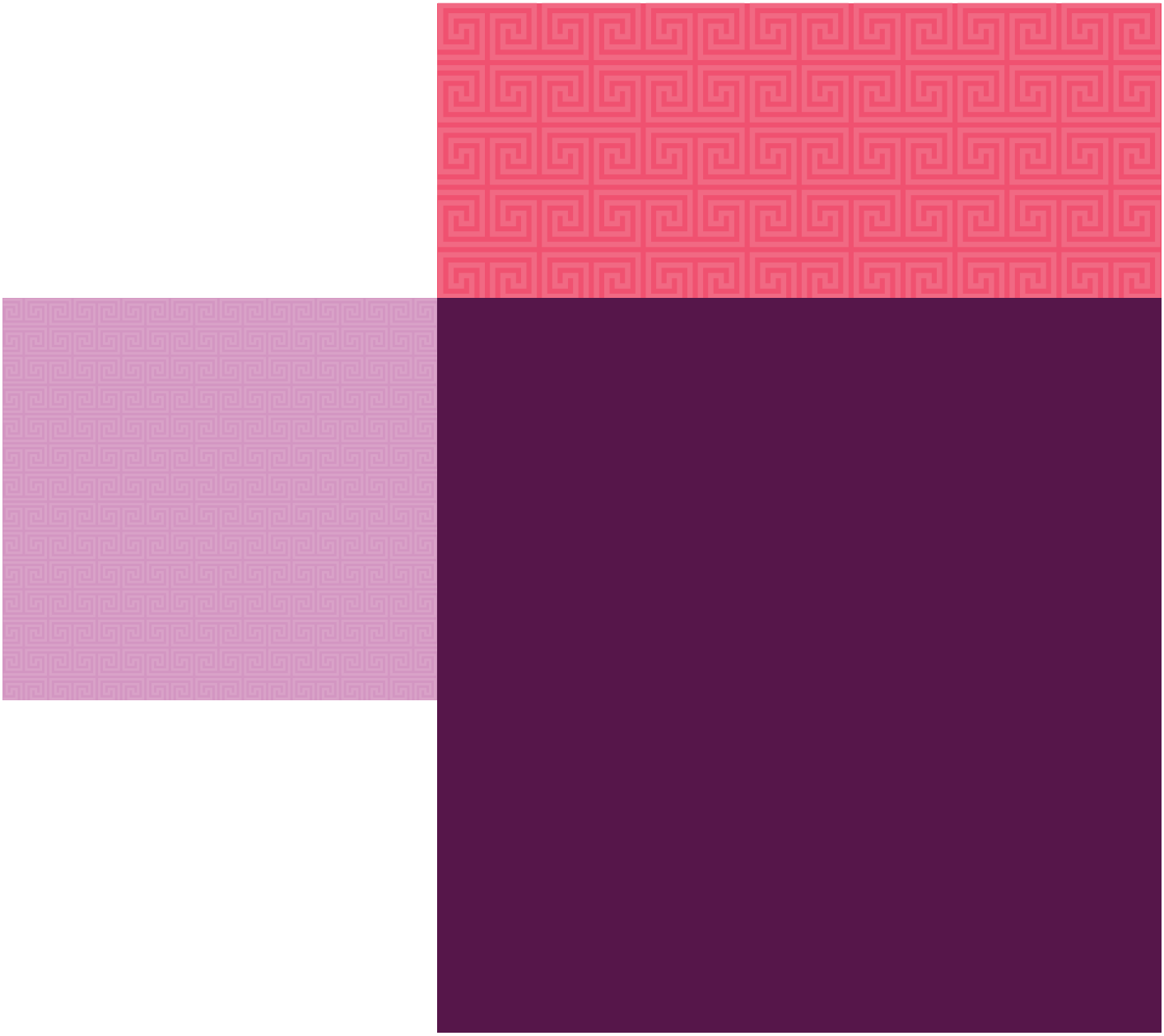
BANK OF ENGLAND

Publication

Financial Stability Paper No. 46

Global value chains, volatility and safe openness: is trade a double-edged sword?

January 2021



BANK OF ENGLAND

Financial Stability Paper No. 46 – January 2021

Global value chains, volatility and safe openness: is trade a double-edged sword?

Lucio D'Aguanno, Oliver Davies, Aydan Dogan, Rebecca Freeman, Simon Lloyd, Dennis Reinhardt, Rana Sajedi and Robert Zymek

The authors would like to thank Richard Baldwin, Stuart Berry, Ben Broadbent, Ambrogio Cesa-Bianchi, Giancarlo Corsetti, Rob Edwards, Alex Haberis, Andy Haldane, John Lewis, Kalina Manova, Jeremy Martin, James Talbot and Silvana Tenreyro for useful discussion and comments.

lucio.daguanno@bankofengland.co.uk
International Directorate, Bank of England, Threadneedle Street, London EC2R 8AH
oliver.davies@bankofengland.co.uk
International Directorate, Bank of England, Threadneedle Street, London EC2R 8AH
aydan.dogan@bankofengland.co.uk
Monetary Analysis Directorate, Bank of England, Threadneedle Street, London EC2R 8AH
rebecca.freeman@bankofengland.co.uk
International Directorate, Bank of England, Threadneedle Street, London EC2R 8AH
simon.lloyd@bankofengland.co.uk
International Directorate, Bank of England, Threadneedle Street, London EC2R 8AH
dennis.reinhardt@bankofengland.co.uk
International Directorate, Bank of England, Threadneedle Street, London EC2R 8AH
rana.sajedi@bankofengland.co.uk
Research Hub, Bank of England, Threadneedle Street, London EC2R 8AH
robert.zymek@ed.ac.uk
School of Economics, University of Edinburgh, 31 Buccleuch Place, Edinburgh EH8 9JT

ISSN 1754–4262

Executive summary

Modern production has become increasingly reliant on inputs sourced from abroad. These multi-country production processes are known as global value chains (GVCs). While it is generally accepted that GVCs increase productivity, by allowing producers to specialise and reap the gains from their individual comparative advantage, there is disagreement on the effects they have on macroeconomic volatility. In particular, some have argued that GVCs are a 'double-edged sword': they increase productivity, but also increase volatility.

In this paper, we show that the relationship between GVC integration and volatility is ambiguous in theory, and insignificant in the data. We first examine today's GVC landscape, showing that the extent of countries' integration into GVCs is related to different structural factors — including geographic and policy barriers to trade. We then focus on the role of trade policy by embedding intermediate inputs trade in an otherwise standard multi-country macroeconomic model. In the model, higher barriers to intermediate inputs trade reduce a country's GVC integration and productivity, but have an ambiguous effect on GDP volatility. This is consistent with the empirical evidence on the relationship between openness and countries' aggregate and sector-level outcomes. This supports our headline conclusion that there is no compelling reason to fear the double-edged sword: a blanket reduction in GVC integration would impose economic costs without necessarily, or significantly, reducing economic volatility.

Another salient feature of today's GVCs is their concentration around a few central 'hubs'. This has given rise to a discussion of alternative industrial policies that can reshape GVCs in the longer-run, in particular re-shoring and diversification. Within our model, we find that policies to re-shore production lead to an increase in aggregate volatility, as they effectively increase the concentration of value chains on domestic sources. On the other hand, diversification of GVCs among foreign suppliers can lower volatility, by lowering the exposure to any single country.

Finally, while the debate around the effects of trade on business-cycle volatility pre-dates the Covid-19 pandemic, recent events have increased the broader discussion of 'safe trade openness'. We discuss the scope for policy actions to make trade safe and open, drawing out an analogy with the financial sector reforms enacted following the Global Financial Crisis. We emphasise the merits of co-operation and multilateralism in order to underpin safe openness in the global trading system, and caution against direct policy interventions that are not targeted to address well-identified market failures.

Contents

1 Introduction

The world economy has become increasingly integrated since the end of World War II. Countries have become more interconnected through trade in goods and services, spurred by reductions in trade barriers, including an increasing number of Free Trade Agreements (FTAs).

Global Value Chains (GVCs) have been a key component of trade integration since the 1990s, with economies becoming ever more reliant on one another for intermediate inputs. These intermediate goods can be used to produce final goods for both home consumption and exports, but can also feed into domestic production of further intermediate goods — again, either to be used domestically or exported. The *World Development Report* (World Bank, (2020)) shows that around half of world trade was characterised by GVC flows in 2015.

The emergence of GVCs has brought benefits, in terms of both aggregate and firm-level economic outcomes. At the macro-level, GVCs have been shown to boost aggregate productivity by, for example, fostering specialisation, encouraging competition, and enabling technological spillovers (Grossman and Rossi-Hansberg (2008); Taglioni and Winkler (2016)). At a granular level, ample evidence shows that firms can benefit from GVCs by sourcing cheaper inputs, accessing a wider variety of goods (Topalova and Khandelwal (2011); Helpern *et al* (2015)), and from knowledge transfers (Bas and Strauss-Kahn (2014); Chor *et al* (2020)).

At the same time, some have argued that trade openness is a 'double-edged sword': while it can boost *productivity*, this comes at the expense of increased *volatility.* The Covid-19 pandemic has renewed interest in this debate, highlighting the potential for complex supply-chain linkages to amplify the effect of shocks across countries (Baldwin and Tomiura (2020)) and contribute to macroeconomic volatility (Bonadio *et al* (2020)).

From the perspective of economic theory, however, the link between trade openness and macroeconomic volatility is not clear-cut. On the one hand, openness can increase volatility by encouraging specialisation and, thus, limiting the degree of flexibility in the face of shocks (Newbery and Stiglitz (1984)). On the other hand, by allowing countries to diversify supply and demand internationally, openness can lower volatility by reducing exposure to domestic shocks (Caselli *et al* (2020)). Indeed, Caselli *et al* (2020) show empirically that this latter effect has dominated in recent decades, with international trade reducing volatility in most countries. More generally, other authors have shown that the openness-volatility relationship is ambiguous. For instance, Rodrik (1998), Easterly *et al* (2001), Kose *et al* (2003) and di Giovanni and Levchenko (2009) find that the relationship can be positive, while Bejean (2006), Cavallo (2008), Buch *et al* (2009), Haddad *et al* (2010), Parinduri (2011) and Burgess and Donaldson (2012) reach the opposite conclusion.

In this paper, we take another look at the link between trade openness, productivity and macroeconomic volatility. In particular, we assess the extent to which trade openness can be a double-edged sword when we account for trade in intermediate inputs in addition to final goods.

Both our empirical and theoretical findings suggest that trade openness need not be, and has not systematically been, a double-edged sword. To reach this conclusion, we build a multi-country macroeconomic model with intermediate inputs trade, in which trade costs influence the degree of GVC integration. We complement this with empirical evidence using both aggregate and sectoral data. While we find a positive association between GVC integration and productivity, the impact on GDP volatility is ambiguous within our model and insignificant in the data. Hence, our analysis supports the headline conclusion that there is no compelling reason to fear the double-edged sword: a blanket reduction in GVC integration would impose economic costs without necessarily, or significantly, reducing volatility.

We then assess the effects on volatility when accounting for the concentration of GVCs around a few central 'hubs', a salient feature of today's global trade landscape. GVC concentration has given rise to concerns that trade openness may increase volatility by exposing economies to country-specific shocks from abroad. This has led to a discussion around alternative industrial policies that can reshape GVCs and influence the nature of trade openness in the longer-run, in particular re-shoring and diversification. Within our model, we find that policies to re-shore production actually lead to an increase in aggregate volatility, as they effectively increase the concentration of GVCs on domestic sources. On the other hand, diversification of GVCs among foreign supplies can lower volatility, by lowering the exposure to any single country.

It is worth noting that the focus of our analysis is on overall business-cycle volatility, rather than vulnerabilities in the face of large shocks specifically. This reflects the long-standing question around trade openness and macroeconomic volatility, which pre-dates the Covid-19 pandemic. In our relatively standard theoretical model, small and large shocks have roughly proportional effects. There are also challenges to studying rare extreme events empirically, since systematic data measuring GVC integration are typically annual, and sources providing the largest country coverage have a relatively short time dimension.[1]

Nonetheless, we provide a discussion of some key lessons about GVCs from the recent Covid-19 pandemic. The main message is that supply chains have been highly agile and resilient. Overall trade figures show a strong recovery over the summer of 2020. While supply-chain capacity for food and medical supplies was strained at the onset of the pandemic, this was predominantly due to a surge in demand rather than disruptions to supply. Hence, despite going through an unprecedented large, global shock, the evidence of large-scale supply-chain vulnerabilities is limited.

We further contribute to the broader discussion of policy actions to achieve 'safe trade openness'. We emphasise the merits of *policy reforms* aimed at strengthening co-operation and multilateralism in the global trading system. These include possible stress-testing frameworks for critical supply chains, and the collection and dissemination of more timely data on GVC trade. These reforms have parallels with the push for 'safe openness' in the international financial system following the global financial crisis (GFC). We also discuss the case for *policy interventions* in the global trading system that may trade off openness for safety. We caution against interventions not targeted to address well-understood market failures and externalities. While the academic literature to date on GVCs provides little evidence on the existence of such market failures, there is scope for policy experience and further economic research to join forces to assess whether such market failures exist. We highlight potentially fruitful areas for future research in this vein. A clear diagnosis of such potential sources of inefficiencies is essential to devise welfare-improving policy interventions.[2]

The rest of this paper is structured as follows: Section 2 draws out some stylised facts about today's trade landscape and determinants of GVC integration. Section 3 considers the effect of trade policy on productivity and volatility within the theoretical model. Section 4 provides empirical evidence on the effect of GVC integration. Section 5 considers re-shoring and diversification. Section 6 discusses safe trade openness more broadly. Section 7 concludes.

1 While the Covid-19 pandemic has raised an interesting debate on the effects of large shocks in the presence of GVCs, the analytical tools to address this question are limited. Bodenstein *et al* (2020) and Baqaee and Farhi (2020) study Covid-19 within closed-economy models with non-linearities in supply chains. There is a related strand of empirical literature using specific case studies, such as the 2010 Tōhoku earthquake (Todo *et al* (2015); Carvalho *et al* (2020)). Developing these tools further to study the effects of extreme events in the presence of GVCs is a question for future research.

2 The same would not be true for policy interventions targeted at distributional concerns, rather than economic inefficiencies. These types of concerns are not the focus of this paper. See Helpman (2017) for a recent review of the theoretical literature on trade and wage inequality, for example.

2 Global value chain integration: definitions and stylised facts

2.1: What is a global value chain?

To produce their output, firms rely on raw factor inputs, like labour and capital, as well as intermediate inputs produced by other firms. The linkages between firms via intermediate inputs are referred to as 'value chains'. The term *global* value chains (GVCs) is used to describe the situation in which firms in one country rely on intermediate inputs produced in another.

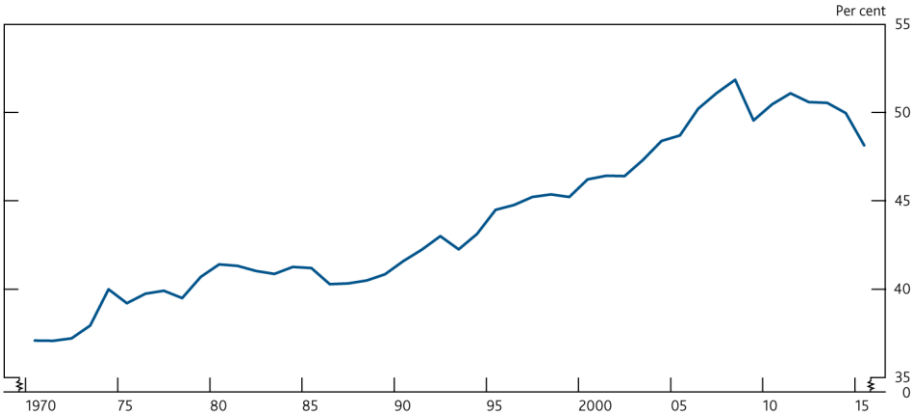
Within a GVC, production is fragmented into multiple stages, which take place across at least one border. Value is added at each production stage, and a minimum of two stages are involved. Baldwin and Venables (2013) point out that GVCs can take the form of either 'spiders' or 'snakes'. In the spider-like case, multiple parts and components, sourced from various locations, converge in one central 'hub'. In the snake-like case, value is added sequentially, and inputs build upon each other until a final good or service is produced.

Importantly, the fragmentation of production across different countries allows producers to reap the gains of specialisation, benefiting from their individual comparative advantages. To take a simplified version of perhaps the most widely used example, the iPhone is produced through a GVC: it is designed and marketed by the US firm Apple, but assembled in China using parts and components predominantly from Korea.

Why is GVC trade important?

Understanding the landscape of GVC trade is important for three main reasons. First, GVCs have become a prominent feature of today's trade landscape. The *World Development Report* (World Bank (2020)) shows that GVC trade as a share of global trade grew significantly in the 1990s and 2000s, with some levelling off after the GFC, making up about half of world trade in recent years (**Chart 1**).

Chart 1: GVC trade as a share of world trade



Source: Figure 1.2, World Development Report (World Bank (2020)).

Second, in the presence of GVCs, official trade statistics — which record direct transactions between two countries — mask the true value that each country adds to a given product. Within the simplified iPhone example laid out above, this is seen by the fact that China's gross exports of assembled iPhones will include value added originating from Korean parts and components. As such, the recorded value of a product in gross trade statistics will reflect the accumulation of value added at each production stage, ie Korean value added of iPhone parts would already be

accounted for in Korea's exports to China.[3] Hence, mapping out GVC trade can help us trace where and how much value is sourced from any given country.[4] Unpacking the data in this way allows us to form a clearer picture of the overall importance of *indirect* trade links, which arise when multiple production stages are involved to produce a final good. This provides a more comprehensive view of world trade patterns.

Finally, understanding GVC trade can help us think about how shocks might propagate through the global trade network. Returning to the iPhone example, if China were unable to source iPhone parts from its Korean suppliers, this could affect its ability to assemble the iPhone and subsequently deliver it to Apple on time for distribution. Hence, a shock to Korean suppliers could negatively affect China's ability to assemble the product, and have knock-on effects in the US, even when there is no direct trade link between Korea and the US.

2.2: Empirical measures of GVC integration

In practice, any attempt to measure the extent of countries' integration into GVCs needs to face up to the challenge of how to reflect the complex input linkages between countries. This is usually tackled by using world input-output (IO) tables, which show countries' production in different sectors, as well as how much of it is sold as intermediate inputs (domestically and abroad) versus final goods and services (again at home and abroad). In addition, IO tables show countries' value-added for all sectors — ie payments to inputs like labour, capital services, and profits.[5] Mathematical manipulations of IO tables can then help to trace out all direct and indirect production linkages, both across international borders and within domestic economies.

We compute a standard measure of countries' backward plus forward linkages (BFL) as a measure of GVC integration. More specifically, the BFL measure captures the extent to which (i) a country's exports rely on the value added of other countries, and (ii) its own value added is used in other countries' exports. Thinking back to the iPhone example, Korea's value added embodied in China's exports of iPhones is a backward linkage for China. US exports of iPhones containing Chinese value added are a forward linkage for China.

The BFL measure reflects the sum of all these linkages across economic activities and trade partners for a given country. As such, this measure provides a comprehensive view of countries' integration into GVCs, both as a user of foreign inputs, and a supplier of inputs used in other countries' exports.[6]

In practice, several measures of GVC integration exist, with some conceptual similarities. Box 1 includes a non-technical overview of the BFL measure and three additional indicators used in the literature. At the country level, all GVC measures are highly correlated with one another. Thus, while overall magnitudes differ across indicators, consistent broad trends and rankings are present irrespective of the indicator used.

2.3: GVC linkages among major economies

In the following, we illustrate some features of the GVC landscape using the backward and forward linkages, firstly between countries, and then by broadly defined sectors.

GVCs centre around key hubs and regional trading blocs

Chart 2 depicts backward linkages in the year 2015 for all G7 members plus China and Korea — all key players in terms of their importance for GVC networks — broken down by trade partner.[7] Recall that backward linkages capture the foreign value added in a country's exports. In the chart, the row country is the exporter and the column country is the source of the value added. Thus, for example, the red-shaded cell in the row for Canada (CAN) and the column for the United States (USA) means that 10% of Canada's gross exports in 2015 were made up of

3 This accumulation of value added at each production stage being reflected in gross trade statistics is termed 'double-counting' in the international trade literature. For further discussion, see Miroudot and Ye (2020).
4 In reality it is very challenging to get down to the individual product level, but we can develop a good understanding of GVC trade at a fairly disaggregated sectoral level.
5 Key sources for IO data are the OECD Inter-Country Input-Output (ICIO) tables, the World Input-Output Database (WIOD), and UNCTAD's EORA database.
6 BFL are also widely used measures by a range of international organisations — such as the OECD, World Bank, World Trade Organisation (WTO), UNCTAD, and others.
7 Baldwin and Freeman (2020a,b) use similar figures to illustrate the patterns of GVC linkages, but on the basis of a different value chain integration measure — 'total foreign reliance' (see Box 1).

US value added. The colouring scheme is a heat map, where the green values indicate smaller shares, orange values indicate moderate shares, and red values indicate high shares.

Two key messages emerge. First, the share of Chinese and US value added in all nations' exports is relatively large. This can be seen from the predominantly orange columns for China and the US, respectively. Second, backward linkages tend to be quite strong among nearby trade partners, as seen by the fact that the cells inside the regional boxes are predominantly orange and red. For example, German value added is a large share of other European countries' exports.

Chart 3, similarly, shows countries' forward linkages by trade partner. Forward linkages are defined as the domestic value added of the row country exported by the column country, relative to the row country's gross exports. Thus, for example, the red-shaded cell in the row for Canada (CAN) and the column for the United States (USA) means that, in 2015, Canadian value added contained in US exports amounted to 6.7% of Canada's gross exports. **Chart 3** employs the same heat-map colouring scheme as **Chart 2**.

Chart 2 demonstrated that China and the US are major sources of value added used by other countries. **Chart 3** shows that they are also major users of value added generated by other countries. Together, the two charts highlight that the US and China are central to the global network of GVC linkages, with Germany playing a central role within Europe. **Chart 3** further confirms the strong regional pattern in these linkages: like backward linkages, forward linkages between regional partners are higher than across regions, as indicated by the orange and red cells inside the boxes for North America, Europe, and Asia.

Chart 2: Backward linkages: value added of column country embodied in row-country's exports (per cent, 2015)

		North America		Europe				Asia		
		USA	CAN	DEU	GBR	FRA	ITA	CHN	JPN	KOR
North America	USA		1.5	0.5	0.3	0.2	0.2	1.8	0.5	0.3
	CAN	10.0		0.6	0.5	0.3	0.2	2.0	0.5	0.3
Europe	DEU	1.9	0.2		1.3	1.5	1.0	1.6	0.5	0.2
	GBR	2.1	0.4	1.8		1.1	0.6	1.2	0.4	0.2
	FRA	2.3	0.3	3.3	1.5		1.2	1.4	0.4	0.2
	ITA	1.4	0.1	2.9	1.0	1.8		1.7	0.3	0.3
Asia	CHN	1.9	0.3	0.8	0.3	0.3	0.2		1.5	1.9
	JPN	1.5	0.2	0.5	0.3	0.2	0.1	2.5		0.5
	KOR	3.4	0.3	1.4	0.7	0.5	0.3	7.0	2.9	

Chart 3: Forward linkages: value added of row country embodied in column-country's exports (per cent, 2015)

		North America		Europe				Asia		
		USA	CAN	DEU	GBR	FRA	ITA	CHN	JPN	KOR
North America	USA		2.2	1.2	0.7	0.8	0.4	2.0	0.6	1.0
	CAN	6.7		0.5	0.5	0.4	0.2	1.3	0.3	0.4
Europe	DEU	0.8	0.2		1.0	1.7	1.2	1.3	0.3	0.7
	GBR	1.0	0.3	2.4		1.4	0.7	0.8	0.3	0.6
	FRA	0.6	0.2	3.0	1.1		1.4	1.0	0.2	0.5
	ITA	0.7	0.2	2.6	0.7	1.6		0.9	0.2	0.4
Asia	CHN	1.6	0.4	1.0	0.4	0.4	0.4		0.8	2.0
	JPN	1.4	0.3	0.9	0.4	0.4	0.2	4.6		2.4
	KOR	0.9	0.2	0.5	0.2	0.2	0.2	6.7	0.6	

Notes: All values are relative to row-country's total gross exports. Country abbreviations follows standard alpha-3 ISO codes.

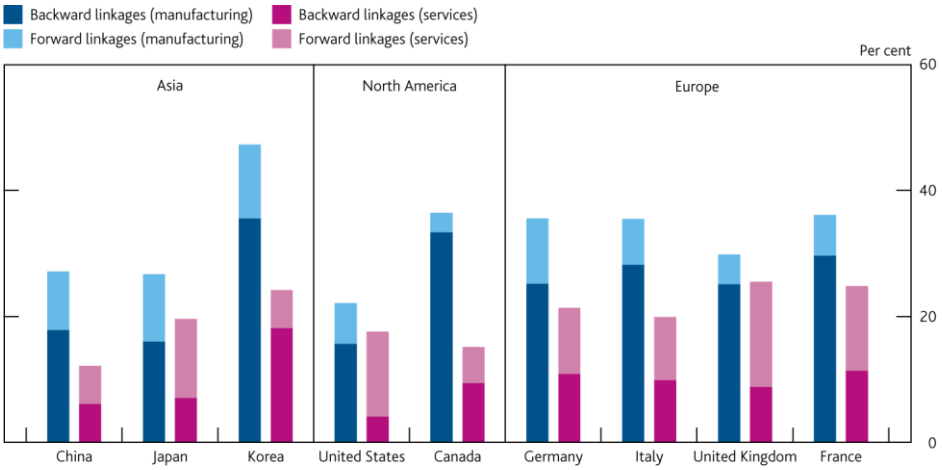
Source: Bank calculations based on OECD ICIO tables.

Manufacturing sectors exhibit the highest level of GVC integration

Manufacturing-sector value chains appear to be more internationally integrated than service-sector value chains. This can be seen in **Chart 4**, which presents total forward and backward linkages with the rest of the world for each of the G7 countries plus China and Korea, broken down by manufacturing and services activities. Across the board, the chart shows that manufacturing GVC integration exceeds services GVC integration. This is not surprising, as it is generally acknowledged that manufacturing production involves longer value chains (Antràs and Chor (2018)). This implies that there is more scope for the fragmentation of production across borders in manufacturing than there is in services.

In line with this, it is noteworthy that manufacturing sectors tend to have stronger backward linkages than forward linkages, while the reverse is true for services sectors. This suggests that services are relatively more likely to be used as an input towards other countries' exports, while manufacturing exports are relatively more likely to themselves be comprised of other countries inputs.

Chart 4: Backward and forward linkages, 2015 (manufacturing versus services)



Source: Bank calculations based on OECD ICIO tables.

2.4: Determinants of GVC integration

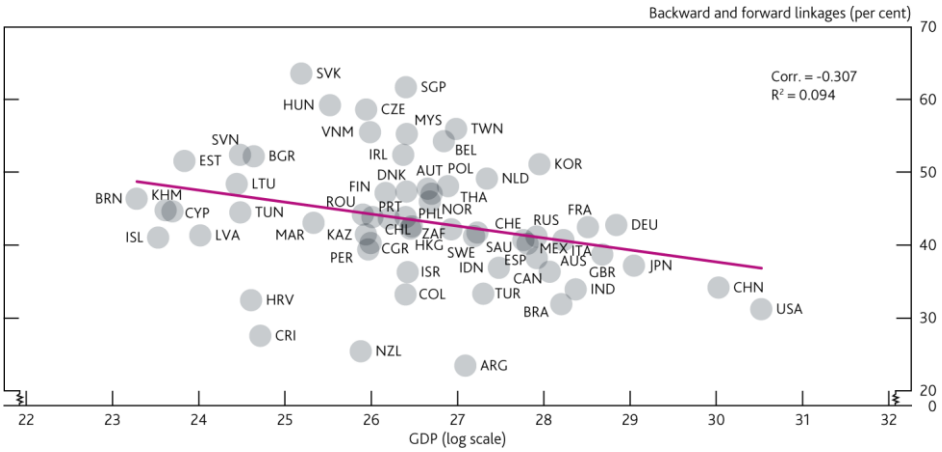
Countries' size and production composition matter

We now aggregate our measure of backward and forward linkages into a single country-level figure, capturing the sum of a country's total backward and forward linkages with the rest of the world for all sectors. We then correlate this measure of GVC integration with different country characteristics to tease out some of the key determinants of a country's degree of integration into GVCs.[8]

Chart 5 shows that countries that have larger markets tend to look less integrated into GVCs in the aggregate. Again, this is not surprising: GVC integration ultimately depends on the split of a country's spending between domestic and foreign goods. It is a well-known feature of international trade data that larger countries tend to spend more on domestic goods as a share of their overall incomes — this is related to the 'gravity equation' of international trade.[9] This feature of the data makes them look less integrated into GVCs.

Chart 6 shows that countries whose output is skewed towards manufacturing goods look more integrated into GVCs. This observation squares with the sectoral evidence in Section 2.3, that manufacturing production is more fragmented across international borders. Correspondingly, more manufacturing-oriented economies tend to be more integrated into GVCs.

Chart 5: Smaller countries are more integrated into GVCs

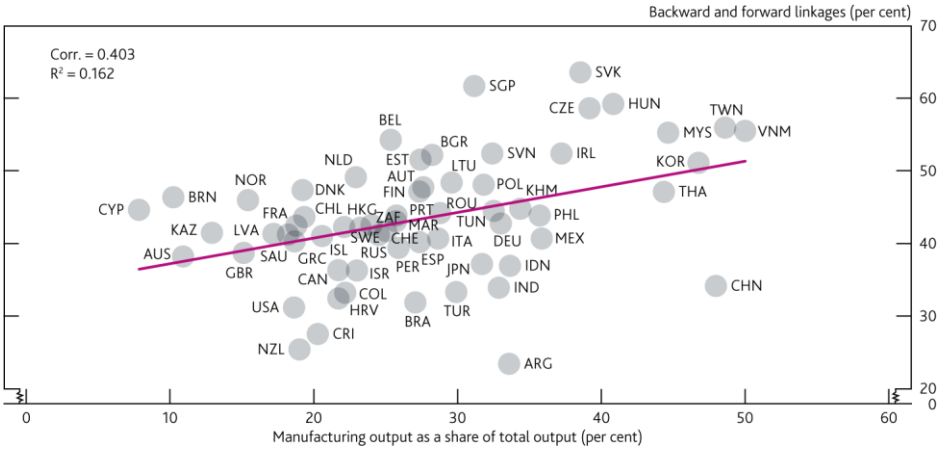


Notes: Data for year 2015. Charts exclude Luxembourg, Malta, and the Rest of world aggregate and cover 62 countries.

Source: Bank calculations based on OECD ICIO tables and CEPII.

8 These determinants are discussed in ample work on GVCs. See World Bank (2020) for an overview, as well as Johnson and Noguera (2017).
9 See, for example, Anderson and Van Wincoop (2003).

Chart 6: Manufacturing-oriented countries are more integrated into GVCs



Notes: Data for year 2015. Charts exclude Luxembourg, Malta, and the Rest of world aggregate and cover 62 countries.

Source: Bank calculations based on OECD ICIO tables.

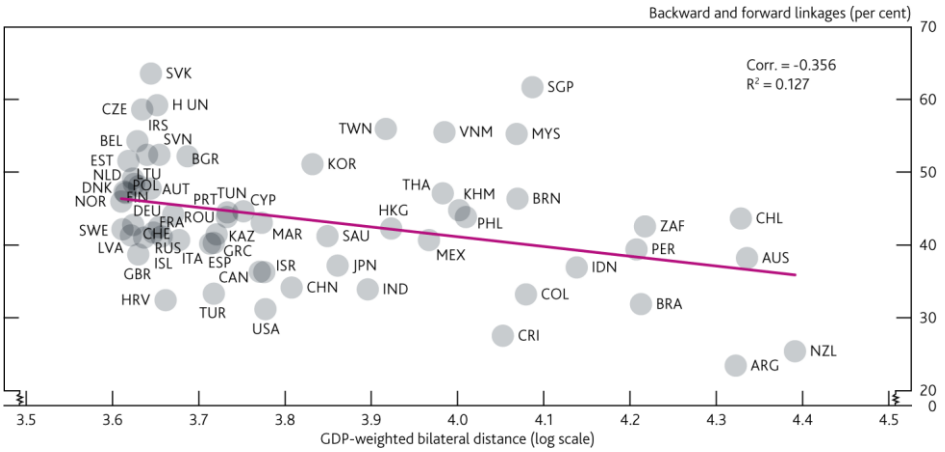
Low trade barriers facilitate GVC integration

In addition to country size and production composition, trade barriers influence the extent of a country's integration into GVCs. This is true both for natural barriers to trade, such as geography, and for policy barriers to trade, such as tariffs and other government restrictions on economic transactions across borders.

Chart 7 uses countries' weighted geographic distance from other economies as a proxy for natural barriers to trade. It shows that countries that are geographically close to their export partners tend to be more integrated into GVCs. This squares with the earlier findings that GVCs are largely regionalised. A range of possibilities could explain this phenomenon. For example, proximity plays a crucial role for just-in-time delivery, especially for goods that cross borders more than once (Pisch (2020)). This notion is echoed by Conconi *et al* (2020), who suggest that trade in inputs is more sensitive to distance than is final goods trade, as sourcing inputs from nearby partners helps with overall co-ordination and production monitoring along GVCs.

Chart 8 uses the share of global economic activity into which a country is tied by means of an FTA as a proxy for policy barriers to trade. It is widely accepted that FTAs promote bilateral trade (see Baier and Bergstrand (2007); Baier *et al* (2014); as well as Limão (2016) for a review). In the chart, countries that have FTAs with a larger share of the global economy face fewer policy barriers to trade. As can be seen, these countries have higher levels of GVC integration.

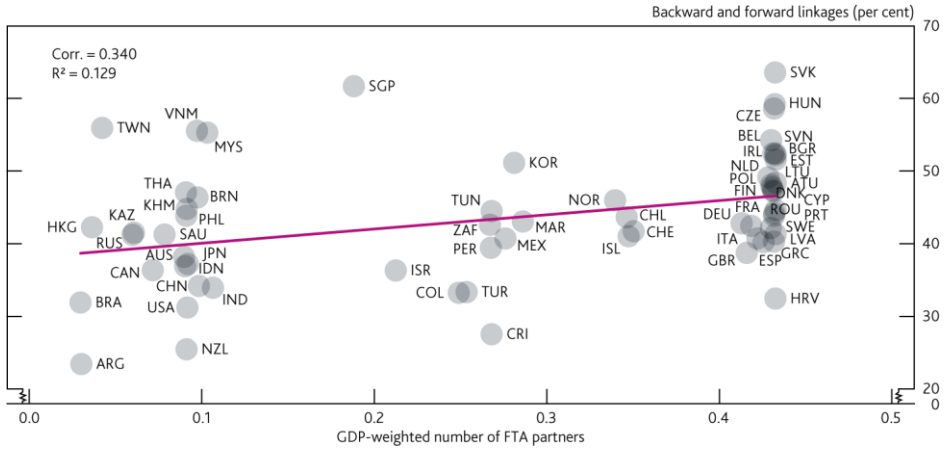
Chart 7: Nearby trading partners are more integrated into GVC



Notes: Data for year 2015. The X-axis plots the bilateral distance between a country and all export partners, weighted by the partners' share in world GDP. Charts exclude Luxembourg, Malta, and the Rest of world aggregate and cover 62 countries.

Source: Bank calculations based on OECD ICIO tables and CEPII.

Chart 8: Countries with many FTA partners are more integrated into GVCs



Notes: Data for year 2015. The X-axis plots the number of FTAs between a country and all export partners, weighted by the partners' share in world GDP. Charts exclude Luxembourg, Malta, and the Rest of world aggregate and cover 62 countries

Source: Bank calculations based on OECD ICIO tables and CEPII.

Importantly, there is also likely to be some interaction between countries' bilateral distance and the impact of FTAs on GVC trade. For example, Freeman and Pienknagura (2019) show that the marginal effect of a trade agreement is stronger for nearby trading partners, and that this works through the channel of intermediate goods trade in particular. These effects are strengthened when controlling for the depth of trade agreements, which is an important defining feature of modern trade agreements amongst nearby countries.

The dimension of GVC integration that is affected by trade policy decisions will be the focus of the next section, where we look at the theoretical relationship between openness, productivity and volatility.

Box 1
Comparing empirical measures of GVC integration

Here, we describe four common measures of GVC integration which are computed from input-output tables.

Domestic input share (DIS)

Perhaps the most straightforward measure of GVC integration is a country's domestic input share. This measures the proportion of a country's inputs that are sourced domestically. It is an inverse measure of GVC integration: a lower DIS implies a higher level of integration. In many standard trade models, the DIS is a sufficient statistic for the economic impact of trade openness (eg Arkolakis *et al* (2012); Costinot and Rodríguez-Clare (2014)). Importantly, the DIS reflects only directly observed trade links.

Backward and forward linkages (BFL)

Backward GVC linkages refer to the foreign value-added content of a country's exports. Otherwise put, this indicator answers the question: what share of a country's exports is made up of foreign value added? Forward linkages, on the other hand, show the share of a country's domestic value added that is exported by third countries. The sum of the two, for a given country, paint a picture of their overall integration into GVCs, with a higher value indicating higher integration. Measuring GVCs through backward and forward linkages was first proposed by Hummels *et al* (2001), and Koopman *et al* (2010) show that they are appropriately seen in combination with each other for a full view of the participation of countries in GVCs.

Value added to gross export (VAX) ratio

The VAX ratio, proposed by Johnson and Noguera (2012), is computed in two steps. First, it tracks how much value added from one country is absorbed in another via direct and indirect trade linkages. Then it divides this value by the gross exports from the first country to the second. Thus, a smaller VAX ratio means that less value added is conveyed between the two countries for a given dollar of gross exports — suggesting that intermediate goods make up a larger portion of trade between them. Hence, the VAX ratio is an inverse measure of GVC integration: a lower VAX ratio implies a higher level of integration.

Total foreign reliance (TFR)

A country's total foreign reliance, used recently by Baldwin and Freeman (2020a,b), is the share of a country's gross output that relies on foreign inputs, both directly and indirectly. This 'gross-output measure' differs conceptually from the others, capturing the share of a country's total production (to be consumed domestically or exported) that relies on imports, instead of the share of gross exports. This measure can also be seen as the foreign component of what Miller and Temurshoev (2017) and Antràs and Chor (2018) refer to as 'Downstreamness' to measure a country's *position* in GVCs (rather than their integration per se).

How do these GVC indicators compare to backward and forward linkages (BFL)?

While there are conceptual differences at the country level, these measures of GVC integration are highly correlated with one another in the expected direction, as shown in **Table 1**. This suggests that, although these measures view GVC integration through different lenses, their variation captures the same underlying differences in country characteristics that promote or obstruct integration into GVCs.

Table 1: Correlation between key GVC integration measures in logs, 2005–15 average

	BFL	VAX	DIS	TFR
BFL	1.000			
VAX	-0.791	1.000		
DIS	-0.727	0.887	1.000	
TFR	0.790	-0.901	-0.853	1.000

Notes: GVC integration measures computed based on underlying data from OECD ICIO Tables. (N = 65).

3 GVC integration, productivity and volatility in a theoretical model

We explore the theoretical underpinnings of the relationship between a country's barriers to trade, and the level and volatility of income, to answer the underlying question of whether trade openness is a double-edged sword. To do so, we set up a structural model in which barriers to input trade are inversely related to the degree of GVC integration — ie lower barriers to input trade imply greater trade openness and more GVC integration.

The benchmark model comprises two fully symmetric countries, labelled 'Home' and 'Foreign'. Building on the setup in, for example, Cole and Obstfeld (1991) and Corsetti *et al* (2008), each country produces a specialised output.

Households in each country consume both goods, such that there is trade in final goods, albeit with some 'home bias' for goods produced domestically. Throughout, we assume that final goods from different countries are somewhat substitutable, such that the relative consumption of domestic and imported final goods is responsive to changes in their relative price.

In addition to final goods trade, we introduce intermediate inputs trade into our model to reflect GVC trade. This means that firms also sell their output to firms, domestically and abroad, for use as an intermediate input in production.[10] There is a model parameter guiding the extent to which firms substitute between Home and Foreign inputs, which we vary in our subsequent experiments. We label this parameter the 'elasticity of intermediates trade'. As with final goods trade, we assume a degree of 'home bias' for intermediate inputs sourced domestically.

Within each country, these individual intermediate inputs are bundled into an aggregate intermediate input. This is then combined with labour, supplied by domestic households, to produce the country-specific output. This means that labour is the only source of value added in each country. Labour and intermediate inputs are themselves somewhat substitutable in the production process.

3.1: Transmission of shocks in the presence of intermediate input trade

Before turning to the question of the double-edged sword, we first explain how the introduction of trade in intermediate inputs affects the transmission of shocks. Suppose, for instance, the Home country faces a positive productivity shock that boosts its supply capacity.[11] The greater abundance of Home goods will reduce their price relative to the price of Foreign goods. Home output — both intermediate inputs and final goods — can now, in effect, be enjoyed more cheaply.

In the market for final goods, since Home and Foreign goods are somewhat substitutable, demand from households in both countries shifts towards the relatively cheaper Home good. We call this the *relative-price effect*.

For intermediate inputs trade, there are two effects. On the one hand, the *relative-price effect* will also be operative here. The decrease in the relative price of Home output will make it relatively cheaper for both Home and Foreign firms to use Home intermediate inputs. The contrasting increase in the relative price of Foreign inputs will suppress demand for the relatively more expensive Foreign intermediate inputs from both countries. On the other hand, for Home firms, there will also be a *marginal-productivity effect* arising from the direct effect of the shock.

10 The assumption that firms are using some of their own output as an intermediate input is referred to as 'round-about production', and is a common way of modelling value chains when there is a single firm (see, eg, Baxter (1995)).

11 Here, we focus on a domestic shock and discuss its spillovers to the foreign country. Since the model is symmetric, the discussion can be equally interpreted as spillovers to the domestic country from a foreign shock.

The higher total factor productivity in the Home country leads to an increase in Home firms' demand for all their factor inputs, including Foreign intermediates.

Within our model, the elasticity of intermediates trade is an important factor influencing the size of these two effects, because it essentially determines the size of the relative-price effect.[12]

When the elasticity is high — meaning when domestic and imported inputs are highly substitutable — the relative-price effect is large: for a given change in the relative price, demand switches more strongly towards the cheaper input. The composition of Home firms' demand for intermediates will tilt towards the relatively cheaper Home-produced inputs. Home firms will also increase their demand for Foreign inputs, owing to the marginal-productivity effect, but this effect is relatively small when inputs are substitutable. Consequently, Home firms' overall use of intermediates increases, driven by increased use of the more abundant domestic inputs, and Home GDP rises.

At lower elasticities, when domestic and imported inputs are more complementary, the extent to which Home firms' demand will tilt towards the relatively cheaper Home inputs will diminish. This dampens the Home GDP boom following a positive Home productivity shock. Compared to the high-elasticity case, Home demand for Home intermediates increases by less when the elasticity is low. Instead, owing to the marginal-productivity effect and the complementarity of domestic and imported inputs in production, Home firms increase their demand for Foreign inputs to use alongside Home inputs. Although Home firms still use more intermediates overall, this increase is smaller than the high-elasticity case, and hence the rise in Home GDP is smaller. As a result, Home GDP volatility is larger when the elasticity of intermediates trade is higher.

3.2: GVC integration in the model

Since our model incorporates intermediate inputs, we can map the degree of model-implied GVC integration to the empirical BFL measure used in Section 2. Three key model factors guide the degree of GVC integration.

First, GVC integration is increasing in the intermediate-input share. The intermediate-input share — one minus the value-added share — measures the overall importance of supply chains, whether domestic or cross-border, in production. As the intermediate-input share increases, production becomes less reliant on domestic value added and more reliant on the aggregate intermediate input. This, in turn, raises the degree of GVC integration.[13] This echoes the empirical finding in **Chart 5**, since the intermediate-input share is typically higher in manufacturing sectors compared to services.

Second, GVC integration is declining in the degree of home bias in intermediate inputs. For a given level of the aggregate intermediate input, the home bias determines how much of this is sourced domestically, rather than imported. By decreasing a country's use of imported intermediate inputs, an increase in this home bias is associated with a decline in GVC integration.

Third, and most important, GVC integration depends on trade policy, which we capture by introducing a trade cost on imports of foreign intermediate inputs.[14] A high trade cost discourages use of imported inputs in favour of domestic inputs, and hence lowers GVC integration. Again, this echoes the empirical results in **Charts 7** and **8**, since the trade cost captures both innate barriers to trade, such as distance, and trade policy, such as FTAs.

Although these trade costs can reflect a range of factors, in the subsequent experiments we interpret them as a policy instrument. We will focus on the effect of changing the intermediate input trade cost, referring to this interchangeably as changing the 'degree of openness' or the 'degree of GVC integration'.[15]

12 The elasticity of trade is widely recognised as a key parameter that can influence the overall gains from trade (Arkolakis *et al* (2012)).
13 Note that this feature of the model would apply to any sources of domestic value added, not only labour but also tangible and intangible capital, and so does not speak to the relationship between trade integration and the labour share.
14 To focus attention on intermediate inputs trade, motivated by our stylised facts from Section 2, we do not introduce a trade cost on final goods in our experiments.
15 Throughout, we will consider symmetric changes in the trade costs on the imports of intermediate inputs in both countries.

3.3: Openness and the double-edged sword

We now turn to the central question of this section: is openness a double-edged sword? We do this by considering the effect of increasing the intermediate input trade cost on both the long-run level of productivity and the volatility of GDP in our model.

Level of productivity

To assess the link between openness and the *level* of productivity, we compare the long-run (steady state) level of domestic GDP per hour worked — a measure of overall productivity — at different intermediate trade costs. Results are presented in **Chart 9**. As trade costs increase, and the degree of openness falls, the level of productivity declines. This is the case for both high and low levels of the elasticity of intermediate inputs.

Trade costs have this effect on productivity because they limit the extent to which intermediate goods are efficiently allocated to production across countries. By making imported intermediate inputs more expensive, trade costs prevent domestic firms from sourcing intermediate goods as they would otherwise. Unable to completely substitute these goods with either additional labour or domestic intermediates, firms produce less.

The elasticity of intermediates trade does not alter the qualitative link between openness and productivity, but it does influence its magnitude. At higher elasticities, firms are able to substitute between domestic and imported inputs more readily, limiting the extent to which productivity falls in response to trade costs.

Volatility of GDP

Although the relationship between trade openness and the *level* of economic activity is widely thought to be positive, the relationship between openness and the *volatility* of economic activity is less clear-cut. Our own model reflects this ambiguity, yielding both positive and negative relationships between GVC integration and GDP volatility, depending on the parameterisation.

To demonstrate this, we analyse the volatility of Home GDP implied at different levels of intermediate input trade costs. We focus on a case where the two countries face independent and uncorrelated shocks to their productivity, of equal variance.[16] **Chart 10** plots the model-implied Home GDP volatility against intermediate trade costs, at high and low levels of the elasticity of intermediates trade. As described in Section 3.1, aggregate volatility is larger at the higher elasticity, regardless of the trade cost. However, more importantly, the slope of the line with respect to the trade cost has the opposite sign depending on the elasticity.

Chart 9: Higher intermediate trade costs are associated with a lower level of productivity

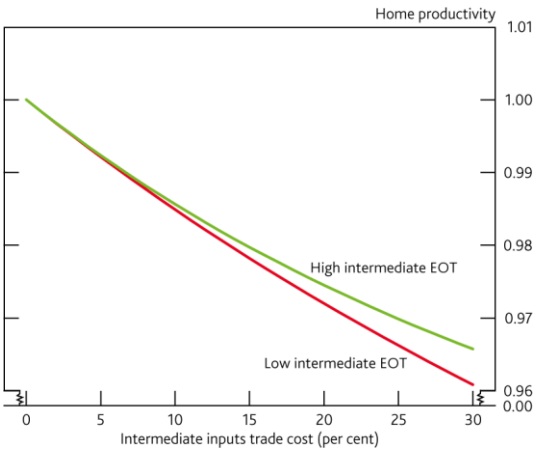
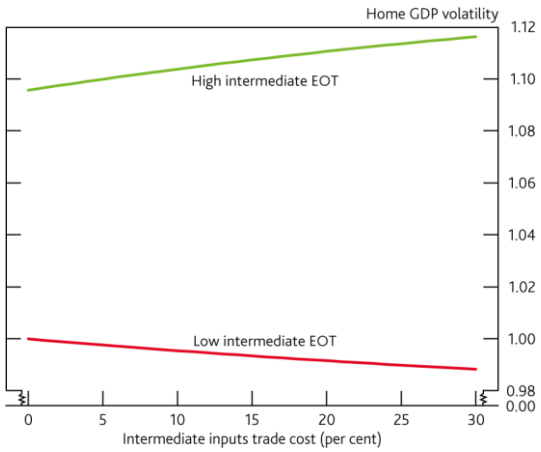


Chart 10: Relationship between intermediate trade costs and GDP volatility can go either way



Notes: **Left-hand chart**: Steady-state level of Home GDP, holding hours worked constant, at different intermediate trade costs. **Right-hand chart**: Volatility of Home GDP at different intermediate trade costs. **Both charts**: Use symmetric two-country model, where trade costs are the same in both countries and countries are subject to uncorrelated productivity shocks of equal variance. 'Intermediate EOT' is the elasticity of intermediate input trade. Intercept normalised to 1 for low-intermediate-EOT case. In left-hand chart, EOT does not affect the steady-state level of productivity in the absence of trade costs.

16 Given the focus on trade in intermediate inputs to production, it is natural to consider productivity shocks. With consumption-preference shocks, proxying demand factors, barriers to trade in intermediates raise volatility; there is no double-edged sword with preference shocks. Instead, in that case, barriers to trade in final consumption goods have an ambiguous volatility effect, depending on the elasticity of trade in final goods.

By making imports more costly, intermediate input trade costs amplify the relative-price effect for Home firms in response to a positive domestic shock. For a given change in the relative price, they are more willing to tilt their demand towards relatively cheaper Home inputs, given that Foreign inputs imply an additional cost. At the high elasticity, when this relative-price effect is more important, and acts to amplify the response of Home GDP, trade costs therefore further amplify Home GDP volatility.

Trade costs also mute the marginal-productivity effect for Home firms in response to a positive domestic shock. Despite the rise in the productivity of all their factor inputs, they are less inclined to increase their use of the Foreign inputs, because of the additional cost associated with doing so. At the low elasticity, where this effect is relatively more important, and acts to dampen the response of Home GDP, this means that the domestic effect of the shock is attenuated in the presence of trade costs, and the effect on overall volatility is negative.

Taken together, these qualitative results highlight that trade openness need not be a double-edged sword. At a low elasticity of intermediates trade, openness is associated with higher volatility. But, at a high elasticity, the relationship is reversed.[17]

Quantifying the double-edged sword

In addition to this qualitative ambiguity, our model indicates that, where the double-edged sword does exist, the quantitative costs of openness in terms of volatility are small in comparison to the gains in productivity.

To see this, **Table A** presents the range within which Home GDP varies 95% of the time.[18] These are symmetric ranges, in percentages, around the steady-state level, which is normalised to 100 when trade costs are zero. As steady-state productivity declines with higher trade costs, the central point of the range falls. As the volatility of GDP rises or falls, depending on the parameterisation, the size of the range around this central point rises or falls. Hence, the double-edged sword would be seen as a decline in the central point and a narrowing of the size of the range, as trade costs increase.[19]

Panel A shows the benchmark results. Absent trade costs, Home GDP varies within a range of 100 ± 11.65% at the low elasticity, and ± 12.2% at the higher elasticity. As trade costs increase, the level of GDP falls and so the centre of each range declines, by 3 or 4pp with a 30% trade cost. At the high elasticity, this is accompanied by a slight widening of the range, of 0.1pp, as the volatility of GDP is increasing with the trade cost.

At the low elasticity, where the double-edged sword exists in our model, the range narrows somewhat. However, the size of this effect is comparatively small. A 30% trade cost is associated with a range for Home GDP of ± 11.55%, only 0.1pp below the range with zero trade costs. The overall level of foregone income, at 4pp, is large in comparison. In other words, the double-edged sword is not particularly ‘sharp’: openness increases the level of economic activity at a very small cost in terms of volatility.

3.4: The double-edged sword in the presence of additional mechanisms for openness

Our benchmark model has yielded two key results. First, openness need not be a double-edged sword. Second, where it does exist, the double-edged sword is not particularly ‘sharp’.

We now demonstrate the robustness of these conclusions when accounting for other factors that are cited as particular concerns in the debate around openness.

17 There is a wide degree of uncertainty around empirical estimates of the general elasticity of trade (see, eg, Feenstra *et al* (2018)). This uncertainty stems from a range of sources, including country differences, sectoral variation and estimation challenges. Moreover, there is even greater uncertainty around the elasticity of trade for *intermediate inputs* specifically, where there is limited empirical evidence due to data constraints. Our ‘high’ and ‘low’ elasticities fall within the range of existing elasticity estimates, so the ambiguity we emphasise in the openness-volatility link can be interpreted as within realistic bounds.

18 As noted under Chart 9, our steady-state comparisons hold hours work fixed, so it is equivalent to talk about steady-state GDP and productivity.

19 In **Table A**, country-specific productivity shocks are assumed to have a standard deviation of 5% per quarter. These numbers are illustrative, but can be interpreted as an upper bound for the effects of trade costs on macroeconomic volatility, since 5% is over double estimates in the literature (eg Benigno and Thoenissen (2008); Küçük and Sutherland (2015)).

Table A: Ranges within which Home GDP can vary 95% of the time at different trade costs

	Trade costs		
	0%	**15%**	**30%**
A. Benchmark			
Low EOT	100 ± 11.65%	98 ± 11.60%	96 ± 11.55%
High EOT	100 ± 12.20%	98 ± 12.25%	97 ± 12.30%
B. Positive cross-border shock correlation			
Low EOT	100 ± 11.40%	98 ± 11.30%	96 ± 11.25%
High EOT	100 ± 11.55%	98 ± 11.45%	97 ± 11.40%
C. More specialisation in production			
Low EOT	100 ± 12.30%	98 ± 12.25%	96 ± 12.25%
High EOT	100 ± 12.70%	98 ± 12.75%	97 ± 12.80%
D. Small economy			
Low EOT	100 ± 11.95%	97 ± 11.90%	94 ± 11.90%
High EOT	100 ± 13.15%	96 ± 13.15%	94 ± 13.15%

Notes: Symmetric ranges around the steady-state level of Home GDP, normalised to 100 when trade costs are zero. The ranges are in percentage terms relative to the central point, rounded to the nearest 5 bps. Ranges have been calculated assuming that the productivity shock in both countries have a standard deviation of 5% per quarter. 'EOT' is the elasticity of intermediate input trade.

Cross-border shock correlation

So far, we have assumed that the sources of volatility across countries are uncorrelated. We have shown that, in this setting, trade can transmit the effects of a shock in one country to another, in a way that may give rise to 'trade co-movement' (Kose and Yi (2006); di Giovanni and Levchenko (2010); Johnson (2014)). We now explore how our conclusions are affected if we assume that Home and Foreign productivity shocks are positively correlated, for reasons unrelated to trade.

Panel B of **Table A** reports results from experiments with positively correlated Home and Foreign shocks. A positive Home productivity shock now leads to more muted relative-price movements, since Foreign output also becomes more abundant. Hence, the relative-price effect is dampened, regardless of the elasticity or trade cost. This has two effects. First, it lowers volatility in both the low- and high-elasticity cases. At zero trade costs, the ranges shrink from ± 11.65% to ± 11.4% and from ± 12.2% to ± 11.55%, respectively.

Second, the muted relative-price effect causes the double-edged sword to emerge even in the high-elasticity case. Nonetheless, the costs of the associated volatility remain small. A 30% trade cost lowers the range for Home GDP to ± 11.25% with low elasticity and ± 11.4% with high elasticity, both 0.15pp reductions. The central point still declines by around 3 or 4pp in both cases.

Specialisation in production

As described in Section 2, GVC integration is linked to increased specialisation in production across borders, and indeed this is often cited as one of the sources of productivity gains from openness. However, specialisation may create additional volatility, by increasing a country's exposure to sector-specific shocks (Newbery and Stiglitz (1984)). Although our model does not allow for a sectoral exploration of specialisation, we can proxy this mechanism by limiting the extent to which labour supply adjusts to shocks. The smaller this adjustment, the more specialised is production, since the key domestic factor input is less flexible.

The results are in Panel C of **Table A**. Our model indicates that greater specialisation is associated with a higher overall level of volatility: even at zero trade costs, the 95% bands increase to ± 12.3% and ± 12.8% in the low- and high-elasticity cases, respectively. The double-edged sword continues to arise only in the low-elasticity case, and is again quantitatively small, with the 30% trade cost narrowing the range by 0.05pp to ± 12.25%.

It is important to note that, while our model is consistent with the idea that specialisation increases overall volatility, our results do not speak to whether increased openness raises volatility through this channel. If anything, recent academic work would suggest the opposite. For instance, Caselli *et al* (2020) quantitatively investigate

whether trade openness increases volatility, via specialisation, or reduces it, via diversification. They find that the latter effect has dominated for most countries, and increased trade openness since the 1970s has reduced income volatility.

Small-open economies

It is well known that small-open economies tend to be more reliant on foreign goods for production and consumption. In this case, concerns around the double-edged sword might be more acute. To address this, Panel D of **Table A** presents results from an experiment where the Home country is a small fraction of the world, trading with a large Foreign country.

Here, both sides of the double-edged sword can 'sharpen'. Smaller economies face higher overall volatility, but also face a large reduction in the level of GDP when trade costs increase. In fact, the 30% trade cost is now associated with over 6pp decline in GDP. On the other hand, the double-edged sword continues to arise only with the low elasticity, and is again very small, with the 30% trade cost narrowing the range from ± 11.95% to ± 11.9%.

In sum, these three robustness exercises support the two key conclusions from our benchmark model. First, the link between openness and volatility is ambiguous, and depends on structural features of the economy. Second, where the double-edged sword does exist, the quantitative effects of higher volatility are small in relation to the foregone productivity. Ultimately though, the relationship between GVC integration and the level and volatility of income is an empirical question, and one to which we now turn.[20]

20 One factor we do not consider is the extensive margin of trade: firm entry or exit in export markets. Ghironi and Melitz (2005) show that the extensive margin, in particular the number of exporting firms, has important consequences for the business-cycle fluctuations of macroeconomic variables in open economies. Although this may have implications for the link between openness and volatility, incorporating trade in intermediate inputs into that framework is outside the scope of this paper, and we leave this for future research.

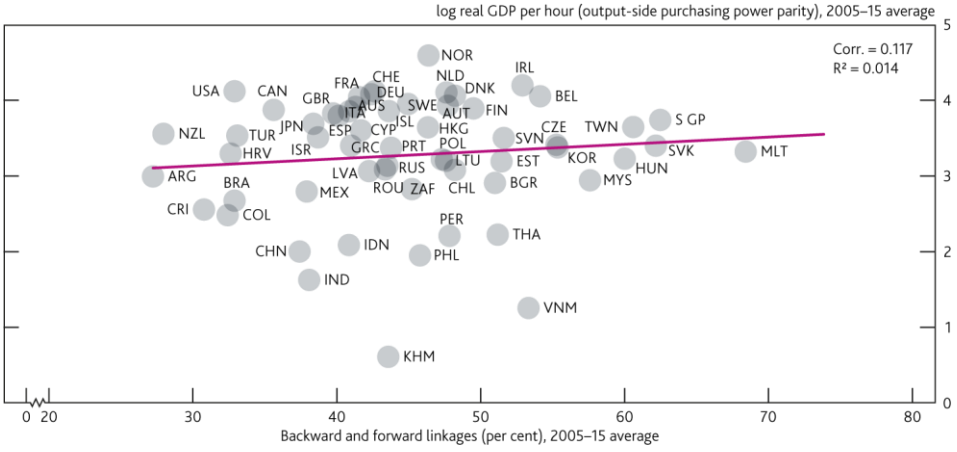
4 Empirical evidence on the effect of GVCs on productivity and volatility

Our modelling suggests that greater openness to trade in intermediate inputs raises countries' productivity in the long run, but has an ambiguous and small effect on economic volatility. In this section, we document that these predictions appear consistent with the data. We do so by considering evidence on differences in the economic outcomes of countries with different degrees of GVC integration, using the measures described in Section 2, at the aggregate and sector levels.

4.1: Correlations at the country level

Chart 11 correlates a measure of aggregate productivity — real GDP per hour worked — with our preferred measure of GVC integration — the sum of a country's backward and forward linkages — for 59 countries.[21] Both measures are averaged over the 2005–15 period, to abstract from business cycle dynamics and fit with the long-run analysis in the model. The chart shows that there is a positive correlation: countries which are more integrated into GVCs tend to have higher levels of productivity. Given the correlations noted in Box 1, this is true no matter which indicator of GVC integration we employ. However, GVC integration can at best account for a small portion of the productivity differences between countries observed in the data. This is reflected in the very low R^2 (at 0.014) of the line of best fit in **Chart 11**. This is not surprising: in practice, countries' productivity is determined by many other factors besides GVC integration.

Chart 11: Productivity and GVC integration



Source: Bank calculations based on OECD ICIO tables and PWT.

Table B illustrates this point. It shows that countries' real GDP per hour is also (strongly) correlated with capital stock per work hour and an index of their workforce skill — both well-known determinants of aggregate productivity. Moreover, countries with relatively high physical and human capital endowments also appear to be more integrated into GVCs. The fact that countries with a high degree of GVC integration tend to 'do well' along a range of other dimensions makes it difficult to isolate the true causal effect of openness on aggregate productivity.[22]

21 Our data covers the 36 OECD countries as well as a number of non-OECD countries, including the large economies of Argentina, Brazil, China, India, Indonesia and Russia.

22 This issue is central to a large research literature on the effects of trade openness on productivity and incomes. Studies have tried to overcome the problem either by relying on instruments and natural experiments (eg Frankel and Romer, 1999; Feyrer (2019)) or by interpreting the data through the lens of structural models in which key parameters are identified from external evidence (eg Eaton and Kortum (2002); Costinot and Rodríguez-Clare (2014)).

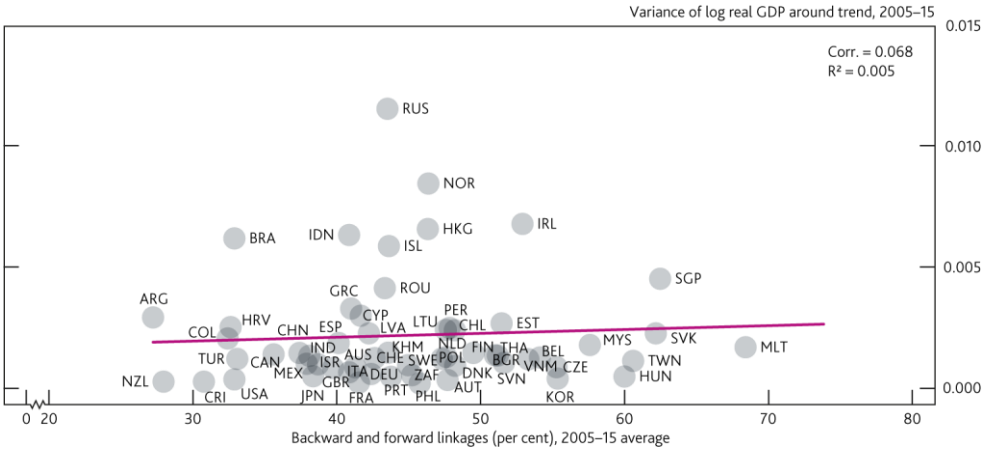
Table B: Correlation between macroeconomic indicators in logs, 2005-15 average

	GDP/hour	BFL	Capital/hour	Workforce skill
GDP/hour	1.000			
BFL	0.113	1.000		
Capital/hour	0.959***	0.161	1.000	
Workforce skill	0.779***	0.213*	0.728***	1.000

Source: Bank calculations based on OECD ICIO tables and PWT. (N = 59). *. **, and *** refer to statistical significance at the 10%, 5%, and 1% level, respectively.

Chart 12 correlates a measure of economic volatility with GVC integration for the same 59 countries. In line with the model, we define volatility as the average log deviation of a country's GDP from trend over the sample period. The chart shows a barely positive correlation between aggregate volatility and GVC integration, with an even lower R^2. This squares with the theoretical prediction that there is no clear relationship between trade integration and volatility. However, the evidence in **Chart 12** is subject to the same limitations as the evidence in **Chart 11**.

Chart 12: GDP volatility and GVC integration



Source: Bank calculations based on OECD ICIO tables and PWT.

4.2: Regressions at the sector level

Overall, macro-level correlations provide some support for the predictions of our model, but this evidence is indicative at best and cannot be interpreted causally. For stronger evidence on the impact of GVC integration on economic outcomes, we turn to sector-level data.

Sectors differ considerably in their reliance on intermediate inputs. In general, services sectors rely less on intermediate inputs than the rest of the economy, ie the goods-producing primary and manufacturing sectors. Even among goods-producing sectors the share of intermediate inputs in production can vary. For example, in US input-output data, the intermediate share for goods-producing sectors ranges from 30% ('Mining and quarrying of energy producing materials') to 77% ('Motor vehicles').[23] Using this variation, we can explore whether the effect of a country's integration into GVCs depends on the input-dependence of a given sector.

If there is a productivity effect from GVC integration, it should be most pronounced in highly input-dependent sectors. While any volatility effect should also be greater in magnitude if production is more input-intensive, theory suggests that the direction of the effect is ambiguous — so GVC integration may raise or lower volatility depending on other factors, and we would expect no clear effect either way 'on average'.

We exploit these observations for an empirical strategy that uses less input-dependent sectors as a 'control group' for the effects of a country's integration into GVCs. Specifically, we test whether a higher degree of GVC integration

23 To rank sectors by input dependence, we use US data throughout. This is because the US is likely to be the most frictionless economy in our sample, so its sectoral input use is most likely to be reflective of technological differences between sectors, rather than market distortions. However, this choice makes little practical difference as the ranking of sectors by input dependence is very strongly correlated across countries.

at the country level is associated with different economic outcomes in input-dependent sectors relative to their less input-dependent counterparts. One advantage of this approach is that it allows us to use fixed effects to control fully for structural differences between countries (such as capital stocks or workforce skills) and between sectors (such as the sector-specific nature of production technologies). This gets us closer to a causal interpretation of the effect of GVC integration, exploiting this identifying variation specifically in the data.

Columns (1) and (2) in **Table C** report the results of this empirical test when the outcome variable is sector-level productivity. In both columns we use sectors with an intermediate share below 40%, roughly corresponding to the bottom half of sectors in terms of input-dependence, as a control group for the effect on the more input-dependent sectors. In column (1) we include all sectors of the economy in our regression. Since service sectors are generally not very input-dependent, they make up a large portion of our control group in this regression. In column (2), we drop services and utilities from our regression and focus exclusively on goods-producing sectors. Now the control group is made up only of goods-producing sectors with a low dependence on inputs.

Table C: Differential impact of GVC integration on sectoral productivity and volatility

Sample:	**(1) All sectors**	**(2) Goods only**	**(3) All sectors**	**(4) Goods only**
Dep. variable:	**Log value added per hour in country-sector**		**Variance of country-sector log value added around linear trend**	
High sector input dependence × Country GVC integration	0.320**	0.565*	0.016	0.036
	(0.143)	(0.298)	(0.012)	(0.035)
R^2	0.82	0.81	0.30	0.31
Observations	1,448	756	1,512	788
Countries	45	45	48	48
Sectors	36	20	36	20
Control variables	Country fixed effects, sector fixed effects			

Notes: Standard errors in parentheses; * significant at 10% level; ** significant at 5% level. Productivity regressions use OECD STAN and WIOD SEA data for 45 countries. Volatility regressions use data for 48 countries. 'High' sector input dependence is defined as an input share larger than 40%. Country GVC integration is defined as the log sum of backward and forward linkages (see Section 2.2).

The positive coefficients on the interaction between high sectoral input-dependence and country-level GVC integration in both columns highlight that input-dependent sectors are more productive in countries that are highly integrated into GVCs. This is consistent with the idea that GVC integration raises productivity, and this effect is felt more strongly in more input-dependent sectors. This difference is statistically and economically significant, and does not hinge on the use of any particular measure of GVC integration.

To better understand the economic significance of the estimates, consider the example of Greece — a country in the bottom 25% of the distribution of GVC integration in our sample — and Estonia — a country in the top 25%. In 2015, the backward and forward linkages of Estonia were roughly 23% larger than those of Greece. The estimates in columns (1) and (2) imply that input-dependent sectors were between (0.320×23%=) 7% and (0.565×23%=) 13% more productive in Estonia as a result of the country's deeper GVC integration.

To study the other side of the double-edged sword, Columns (3) and (4) in **Table C** repeat the same exercise for sector-level volatility. The small and statistically insignificant coefficients suggest that the incomes generated in input-dependent sectors do not, on average, become relatively more volatile as a result of greater GVC integration. This finding does not necessarily preclude higher volatility in *some* sectors as a result of greater openness to input trade. However, in line with the predictions of the theoretical model, it does indicate that there is no systematic volatility effect in one direction or the other for the sectors most exposed to GVC integration.

5 Re-shoring and diversification as alternative long-run policy tools

Taken together, our model and empirical results indicate that there is no clear double-edged sword when it comes to openness. So far, we have considered openness in terms of trade costs: the interpretation of 'reduced openness' has been a government raising trade barriers, and 'increased openness' has meant removing those barriers, for example by signing FTAs that award bilateral tariff preferences and ease non-tariff trade costs.

However, governments also have other policy actions at their disposal, which can affect GVC integration. In particular, there is debate around the potential benefits of re-shoring supply chains — encouraging firms to source more inputs domestically — or, instead, diversifying GVCs — encouraging firms to source imported inputs from more trading partners. The Covid-19 pandemic has re-focused attention on this issue. As summarises in Box 2, the pandemic challenged the robustness of some supply chains, especially in critical sectors like medical supplies. In this context, González (2020) highlights that many nations imposed export restrictions on medical supplies in an attempt to boost local availability and increase self-reliance. However, Miroudot (2020a) argues that a policy of diversification, not re-shoring, might be better suited to tackling such disruption.

As in the general discussion around the double-edged sword, these policies are often motivated by a focus on volatility, and in particular a perception of a need to avoid heavy reliance on a small set of countries, and hence increase exposure to shocks from those countries.

In this section, we use our model to assess how these policies affect macroeconomic volatility. We can think of these as 'industrial policies', as opposed to trade policy. Within the model, the key difference is that these are changes to the parameters of the production function. We consider two different exercises. First, we explore the effect of re-shoring, modelled as an increase in the share of domestic inputs in the aggregate intermediate input within our two-country model. Second, we use a three-country version of the model to look at diversification. To this end, we vary the relative intermediate input shares of the two trading partners with respect to the Home country.

5.1: Re-shoring to reduce volatility?

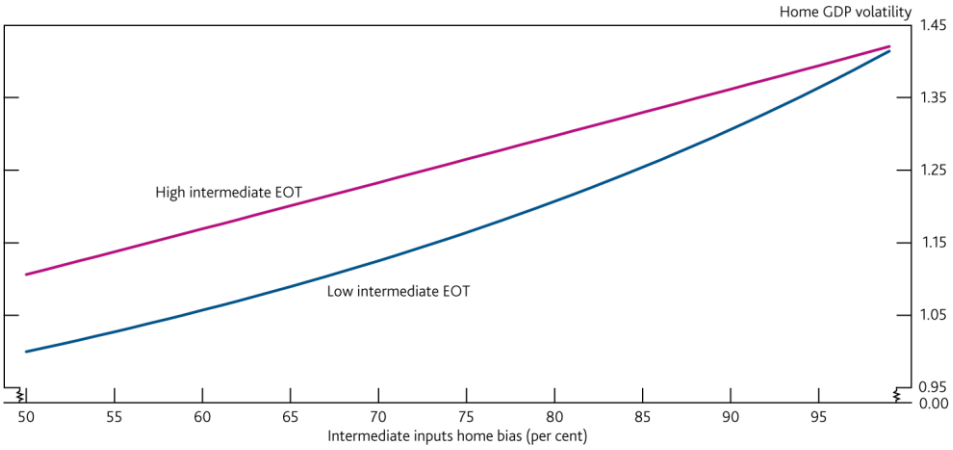
Within our two-country model, we explore the effects of an increase in home bias for intermediate inputs. Higher home bias is associated with higher reliance on domestically-produced inputs and, thus, a re-shoring of production.[24]

Our model indicates that re-shoring might be counterproductive at reducing aggregate volatility. As **Chart 13** demonstrates, re-shoring raises aggregate volatility at both high and low elasticities. Although the greater self-reliance can reduce the influence of *foreign* shocks on the domestic economy, it leaves firms less able to diversify the effects of domestic ones.

As Baldwin and Freeman (2020b) put it, 'putting all your eggs in one basket does not diversify risk — even if the basket is at home'.

24 A range of policy actions may generate an increase in the effective home bias, including subsidies designed to encourage the use of domestic intermediates in production.

Chart 13: Re-shoring raises total volatility



Notes: Volatility of Home GDP at different levels of intermediate inputs home bias. Use symmetric two-country model, where trade costs are the same in both countries and countries are subject to uncorrelated productivity shocks of equal variance. 'EOT' is the elasticity of intermediate input trade. Intercept normalised to 1 for low-EOT case.

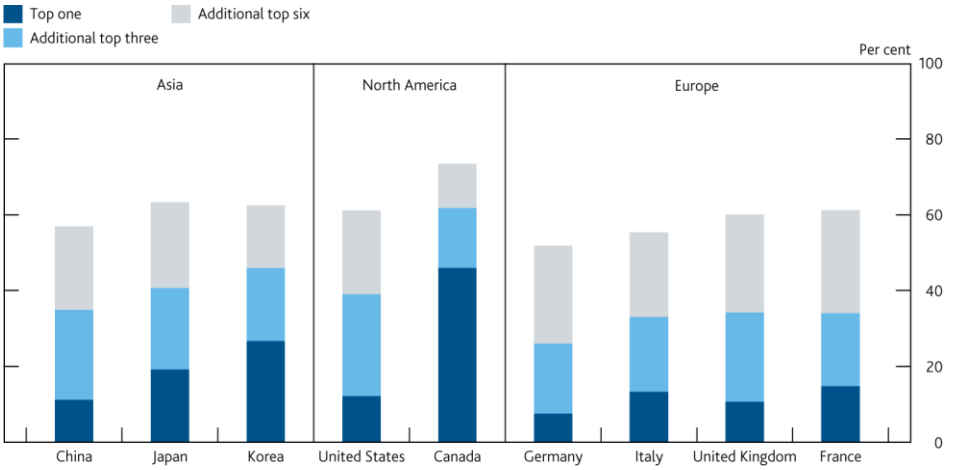
5.2: Diversification and concentration

This leads to our second experiment, focused on diversification. More specifically, we have seen that re-shoring is not an effective way to mitigate volatility, since it increases the reliance on a single country. What about a situation where GVCs are relatively concentrated with one trade partner, and countries enact industrial policy to diversify their GVC linkages towards other foreign trade partners?

Such a thought experiment is particularly important in relation to the current GVC landscape, where countries' overall levels of integration tend to be relatively concentrated with a small share of trade partners.

This notion is supported by **Chart 14**, which presents the share of countries' BFL that is concentrated among their top one, four and ten trading partners. As shown in the chart, for most countries, between one-quarter and one-third of all backward and forward links are concentrated among just four trade partners. Korea and Canada have even higher concentration, with 46% and 62% of their BFL concentrated among their top four trade partners, respectively.

Chart 14: Concentration of BFL among top one, four and ten trading partners, 2015 (share of countries' overall BFL measure)



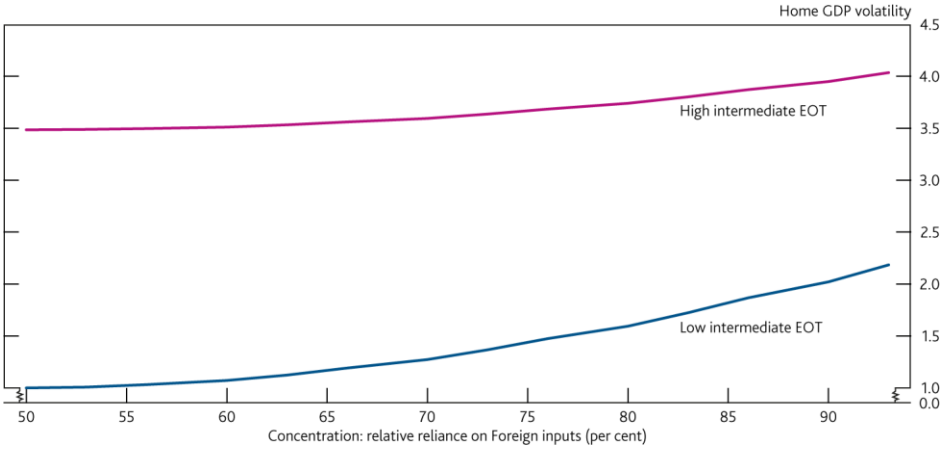
Source: Bank calculations based on OECD ICIO Tables.

Examining countries' top 10 partners reveals that between one half and two thirds of all countries' BFL are concentrated among just 10 partners. These tend to be major GVC hubs and regional trade partners, where, as shown in **Charts 2** and **3**, trade links are known to be particularly strong.

To assess the potential effects of diversification on aggregate volatility, we use a three-country variant of our model. We capture the idea of GVC concentration by assuming that the Home economy is a heavy user of inputs from a single Foreign country and, in turn, a limited user of inputs from the 'Rest of the world' — the third region in the model.[25] Diversification can then be thought of as a reduction in the reliance on Foreign inputs, whereby the Home country increasingly sources inputs from the Rest of the world.

Chart 15 plots aggregate Home GDP volatility with respect to this degree of concentration, at high and low elasticities. To focus on the effect of the relative exposure to the Foreign and Rest of the world shocks, in these exercises we assume no shocks to the Home country. The chart shows that, at both elasticity levels, when the Home economy has a high reliance on a single foreign supplier, the overall level of volatility is higher. This occurs because an increased reliance on a single (Foreign) trade partner for intermediate inputs leaves the domestic economy more exposed to shocks in the Foreign country. With a limited ability to draw on supply chains in the Rest of the world in the face of Foreign shocks, income varies by more in the Home economy. Hence, diversifying by making increased use of inputs from the Rest of the world can lower volatility.

Chart 15: Heavy reliance on a single supplier is associated with higher aggregate volatility



Notes: Volatility of Home GDP at different levels of intermediate inputs concentration, defined as the share of intermediate inputs from Foreign relative to sum of intermediate inputs from abroad (both Foreign and Rest of World). Use symmetric three-country model, where trade costs are the same in all three countries and Foreign and Rest of World are subject to uncorrelated productivity shocks of equal variance. 'EOT' is the elasticity of intermediate input trade. Intercept normalised to 1 for low-EOT case.

Our model has indicated that re-shoring to reduce GDP volatility is counter-productive, while diversification can be helpful, especially for diversifying among foreign shocks.[26] Nonetheless, it is also noteworthy that concentration risk may vary depending on countries' top trading partner(s), due to the fact that some partners have more internal diversity in terms of exporting firms within an industry, or a more diverse industrial composition overall. In this case, some risks may be mitigated by diversifying suppliers within, in addition to across, countries, to the extent possible.

25 We further assume that the Rest of the world is symmetric to the Home country, ie it makes heavy use of inputs from the Foreign country and little use of Home inputs. This arrangement makes the Foreign country a central role in the global production of intermediate inputs. Note that 'concentration' does not have any implication for optimality.

26 Assuming that concentration patterns are the result of countries' comparative advantages, diversification could come at the expense of other factors. For example, producers in diversified locations might have different levels of productivity or differing product qualities, among other things.

Box 2
Global value chains in 2020: lessons from the Covid-19 experience

The global nature of the economic shock following the Covid-19 pandemic brought supply chains into sharp focus. Baldwin and Tomiura (2020) identify supply-chain contagion — the amplification of shocks through countries' complex trade networks — as the third component of a 'triple hit' to manufacturing, alongside direct supply disruptions, as countries locked down their economies, and lower aggregate demand overall. In what follows, we discuss five main lessons from the Covid-19 experience for GVCs.

1. Demand was a key factor in the early disruptions

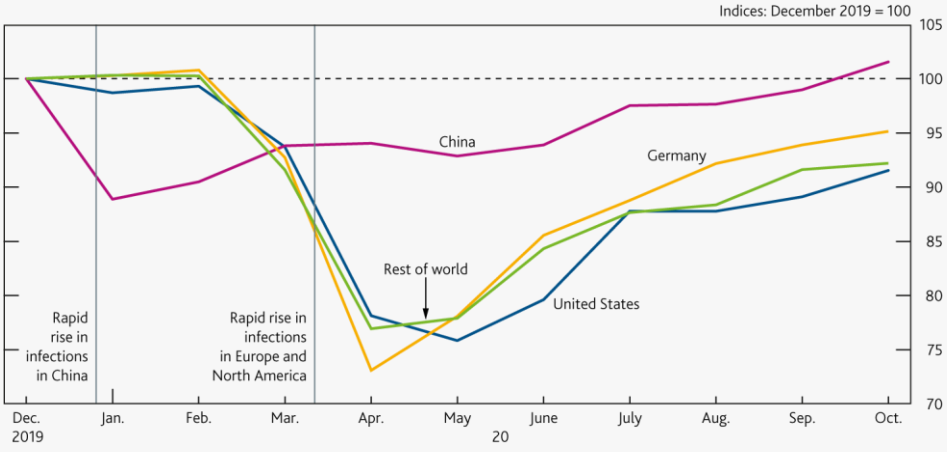
The pandemic, of course, was not only a shock to trade, and was instead a wider economic shock leading to a decline in global demand. This decline in demand directly contributed to declining trade; indeed IMF (2020) find that the decline in global goods trade is almost entirely accounted for by the decline in demand.

While aggregate demand was lower, demand surged in some specific sectors. Medical supplies and food products were in particularly high demand at the onset of the crisis. Early shortages were predominantly the result of the demand surge, for example the WHO (2020) calculated that manufacturing would need to rise by 40% to meet the increase. The demand surge was driven both by actual need and precautionary stockpiling. Similarly, according to a survey of supply-chain managers in May 2020, the key source of supply-chain vulnerability was 'demand variability' (MGI (2020)).

2. Supply chains are resilient and robust

While there were dips in exports and imports following initial infection waves, early evidence suggests that supply chains continued to function relatively well in the first six months of the pandemic, despite initial shocks to countries' productive capacities. This is backed up by monthly data, which shows that trade is recovering rapidly (**Chart A**). In fact, the latest WTO reports forecast a smaller decline in world trade than their 'optimistic scenario' in April (WTO (2020)).

Chart A: World goods trade in 2020, sum of exports and imports



Source: CPB World Trade Monitor.

When China first locked down its economy, suppliers in other countries expanded their production. Moreover, in some instances, supply chains were able to adapt by relocating production, or even activating international networks to produce supplies to help fight the pandemic itself (Miroudot (2020a)). Anecdotal evidence shows that food-sector supply chains were able to rapidly switch away from supplying restaurants to meet demand from retailers (Financial Times (2020b)).

3. Export controls can limit both the global and local supply of vital goods

Policies that seek to re-shore production can be harmful to global supply chains. In early 2020, there was a dramatic increase in export restrictions from major economies, particularly for products and sectors deemed vital to fighting the pandemic itself. As of 15 October, 215 export controls on medical supplies and medicines had been put in place by 92 jurisdictions (Global Trade Alert (2020)).

While these restrictions can reduce global capacity, they can also be counterproductive for the countries that apply them. Bamber *et al* (2020) show that the prevalence of GVCs in the production of medical supplies and devices over recent decades has increased — and not diminished — the ability of countries to respond to the sudden spikes in demand during the Covid-19 crisis. In fact, they point out that export controls threaten to reduce rather than increase *local* availability, especially if a country exports parts and components but imports finished medical supplies.

Summarising the many export restrictions that some major economies have placed, not only on PPE, but also on hospital equipment, pharmaceuticals, and food, Bown (2020) notes that such actions reduce many countries' access to much-needed products at a global scale. This is evident as taking supplies off the market can spark retaliations, lead to higher prices, and harm those in need in other countries.

4. Re-shoring will not insulate economies in the face of global, synchronised shocks

With respect to economic performance overall, Bonadio *et al* (2020) model the Covid-19 pandemic as a shock to global labour supply and find that one third of pandemic-related GDP contractions were attributed to the shock propagation through GVC networks. Nonetheless, they show that re-shoring production would not insulate economies from similar events in the future, given that the shock affected most countries. Similar points have been made anecdotally. For example, recognising that factories and operations all over the world stopped, John Neill, the CEO of the UK logistics and supply chain firm Unipart, noted that 'we'd still be in the same position' had all requirements been sourced from home (quoted in Beattie (2020)).

5. Diversification can help reduce economic volatility

Meier and Pinto (2020) show that US sectors with a large exposure to intermediates imports from China — the first country to impose widespread lockdowns — contracted significantly more than other sectors. In particular, highly exposed sectors suffered larger declines in production, employment, imports, and exports. The authors observe, however, that the effects were relatively transitory, and became insignificant by July. Looking at textiles value chains, Heise (2020) shows that from January to March some US firms shifted their imports of particular goods from China to Vietnam and Bangladesh. This was more so the case for firms that already imported from these alternative countries — indicating that pre-existing commercial relationships are important, and that diversification is a useful tool for building supply chain resilience.

This echoes earlier literature. Concentrated reliance on a single country — either at home or abroad — can increase the risk of a country-specific shock propagating through supply chains, and negatively affecting global economic activity. Caselli *et al* (2020) make this point using a large-scale general equilibrium model which incorporates input-output linkages. They show that, overall, countries that source from a variety of locations are better shielded from shocks and experience less volatility. This is supported by evidence from past disasters, such as the 2011 Tōhoku earthquake in Japan (Todo *et al* (2015)).

6 Discussion of the broader 'safe trade openness' debate

Our analysis has looked at the effects of openness on aggregate volatility over the business cycle. We have shown that raising barriers to trade or re-shoring production do not necessarily, or significantly, reduce volatility, while diversifying foreign suppliers can.

In this section, we address the broader debate around safe trade openness. The recent Covid-19 pandemic has raised further questions about the safety of the global trading system, not addressed by our analysis. To structure our discussion, we consider the case for *policy reforms* in the global trading system, aimed at strengthening co-operation, and *policy interventions*, designed to address specific market failures.

6.1: Policy reforms

There is a good case for policy reforms in the global trading system, with similarities to the push for safe openness in the international financial system in the wake of the GFC. In the financial sector, this has involved building a system based around: a shared commitment to markets; common minimum standards; high degrees of co-operation amongst regulators; and resilient institutions. The need for international co-operation was motivated by the complex, global nature of the financial system; this is no less true in the trading system. In Box 3, we highlight three areas of post-GFC policy reforms in the financial sector, aimed at strengthening co-operation and improving the trade-off between openness and safety. Here, we emphasise their read-overs to trade.

The first, and somewhat overarching, theme is building frameworks that ensure multilateralism. The gains from trade-policy co-operation have long been acknowledged in international economics. While individual countries may have incentives to levy tariffs, they can lead to globally suboptimal outcomes (eg Broda *et al* (2008)).[27] In addition, trade-policy uncertainty can harm macroeconomic activity (Handley and Limão (2017); Caldara *et al* (2020)). With these arguments in mind, the WTO was designed to engender co-operation between countries in trade policy.

However, as noted in Box 2, the Covid-19 pandemic led to unilateral export restrictions in some sectors, and uncertainty about increases in protectionism overall (Antràs (2020); Bown (2020)). Against this backdrop, there have been renewed calls for efforts to foster co-ordination and bolster trade openness in times of heightened stress in global production networks (Miroudot (2020b)). Efforts to reform the WTO to ensure that multilateral trade rules are best administered in the face of new challenges to the global trading system could enhance its role in promoting safe trade openness (Evenett and Baldwin (2020)).

Second, the idea of 'stress testing', which has become standard in financial regulation, can also be useful within the trading system, in particular for critical sectors. While supply chains for food have often been noted as a potential source of risk that require government policy to ensure domestic security (Martin and Glauber (2020)), Covid-19 has highlighted other potential critical sectors — most notably medical supplies. Governments may want to ensure supply in these sectors for security reasons, especially during crises, outside of the considerations of economic gains or costs. Identifying critical sectors, and stress testing them to assess potential risks in their supply chains, can be helpful in these cases (Simchi-Levi and Simchi-Levi (2020)). International co-operation could help identify the nature of critical sectors, key risks and transmission channels.

More generally, frequent and consistent dialogue with supply-chain managers in critical sectors may help to assess the degree of robustness and resilience in the system. Questions around robustness were a key source of uncertainty early in the Covid-19 crisis, with some suggesting that supply-chain managers were not aware of their indirect exposures via their suppliers and buyers (Financial Times (2020a); MGI (2020)).[28] Hoekman (2014) proposes mechanisms to aid the exchange of information between governments and businesses, including the formation of

27 Indeed, even within our model, a unilateral increase in trade costs in one country negatively impacts the other.
28 As discussed in Box 2, however, supply chains ultimately proved to be agile, robust and resilient.

'supply chain councils' at the WTO. Such a multilateral approach to these dialogues might be useful, given the presence of multinational firms in the global trading system for critical sectors. The aim would be to reduce uncertainty and the lack of information around GVC risks, in a similar way to regulatory and supervisory co-operation in the financial system.

Finally, financial reforms have been underpinned by a substantial effort to increase data availability, to improve our understanding of the global financial system. The same is needed in the trading system, where a lack of transparency in complex GVCs could make it difficult for policymakers to monitor risks. Despite the complexity of the data introduced in Box 1 and Section 2, there is limited availability of timely, granular data on GVCs. The IO tables used in this paper to compute GVC measures are at annual frequency and end in 2015. In order to, for example, identify and understand the effects of extreme events and tail risks, as opposed to business-cycle volatility, more timely and disaggregated data are needed.

6.2: Policy interventions

Our analysis shows that GVC integration need not be a double-edged sword: trade openness only raises volatility under certain conditions and to a limited degree. Even where it exists, the double-edged sword may not in itself be a cause for policy intervention. As our model exercises show, the existence of higher volatility is likely to be outweighed by the benefits of higher productivity.

The structure of GVCs is the outcome of decisions made by private firms, choosing their international production linkages — through their buying and selling relationships — with an eye on both productivity and risk. A double-edged sword only justifies policy intervention to the extent that these decisions put a different weight on risks than is socially optimal — in other words, if some market failure is present.

As Box 3 notes, there were well-established market failures in the financial sector that drove post-GFC interventions (Holmström and Tirole (1997); Kiyotaki and Moore (1997)). The crucial lesson when thinking about trade openness and GVCs is whether any such market failures are present that would justify interventions.

Reflecting standard modelling assumptions in international macroeconomics, our theoretical work cannot speak to this issue, as no market failures are present in the model. Even when trade costs lower the level of volatility, they are not dampening an inefficient source of fluctuations. The same is true for the exercises in Section 5, which study re-shoring and diversification. This does not necessarily mean that there are no frictions that need to be addressed. More research is needed in this space to consider where the existence of market failures may create a role for appropriate welfare-improving policy interventions.[29] For example, further research could focus on information asymmetries, a potential friction in GVCs. As noted earlier, better mapping of GVCs and stress testing could help enhance understanding of the risks, but barriers to information dissemination, such as commercial sensitivities, may require additional action.

Recently, the Covid-19 pandemic has given rise to discussion of potential market failures or externalities, and much of this discussion has been focused on the role of large countries or firms. In the remainder of this section, we outline some key arguments that have been made, and highlight where more research is needed to assess whether there is a case to be made for policy interventions in GVCs.

As discussed in Sections 2 and 5, GVCs are typically concentrated around a few large economies that play a significant role in the GVC participation of other countries. Given that these central GVC hubs were among the first to be affected by the pandemic (Baldwin and Freeman (2020a)), some have argued that the heavy reliance on a few countries needs to be rethought (Javorcik (2020)). Further research could help ascertain whether there are specific market failures that would require policy interventions, or whether the focus should be on ensuring that the risks associated with concentrated GVCs are widely understood. The policy reforms outlined earlier, such as stress testing coupled with more timely and more disaggregate data, would help in the latter case.[30]

29 Policy interventions targeted at distributional concerns, rather than economic inefficiencies, would not necessarily require the existence of market failures. As previously mentioned, these types of concerns are not the focus of this paper.

30 MGI (2020) highlight that firms are already considering diversification and near-shoring, and also discuss the scope for increasing supply-chain resilience going forward, for example by increasing transparency of supply-chain linkages and increasing the use of common components in production.

It is also well known that large firms play an outsized role in international trade (Bernard *et al* (2007); Mayer and Ottaviano (2008)). Moreover, trade openness may allow large and productive firms to increase their market share. If this creates excessive market power and lowers competition, this may justify policy intervention.[31] However, this does not mean that the prescribed intervention is to create barriers to trade. If anything, this argument suggests that there may be advantages to multilateral solutions, for example global competition and antitrust co-operation (World Bank (2020)).[32]

More generally regarding concentration, we do not, to date, have a sufficient understanding of how GVCs are shaped, and which, if any, market failures play a role in this. The existing academic literature on production networks, surveyed in Carvalho and Tahbaz-Salehi (2019), has not looked at how firms' decisions shape domestic and global supply chains.[33] This paper has highlighted the benefits of diversification to avoid concentration risk in GVCs. Another useful area of research would thus be to further explore what the potential barriers and trade-offs to diversification are, the specific relationship between trade openness and supply-chain concentration, and whether policy is needed to address these factors.

31 Of course, it is also worth noting that many papers have found that trade openness increases competition and lowers mark-ups (Feenstra (2010) and (2018)).

32 The existence of large firms could also lead to a 'too-big-to-fail' problem, akin to the GFC. Government support in times of crisis could create 'moral hazard', whereby the private sector does not sufficiently insure against future crises in anticipation of this support. While it is not clear that government support during the pandemic was targeted at firms that faced concentration risk through their GVCs, more research could be done to understand whether there any moral hazard is created by the existence of critical firms and sectors.

33 This literature does find that shocks to specific firms or sectors, which are central to the network, can have large effects (Acemoglu *et al* (2012); di Giovanni *et al* (2014); Baqaee and Farhi (2019)). However, this propagation or amplification of shocks does not by itself imply any need for policy interventions to increase welfare.

Box 3
Post-GFC reforms and international co-operation in the financial sector

The GFC brought tensions between financial openness and financial stability to the fore. It revealed how openness can expose countries to greater economic and financial volatility, amplifying the effect of market failures. Subsequently, global policy makers embarked on policies to improve this trade-off, taking 'the high road to a responsible, open financial system' (Carney (2017)). This has involved building a system based around: a shared commitment to markets; common minimum standards; high degrees of co-operation amongst regulators; and resilient institutions.

These efforts appear to have made the core of the system more resilient during the Covid-19 pandemic. Improvements to capital and liquidity positions over the past decade (see, eg, Lewrick *et al* (2020)), in combination with the additional flexibility built into the international regulatory framework, have meant that banks were able to support the economy (Giese and Haldane (2020)). Reforms to derivatives markets and the introduction of central clearing reduced opacity and counterparty credit exposures. International bodies, such as the Basel Committee and Financial Stability Board (FSB), acted as fora where national authorities were able to co-ordinate their regulatory responses to Covid-19. This included agreeing on key principles for how national authorities would respond to ensure the resilience of international standards (FSB (2020a)). Absent regulatory reforms, a shock of this scale could have resulted in an illiquid banking system, cutting back on credit to remain solvent and further amplifying the effects in the real economy (Cunliffe (2020)). Indeed, the non-bank financial sector, which was subject to less significant reform post-GFC, saw significant stresses.

A closer look at the steps taken to ensure safe openness in the financial sector after the GFC may provide insights relevant to trade. It is useful to distinguish here between *policy reforms* aimed at strengthening co-operation, and *policy interventions* aimed at correcting market failures.

Policy reforms

On policy reforms, three areas stand out in particular: (i) building global frameworks to support safe openness, including regulatory co-operation and common standards, (ii) stress-testing frameworks and (iii) efforts to enhance the collection and sharing of data.

First, an important goal of post-GFC reforms was to balance the need for greater domestic financial stability and the costs of financial fragmentation (discussed, eg, in FSB (2020b)). For example, while domestic financial stability may be improved in some circumstances by trapping pools of capital and liquidity locally, this can also significantly reduce the ability of banks to manage liquidity and protect against shocks at a global level. In other words, domestically optimal regulation may lead to worse outcomes globally.

Importantly, regulatory and supervisory co-operation can improve the trade-off between financial stability and fragmentation. Cross-border resolution frameworks are one good example, providing regulators with greater certainty on how resources will be distributed in the event of bank failure, while minimising economic disruption (FSB (2014); Baudino *et al* (2020)). This, in turn, can allow global banking groups to operate effectively across borders with confidence. A similar case, where international standards and co-operation can help preserve the benefits of global activities, is a recent Memorandum of Understanding between the Bank of England and Commodity Futures Trading Commission regarding co-operation and information exchange in the supervision and oversight of clearing organisations that operate on a cross-border basis in the US and UK. It is based upon mutual respect for each jurisdiction's regulatory regime and supervisory practices. A final example relates to policies affecting the conditions under which foreign branches operate. For instance, in the UK Prudential Regulatory Authority's branching policy (PRA (2018)), the approach to branch authorisation and supervision places considerable weight on assessing the extent and quality of co-operation with the home state supervisor and home resolution authority. In all three examples, financial openness for global banks and markets is conditional on regulatory and supervisory co-operation and common standards.

Second, stress testing became a more notable feature of the global regulatory landscape following the GFC. Stress-testing frameworks were developed in response to the increased awareness of tail risks and the need to examine the transmission of large shocks, such as the one the financial system witnessed during the GFC. It fulfils a few key functions, including providing a base for decisions on enhancing resilience, and increasing the capacity of the private and public sector to detect risks. Stress testing is also an important medium for dialogue between regulators and the financial institutions subject to stress tests.

Third, the GFC also highlighted the lack of data on complex global financial linkages. Good data is needed to carry out stress testing and generally improve dialogue around risks between regulators and firms. Data enhancements reduced uncertainty in the financial sector post-GFC, and have played an important role in fostering research that has improved our understanding of financial stability (see, eg, Ahnert *et al* (2020); Bussière *et al* (2020)). It is instructive to see how dialogue at the international level on key data gaps (eg G20 Data Gaps initiative) fed into the enhancement of key data sources, such as the BIS banking statistics, and new data collections, such as an FSB monitoring exercise of non-bank financial institutions (FSB (2020c)).

Policy interventions

On the other hand, the case for policy interventions rested on a clear formulation of market failures. We again highlight three key examples.

A key issue that arose from the GFC was moral hazard linked to the expectation of government bailouts. This acted as an important driver of banks' excessive risk-taking. This led to a range of policy interventions strengthening banks' loss-absorbing capacity, especially for institutions that were deemed too-big-to-fail.

Likewise, not accounting for systemic risks linked to fire sale externalities (eg Schleifer and Vishny (2011)) caused banks to hold too many illiquid assets and too much demandable debt. This prompted the introduction of liquidity buffers as part of the Basel III regulations to stem such fire sales and contain the system-wide repercussions (Borio *et al* (2020)).

Finally, the existence of currency mismatches and external borrowing constraints in international financial markets has underpinned the recent development of the IMF's Integrated Policy Framework (IPF). The analysis behind the IPF suggests that capital controls and foreign exchange interventions may help to correct such market failures (Basu *et al* (2020)).

Conclusion

Ensuring that the global financial system remained open in a safe manner was by no means a foregone conclusion as the world emerged from the GFC. Subsequent policy reforms that strengthened international co-operation and common standards, as well as policy interventions targeted at clear market failures, successfully improved the trade-off between financial openness and financial stability. While new risks need to be monitored constantly, the frameworks and policies put in place allow countries around the world to reap the benefits of safe financial openness. Section 6 discusses whether the experience with post-GFC reforms offers insights for trade.

7 Conclusion

In this paper, we have re-assessed the link between trade openness, productivity and economic volatility, focusing on the role of GVC integration. While we find a positive association between GVC integration and productivity, we show that the relationship with volatility is ambiguous in theory and insignificant in the data. Therefore, there is no compelling reason to fear a double-edged sword from trade openness: a blanket reduction in GVC integration would impose economic costs without necessarily, or significantly, reducing volatility.

In addition, when accounting for the concentration of GVCs around a few central 'hubs', we find that policies to re-shore production lead to an increase in domestic aggregate volatility, as they effectively increase the concentration of GVCs on domestic sources. On the other hand, diversification of GVCs among foreign suppliers can lower volatility in the domestic economy, by lowering the exposure to any single country.

In terms of the broader policy debate around safe trade openness, we have emphasised the merits of *policy reforms* aimed at strengthening co-operation and multilateralism in the global trading system that can help to foster well-diversified GVCs. These include possible stress-testing frameworks for critical supply chains, and the collection and dissemination of more timely data on GVC trade. These reforms have parallels with the push for 'safe openness' in the international financial system following the GFC.

However, we caution against direct *policy interventions* in the global trading system that are not targeted to address well-identified market failures. While there is limited evidence on the existence of such market failures in the existing academic literature, there is scope for policy experience and further economic research to join forces to assess whether such market failures exist. A clear diagnosis of such potential sources of inefficiencies is essential to devise welfare-improving policy interventions.

References

Acemoglu, D, Carvalho, V M, Ozdaglar, A and Tahbaz-Salehi, A (2012), 'The network origins of aggregate fluctuations', *Econometrica*, 80(5), pages 1977–2016.

Ahnert, T, Forbes, K, Friedrich, C and Reinhardt, D (2020), 'Macroprudential FX regulations: shifting the snowbanks of FX vulnerability?', *Journal of Financial Economics*, in press.

Anderson, J E and Van Wincoop, E (2003), 'Gravity with gravitas: a solution to the border puzzle', *American Economic Review*, 93(1), pages 170–92.

Antràs, P (2020), 'De-globalisation? Global value chains in the post-COVID-19 age', *NBER Working Paper*, No. 28115.

Antràs, P and Chor, D (2018), 'On the measurement of upstreamness and downstreamness in global value chains', *World Trade Evolution: Growth, Productivity and Employment*, pages 126–94.

Arkolakis, C, Costinot, A and Rodríguez-Clare, A (2012), 'New trade models, same old gains?', *American Economic Review*, 102(1), pages 94–130.

Baier, S L and Bergstrand, J H (2007), 'Do free trade agreements actually increase members' international trade?', *Journal of international Economics*, 71(1), pages 72–95.

Baier, S L, Bergstrand, J H and Feng, M (2014), 'Economic integration agreements and the margins of international trade', *Journal of International Economics*, 93(2), pages 339–50.

Baldwin, R and Freeman, R (2020a), 'Supply chain contagion wages: thinking ahead on manufacturing 'contagion and reinfection' from the COVID concussion', VoxEU.org, 1 April; https://voxeu.org/article/covid-concussion-and-supply-chain-contagion-waves.

Baldwin, R and Freeman, R (2020b), 'Trade conflict in the age of Covid-19', VoxEU.org, 22 May; https://voxeu.org/article/trade-conflict-age-covid-19.

Baldwin, R and Tomiura, E (2020), 'Thinking ahead about the trade impact of COVID-19', in: Baldwin, R and Weder di Mauro, B, eds. *Economics in the Time of COVID-19*, London: VoxEU/CEPR.

Baldwin, R and Venables, A J (2013), 'Spiders and snakes: offshoring and agglomeration in the global economy', *Journal of International Economics*, 90(2), pages 245–54.

Bamber, P, Fernandez-Stark, K and Taglioni, D (2020), 'Why global value chains remain essential for COVID-19 supplies', VoxEU.org, 27 May; https://voxeu.org/content/why-global-value-chains-remain-essential-covid-19-supplies.

Baqaee, D R and Farhi, E (2019), 'Networks, barriers and trade', *NBER Working Paper*, No. 26108.

Baqaee, D R and Farhi, E (2020), 'Nonlinear production networks with an application to the Covid-19 crises', *CEPR Discussion Paper*, No. 14742.

Bas, M and Strauss-Kahn, V (2014), 'Does importing more inputs raise exports? Firm-level evidence from France', *Review of World Economics*, 150(2), pages 241–75.

Basu, S S, Boz, E, Gopinath, G, Roch, F and Unsal, F D (2020), 'A conceptual model for the integrated policy framework', *IMF Working Papers,* No. 20/121.

Baudino, P, Richardson, T and Walters, R (2020), 'Cross-border resolution co-operation and information sharing: an overview of home and host authority experience', *BIS FSI Insights on Policy Implementation*, No. 22.

Baxter, M (1995), 'International trade and business cycles', In: Grossman, G M and Rogoff, K, eds. *Handbook of international economics*, Volume 3, Chapter 35, pages 1801–64, Elsevier.

Beattie, A (2020), *Financial Times' Trade Secrets*, Newsletter, 11 May.

Bejean, M (2006), 'Trade openness and output volatility', unpublished manuscript; https://mpra.ub.uni-muenchen.de/2759/.

Benigno, G and Thoenissen, C (2008), 'Consumption and real exchange rates with incomplete markets and non-traded goods', *Journal of International Money and Finance,* 27(6), pages 926–48.

Bernard, A B, Bradford Jensen, J, Redding, S J and Schott, P K (2007), 'Firms in international trade', *Journal of Economic Perspectives*, 21(3), pages 105–30.

Bodenstein, M, Corsetti, G and Guerrieri, L (2020), 'Social distancing and supply disruptions in a pandemic', *Covid Economics*, 19, pages 1–52.

Bonadio, B, Huo, Z, Levchenko, A A and Pandalai-Nayar, N (2020), 'Global supply chains in the pandemic', *CEPR Discussion Paper*, No. 14766.

Borio, C, Farag, M and Tarashev, N, (2020), 'Post-crisis international financial regulatory reforms: a primer', *BIS Working Papers*, No. 859.

Bown, C P (2020), 'COVID-19: demand spikes, export restrictions, and quality concerns imperil poor country access to medical supplies', in: Baldwin, R and Evenett, S J, eds. *COVID-19 and trade policy: why turning inward won't work*. London: VoxEU/CEPR.

Broda, C, Limão, N and Weinstein, D E (2008), 'Optimal tariffs and market power: the evidence', *American Economic Review*, 98(5), pages 2032–65.

Buch, C M, Döpke, J and Strotmann, H (2009), 'Does trade openness increase firm-level volatility?', *Deutsche Bundesbank Discussion Paper Series 1: Economic Studies*, No. 40.

Burgess, R and Donaldson, D (2012), 'Railroads and the demise of famine in Colonial India', unpublished manuscript.

Bussière, M, Cao, J, de Haan, J, Hills, R, Lloyd, S P, Meunier, B, Pedrono, J, Reinhardt, D, Sinha, S, Sowerbutts, R and Styrin, K (2020), 'The interaction between macroprudential policy and monetary policy: overview', *Review of International Economics,* in press.

Caldara, D, Iacoviello, M, Molligo, P, Prestipino, A and Raffo, A (2020), 'The economic effects of trade policy uncertainty', *Journal of Monetary Economics*, 109(C), pages 38–59.

Carney, M (2017), 'The high road to a responsible, open financial system', speech given at Thomson Reuters; www.bankofengland.co.uk/speech/2017/the-high-road-to-a-responsible-open-financial-system.

Carvalho, V M and Tahbaz-Salehi, A (2019), 'Production networks: a primer', *Annual Review of Economics*, 11, pages 635–63.

Carvalho, V M, Nirei, M, Saito, Y U and Tahbaz-Salehi, A (2020), 'Supply chain disruptions: evidence from the great East Japan Earthquake', *The Quarterly Journal of Economics*, in press.

Caselli, F, Koren, M, Lisicky, M and Tenreyro, S (2020), 'Diversification through trade', *The Quarterly Journal of Economics*, 135(1), pages 449–502.

Cavallo, E (2008), 'Output volatility and openness to trade: a reassessment', *Economía*, 9(1), pages 105–52.

Chor, D, Manova, K and Yu, Z (2020), 'Growing like China: firm performance and global production line position', in: Frankel, J A and Rey, H, eds. *NBER International Seminar on International Macroeconomics 2020*, National Bureau of Economic Research.

Cole, H L and Obstfeld, M (1991), 'Commodity trade and international risk sharing: how much do financial markets matter?', *Journal of Monetary Economics*, 28(1), pages 3–24.

Conconi, P, Magerman, G and Plaku, A (2020), 'The gravity of intermediate goods', *Review of Industrial Organization*, 2/2020, pages 1–21.

Corsetti, G, Dedola, L and Leduc, S (2008), 'International risk sharing and the transmission of productivity shocks', *Review of Economic Studies*, 75(2), pages 443–73.

Costinot, A and Rodríguez-Clare, A (2014), 'Trade theory with numbers: quantifying the consequences of globalization', in: Gopinath, G, Helpman, E and Rogoff, K, eds. *Handbook of International Economics*, Volume 4, Chapter 4, pages 197–261, Elsevier.

Cunliffe, J (2020), 'Financial system resilience: lessons from a real stress', speech given during the Investment Association webinar; www.bankofengland.co.uk/speech/2020/jon-cunliffe-speech-at-investment-association.

di Giovanni, J and Levchenko, A A (2009), 'Trade openness and volatility', *Review of Economics and Statistics*, 91(3), pages 558–85.

di Giovanni, J and Levchenko, A A, (2010), 'Putting the parts together: trade, vertical linkages, and business cycle comovement', *American Economic Journal: Macroeconomics*, 2(2), pages 95–124.

di Giovanni, J, Levchenko, A A, Mejean, I (2014), 'Firms, destinations, and aggregate fluctuations', *Econometrica*, 82(4), pages 1303–40.

Easterly, W, Islam, R and Stiglitz, J E (2001), 'Shaken and stirred: explaining growth volatility', in: Pleskovic, B and Stiglitz, J E, eds. *Annual World Bank Conference on Development Economics*, pages 191–212, Washington, D.C.: World Bank.

Eaton, J and Kortum, S (2002), 'Technology, geography, and trade', *Econometrica*, 70(5), pages 1741–79.

Evenett, S J and Baldwin, R (2020), *Revitalising multilateralism: pragmatic ideas for the new WTO Director-General*. London: VoxEU/CEPR.

Feenstra, R C (2010), 'Measuring the gains from trade under monopolistic competition', *Canadian Journal of Economics*. 43(1), pages 1–28.

Feenstra, R C (2018), 'Alternative sources of the gains from international trade: variety, creative destruction, and markups', *Journal of Economic Perspectives*, 32(2), pages 25–46.

Feenstra, R C, Luck, P, Obstfeld, M and Russ, K N (2018), 'In search of the Armington elasticity', *Review of Economics and Statistics*, 100(1), pages 135–50.

Feyrer, J (2019), 'Trade and income—exploiting time series in geography', *American Economic Journal: Applied Economics*, 11(4), 1–35.

Financial Times (2020a), 'Companies' supply chains vulnerable to coronavirus shocks', 9 March; www.ft.com/content/be05b46a-5fa9-11ea-b0ab-339c2307bcd4.

Financial Times (2020b), 'Covid-19 has exposed the world's fragile, complex food supply chains', 24 September; www.ft.com/content/65ad7504-b7de-4df4-8747-f669a2e541fe.

Frankel, J A and Romer, D H (1999), 'Does trade cause growth?', *American Economic Review*, 89(3), pages 379–99.

Freeman, R and Pienknagura, S (2019), 'Are all trade agreements equal? The role of distance in shaping the effect of economic integration agreements on trade flows', *Review of World Economics*, 155(2), pages 257–85.

FSB (2014), 'Key attributes of effective resolution regimes for financial institutions'; www.fsb.org/wp-content/uploads/r_141015.pdf.

FSB (2020a), 'COVID-19 pandemic: financial stability implications and policy measures taken'; www.fsb.org/2020/04/covid-19-pandemic-financial-stability-implications-and-policy-measures-taken/.

FSB (2020b), 'Report on market fragmentation'; www.fsb.org/2019/06/fsb-report-on-market-fragmentation-2/.

FSB (2020c), 'Global monitoring Report on non-bank financial intermediation 2019'; www.fsb.org/2020/01/global-monitoring-report-on-non-bank-financial-intermediation-2019/.

Ghironi, G and Melitz, M J (2005), 'International trade and macroeconomic dynamics with heterogeneous firms', *The Quarterly Journal of Economics*, 120(3), pages 865–915.

Giese, J and Haldane, A (2020), 'COVID-19 and the financial system: a tale of two crises', *Oxford Review of Economic Policy*, 36(S1), pages 200–14.

Global Trade Alert (2020), *Global Trade Alert website*; www.globaltradealert.org/.

González, A (2020), 'Yes, medical gear depends on global supply chains. Here's how to keep them moving', VoxEU.org, 1 April; https://voxeu.org/content/yes-medical-gear-depends-global-supply-chains-heres-how-keep-them-moving.

Grossman, G M and Rossi-Hansberg, E (2008), 'Trading tasks: a simple theory of offshoring', *American Economic Review*, 98(5), pages 1978–97.

Haddad, M, Lim, J J, Pancaro, C and Saborowski, C (2010), 'Trade openness reduces growth volatility when countries are well diversified', *Canadian Journal of Economics*, 46(2), pages 765–90.

Handley, K and Limão, N (2017), 'Policy uncertainty, trade, and welfare: theory and evidence for China and the United States', *American Economic Review*, 107(9), pages 2731–83.

Heise, S (2020), 'How did China's COVID-19 shutdown affect US supply chains?', *Liberty Street Economics*, 12 May; https://libertystreeteconomics.newyorkfed.org/2020/05/how-did-chinas-covid-19-shutdown-affect-us-supply-chains.html.

Helpern, L, Koren, M and Szeidl, A (2015), 'Imported inputs and productivity', *American Economic Review*, 105(12), pages 3660–703.

Helpman, E (2017), 'Globalization and wage inequality', *Journal of the British Academy*, 5, pages 125–62.

Hoekman, B (2014), *Supply chains, mega-regionals and multilateralism: a road map for the WTO*', London: CEPR Press.

Holmström, B and Tirole, J (1997), 'Financial intermediation, loanable funds, and the real sector', *The Quarterly Journal of Economics*, 112(3), pages 663–91.

Hummels, D, Ishii, J and Yi, K M (2001), 'The nature and growth of vertical specialization in world trade', *Journal of international Economics*, 54(1), pages 75–96.

IMF (2020), *2020 External Sector Report: Global imbalances and the COVID-19 crisis*, Washington, D.C.: International Monetary Fund.

Javorcik, B (2020), 'Global supply chains will not be the same in the post-COVID-19 world', in: Baldwin, R and Evenett, S J, eds. *COVID-19 and trade policy, why turning inward won't work*. London: VoxEU/CEPR.

Johnson, R C (2014), 'Trade in intermediate inputs and business cycle comovement', *American Economic Journal: Macroeconomics*, 6(4), pages 39–83.

Johnson, R C and Noguera, G (2012), 'Accounting for intermediates: production sharing and trade in value added', *Journal of International Economics*, 86(2), pages 224–36.

Johnson, R C and Noguera, G (2017), 'A portrait of trade in value-added over four decades', *Review of Economics and Statistics*, 99(5), pages 896–911.

Kiyotaki, N and Moore, J H (1997), 'Credit cycles', *Journal of Political Economy*, 105(2), pages 211–48.

Koopman, R, Powers, W, Wang, Z and Wei, S J (2010), 'Give credit where credit is due: tracing value added in global production chains', *National Bureau of Economic Research, Working Paper*, No. 16426.

Kose, M A and Yi, K M (2006), 'Can the standard international business cycle model explain the relation between trade and comovement?', *Journal of International Economics*, 68(2), pages 267–95.

Kose, M A, Prasad, E S and Terrones, M E (2003), 'Financial integration and macroeconomic volatility', *IMF Staff Papers*, 50(1), pages 119–42.

Küçük, H and Sutherland, A (2015), 'International Risk sharing and portfolio choice with non-separable preferences', *CEPR Discussion Papers*, No. 10724.

Lewrick, U, Schmieder, C, Sobrun, J and Takáts, E (2020), 'Releasing bank buffers to cushion the crisis – a quantitative assessment', *BIS Bulletin*, No. 11.

Limão, N (2016), 'Preferential trade agreements' in: Bagwell, K and Staiger, R W, eds. *Handbook of Commercial Policy*, Volume 1, Chapter 6, pages 279–367, Elsevier.

Martin, W and Glauber, J W (2020), 'Trade policy and food security', in: Baldwin, R and Evenett, S J, eds. *COVID-19 and trade policy, why turning inward won't work*, London: VoxEU/CEPR.

Mayer, T and Ottaviano, G I P (2008), 'The happy few: the internationalisation of European firms', *Intereconomics*, 43, pages 135–48.

Meier, M and Pinto, E (2020), 'Covid-19 supply chain disruptions', *Covid Economics*, 48.

MGI (2020), *Risk, resilience, and rebalancing in global value chains*, McKinsey Global Institute Report; www.mckinsey.com/business-functions/operations/our-insights/risk-resilience-and-rebalancing-in-global-value-chains.

Miller, R E and Temurshoev, U (2017), 'Output upstreamness and input downstreamness of industries/countries in world production', *International Regional Science Review*, 40(5), pages 443–75.

Miroudot, S (2020a), 'Resilience versus robustness in global value chains: some policy implications', in: Baldwin, R and Evenett, S J, eds. *COVID-19 and trade policy, why turning inward won't work*, London: VoxEU/CEPR.

Miroudot, S (2020b), 'Lessons from the pandemic for trade cooperation on cross-border supply chains', in: Baldwin, R, and Evenett, S J, eds. *Revitalising multilateralism*. London: VoxEU/CEPR.

Miroudot, S and Ye, M (2020), 'Multinational production in value-added terms', *Economic Systems Research*, 32(3), pages 395–412.

Newbery, D and Stiglitz, J E (1984), 'Pareto inferior trade', *Review of Economic Studies*, 51(1), pages 1–12.

Parinduri, R (2011), 'Growth volatility and trade: evidence from the 1967–1975 closure of the Suez Canal, unpublished manuscript'; https://mpra.ub.uni-muenchen.de/39040/.

Pisch, F (2020), 'Managing global production: theory and evidence from just-in-time supply chains', *CEP Discussion Paper*, No 1689.

PRA (2018), 'International banks: the Prudential Regulation Authority's approach to branch authorisation and supervision', *PRA Supervisory Statement SS1/18*; www.bankofengland.co.uk/prudential-regulation/publication/2018/international-banks-pras-approach-to-branch-authorisation-and-supervision-ss.

Rodrik, D (1998), 'Why do more open economies have bigger governments?', *Journal of Political Economy*, 106(5), pages 997–1032.

Schleifer, A and Vishny, R (2011), 'Fire sales in finance and macroeconomics', *Journal of Economic Perspectives*, 106(1), pages 29–48.

Simchi-Levi, D and Simchi-Levi, E (2020), 'We need a stress test for critical supply chains', Harvard Business Review, 28 April; https://hbr.org/2020/04/we-need-a-stress-test-for-critical-supply-chains.

Taglioni, D and Winkler, D (2016), *Making global value chains world for development*. Washington, D.C.: World Bank.

Todo, Y, Nakajima, K and Matous, P (2015), 'How do supply chain networks affect the resilience of firms to natural disasters? Evidence from the great East Japan earthquake', *Journal of Regional Science*, 55(2), pages 209–29.

Topalova, P and Khandelwal, A (2011), 'Trade liberalization and firm productivity: the case of India', *Review of Economics and Statistics*, 93(3), pages 995–1009.

World Bank (2020), *World Development Report 2020: trading for development in the age of global value chains*, Washington, D.C.: World Bank.

WHO (2020), 'Shortage of personal protective equipment endangering health workers worldwide', 3 March; www.who.int/news/item/03-03-2020-shortage-of-personal-protective-equipment-endangering-health-workers-worldwide.

WTO (2020), 'Trade shows signs of rebound from COVID-19, recovery still uncertain', 6 October; www.wto.org/english/news_e/pres20_e/pr862_e.htm#:~:text=The%20WTO%20now%20forecasts%20a,and%20government%20responses%20to%20it.