response of central banks was critical for how this propagated in different economies. While a flexible exchange rate could offset the change in the overall price level it could do little to offset any changes in relative prices occurring through trade flows.

A further interesting result was that a change in US monetary policy (of the scale of monetary relaxation that was observed from 2001 to 2004) not only changed the US price level as expected, but it also led to a persistent change in relative prices within the US economy. The capital intensity of production and the elasticity of demand in response to income and price changes in general equilibrium, meant that a fall in interest rates would impact demand and supply across sectors differently. The more capital-intensive sectors would get more investment for a fall in interest rates and the supply response, although eventually returning to baseline, persisted for up to a decade. This monetary policy was shown in the model to change relative prices for a number of years during the adjustment back to a monetary neutral long run. It was interesting that a country like Australia experienced an appreciation of the currency which partly offset the transmission of the US monetary policy to the Australian economy, but the nominal exchange rate change did nothing to offset the relative price changes emanating from changes in US monetary policy. This is not surprising because there were price changes across the six sectors but only one exchange rate which offset the average price change. Much of what is understood about the neutralizing role of flexible exchange rate in offsetting monetary shocks is from one-good models, but the story is much richer and realistic in a multiple-good world.

IV. An application: implications for understanding the impact of Trump's economic policies

In this section we summarize some results from McKibbin and Stoeckel (2017) which focused on President Trump's proposed economic policies. We explore the impacts of deporting illegal immigrants and the impact of a plausible fiscal package implemented by the Trump Administration. This shows both the macroeconomic and sectoral consequences and how they interact. It also answers a question posed by Blanchard (2018) in this issue on the global impact of the Trump Administration's fiscal policy.

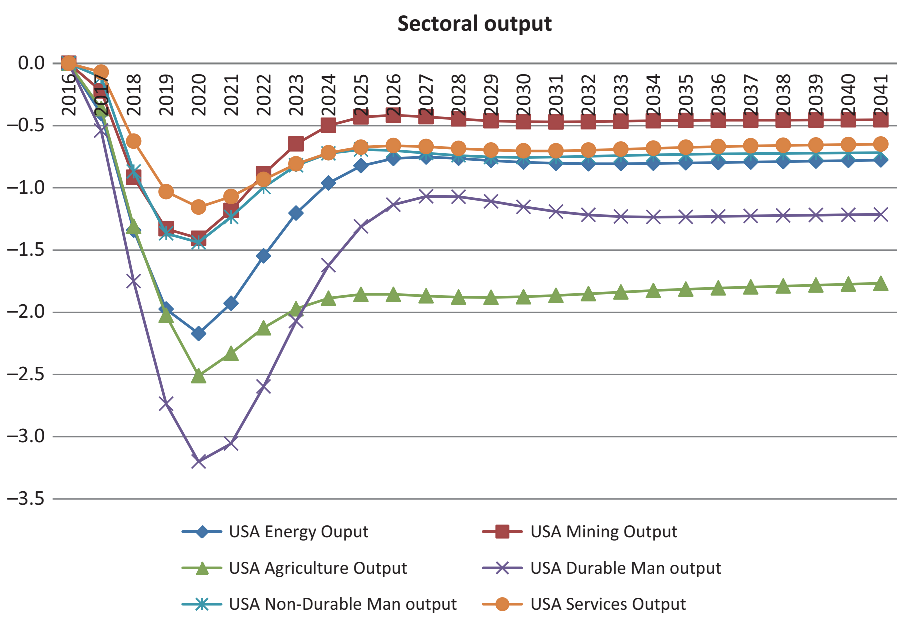
(i) Immigration

A major area of policy reform with significant potential economic impacts is the Trump Administration's policies on immigration. The simulation explored in McKibbin and Stoeckel (2017) is that by the deportation of illegal workers, the US labour force would be reduced by 1.5 per cent on average, with the largest falls in agriculture and durable manufacturing. The shock was designed to be consistent with the Pew Research study (Krogstad *et al.*, 2017) on the distribution of illegal workers across the US economy.

After the deportation of immigrants, the economy will need to settle down on a new Ramsey growth path, with a lower level of population. Because the labour force is lower, the stock of capital will need to be lower, and so there is a fall in investment. This leads to a lower interest rate, currency depreciation, and current account surplus, as a way of preserving aggregate demand as the economy adjusts to the new Ramsey equilibrium path.

Since there are more illegal immigrants in some sectors than others, the effects on sectoral output differ significantly. These are shown in Figure 3. Durable manufacturing and agriculture are initially the hardest hit because that is where the reductions in workforce are highest and the durables sector is also adversely affected by the loss of investment caused by the loss of output. The decline in output means there is less need for the existing stock of capital, which means less investment than otherwise. Economy-wide

Figure 3: Effects on USA output from deporting illegal immigrants, % deviation from baseline



Source: McKibbin and Stoeckel (2017).

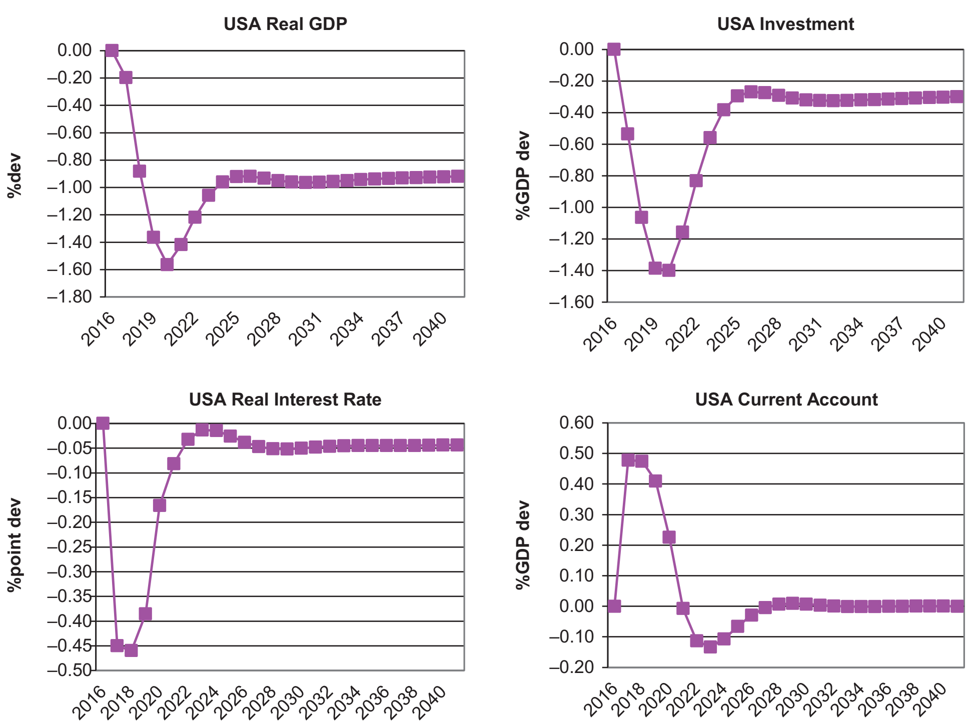
investment could be 1.4 per cent lower by 2019 and 2020 than baseline (Figure 4, top right panel). The composition of investment across sectors is very different. The largest falls occur in the sectors losing more workers because the return to capital in those sectors is hit hardest. In addition, the durable goods sector provides most of the investment goods for the rest of the economy, so that sector takes a second hit from the aggregate slowdown in investment. Output in durable manufacturing could be 3.2 per cent below baseline by 2020, and for agriculture, 2.5 per cent lower.

With less output in each sector, aggregate real GDP must be lower. This is shown in Figure 4. Real GDP could be 1.6 per cent below base by 2020, before settling at 1 per cent below what it might otherwise have been from 2023 onwards because the workforce is permanently smaller. There is an interesting aggregate dynamic due to the sectoral shocks.

Less activity and less investment means less demand for borrowed funds so real interest rates are less than baseline by some 45 basis points in 2017 and 2018 (Figure 4, bottom left panel). Less borrowing than otherwise, some of which would have come from overseas, means the current account deficit (as a % of GDP) is not as large and the temporary gain is shown in the bottom right panel of Figure 4. That implies the trade balance is better than otherwise (not shown), the equilibrating mechanism being a small initial real depreciation of the real exchange rate.

It is interesting that the stated goal of the policy to improve job prospects in the manufacturing sector is not achieved. In aggregate, GDP is lowered by the policy of deporting migrant workers but particularly output falls in the manufacturing sector.

Figure 4: USA macroeconomic effects from deporting illegal immigrants, deviation from baseline



(ii) Fiscal policy—tax and spending (important sectoral and macroeconomic effects)

McKibbin and Stoeckel (2017) also modelled a change in US fiscal policy. Although the actual policies were unclear at the time of writing, and still are, the modelled policy was:

- cut corporate tax rate by half;
- cut household tax rate by a quarter;
- increase spending on goods and services by 2 per cent of GDP to capture the infrastructure spending, defence spending, and the cost of building a wall on the Mexican border.

The combination of company tax cuts, personal tax cuts, and the spending of an extra 2 per cent of GDP, all unfunded, expand the fiscal deficit. The net effect on the deficit is shown in the top left panel of Figure 5, which is to expand the fiscal deficit by an extra 5 per cent of GDP (with little variation) relative to the baseline or 'business-as-usual' case. There is an immediate boost to consumption (top right panel) of 3 per cent above baseline in 2017, this falls to 1 per cent in 2018, stays that way until 2024, and thereafter declines to be below baseline by 2 per cent beyond 2040. The reason for that pattern is the extra debt to fund the consumption has to be paid for, in effect bringing future consumption forward.

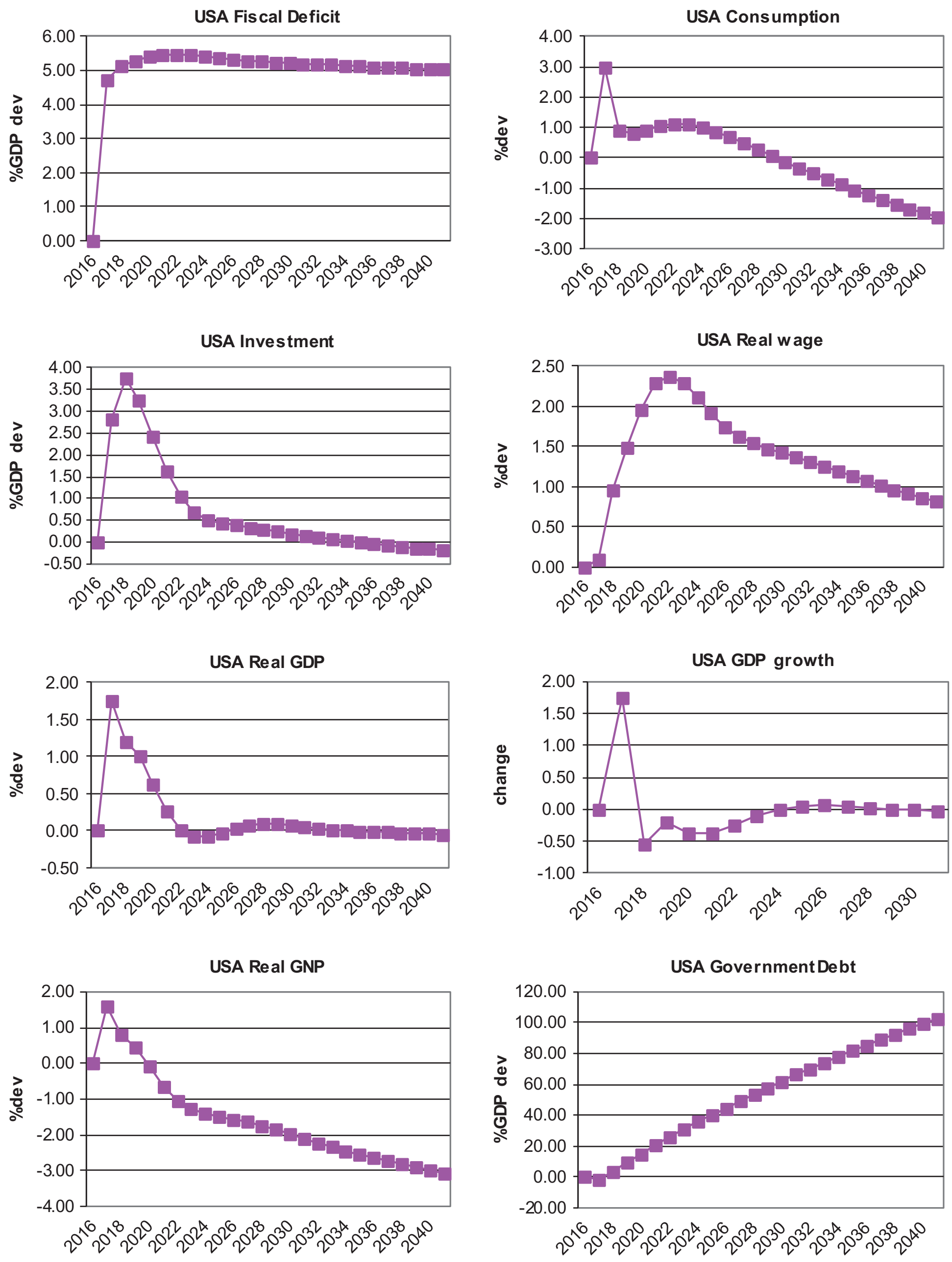
The company tax cuts boost after-tax profits, lifting the return on capital and encouraging new investment (next panel in sequence). Investment rises to nearly 4 per cent above baseline in 2018 and thereafter declines quickly to 1 per cent above base before tapering back to baseline thereafter. Commensurate with the incentive to invest, there is an incentive to hire workers, so real wages rise, peaking at 2.4 per cent above baseline in 2022 in the pattern shown in the right-hand panel, second row, of Figure 5.

Since consumption and investment are large components of GDP (a common measure of economic activity), the next panel shows the spike that can be expected. Real GDP rises by 1.7 per cent above base in 2017 and falls close to baseline by 2022 and remains there thereafter. This gain is in terms of extra GDP over the *level* of real GDP that would have prevailed in the absence of the stimulus. In familiar growth terms (the year-on-year change), the next right-hand panel shows the extra 1.5 per cent growth in 2017 but slightly lower growth than otherwise in the years to 2024 because the extra boost to activity is declining after 2017. It makes it obvious that the short-term benefits of Trump's fiscal policies are at the expense of the future.

Higher real wages and more activity initially sound impressive, which they are, but the trouble is that GDP is a measure of economic activity in the country regardless of who owns the productive assets. The substantial borrowing by the US as a consequence of the fiscal policies means we should consider net payments abroad of interest, profits, dividends, and rents—something the G-Cubed model does. In other words, we should consider the total income earned by residents of a country. That is, gross national product (GNP) is a better measure of the welfare of US residents.[3] Once we consider payments abroad, the extra borrowings, capital inflow, and what happens to the trade balance, the picture is not as rosy.

[3] GNP = GDP + net income from (or payments to) abroad.

Figure 5: Effects from fiscal programme of President Trump, deviation from baseline



Source: McKibbin and Stoeckel (2017).

Real GNP (bottom left panel of Figure 5) is higher than baseline in 2017, in line with the extra GDP, but is back to baseline by 2020, and steadily declines below baseline thereafter with the on-going borrowings needed to fund the deficit and therefore rising interest payments abroad. The net gain to US residents (the integral under the real GNP curve) is now negative.

The adjustment story is again familiar from the standard Ramsey growth model with OLG consumers. The US economy returns to a Ramsey growth path with a larger government and permanently higher government debt. The fiscal closure in the model is what is called an 'incremental interest payments rule' in which, within each country, a lump sum tax is levied on households to cover changes in interest payments on the stock of government debt. Thus, the long-run change in US government debt will be the long-run change in the fiscal deficit (in this case roughly 5 per cent of GDP) divided by the long-run growth rate in the model (1.4 per cent productivity growth in all sectors plus zero population growth). This works out to be an additional 357 per cent of GDP, which is clearly extremely large but not explosive because the tax rate adjusts to prevent an explosion of interest payments. It also takes more than a century to converge to this point.

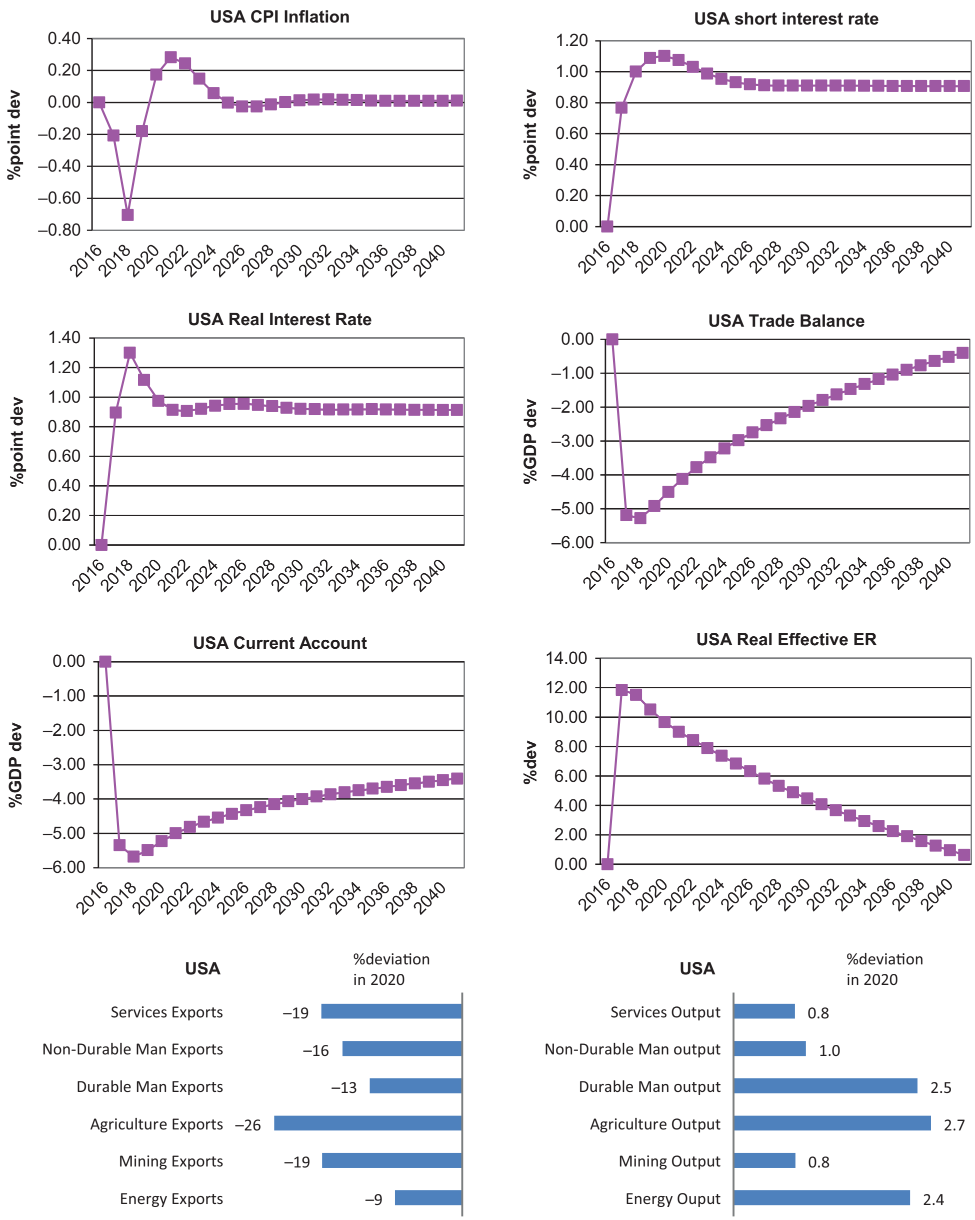
The trade balance also initially moves into deficit as part of the early financing of this debt expansion, but eventually moves into substantial surplus as exports must exceed imports in the process of transferring resources to the foreign owners of US assets. The real exchange rate, although initially appreciating as capital flows into the US economy, must eventually depreciate to enable exports to rise above imports and meet this intertemporal budget constraint facing the entire US economy. Because of the existence of non-Ricardian consumers, interest rates have to rise permanently in the US to crowd out investment and achieve a balanced growth equilibrium. Lower investment results in a lower capital stock. With less capital, output will be lower. This makes it even harder to generate resources to service foreign holders of US assets. Thus, the real exchange rate must depreciate even more in the long run, to generate the transfer of resources to foreign owners of capital and debt, than would be the case in a model with Ricardian consumers. It is hard to see how the approach proposed by Hendry and Muellbauer (2018) could capture this critical, externally driven, structural adjustment process.

As mentioned above, a string of extra deficits and borrowings expands the government debt ratio, which could be double what it might otherwise be by 2040 (right-hand panel). This outcome is problematic: Congressional Budget Office (CBO) projections of future government debt in the US under existing policies show a large and rising debt burden to around 150 per cent of GDP by 2047 (CBO, 2017). Recall that this model incorporates any extra tax revenue from the extra domestic activity, but these results show that the tax cuts dominate. The expansion is not 'self-financing'.

It might be thought the extra early stimulus would boost inflation in the US. It tends to, but there is more going on; the capital inflow necessitated by the extra corporate and government borrowing causes the exchange rate to appreciate, lowering import prices, the fall being enough initially to offset any tendency for inflation to rise. Inflation could fall to 0.7 percentage points below baseline in 2018 (Figure 6, top left panel). Note short-term rates rise (right-hand panel) because, under the monetary policy rule, the Fed is targeting both activity and inflation and there is some policy tightening as a result.

Extra borrowing to fund the deficit causes long-term interest rates to rise (left-hand panel); rates settling at nearly 1 percentage point higher than otherwise over the long term because of the existence of non-Ricardian consumers. Higher rates encourage capital inflow which must be matched by deterioration in the current account deficit.

Figure 6: Effects from fiscal programme of President Trump, deviation from baseline



Source: McKibbin and Stoeckel (2017).

This deficit (as a percentage of GDP) is 5.7 per cent worse in 2018 than it would otherwise be. The trade balance shows a similar pattern early on since it is a large component of the current account, but later there is a difference (right-hand panel). The deviation from baseline in the trade deficit gradually narrows, and, although not shown on the chart, would turn positive at some distant point in the future to fund the increasing interest payment component of the current account on the balance of payments. This initial deterioration of the trade balance will cause a problem for the Trump Administration, given its rhetoric on this measure outlined during the election campaign and subsequently.

The mechanism by which the trade balance deteriorates to enable the capital inflow is an appreciation of the real exchange rate. The US dollar appreciates by 12 per cent in 2017 (expressed in real effective terms) relative to what it otherwise would have been. The appreciation encourages imports (and seen earlier keeps inflation low) and discourages exports. Agricultural exports are hit the hardest (Figure 6, bottom left panel) and could be 26 per cent below baseline in 2020, the year of the next presidential election. Note that total agricultural output will still be higher in 2020 (bottom right panel) because domestic consumption (around 80 per cent of production by volume) is higher as a result of the extra total domestic consumption shown earlier in Figure 5. But, had an even more disaggregated model been used, it would show that some mid-western states, heavily dependent on agricultural exports, would be worse off under the higher dollar, creating political problems come election time.

The decline in exports is across the board, so a similar set of arguments will apply to manufacturing, even though the value of total domestic manufacturing output should be slightly higher in 2020 because total consumption is higher. Under current policy proposals, it will not be possible for President Trump to stimulate the domestic economy *and* promote exports. That is why it is important to understand the economics behind the policies and avoid a resort to trade protection being the resolution of this contradiction.

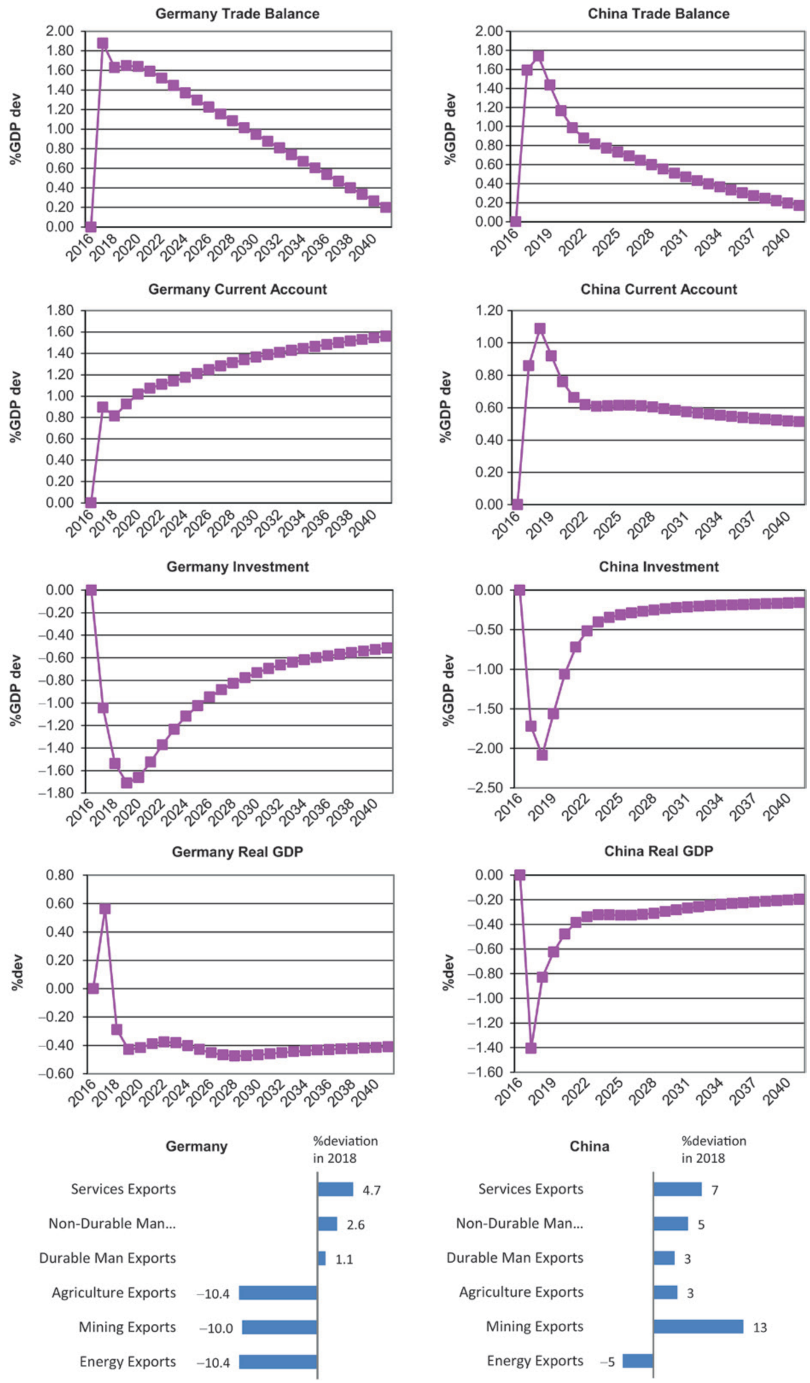
There are important repercussions for other economies. Two other countries with large current account surpluses and bilateral trade surpluses with the United States that have already drawn the ire of President Trump[4] are China and Germany. The effects of President Trump's fiscal programme on Germany and China are shown in Figure 7. The extra borrowing by America to fund the expansion has to come from domestic and overseas sources. Germany and China are two such sources. So the capital outflow from these two countries must cause their current account surpluses to rise and with them the trade surpluses (Figure 7, top four panels). In 2017 Germany's trade surplus could rise by 1.9 per cent (as a share of GDP) over baseline and for China the increase could be 1.6 per cent. Notice the different trends between the trade balance and current accounts. As income earnings continue to rise on the extra loans made to America, the current account (as a share of GDP) continues to increase over baseline. But eventually this extra income will be spent and the trade balance would fall below baseline if the graphic was extended far enough out.

The end result is that for Germany and China, net exports rise, especially in the early years, and mirror the deterioration of the trade balance in the United States. The mix of export changes is different across the sectors, though—shown in the bottom panels of Figure 7. The differences are due to changing exchange rates across countries due to differences in comparative advantage and in capital flows.

More net exports could be thought to encourage more investment in Germany and China. But higher interest rates in the US also lead to higher interest rates in Germany

[4] In May this year President Trump described Germany's trade surplus with America as 'very bad' and it needed to change (Jacoby, 2017).

Figure 7: Effects on Germany and China from US fiscal programme, deviation from baseline



Source: McKibbin and Stoeckel (2017).

and China due to linkages between capital markets. This effect dominates and so investment in both Germany and China falls initially below baseline (Figure 7, second bottom panel). This fall in investment is more important in China than for Germany since investment in China as a share of GDP is much higher (over 40 per cent of GDP). So although net exports in China are higher, this positive effect on activity is outweighed by the negative effect of investment and GDP falls below baseline by 1.4 per cent in 2017 (bottom panel). For Germany, investment as a share of GDP is smaller than for China and net exports larger so on balance there is a small initial boost to GDP which rises by 0.6 per cent in real terms in 2017. It falls below baseline after that because the boost from net exports declines while the fall in investment continues to grow for another 2 years before returning to baseline. Longer term, China and Germany are worse off in terms of real GDP by around 0.4 per cent below baseline.

V. Conclusion

This paper argues that important aspects of the world economy that tend to be missing in most macroeconomic models are the importance of global linkages in trade and financial markets, the role of relative prices (sectoral disaggregation), and changes in risk premium. These have been important sources of shocks for most countries since 2000. Despite this, it is still the case that there are closed economy models being used for policy analysis in major economies, with no role for the exchange rate or for the major sources of economic growth in the global economy. Many models are missing the sources and consequences of the major shifts in risk and relative prices since 2000 and therefore the nature of the most important shocks is not identified because there is no detailed structural model.

While aggregate models will remain useful for exploring some issues, there is also a case for using models with a consistent macroeconomic closure, such as found in DSGE models, but allowing for greater complexity in the modelling of adjustment at the sectoral level to aggregate and sectoral shocks. With the world economy continuing to undergo major structural change due to the growth of large emerging countries, and differential degrees of technological innovation in different sectors, future shocks are more likely to involve significant changes in relative prices and risk. If these features are not incorporated into our macro models for policy analysis, then it is likely that many structural problems will be interpreted as cyclical issues at the aggregate level. This is problematic for understanding the consequences of the shocks and the nature of policy design.

As Blanchard (2017) wisely argues, there is a role for many different types of models for addressing different types of questions. There is a role for more complex but internally consistent models that capture observed changes in the global economy that must be relevant for the macroeconomic policy design in all open countries. The examples in the paper drawn from studies using the G-Cubed multi-country model, demonstrate the insights that can be gained from allowing for complexity when it is relevant.

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