COVID-19 and Productivity: Unwinding Global Value Chains

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Talia Melsom

Master of International and Development Economics

talia.melsom@anu.edu.au

Supervisor: Dr Adam Triggs

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Abstract:

De-globalisation, increasing protectionism and COVID-19 have led to an unprecedented productivity crisis around the world. As global value chains (GVCs) breakdown, economic growth and living standards are increasingly at risk. This paper presents a unique analysis of the implications of a sudden contraction in total factor productivity (TFP) growth for the global economy. A computable general equilibrium model is used to compare and analyse this contraction, across both permanent and temporary scenarios. The paper also investigates the differences between a contraction of TFP globally and separately in emerging markets, to analyse the asymmetric effects of trade and COVID-19. Simulations of the model show a significant decline in economic growth, labour markets, and trade and capital flows. Results highlight the necessity to enhance the resilience of GVCs, and present new insights into the importance of productivity for policymakers globally in the post-COVID-19 era.

1. Productivity Plummet

The world is facing a productivity crisis that is dragging down economic growth and living standards globally. Productivity growth has been slowing since the 1990s, with most of this decline occurring in the aftermath of the Global Financial Crisis (GFC). From 2007 to 2015, productivity growth fell by the 'steepest, longest and broadest' rate on record (World Bank 2020b). Ageing populations, weak investment, slower human capital accumulation, and decreasing trade integration have cumulatively contributed to stagnating total factor productivity (TFP) (Adler et al. 2017 p.7). The Asia-Pacific region has bucked the trend in many of these areas, particularly in the development of Global Value Chains (GVCs), where trade interconnectedness means exports rely more than ever on imports. However, as trade tensions emerge and international cooperation has declined, the region has leaned heavily on a rules-based international order to ensure stability and the safety of these GVCs (EAF 2020). Disruptions to supply chains in the region and challenges to multilateralism now threaten the productivity gains that have come from these integrated production networks. International trade had already showed signs of contracting in Asia in 2018, before ongoing trade tensions erupted between the United States (US) and China in 2019 (APO 2019 p.15; Fajgelbaum et al. 2019 p.2; Legg 2020). The coronavirus (COVID-19) pandemic is now testing an already fragile multilateral system and will have wide-reaching implications for productivity.

The breakdown of GVCs in 2020 caused by COVID-19 and the US-China trade war, have created a veritable tipping point for productivity levels globally. The pandemic has transformed from an 'Asia-focussed supply chain shock' to a complete halt in global economic activity. As the virus spread, production ceased, borders closed, and labour mobility was severely restricted (Oxford Economics 2020 p.1). Average productivity and economic growth rates in Asia are now lower than at any other time in the last 60 years (Rhee 2020; Mann 2016). As emerging markets experience the largest capital outflows in history, fear surrounding debt repayments and growing fiscal uncertainty have led over 100 countries to request assistance from the International Monetary Fund (IMF) (Basri, Drysdale & Triggs 2020; IMF 2020a). To stimulate economic growth, countries have distributed unprecedented fiscal stimulus packages, amounting to 14 percent of gross domestic product (GDP) in Australia and 21.1 percent of GDP in Japan (Duffin 2020). However, there is no consensus as to whether these packages, implemented during a period of sudden economic lockdown, will be able to improve productivity in the long-run. As the northern hemisphere is now enduring a second wave of COVID-19 infections, it has become clear that health and economic effects vary significantly with international exposure and containment measures (WHO 2020). The next six months will be vital to both controlling the spread of the virus and adapting GVCs to improve the long-run economic outlook.

This paper uses G-Cubed, a computable general equilibrium model, to analyse the impacts of both temporary and permanent losses in productivity in the Asia-Pacific due to COVID-19 and ongoing geopolitical tensions. The shocks are applied globally, and then separately in emerging market economies (EMEs), to analyse the case where COVID-19 and the resulting breakdown in GVCs are felt asymmetrically. Australia, Japan, and the US are analysed, representing advanced economies in the model, and are compared to China and Indonesia as EMEs. The paper first presents an overview of productivity in the context of de-globalisation, geopolitical pressures, and COVID-19 before providing a comprehensive analysis of the implications of a loss in productivity. Finally, policies to improve long-run productivity and stimulate economic growth are considered.

2. Globalisation and Global Value Chains (GVCs)

Productivity is the amount of output produced per unit of inputs, or, in terms of total factor productivity (TFP), the efficiency with which inputs and technology are utilised (Black et al. 2012 p.410). According to the Asian Productivity Organisation (APO 2019 p.43), TFP growth across 24 economies in Asia accounted for 21 percent of all economic growth from 2010 to 2017, highlighting the centrality of productivity to the global economy. Since the post-war era and the creation of the Bretton Woods institutions, openness to trade has been linked to greater productivity, stability, and economic prosperity (Conway 2009 p.167). The GFC halted this trend by changing perceptions of financial risk, driving a legacy of weak demand and lower capital investment, that has since slowed the pace of technological progress (McKibbin & Stoeckel 2009 p.1; UN 2017). These factors, combined with increasing public and political pressure from rising inequality and ageing populations, culminated in a turning point for globalisation in the mid-2000s (MGI 2019 p.25). As a result, large companies, such as Evolve Group, an Australian plastics manufacturer, began to onshore processes, structures, and production to escape supply chain complications and foreign exchange risk (Sheedy 2020). From the late 1990s to the GFC, growth in the volume of world trade averaged 7 percent per year. In its aftermath, and as countries implemented greater protectionism, growth in world trade volumes fell to 3 percent from 2012 to 2016 (UN 2017).

GVCs are closely linked to patterns of globalisation, having rapidly expanded in the 1990s and early 2000s to account for 52 percent of global trade by 2008 (World Bank 2020a p.2). Since then, trade integration has declined, despite overall trade increasing, and GVCs now only account for around 45 percent of trade globally (Razeen 2013; World Bank 2020a p.2). The vulnerability of productivity in the post-GFC era is closely linked to the highly integrated nature of these production networks, also known as 'supply chains 4.0' (WTO 2019 p.4). Firms are now hyper-specialised and vertically integrated across country borders, with production processes and consumption likewise spanning multiple countries (Gertz 2020). Supply chains have become increasingly regional and are now concentrated in 'hubs' in China, Germany and the US (WTO 2019 p.31). However, when any link in the chain is disrupted, for instance in a productivity or demand shock, both upstream and downstream processes are affected (World Bank 2020a, p.113). This means that the speed at which shocks are transmitted is much faster, and the impacts are far greater and more global.

'From great integration to great fragmentation' – OECD (2020a)

In 2019, the US-China trade war showed how vulnerable the world economy had become. Trade volumes fell to 1 percent, the lowest level since 2012, and global GDP was reduced by 0.8 percent through 2019 (Gopinath 2019). Advanced manufacturing was hit hardest, causing the current account surplus in Japan alone to fall by 3.3 percent (IMF 2020b p.30). Some countries, such as Vietnam, felt some benefits of trade diversion from China, however, these were outweighed by the downturn in trade across southeast Asia (APO 2019 p.16). Prolonged uncertainty was damaging to already weak investment and demand before the outbreak of the coronavirus pandemic. The scale of this protectionism, unprecedented in the post-war era, has highlighted long-term trends in structural factors that have increased disparities between advanced and emerging economies, and accelerated the path to de-globalisation (Fajgelbaum 2019, p.2).

EMEs integrated in GVCs in Asia are more sensitive to global shocks. Weak investment following the GFC reduced technology transfer between advanced and emerging economies, reducing capital stocks, particularly in South Asia, and pushing down the wages of low-skilled workers (Kambayashi 2020; Mann 2016). From 2007 to 2015, productivity growth among EMEs fell from 6.6 to 3.2 percent causing output per worker in EMEs to fall to less than one-fifth of that in advanced economies (World Bank 2020b). A 9-percentage point productivity gap persisted in 2017 between the US and Singapore, Asia's pre-eminent productivity leader (APO 2019 p.45).

Conversely, advanced economies have struggled with persistently low inflation, interest rates at the zero-lower bound, and rapidly ageing populations. Japan, for example, has only realised two years of inflation since 1998 in a period of prolonged stagnation now widely recognised as the 'lost decades of growth' (MGI 2015 p.1; Funabashi & Kushner 2015, p.xxv; Nishikazi, Sekine & Ueno 2014, p.21-31). Since the workforce began shrinking in 2011, labour productivity has fallen to the lowest of the G7 economies (Masayuki 2019; Nippon 2020). As 28 percent of the population are now over the age of 65, this trend is likely to continue (World Bank 2020c). Ageing populations are a barrier to improving productivity if they cannot be engaged constructively in the economy. These large gaps in both the impacts of GVCs and structural factors of development between advanced and emerging markets, suggest any shocks to productivity, such as from COVID-19, are likely to be felt asymmetrically across the world.

'It may only become clear just how central a particular export hub is upon its sudden failure' – Gertz (2020)

Over 50 million cases of COVID-19 have now been recorded across 219 countries (WHO 2020). From small beginnings in Wuhan, China, in late 2019, over 100 countries had implemented containment measures by March 2020 (WHO 2020). Manufacturing in Japan, Indonesia, and across southeast Asia, has collapsed, and previously unforeseen chokepoints in production have emerged (Kihara & Leussink 2020). In the early months of the pandemic, pharmaceutical companies struggled to attain basic ingredients for antibiotics as over 80 percent of the world's active medicinal components are sourced from China (Shretta 2020). Similarly, Nissan and Hyundai temporarily closed factories globally as they were unable to attain key automobile parts from China, causing a sudden contraction in their productivity (Shretta 2020). With international border closures likely to persist for the next year at least, debate has increased over the viability of GVCs, with many seeking to re-nationalise supply chains and increase lists of strategic goods for domestic production and stockpiling (OECD 2020c).

Given the integrated and complex network of GVCs today, it is difficult to estimate real economic costs from the sudden, synchronised global shutdown. However, as China supplies over a third of all capital goods imported by most major markets and has implemented some of the strictest COVID-19 containment measures, it is clear that those reliant on Chinese trade have been the worst affected (Oxford Economics 2020 p.8). Sharp contractions have occurred in India, the Philippines and Malaysia, and negative growth is likewise expected following second waves of the pandemic in Australia and Japan (IMF 2020c p.3-4). China is one of the few economies expected to grow in 2020, though GDP growth, at 1.9 percent, will be well below the 6-7 percent average of the last few years (World Bank 2020d). The IMF (2020c p.4) now expects growth in the Asia-Pacific to fall to -2.2 percent in 2020 in the worst contraction the region has experienced since the Great Depression.

3. Literature Review

"The engine of growth is invention" – Jones and Vollrath (2013 p.257)

Productivity has been the topic of economic research since the industrial revolution. For the great economists in history, from Robert Solow and Douglas North to Joseph Schumpeter and the endogenous growth modelists, identifying ways to improve productivity has been key to economic development and living standards (Yueh 2018). While North believed in improving institutions to facilitate growth, Schumpeter saw creative destruction as the path to raising long-run productivity, by eliminating inefficient processes and allowing new and stronger firms to adapt and survive over time (Yueh 2018). Solow went further, showing that technological progress is the key to sustaining economic growth by improving labour productivity and facilitating capital deepening. Known as the Solow residual or TFP, technology in the Solow model is the portion of economic growth not attributed to additional inputs in capital and labour (Black et al. 2012 p.382). Changes in the residual reflect a shift in the production function and may occur due to fluctuations in demand, innovation, the evolution of institutions, and other exogenous shocks (Ferreira 2010 p.299)

These models were developed in an era of rapid economic growth through the industrial revolution and post-war era, and so do not reveal why today's decline in productivity has occurred in the context of vast technological progress. This is the 'Solow Paradox', and much debate in the literature now surrounds whether technologies today may have become a drag on growth, or if it is the diffusion of such technology that has deteriorated (McKibbin & Triggs 2019). Solow, like Gordon (2016), views modern innovations as incomparable with those of the industrial revolution, such as electricity and the internal combustion engine (Yueh 2018 p.269). Nordhaus (2015) instead argues that the long-lag times between innovation and growth are the reason productivity has stalled. Still others view the current stagnation as a result of institutions, de-globalisation, and structural challenges that have narrowed pathways for technology transfer globally (Adler et al. 2017, Jones & Vollrath 2013; World Bank 2020b). 'TFP hysteresis', or the persistence of a loss in TFP following a large economic shock, has also been cited as a factor leading technology to fail to improve productivity (Adler et al. 2017; Duval et al. 2020). As these examples show, most of the literature to date has focussed on the causes of changes in productivity. This paper provides a new take on the productivity puzzle, instead analysing the implications of such changes on the world economy. In doing so, it provides details on the channels through which these impacts may manifest in the longer-term to better inform policy decisions.

Other papers have used dynamic intertemporal or computable general equilibrium models, such as G-Cubed, to investigate implications for the world economy. These models are chosen for their ability to analyse capital flows, prices, risk and contagion effects and long-run growth trends. McKibbin and Triggs (2019) used the G-Cubed model to consider four scenarios based on whether countries can adopt or invest in new technology, and where the largest productivity gains would occur. Advanced and emerging markets were analysed separately to identify the potential for asymmetry in how growth rates are experienced globally. Lee and McKibbin (2014) utilised a shift-share analysis through the G-Cubed model to investigate labour productivity in Asia and found great potential for faster future productivity growth via the services sector. This paper extends the literature on asymmetry in McKibbin and Triggs (2019) by examining changes in productivity separately in emerging markets using the same dynamic model. It differs from both these approaches, however, in that levels of total factor productivity are used, rather than alternative productivity growth rates. This is a unique research design, representing the sudden contraction in productivity growth in 2020 due to the US-China trade war and COVID-19 pandemic.

A plethora of new research has emerged since the outbreak of COVID-19. The IMF (2020c, 2020d), Organisation for Economic Cooperation and Development (OECD) (2020a, 2020b, 2020c) and Oxford Economics (2020) are among those analysing the impact of containment measures and evaluating supply and demand shocks caused by the pandemic. McKibbin and Fernando (2020) used the G-Cubed model to simulate seven potential scenarios for the pandemic. Despite the situation in 2020 now appearing similar to the mid-range scenarios modelled, fortunately, the mortality rate of the predicted scenarios has not yet been reached (WHO 2020). It is still unclear, however, how long COVID may remain a threat to people and the global economy. Seasonal lockdowns or additional waves of outbreaks would be a large threat to global productivity. However, COVID-19 has also been compared to past pandemics. From the Russian Flu (1889-1890) and Spanish Influenza (1918-1919) to the Asian Flu (1957-1958) and SARS (2002-2004), most epidemics of a similar nature to COVID-19 have persisted for 1 or 2 years (Coniff 2020; WHO 2003; Karlsson et al. 2014). Many papers (Oxford Economics 2020; IMF 2020c; Melsom 2020), now consider the main disruptions from COVID-

19 to last for 2-years. Given these forecasts, and with vaccines already proving promising, a 2-year pandemic scenario will be employed in the analysis.

Academic research to date has focussed on explaining the drivers of TFP, trends in productivity growth rates, and the impact on productivity from shocks to the global system (Ferreira et al. 2010; Duval et al. 2020; Andrews et al. 2015). This paper therefore seeks to extend the literature, utilising the dynamic G-Cubed model to investigate the impact on the world economy of a sudden contraction in productivity due to the breakdown in GVCs. It excludes other fiscal, supply, and demand shocks associated with COVID-19 and protectionist tariffs, to focus on the persistence of changes in macroeconomic variables as a direct result of permanent and temporary TFP shocks. Global and emerging markets will be analysed separately to consider the asymmetry in the shock, particularly in a post-COVID-19 world.

4. The Model

The G-Cubed Model incorporates features of intertemporal, computable general equilibrium and dynamic stochastic equilibrium models. Initially developed by McKibbin and Wilcoxen (1999), the model was extended by McKibbin and Triggs (2018) to incorporate all the G20 economies. It has been used to explain the GFC, to analyse causes of the 2003 SARS outbreak and implications of ageing populations (McKibbin & Stoeckel 2009; Lee & McKibbin 2004; Liu & McKibbin 2019). Results from the model have been utilised by central banks, governments, consultancies, and international institutions, such as the IMF's World Economic Outlook (2020d). This paper uses the latest version of the model, GGG6 version 155, including the widest range of countries and updated variables and data.

The model includes 24 autonomous country blocks, as outlined in Table 1. There are 11 advanced economy blocks and the remainder are emerging markets. The real side of the model is disaggregated, allowing for a high level of sectoral differentiation across energy, mining, agriculture, durable and non-durable manufacturing, and services goods. These are not perfect substitutes between countries, meaning there are effectively 144 goods in the model. Markets in the model include those for factors of production, goods and services, bonds, equity, and foreign exchange. The determination of exchange rates follows the Dornbusch model, determined by interest rate differentials in the short run, and purchasing power parity conditions in the longer term, with an allowance for risk premia. Exceptions to this include the Eurozone, where exchange rates are equal, and China and Saudi Arabia, both nominally pegged to the US Dollar (USD).

Table 1: Countries and regions in the G-Cubed Model

Code	Country	Code	Region
Q/ARG	Argentina	E/EUZ	**Rest of Euro Zone***
A/AUS	Australia*		Spain, Netherlands, Belgium, Luxembourg, Ireland,
B/BRA	Brazil		Greece, Portugal, Finland, Cyprus, Malta, Slovakia,
			Slovenia, Estonia
N/CAN	Canada*	O/OEC	**Rest of Advanced Economies***
C/CHI	China		New Zealand, Norway, Sweden, Switzerland,
F/FRA	France*		Iceland, Denmark, Iceland, Liechtenstein
G/DEU	Germany*	P/OPC	**Oil Exporting and Middle East**
D/IND	India		Algeria, Angola, Bahrain, Congo, Ecuador, Iran,
W/INO	Indonesia		Iraq, Israel, Jordan, Kuwait, Lebanon, Libya,
I/ITA	Italy*		Nigeria, Oman, Palestinian Territory, Qatar, Syrian
J/JPN	Japan*		Arab Republic, United Arab Emirates, Venezuela,
			Yemen
X/KOR	Korea	V/OAS	**Other Asia**
M/MEX	Mexico		Hong Kong, Indonesia, Malaysia, Philippines,
R/RUS	Russia		Singapore, Taiwan, Thailand, Vietnam
S/SAU	Saudi Arabia	L/ROW	**Rest of the World**
H/ZAF	South Africa		All countries not included in other groups
T/TUR	Turkey		
K/GBR	United Kingdom*		**Advanced economies. The remainder are emerging economies.*
U/USA	United States*		

The Henderson-McKibbin-Taylor rule determines real interest rates and the actions of central banks. Banks set nominal interest rates to target inflation and unemployment, smoothing adjustments in the long run. Financial capital is completely mobile and flows to the sectors and countries where returns are highest. This means shocks will have larger short-run effects on asset prices. Physical capital is fixed and only changes in value due to saving or depreciation. The dynamic nature of the model allows for capital accumulation and technological progress and can therefore account for global growth.

Governments, households, and firms face intertemporal budget constraints, and firms and households both take prices as given. Each household maximises utility, subject to a lifetime budget constraint over an infinite planning horizon. Financial capital, via savings, and labour are supplied, while labour, capital, goods, and services are consumed. Firms maximise the present discounted value of their cash flow subject to the cost of adjustment of capital and to production technology, that is, to liquidity constraints. Among firms, 70 percent are backwards-looking in their investment decisions. The remainder respond to a forwards-looking Tobin's q, the ratio of the valuation of a firm to the market value of its assets (Black et al. 2013 p.409). This likewise applies to consumers, as 30 percent respond to a forwards-looking consumption expectation and current real interest rates, and the remainder are liquidity constrained, bound by backwards-looking decisions.

Labour is completely flexible inside borders, but immobile between countries. This allows for nominal wages to adjust slowly over time in response to country-specific circumstances, including the supply and demand of labour and expected inflation. Unemployment results from shocks in the system and slowly converges over time, as determined by the exogenous population growth rate.

Government debt and expenditure are key to the dynamics of the model. Expenditure is assumed to include transfers to households, purchases of goods and services and interest payments on government debt. Revenue extends from taxes, which are assumed to be unchanged over time, and the sale of government bonds. A non-Ponzi type-closure rule means government debt, as with all debt in the model, must be serviced indefinitely such that no agent is deterred from holding debt, and that governments running a current deficit must return to surplus in the future. Deficits are financed by borrowing, and real terms are used for all debt dynamics.

Total factor productivity (TFP) is exogenous to the model, acting as a Solow residual as discussed in the literature review. It features in the constant elasticity of substitution (CES) production function, defined by sector by region. Each of the six sectors is represented by a firm with the following output function:

$$Q_i = A_i^o \left(\sum_{j=K,\,L,\,E,\,M} \left(\delta_{ij}^o\right)^{\frac{1}{\sigma_i^o}} X_{ij}^{\frac{\sigma_i^o - 1}{\sigma_i^o}} \right)^{\frac{\sigma_i^o}{\sigma_i^o - 1}}$$

Where *A* represents the remaining contribution to output that is not from capital (*K*), labour (*L*), energy (*E*) or materials (*M*). This means *A* represents the TFP that will be used to shock the model in this analysis. Further detail on the breakdown of productivity in the model can be found in Lee and McKibbin (2014).

Productivity and long-run data are derived from the Groningen Growth and Development Centre, while macroeconomic data are from the IMF World Economic Outlook, World Bank and OECD. Population growth is exogenously determined by United Nations (UN) population projections. All prices are transformed to zero in logs in the base year with an index of one.

The model is solved from 2015 to 2100 at an annual frequency and is then rolled forward to 2020. All variables are plotted as a percentage change from the baseline except for the trade balance, which is a percentage of baseline GDP, and inflation and interest rates, that are percentage point differences from the baseline. Macroeconomic closure rules, the long-run Solow-Swan-Ramsey neoclassical growth model, and nominal rigidities allow for adjustments to the steady state equilibrium. Further detail on the specifics of the model are available in McKibbin and Wilcoxen (1999) and McKibbin and Triggs (2018).

5. The Shocks

Four shocks have been implemented to analyse the various possible scenarios resulting from COVID-19 and the breakdown in GVCs. All shocks commence in 2020 and results are analysed from 2020 to 2040. Two shocks are permanent, and two are temporary. Every iteration is a negative 0.8 percent shock to the level of TFP.

To understand the size of the shock, past improvements in productivity through GVCs and globalisation were analysed. These were found to have led to average TFP growth of 0.8 percent across estimates in the literature. The Asian Productivity Organisation (2019 p.51) estimated that TFP growth among 24 economies in Asia was 0.9 percent from 2010 to 2015 and 0.7 percent among the South Asia economies over the same timeframe. On a country basis, average productivity growth in Japan was 0.89 percent from 1995 to 2020, and TFP growth averaged 0.8 percent in both China and India from 2010-2015 (APO p.112, p.51). Ahn et al. (2019) and Kirchner (2020) modelled the link between GVCs and productivity and found similar results, with estimates varying between 0.5 and 1 percent. The shock represented here is therefore an equal and opposite shift in TFP, representing the unwinding of GVCs as a result of protectionism and the responses to COVID-19.

5.1 Permanent

A permanent negative 0.8 percent shock is implemented to reflect the long-run trends in declining productivity. To date, countries have struggled to recover productivity and long-run growth rates since the GFC, or, as in the case of Japan, since the Asian Financial Crisis (AFC) of the 1990s. A shock to TFP would have a lasting impact on the capacity of countries to find and develop alternative sources of growth (OECD 2020a).

Three linked scenarios may lead to a permanent productivity shock. Firstly, economies may not recover from COVID-19. Cases would persist and a vaccine, even if developed in advanced economies, may not be shared globally with EMEs, so spontaneous lockdowns and disruptions to economic activity would continue. Protectionism and de-globalisation may also persist, reducing trade and producing long-term negative productivity outcomes. Finally, EMEs, given their fiscal and structural capacity, may be unable to catch up with the pace of digitalisation in advanced economies and would fall further behind. These create the conditions for a long-run shock to productivity.

Given these contexts, two permanent, negative 0.8 percent productivity shocks will be analysed through the G-Cubed model. First, a permanent shock to the whole world, then solely to emerging markets. These are represented by Figure 1.

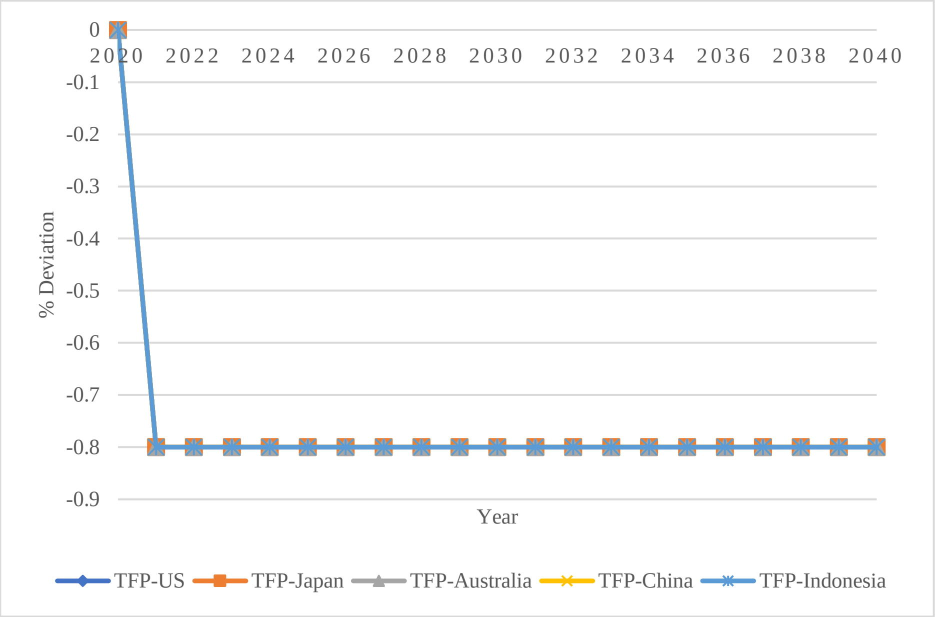

Figure 1: Permanent Negative Shock to Total Factor Productivity (TFP) – global, all sectors

5.2 Temporary

As the second wave of the pandemic has resulted in a lower mortality rate than the first, and as borders begin to open between countries with few COVID cases, a 2-year productivity shock seems increasingly realistic (WHO 2020). The shock is implemented globally, then solely in emerging markets, to analyse the potential impacts on the asymmetric distribution of the pandemic and containment measures. Figure 2 depicts the negative 0.8 percent reduction in productivity that lasts 2 years before returning to the baseline.

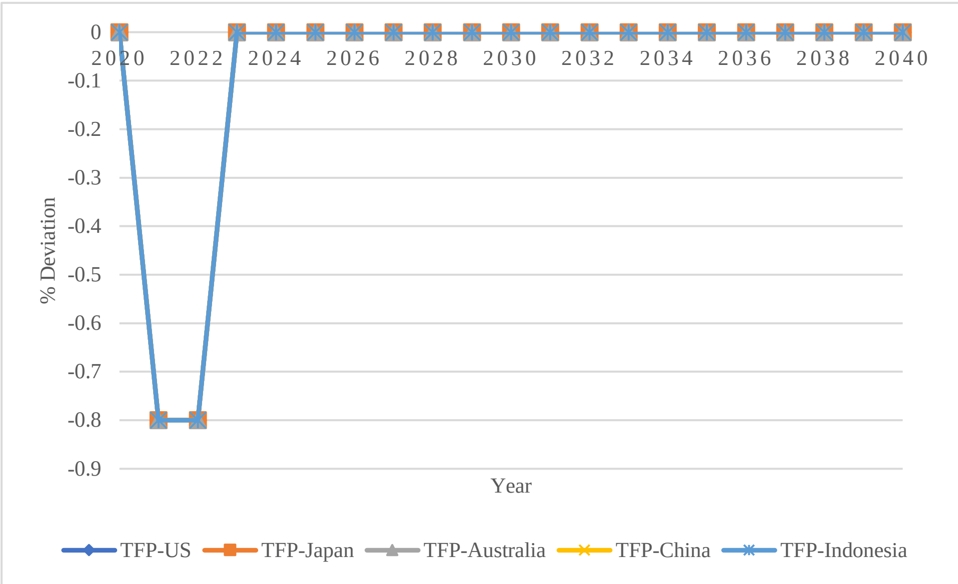

Figure 2: Temporary Negative Shock to Total Factor Productivity (TFP) – global, all sectors

Each shock will be implemented through the Solow residual of the CES production function in all sectors of the economy. Impacts of the shock are expected to flow through domestic economies via sectoral differentiation and labour markets, and globally via capital and trade flows. Volatility in the real economy is likely to be less in the temporary shock, given forwards-looking households and businesses will know that productivity is returning to the baseline in the future.

6. Results and analysis

6.1 Permanent Shock to TFP - Global

Results of the shocks are analysed in Australia, China, Japan, Indonesia, and the US. A permanent negative 0.8 percent shock to productivity globally, is representative of a sudden contraction due to COVID-19 and long-run TFP decline around the world. The shock occurs to firm level production functions across all sectors and all countries, immediately reducing the marginal product of capital. In response, Tobin's q falls in every sector (Figures 4-9), signalling to firms to run down their capital stocks over time. The capital stock is largely built by investment in durable manufacturing and mining. Countries producing or relying on these goods for income therefore experience the largest decrease in stocks and investment due to the significant decline in Tobin's q (Figure 5 and Figure 7).

The supply side shock feeds into demand shocks via investment and consumption. As the lower Tobin's q results in less total financial capital, total investment declines in every country, as evident in Figure 3. Investment in Japan is a significant 16 percent below the baseline in the second year after the shock. This is largely due to Japan's role as a large durable manufacturing hub and export-oriented economy.

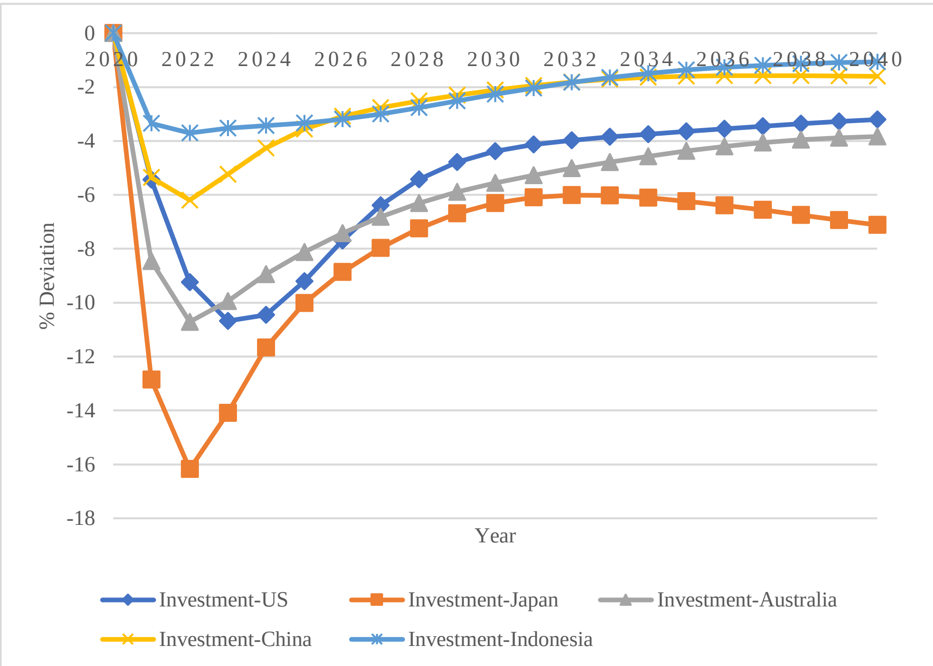

Figure 3: Percentage Change in Investment

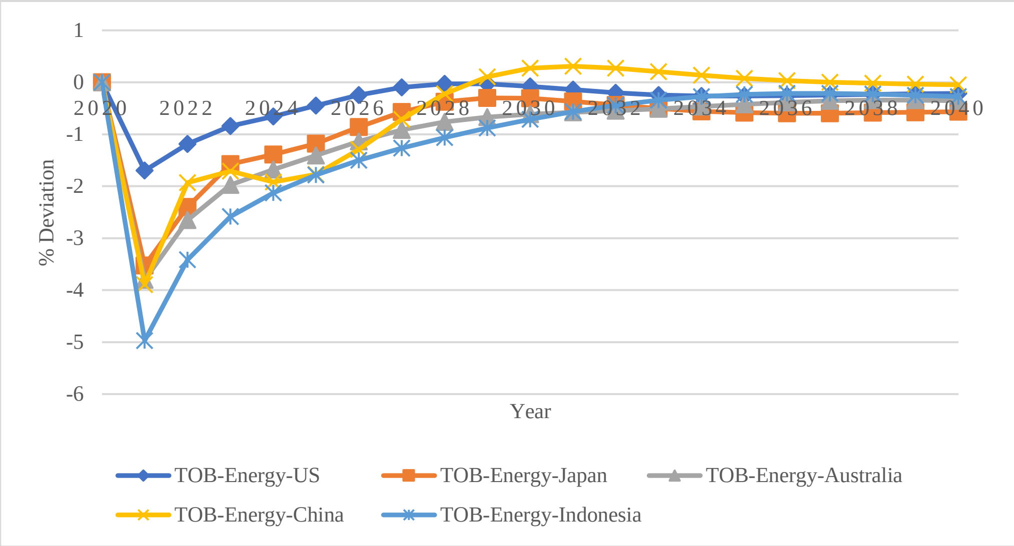

Figure 4: Percentage Change in Tobin's q (TOB) – Energy

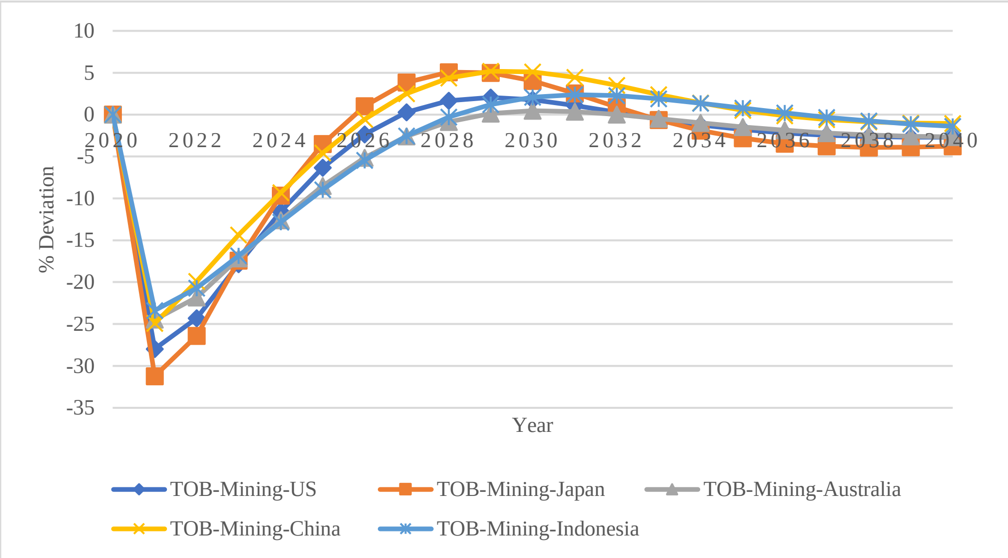

Figure 5: Percentage Change in Tobin's q (TOB) – Mining

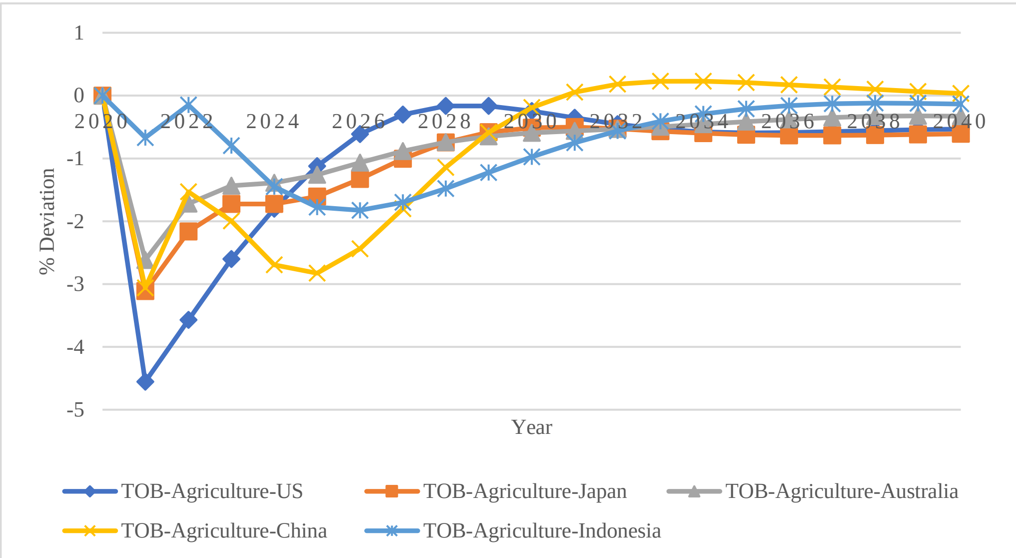

Figure 6: Percentage Change in Tobin's q (TOB) – Agriculture

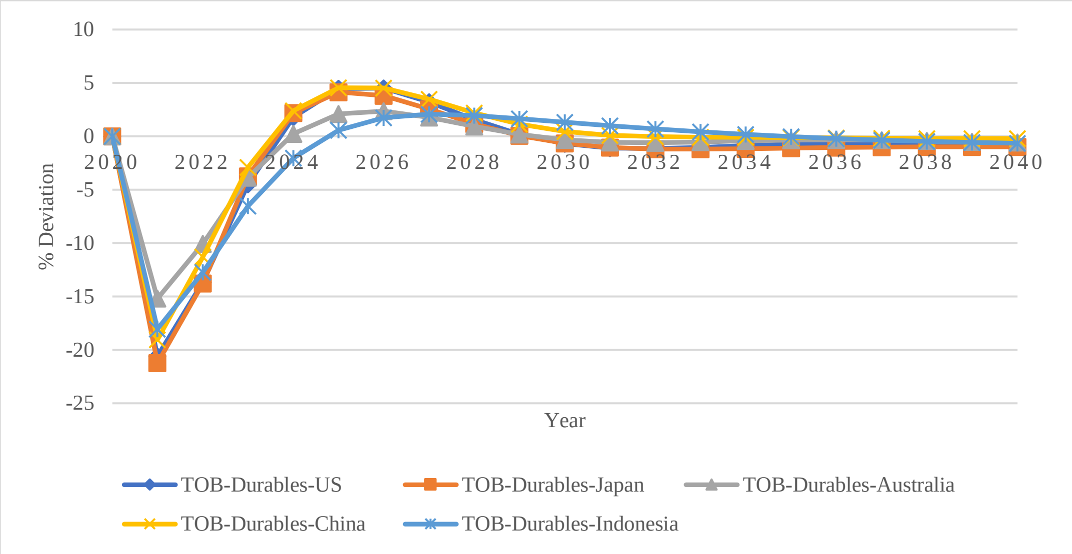

Figure 7: Percentage Change in Tobin's q (TOB) – Durable manufacturing

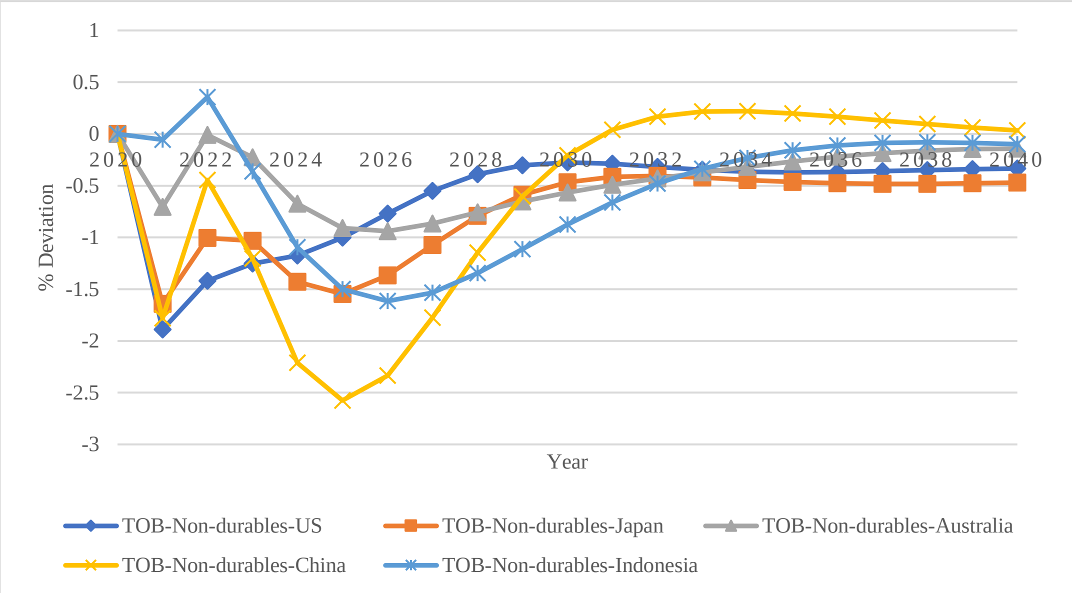

Figure 8: Percentage Change in Tobin's q (TOB) – Non-durable manufacturing

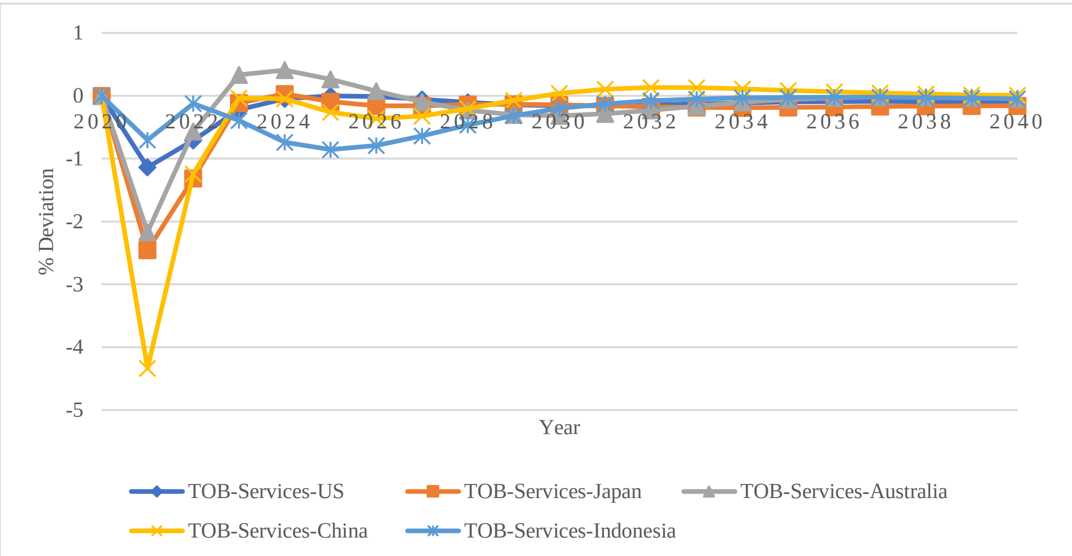

Figure 9: Percentage Change in Tobin's q (TOB) – Services

The lower marginal product of capital also causes real interest rates to fall (Figure 10). Central banks try to stimulate the economy by reducing nominal interest rates (Figure 11). As the lower interest rate registers in the economy, spending is incentivised. After the initial negative shock to spending, this increases household consumption across all sectors, although the effect is only temporary (Figure 13).

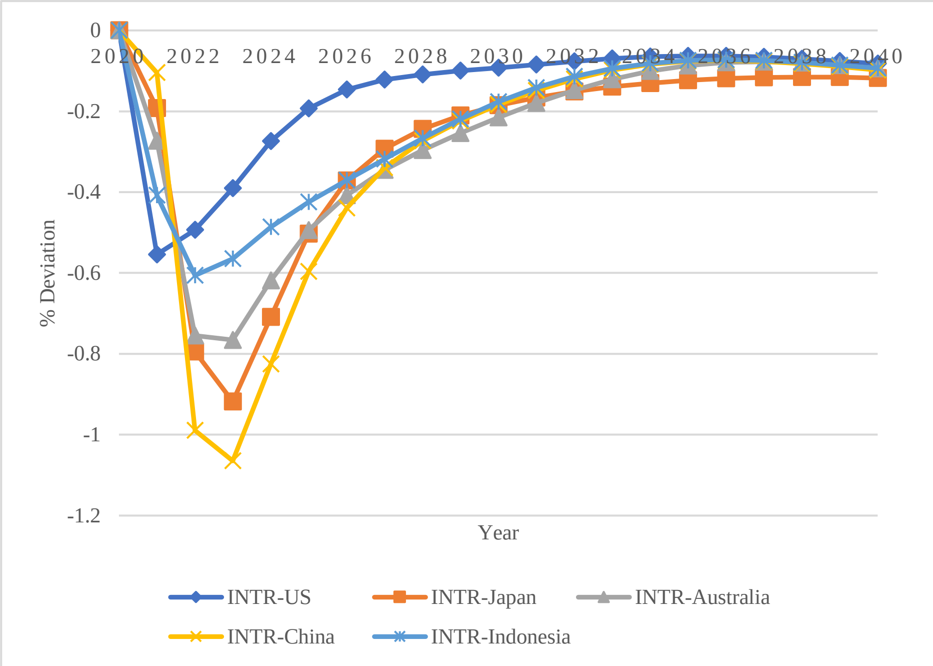

Figure 10: Percentage Point Change in the Short-Term Real Interest Rate (INTR)

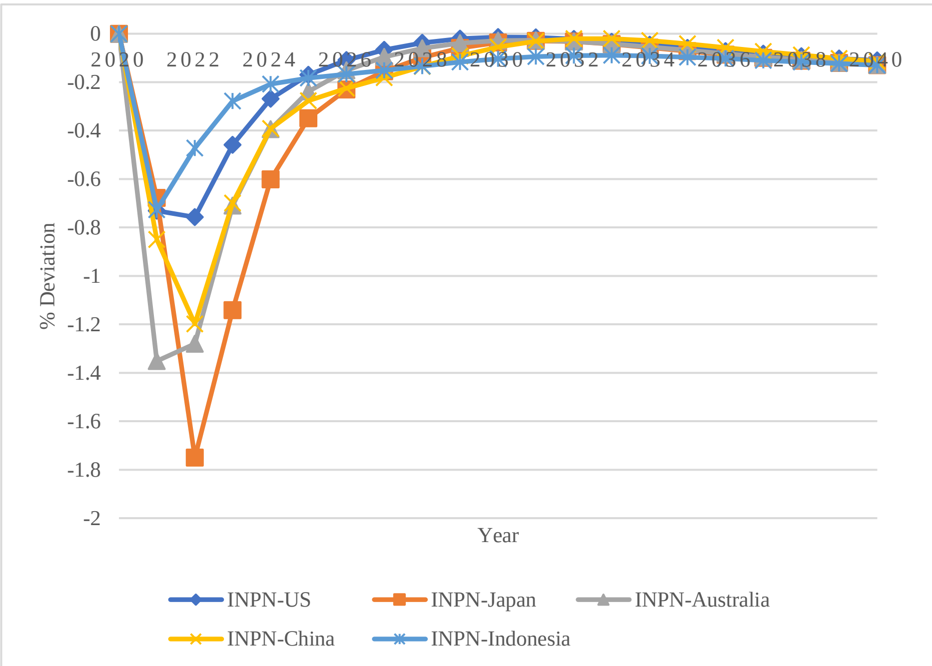

Figure 11: Percentage Point Change in the Nominal Interest Rate (INPN)

As central banks fail to adjust productivity growth estimates when the shock occurs, monetary policy implemented thereafter cannot recover the lost productivity. This makes inflation spike significantly, leading to a permanent decline in consumption, as shown in Figure 12 and 13.

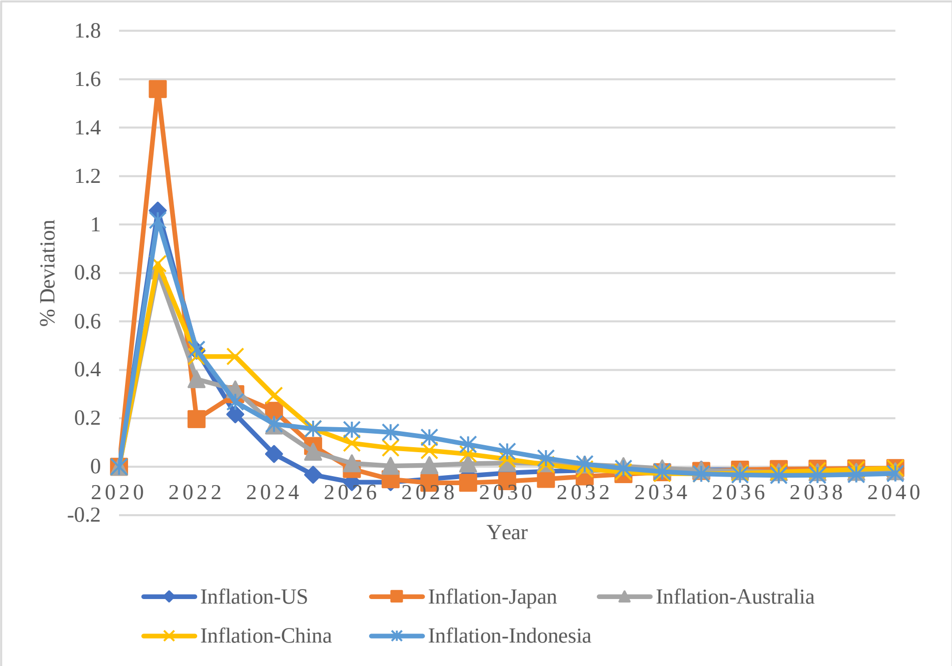

Figure 12: Percentage Point Change in Inflation

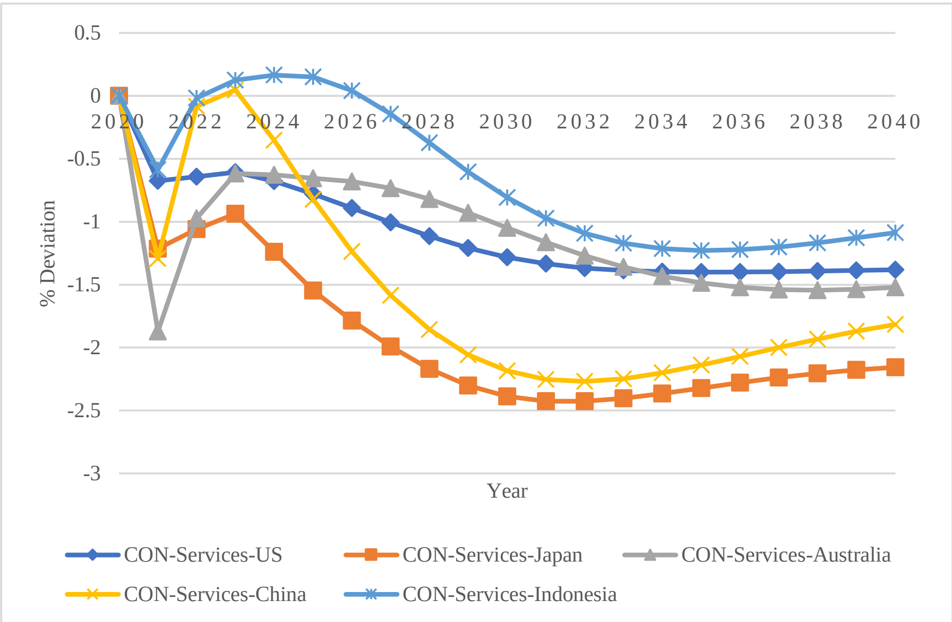

Figure 13: Percentage Change in Consumption (CON) – Services

Investment and capital stocks decline by the largest margin in Japan and Australia. Changes in the capital stock register in the model at the end of the first period (Figure 14). As capital flows out of these economies, their exchange rates depreciate (Figures 15). China's exchange rate also depreciates, though this reflects the crawling peg that ties the Chinese Yuan (CNY) with the US Dollar (USD) through nominal exchange rates. The lower rates place downward pressure on prices, increasing the attractiveness of exports from all three economies and driving an increase in trade balances (Figure 16). This trade surplus creates a stimulus to GDP after the initial productivity shock and helps to offset the losses in capital and investment.

In comparison, the US exchange rate appreciates sharply. This causes a trade deficit, as goods become relatively more expensive, and acts as a negative shock to GDP growth. The volatility in the exchange rate, however, is greater than the decrease in the trade balance, indicating there may be compressed domestic consumption for non-tradable goods.

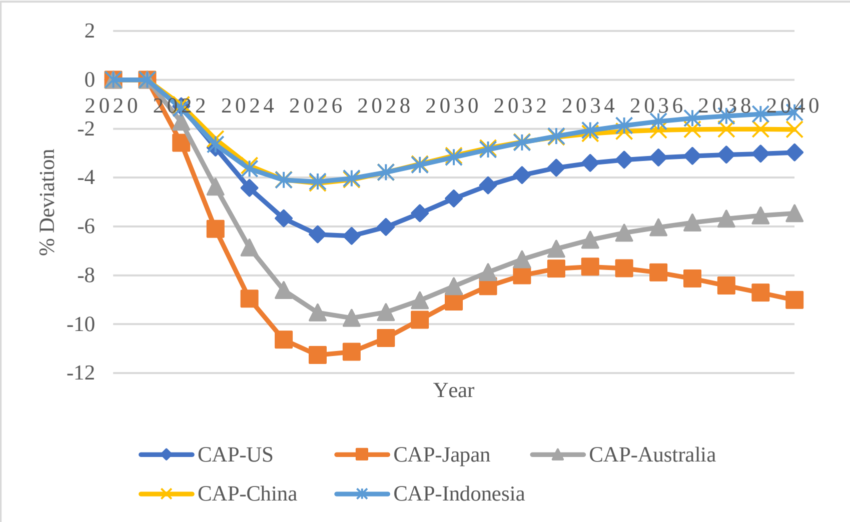

Figure 14: Percentage Change in Total Capital Stock (CAP)

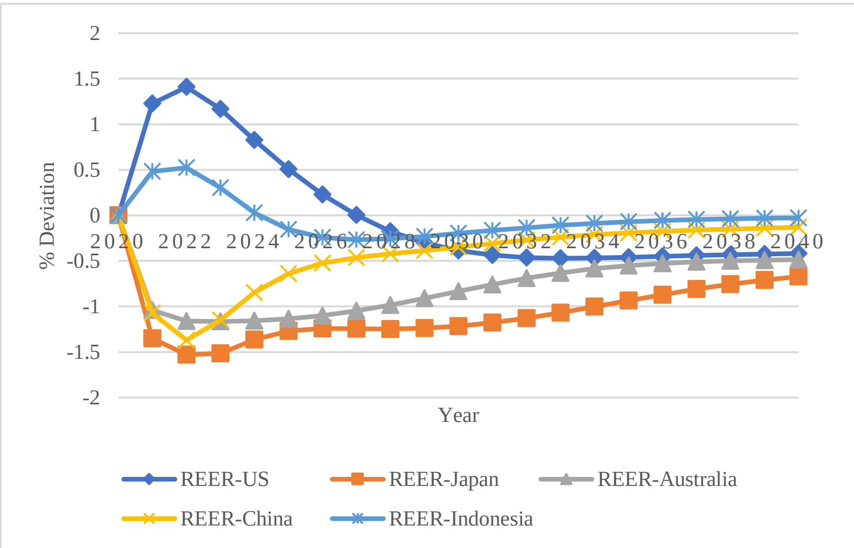

Figure 15: Percentage Change in the Real Effective Exchange Rate (REER)

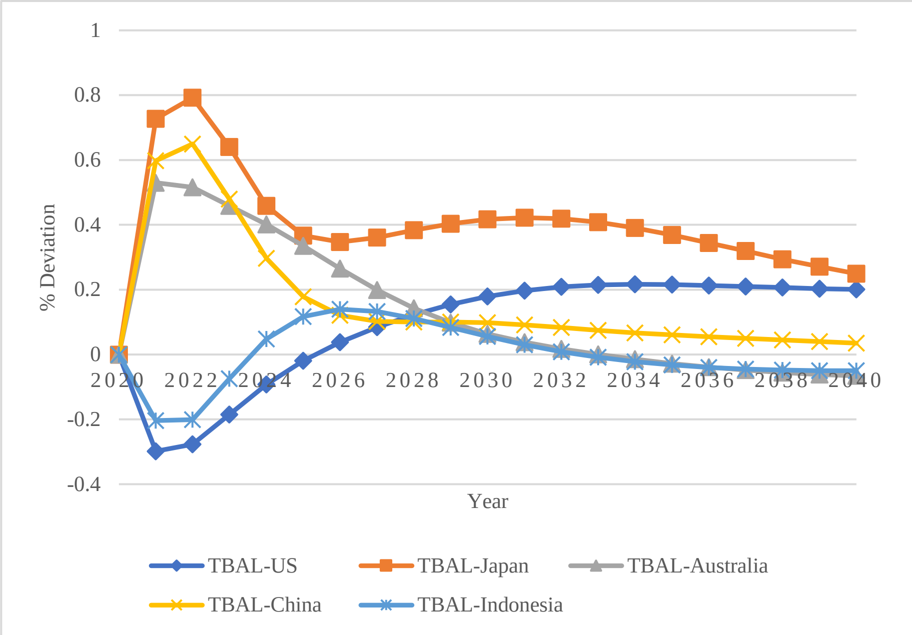

Figure 16: Change in Trade Balance (TBAL) as Proportion of GDP

Overall**,** real GDP is permanently lower in all countries, falling an estimated 1.5 percent below the baseline in Indonesia and 3.5 percent below the baseline in Japan, as shown in Figure 17. Japan and Australia receive the most significant shock to GDP, largely due to the lower Tobin's q running down the capital stock and investment across durable manufacturing and mining. This is partially offset by the trade surplus, raising GDP to less than 3 percent below the baseline in Japan and approaching 2 percent in Australia.

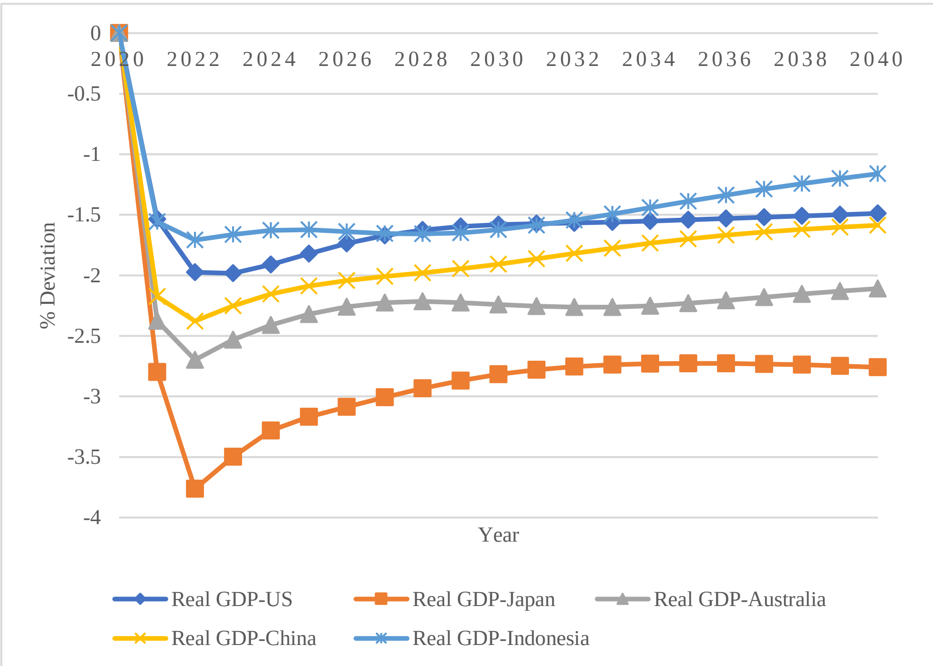

Figure 17: Percentage Change in Real GDP

6.2 Temporary Shock to TFP - Global

In contrast to the permanent scenario, the 2-year scenario sees most variables recover to the baseline within the first decade after the shock. The interaction between forwards and backwards-looking agents in the model, drives this V-shaped recovery. As forwards-looking agents realise productivity will return to normal, they do not change their investment and consumption decisions as much as in the permanent scenario. Backwards-looking agents adjust quickly to the return of productivity to the baseline, offsetting some of the economic losses and providing a stimulus in investment, shown in Figure 18 where US investment rises 4 percent above the baseline.

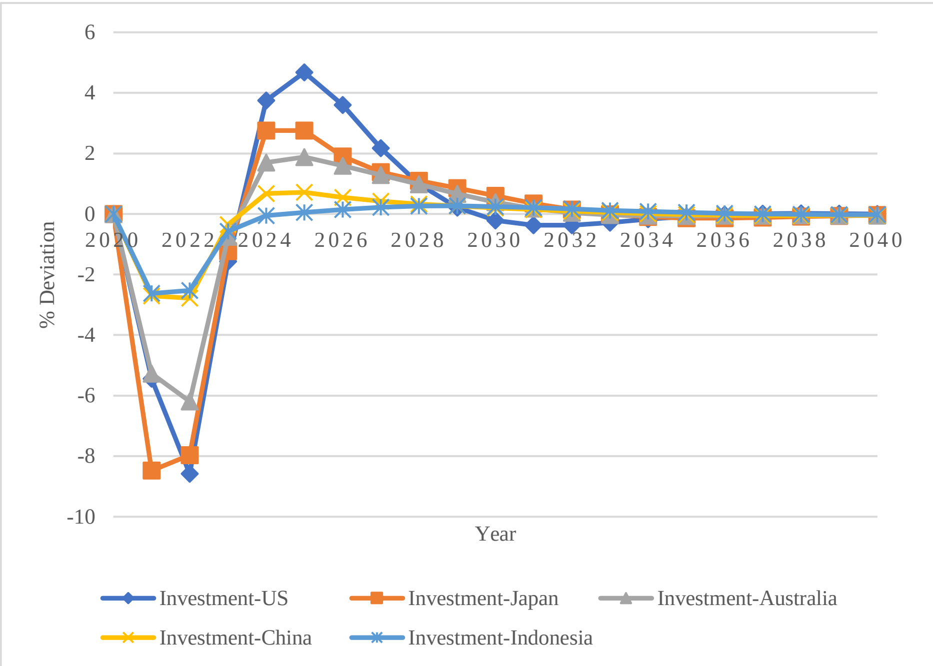

Figure 18: Percentage Change in Investment

To decrease volatility in real interest rates and inflation, central banks ease monetary policy after the initial shock (Figures 19 and 20). As productivity returns to normal levels, central banks raise the nominal policy rate to pre-shock levels. After rising by 1 to 1.5 percent, inflation falls below the baseline, before recovering and stabilising at the baseline in the longer term, as shown in Figure 20.

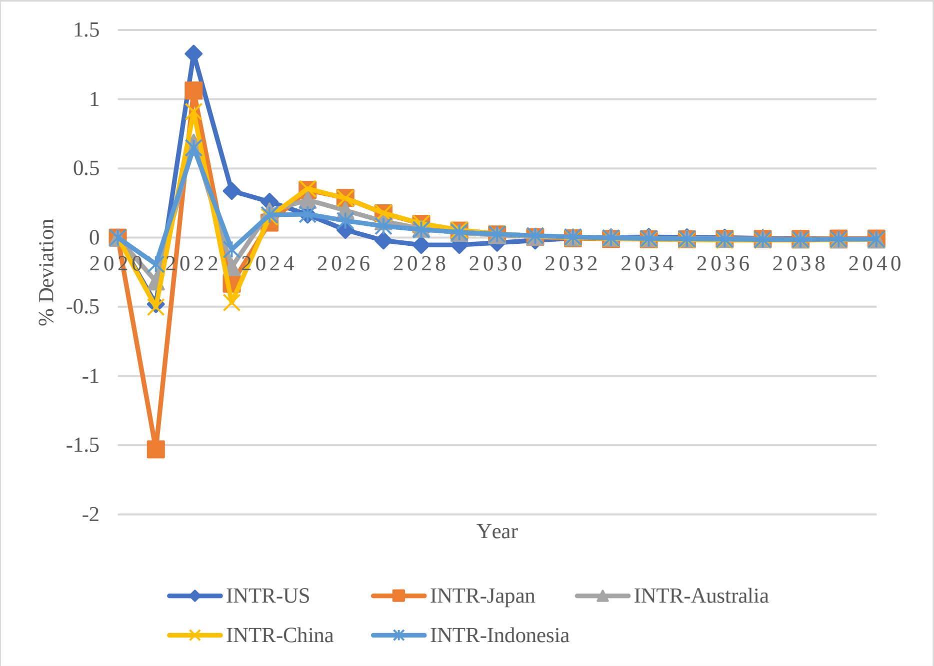

Figure 19: Percentage Point Change in Short-Term Real Interest Rates (INTR)

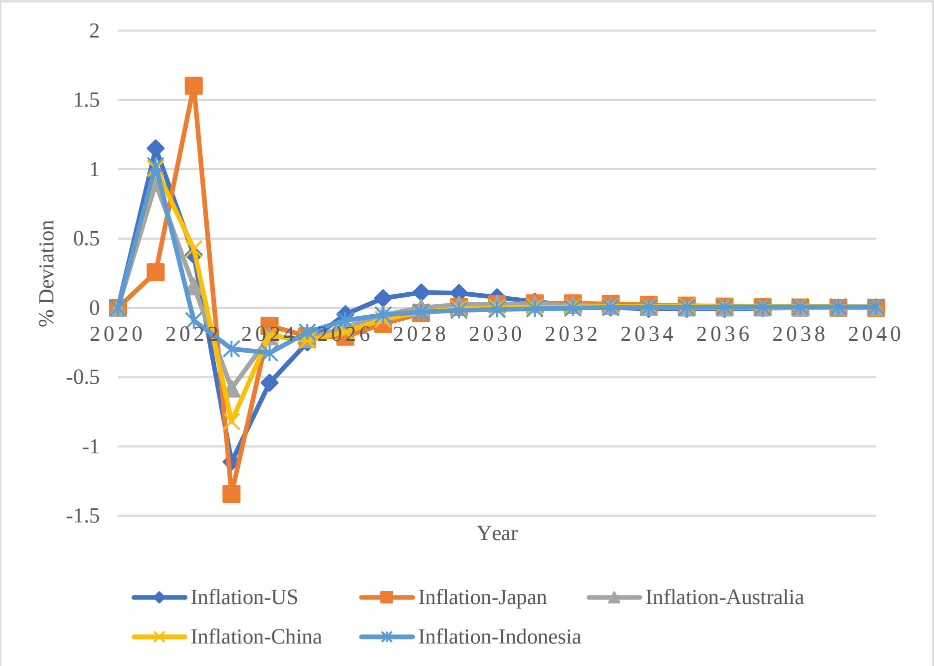

Figure 20: Percentage Point Change in Inflation

The productivity shock reduces the marginal product of labour causing a decrease in labour demand (Figure 21). This falls largely on Japan, where the labour-intensive service sectors form a large portion of total GDP. After an initial spike in inflation, workers incorrectly place upward pressure on wages (Figure 22). Wages fall again as productivity and inflation return to the baseline. This allows labour demand to rise quickly to around 1 percent above the baseline, nearly offsetting the rise in unemployment.

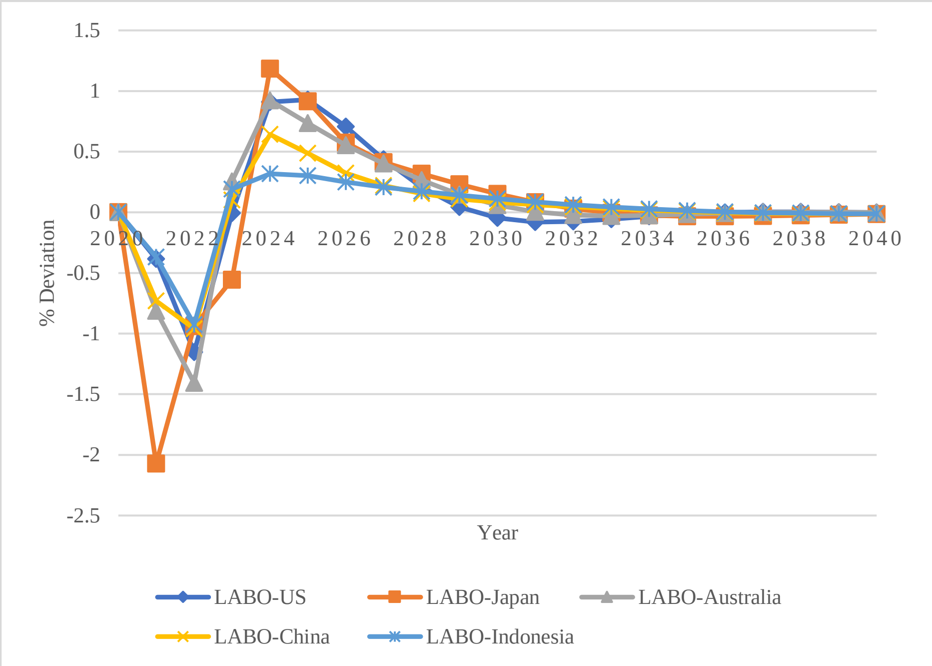

Figure 21: Percentage Change in Labour Demand (LABO)

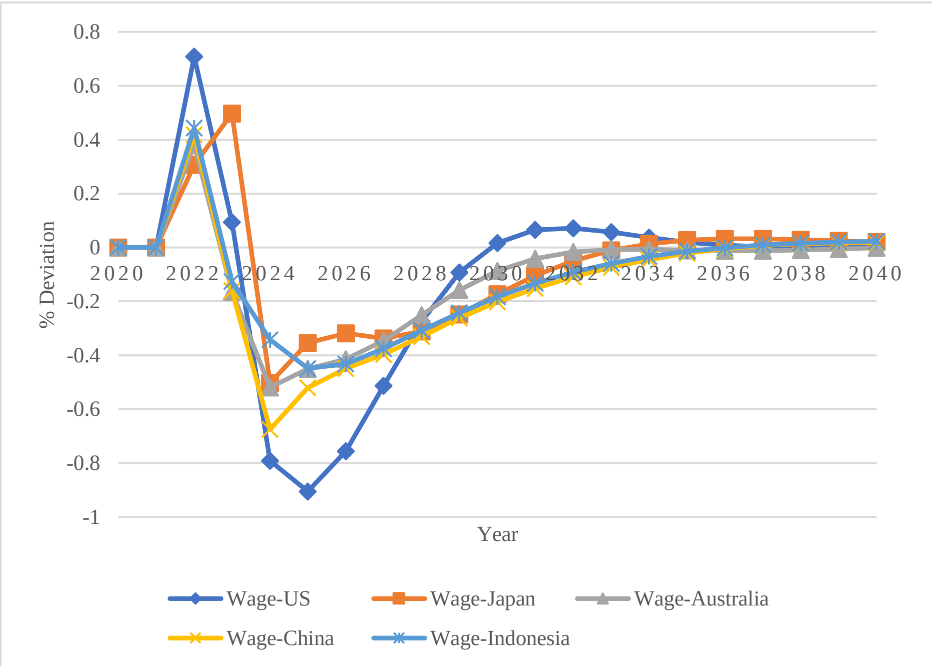

Figure 22: Percentage Change in the Real Wage Rate (Wage)

Two counteracting forces influence the movements of real exchange rates in the 2-year TFP shock (Figure 23). First, backwards-looking agents do not expect the sudden contraction or rebound in productivity. As a result, the agents over-adjust investment and consumption, accounting for the sharp turning points in real exchange rates in Figure 23.

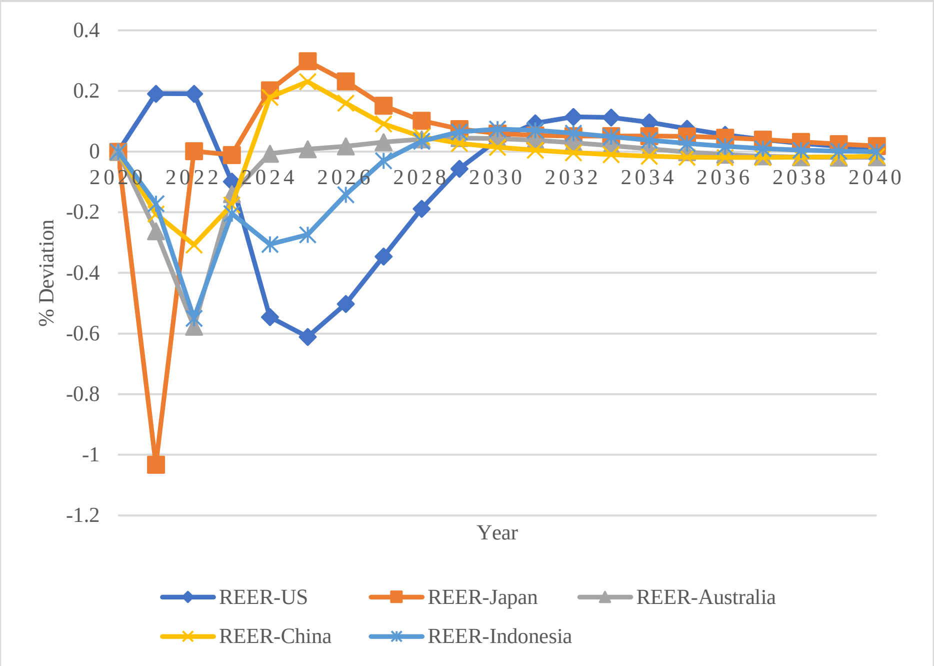

Figure 23: Percentage Change in Real Effective Exchange Rate (REER)

Second, flexible exchange rates, responding to cross-border and inter-sectoral capital flows, fluctuate more widely in the model than those pegged to the USD. China, for example, maintains a managed float of the exchange rate relative to the USD, and so experiences less of the fluctuations seen in the other economies in the model.

Smaller exchange rate movements also lead to smaller trade balance movements, as seen in Figure 24. China's trade balance does not shift significantly in the initial phases of the shock, moving between 0.1 and -0.1 percent around the baseline, before stabilising by 2030. In Japan, a spike in the trade surplus by 0.6 percent mirrors the exchange rate depreciation. This occurs as Japanese exports are more desirable at the lower rate, and so allow trade to act as a stabiliser for GDP.

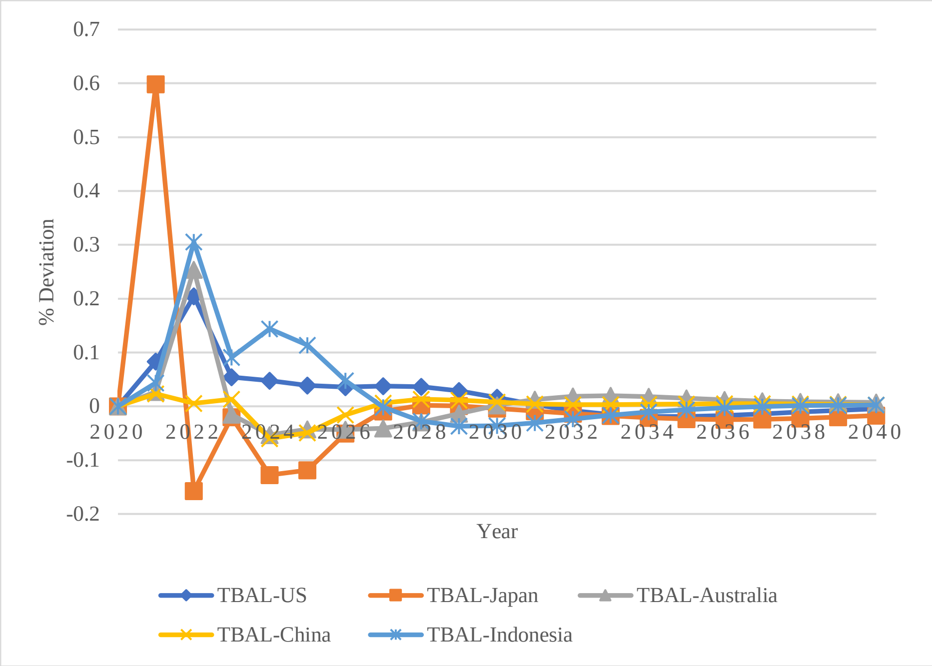

Figure 24: Change in Trade Balance (TBAL) as Proportion of GDP

GDP falls in all economies in the temporary shock (Figure 25). Japan and Australia incur the greatest losses, as GDP falls by 3 and 2.5 percent below the baseline, respectively. Two factors create the uplift in GDP above the baseline in all economies. Firstly, backwards-looking agents register the return to higher productivity after the TFP shock and change their investment and consumption decisions. Second, higher demand for exports after the depreciation of real exchange rates increases the trade balance. Real GDP eventually returns to the baseline by 2030, around a decade after the shock.

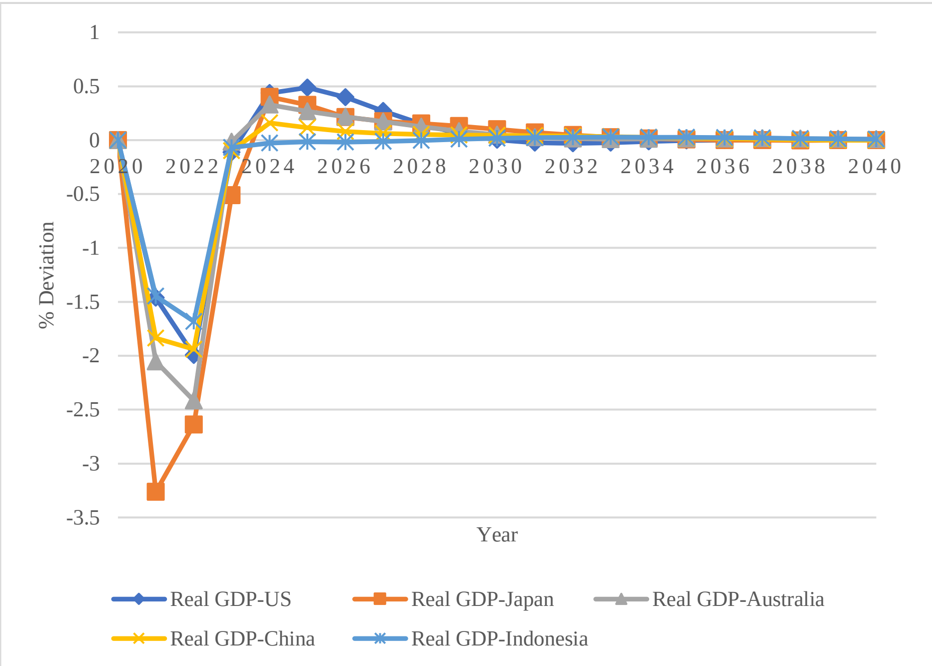

Figure 25: Percentage Change in Real GDP

6.3 Permanent Shock to TFP – Emerging Markets

When the negative 0.8 percent shock to productivity is only applied to emerging economies, there is an opportunity for investment and capital to flow to where there are higher returns. This means where investment falls in EMEs, it flows into advanced economies.

Tobin's q falls in all sectors for EMEs, causing investors to liquidate their holdings and capital stocks. Financial capital therefore flows out of EMEs into advanced economies, where the marginal product of capital is higher. The investment goods that firms buy to build capital stocks are largely in durable goods and mining. As China and Indonesia produce a larger share of these goods and rely on exports as a large portion of income, they therefore experience the largest fall in demand for investment. This process is evidenced by the large fall in Tobin's q for durable manufacturing and mining, around 20 percent below the baseline, in Figures 26 and 27, and the 7 and 5 percent fall in investment in China and Indonesia, in Figure 28.

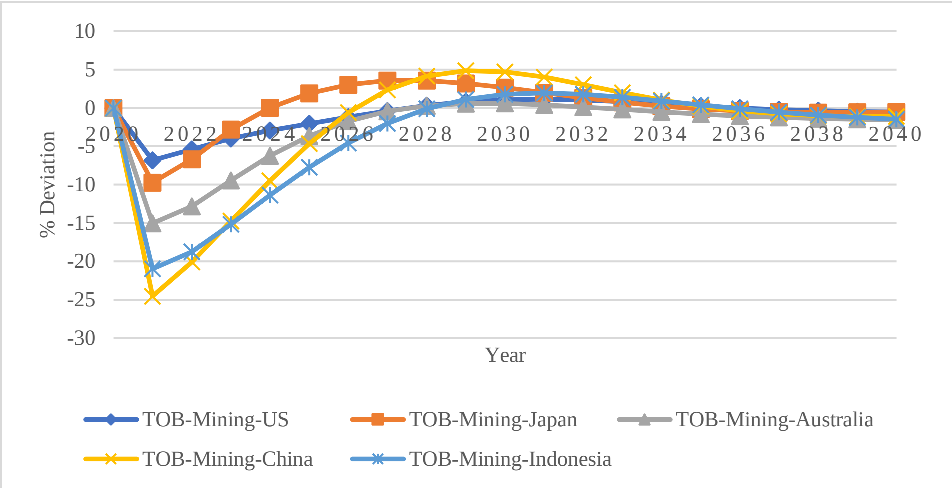

Figure 26: Percentage Change in Tobin's q (TOB) – Mining

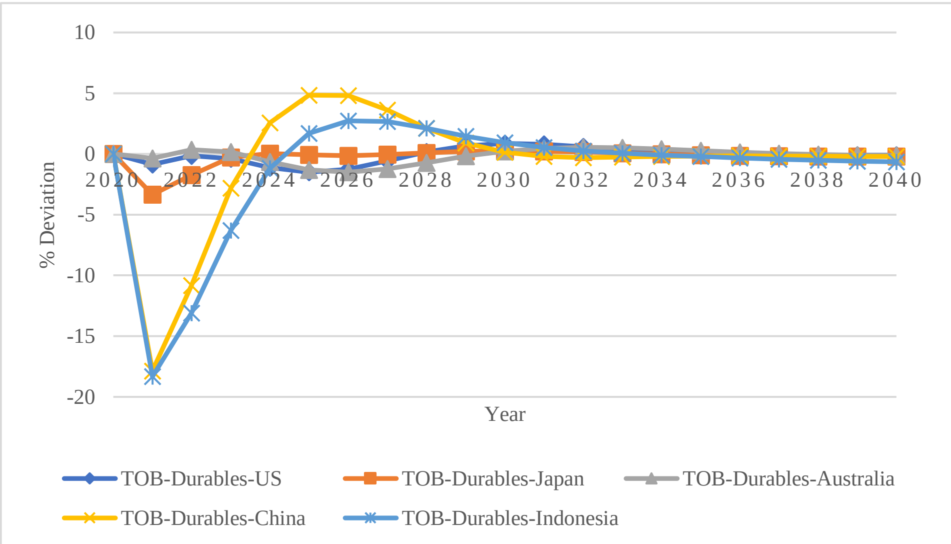

Figure 27: Percentage Change in Tobin's q (TOB) – Durable Manufacturing

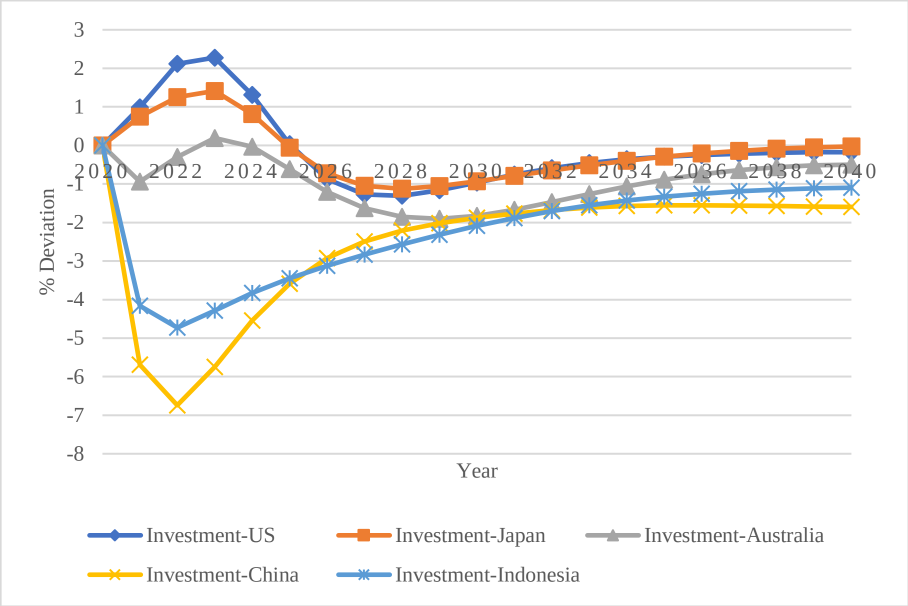

Figure 28: Percentage Change in Investment

Indonesian capital stocks decline in all sectors in response to the lower marginal product of capital and Tobin's q (Figure 29). Durable manufacturing stocks fall by the largest margin to around 4 percent below the baseline. Mining is also lower by around 3 percent. The sectoral differentiation reflects Indonesia's key industries and the sensitivity of the durable manufacturing sector to changes in the macroeconomy.

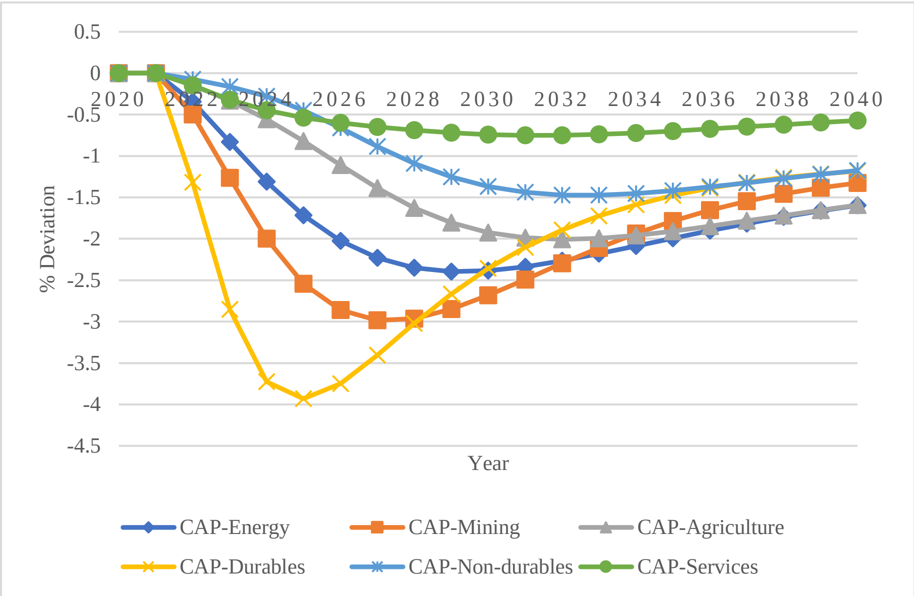

Figure 29: Percentage Change in Capital stock (CAP) in Indonesia

In contrast, and despite not experiencing the TFP shock, Australia also experiences a large reduction in the capital stock for mining, as it is the largest supplier to the Asian region. The fall is not as large as in the global case, but still registers around 3 percent below the baseline, as shown in Figure 30.

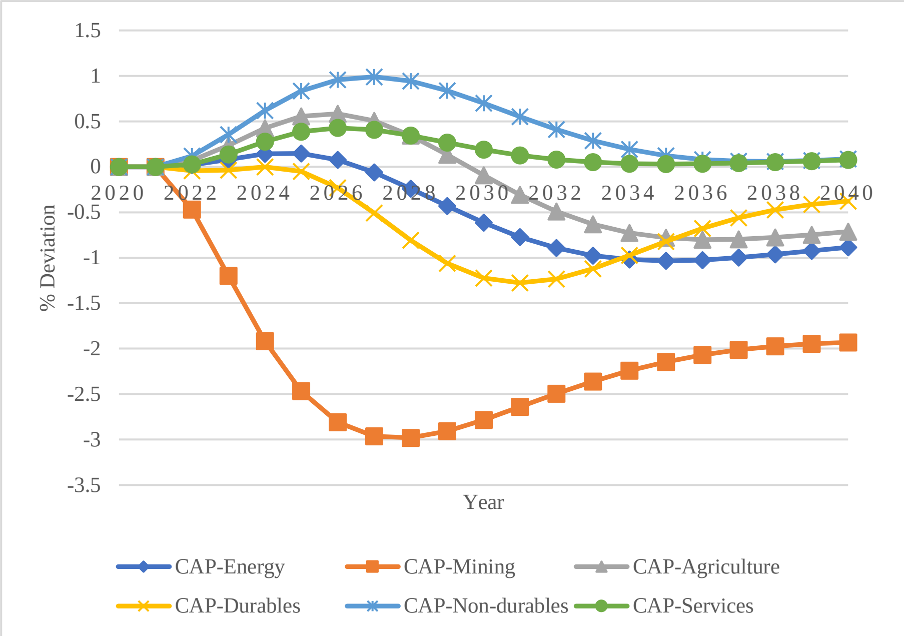

Figure 30: Percentage Change in Capital stock (CAP) in Australia

Labour demand changes due to the fall in productivity and dynamics in real wages. The shock to EMEs reduces the marginal product of labour, causing demand for labour to fall (Figure 31). At the same time, inflation rises as central banks adjust to lower productivity, causing higher wages and unemployment (Figures 32 and 33). However, as inflation, and therefore wages, begin to fall, labour demand recovers and eventually stabilises at the baseline.

The cross-border immobility of labour in the model creates sharp differences between countries in labour demand. Where EMEs experience rising unemployment, labour demand rises in advanced economies. The fall in the capital stock of durable manufacturing and mining frees up labour to be more effectively utilised elsewhere, for instance in agriculture and services. As this surplus capacity enters other sectors, it contributes to lower wages, marginally increasing the overall demand for labour in advanced economies. This effect is short-lived, disappearing within 7 years after the shock, as sectors adjust, and wages stabilise at their initial levels.

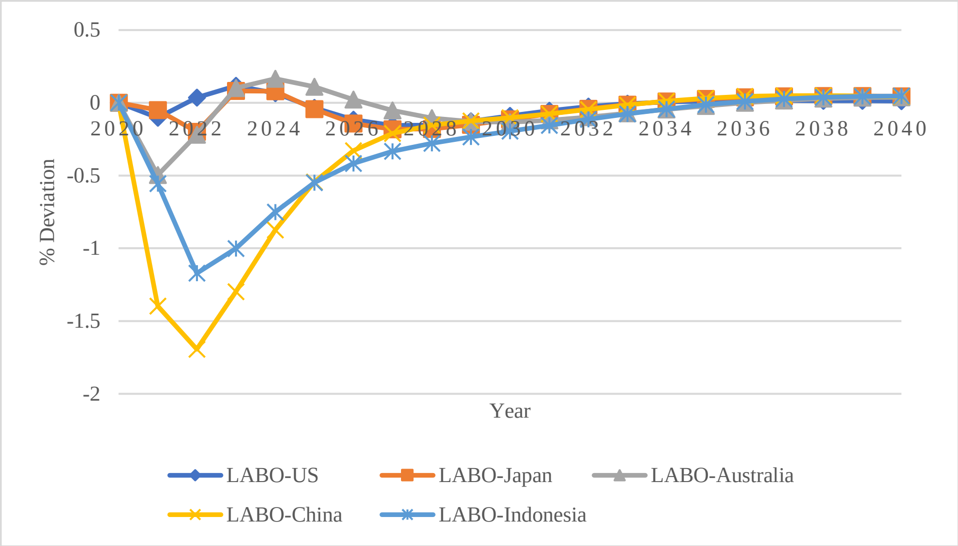

Figure 31: Percentage Change in Labour demand (LABO)

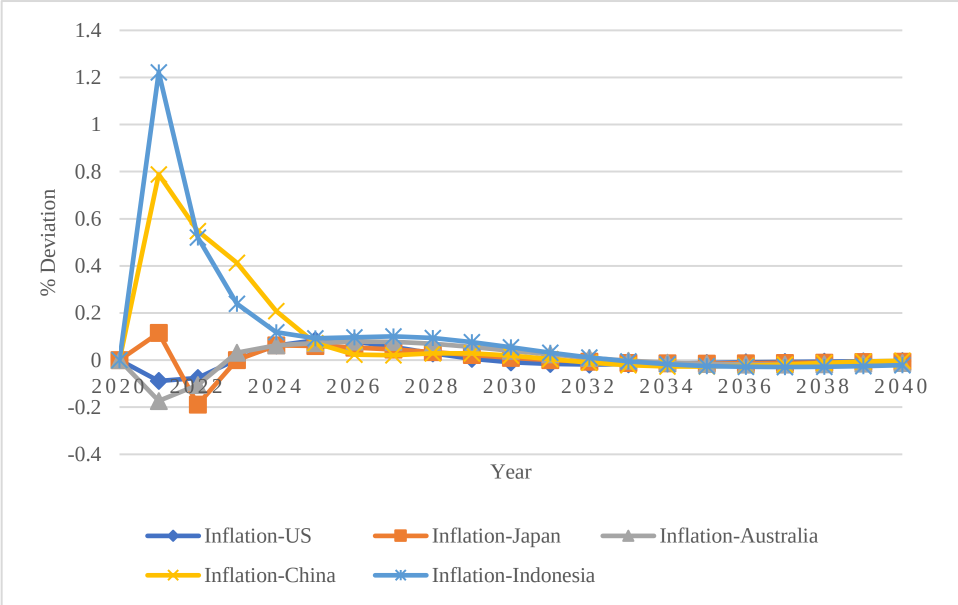

Figure 32: Percentage Point Change in Inflation

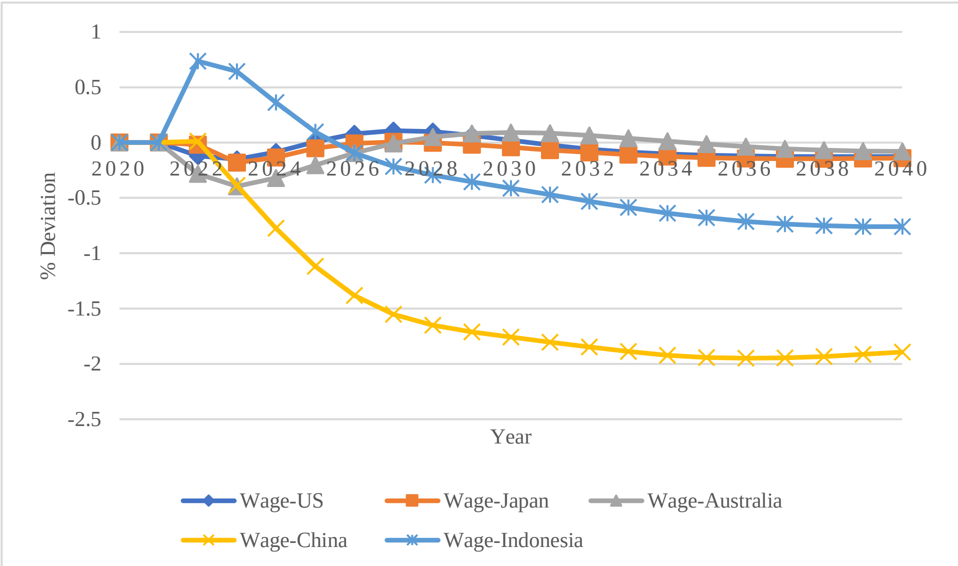

Figure 33: Percentage Change in Real Wage Rate (Wage)

As the marginal product of capital and investment fall, GDP in EMEs collapses permanently below the baseline by over 1.5 percent, rising slightly over time towards 2040, as shown in Figure 34. The advanced economies experience a small and temporary increase in GDP, before returning to the baseline within the first decade after the shock.

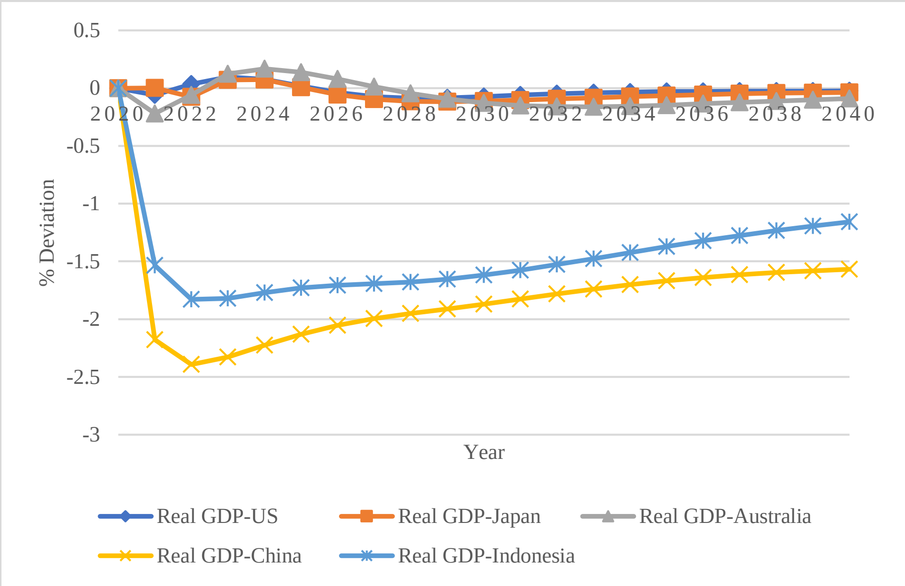

Figure 34: Percentage Change in Real GDP

6.4 Temporary Shock to TFP – Emerging Markets

A temporary productivity shock to emerging markets comes with the interaction of forwards and backwards-looking agents in the model, meaning there is greater volatility, though less deviation from 2020 levels, across all variables. As in the permanent EME scenario, those countries that experience the shock incur a loss in the marginal product of capital that flows, via Tobin's q dynamics, into lower investment. This is shown in Figure 35.

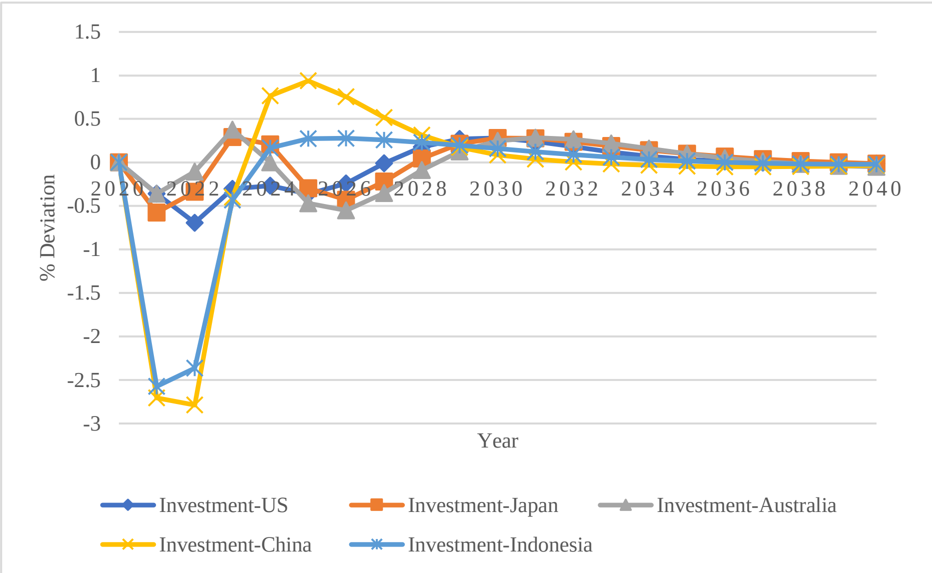

Figure 35: Percentage Change in Investment

As capital flows out of EMEs, goods become scarce and prices rise, causing a sharp spike in inflation, as evidenced by Figure 36. The higher inflation results in a corresponding appreciation of the real exchange rate in China and Indonesia, as in Figure 37. This effect is exacerbated in China, where the crawling peg regime, targeted through the nominal exchange rate, mirrors that of the US. Conversely, advanced economies in the model, receiving financial capital from EMEs, experience depreciating exchange rates.

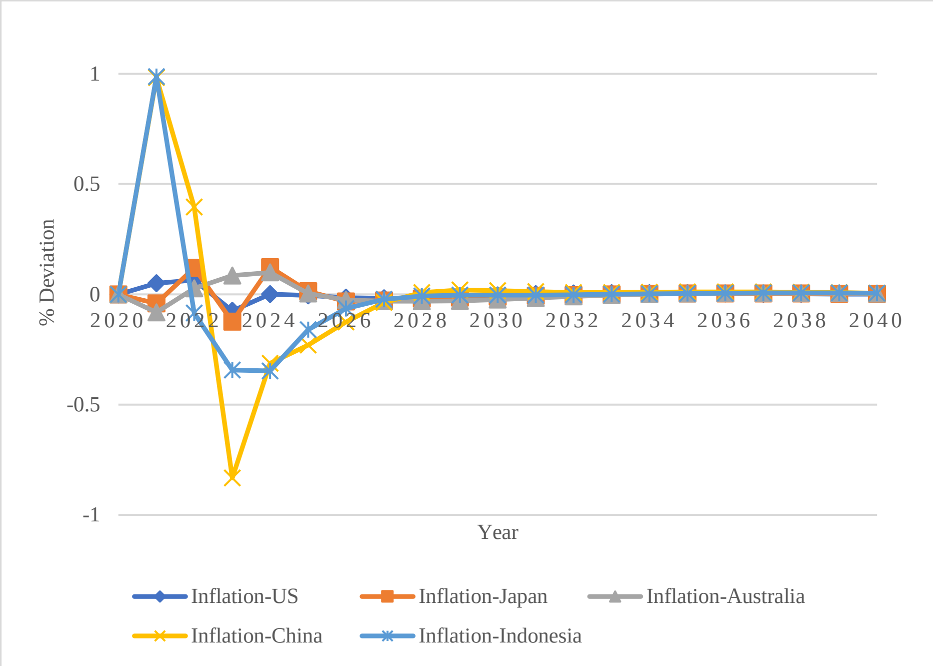

Figure 36: Percentage Point Change in Inflation

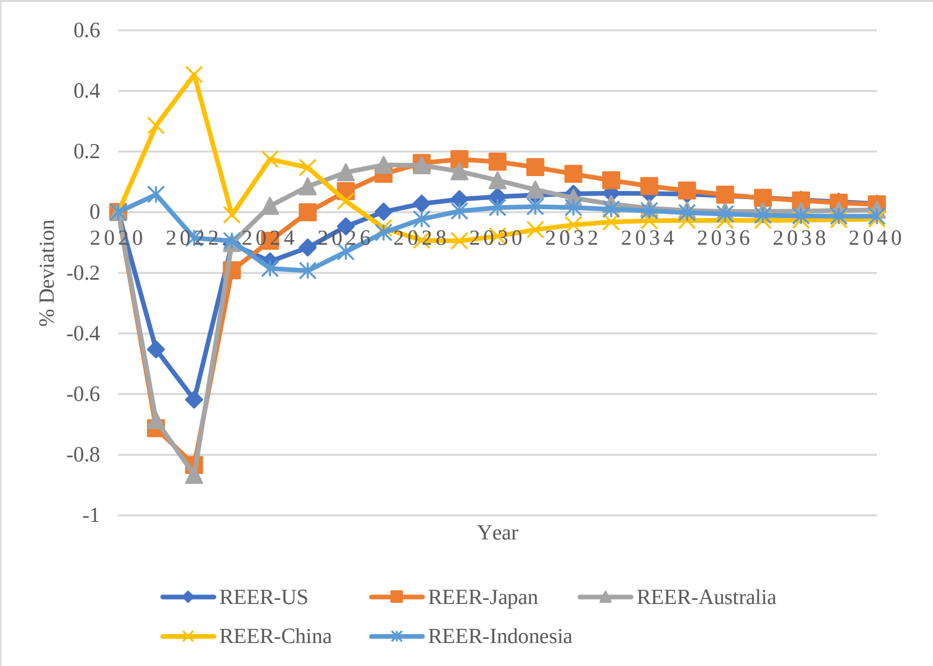

Figure 37: Percentage Change in Real Effective Exchange Rate (REER)

This takes time to register in the economy, ultimately resulting in a corresponding decrease in the trade balance, reflective of the intertemporal budget constraint (Figure 38). The constraint is a unique feature of the G-Cubed model, requiring the real exchange rate to adjust to ensure solvency, until all future trade surpluses equal the initial value of foreign debt.

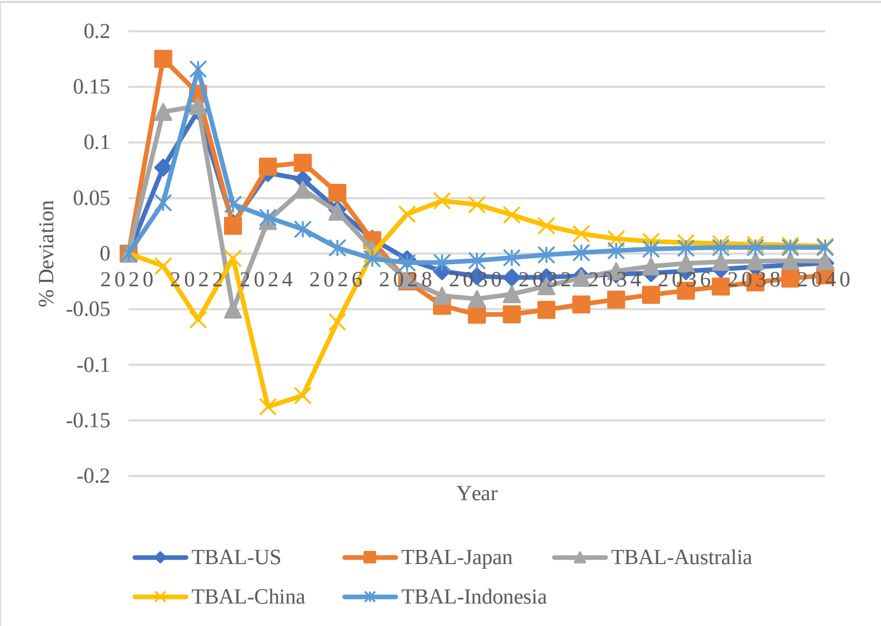

Figure 38: Change in Trade Balance (TBAL) as a Proportion of GDP

Overall, GDP falls by close to 2 percent in EMEs over the duration of the productivity shock, before returning to the baseline, as in Figure 39. The V-shaped recovery is a product of the benefits of trade flows and the interaction of forwards and backwards-looking agents in the model.

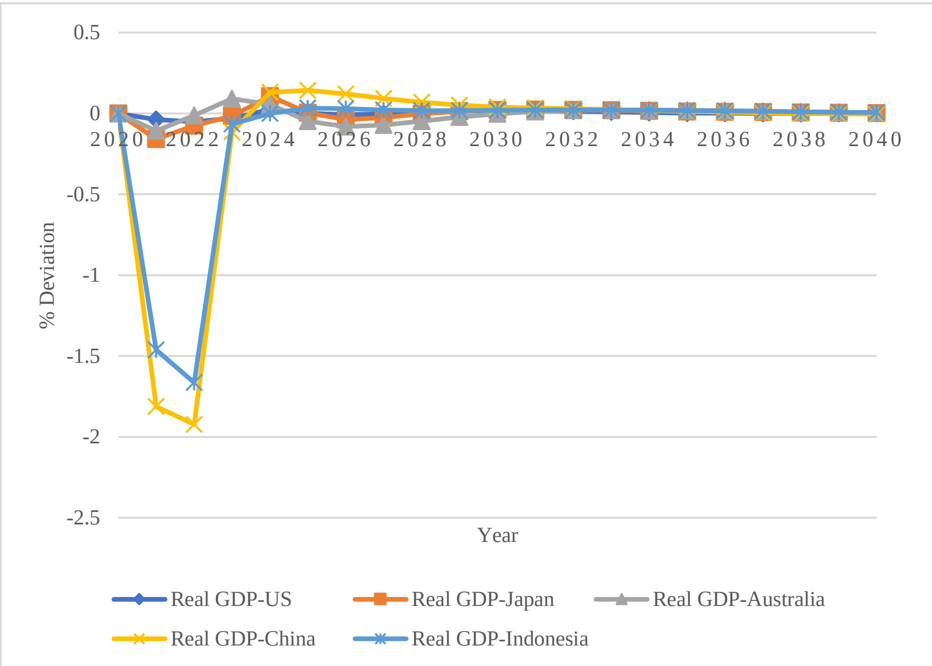

Figure 39: Percentage Change in Real GDP

7. Discussion and Policy Implications

A sudden contraction in productivity causes significant fluctuations across the global economy in growth, interest rates, labour markets, trade, and capital flows. This paper has determined several clear results. First, when a permanent 0.8 percent fall in the level of productivity occurs globally, the results are significant. GDP growth falls by the largest amount in Japan and Australia, to around 3.5 percent and 2.5 percent below initial levels. On implementing the shock to emerging markets only, China experiences the largest GDP collapse, to 2.4 percent below the baseline under a permanent productivity shock. These results show that productivity is closely linked with capital goods investment in durable manufacturing and mining. Australia, Japan, and China, as major producers and exporters of these goods, incur the greatest economic costs.

Second, the persistence of trade tensions in the global economy is a greater threat to long-run economic growth, than the 2-year disruption in supply chains due to COVID-19. A permanent shock to productivity growth due to the unwinding of GVCs leads to lower investment, labour demand, consumption, and GDP that never return to their pre-shock levels. However, when productivity losses from the pandemic are assumed to persist for 2 years, then these variables decline by a lesser amount and return to 2020 levels within 5 to 10 years after the shock. This result occurs due to the interaction of forwards and backwards looking agents in the model. Forwards-looking agents, who anticipate the shock to be temporary, adjust their consumption and investment decisions by a lesser amount, knowing that productivity will return to the baseline after 2 years. Backwards-looking consumers and investors cannot anticipate whether the shock will be temporary or permanent, and so react equally to both scenarios. As productivity returns to the baseline in the temporary shock, however, backwards-looking agents quickly adjust, providing a short and immediate stimulus to GDP. Under the assumption of permanently lower productivity growth, this stimulus does not appear.

On analysing the asymmetric effects of trade and COVID-19, EMEs were not found to be severely affected when all countries experience the same shock. However, significant results in EMEs were found where advanced economies were exempt from any change in productivity growth. The interaction of flexible and fixed exchange rates also highlighted that the largest gains from trade occurred with a depreciation of the real exchange rate that provided a stimulus to GDP. Where exchange rates were fixed, movements in the trade balance were less significant, and so did not help to offset the shocks.

These results indicate areas for policy to facilitate future growth. In labour markets, a productivity shock causes unemployment as labour demand falls by up to 2 percent below the baseline. This is without the additional labour supply shocks caused by COVID-19 that would increase unemployment further. Policies should therefore improve wage flexibility and harness some of the gains in digitalisation that have occurred through COVID-19, to encourage workforce participation, improve labour productivity and facilitate ongoing innovation and entrepreneurship.

Crucially, barriers to trade must also be lifted and the onshoring of manufacturing avoided. Given ongoing geopolitical tensions cause the most significant long-term economic costs, all states should cooperate to reduce barriers to trade, and encourage international and domestic competition through GVCs. This would build the resilience of GVCs, increase investor confidence, halt the onshoring of manufacturing and improve stability in trade. As noted by the OECD (2020a), governments can support firms in GVCs by sharing information on chokepoints revealed through the pandemic, such as those mentioned in pharmaceuticals and automobiles. Improving transparency in GVCs will also encourage firms to diversify across countries, sharing the gains from trade and reducing risks from over-reliance on any one source of imports. Future productivity depends on facilitating innovation and digitalisation. For EMEs like Indonesia, enhancing technological diffusion between countries through GVCs is central to improving long-term productivity outcomes. The integration of supply chains, particularly in the Asia-Pacific, are critically important to building flexibility and resilience into economies and driving long-run growth and development.

There are some limitations to this analysis. Firstly, it does not include the demand, risk or other health-related shocks associated with COVID-19 that would likely amplify the results of the model. Different expectations of the COVID-19 pandemic, for instance three waves or seasonal outbreaks, would produce different results, though the interaction of productivity with key sectors and countries would be the same. Fiscal stimulus packages and changes to tariffs implemented in the aftermath of COVID-19 are also excluded from this analysis. While McKibbin and Vines (2020) and McKibbin and Fernando (2020) discuss the many shocks associated with COVID-19, the interaction of tariffs and productivity in the post-COVID era remains an area for future research.

This paper finds that a permanent loss in productivity, due to the unwinding of GVCs, causes GDP to fall by significant margins in the first few years after the shock. The method used in analysing a sudden contraction in productivity is unique – it has not been previously utilised in the literature. In this way, it presents a new insight into the importance of productivity for policy makers globally, in improving investment, trade balances and monetary and fiscal policy.

Globalisation is at a tipping point. The scope of protectionism rampant in the world today has not been seen for 60 years and occurs amid unprecedented global health and economic crises. No other event of the same scale has occurred in the context of such widespread economic integration. Immediate action to enhance productivity and prevent further unwinding of GVCs is required now to secure long-run economic growth and living standards for the future. Afterall, every unprecedented crisis is also an unprecedented opportunity.

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