Supply chain contagion waves:
Thinking ahead on manufacturing 'contagion and reinfection' from the COVID concussion
Richard Baldwin, *voxeu*, April 1, 2020

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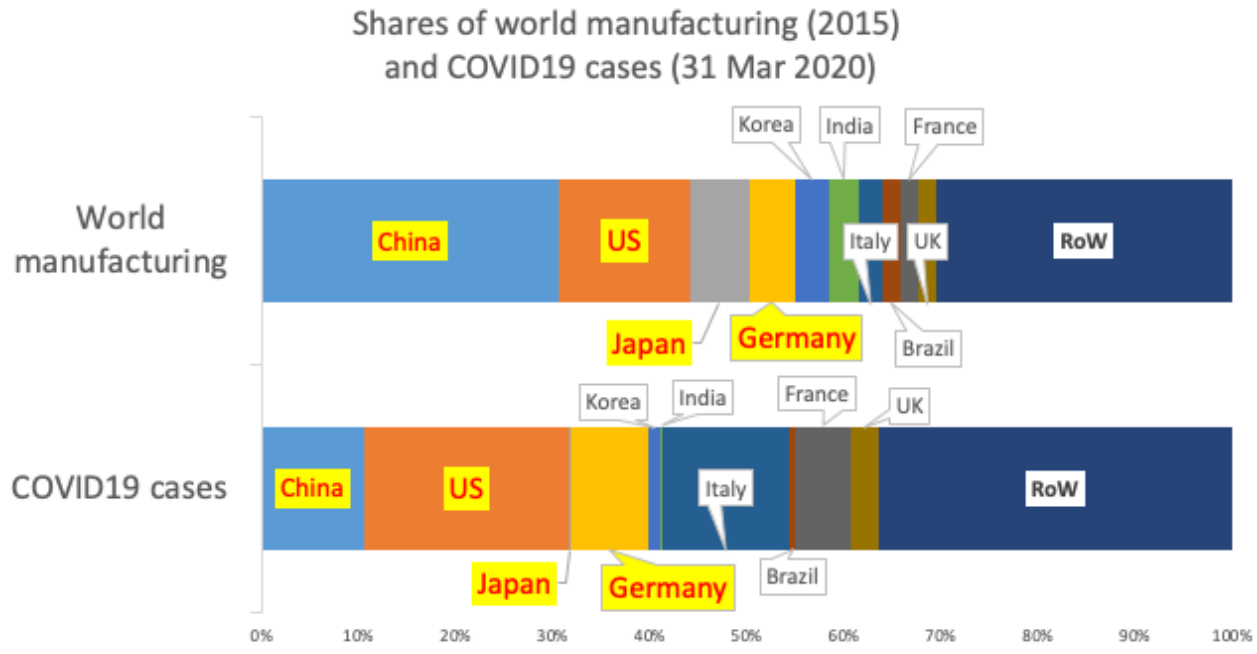
COVID-19 containment policies first shuttered factories in China. Since manufacturers around the world rely on Chinese inputs, Chinese industrial disruption hit other nations via 'supply-chain contagion'. As China gears back up having mastered the first epidemic wave, the explosions of cases in the two other manufacturing giants, Germany and America, are likely to create reverse supply-chain contagion – the industrial equivalent of reinfection. International coordination may reduce the chances that multiple waves of supply-chain contagion hobble global manufacturing until a vaccine is developed.

COVID-19's impact on world manufacturing is radically different than the impact caused by other pandemics over the last 100 years. This one struck all the largest manufacturing economies in the world (Figure 1) – and pretty much all at once. As a result, these nations are entering a very strange type of recession – what might be called the 'COVID concussion.'

Figure 1 Top 10 manufacturing nations (2015) and COVID cases (31/3/2020)



Source: Authors' elaboration of OECD TiVA data on gross manufacturing production.
Notes: This figure shows each countries' share of world manufacturing output in 2015.

The negative impact on manufacturing is not primarily due to the virus itself. It is the human reaction to the virus, as Baldwin and Weder di Mauro (2020a) point out. There are two main shocks.

> **The first shock comes from the containment measures aimed at slowing the rate of infection. By keeping workers away from work, these measures are expressly reducing output.**

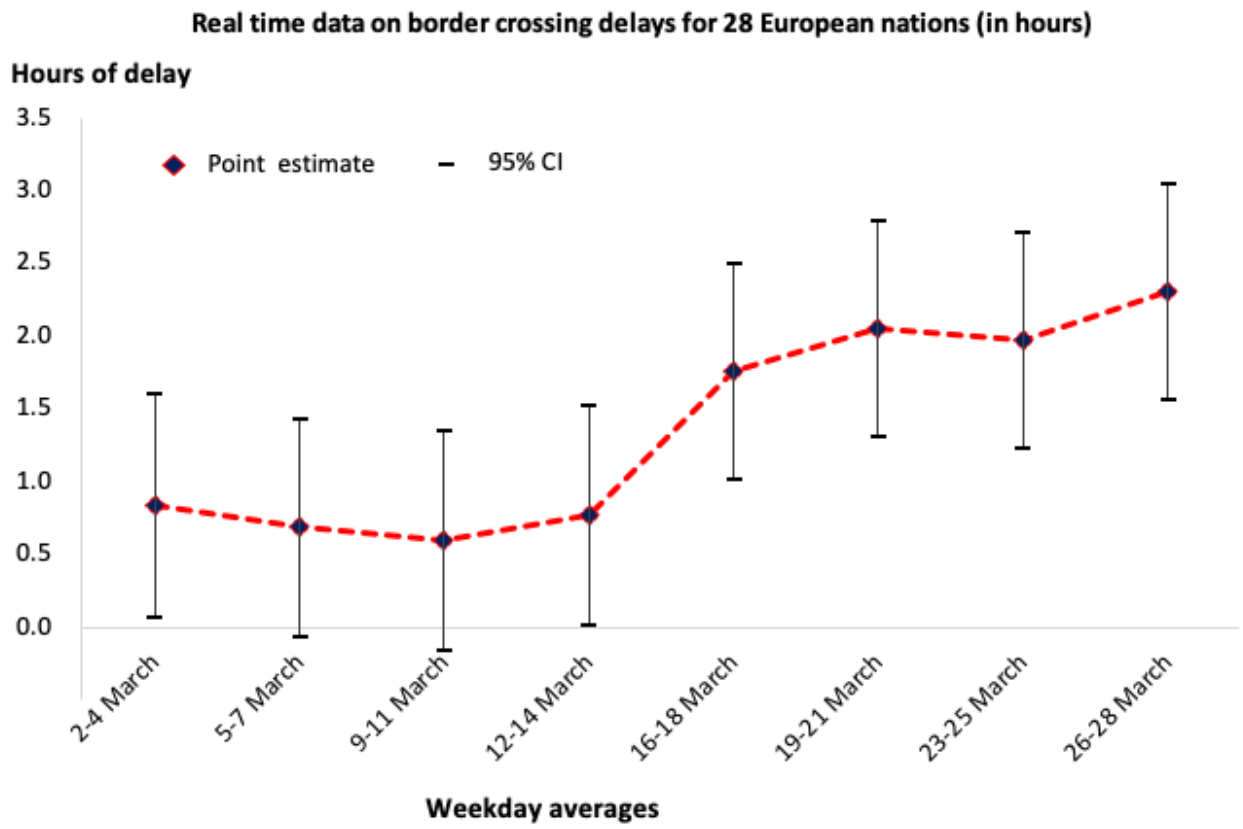
Nations are shutting their economies to slow the disease's progress in a desperate effort to avoid calamity at the hospitals. COVID-19 is so infectious that during the acceleration phase of its epidemiological curve (Baldwin 2020a), the number of people needing hospitalisation explodes. This is overwhelming the healthcare systems of Italy and Spain, and will soon do the same in the US and most European nations. Taking the US as an example, 19,332 new cases were announced on 29 March 2020, bringing the cumulative total far beyond what China experienced.[1] And US cases are on course to double every 2 or 3 days. At this rate, something like 5% of the US population will be showing symptoms and 20% of those will need hospitalisation. That's about 3 million people with severe COVID-19 cases to be handled by a system with about a million beds nationwide (many of which are already occupied).

Hospitals that are this overloaded cannot provide the care that would be needed for that many patients to survive. In short, overwhelmed hospitals means unnecessary deaths. Resultantly, the seemingly extreme containment policies (lockdowns, etc.), are not extreme compared to the nightmare alternative of overwhelmed hospitals being unable to provide the care people need to survive the disease. These policies, however, shut down manufacturing facilities and the logistics needed to keep them functioning.

As Figure 1 shows, the advanced economies that reacted quickly and forcefully when the threat emerged in China in January 2020 have been able to greatly reduce their share of COVID cases. See Japan and Korea in particular, but China as well. These nations, who learned their lessons from the 2003 SARS pandemic; the Western advanced economies did not.

As shown in Figure 2, delays at European border crossings in recent weeks have amplified the direct factory closures. These delays are slowing the delivery of much needed inputs as COVID-19 travel restrictions were put in place by various European governments.

Figure 2 Real time data on border crossing delays for 28 European nations (in hours)



Source: Calculations based on data from Sixfold (www.sixfold.com).
Notes: This figure plots the point estimates of a regression of average border crossing times on dummy variables for each 3-day period. Data for 28 European countries. Sundays excluded due to restrictions on cargo truck travel.

> **The second shock comes from the expectation shock that is hurting demand for manufactured goods.**

As happened during the Global Crisis of 2008-09, the COVID concussion has made consumers and firms cautious about buying things – at least things whose purchase can be put off.

Manufacturing sector gets a triple hit

The world manufacturing sector is getting a triple hit.

1. Direct supply disruptions are hindering production since the disease is focused on the world's manufacturing heartland (East Asia), and spreading fast in the other industrial giants – amongst which are the US and Germany.
2. Supply-chain contagion will amplify the direct supply shocks as manufacturing sectors in less-affected nations find it harder and/or more expensive to acquire the necessary imported industrial inputs from the hard-hit nations, and subsequently from each other.
3. Demand disruptions due to: i) macroeconomic drops in aggregate demand (i.e. recessions); ii) wait-and-see purchase-delays by consumers; and iii) investment-delays by firms.

Manufactured goods, after all, are – on the whole – 'postpone-able' and thus more susceptible to 'sudden stop' demand shocks, as we saw in the Great Trade Collapse of 2009. Of course, the service sector in all affected countries is hit hard – as restaurants and movie theatres emptying out – but it may well be the manufacturing sector that takes the biggest hit.

We don't yet have much data on the direct hit to manufacturing or the impact of demand drops, but we can think ahead about supply chain contagion by looking at the network of supplier relationships using recent, pre-crisis data.

Illustrating trade-linked contagion

Nations are connected by international trade, so trade is an important vehicle for international contagion. Or, to use an unfortunately apt analogy, when trade patterns are simple, the transmission vectors are simple.

> **On the demand side, a drop in one nation's income will reduce its imports from its trading partners.**

Such a drop, in turn, means lower exports, and thus lower aggregate demand, for its trade partners. This is the way demand shocks propagate.

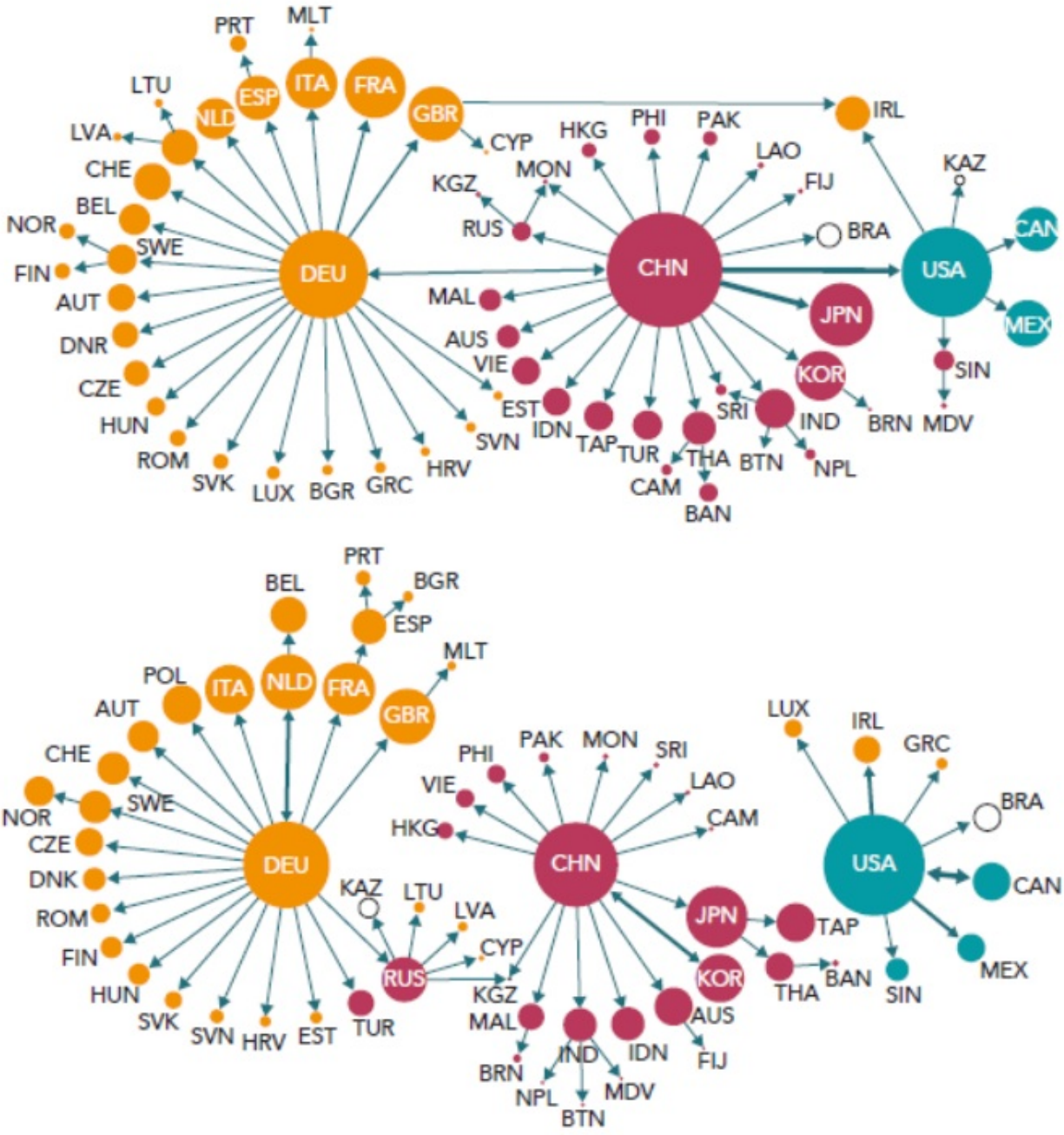
> **On the supply side, a supply disruption in one nation's production shows up as a reduction in its exports to its trade partners.**

The drop in imports, in turn, means either a shift in aggregate demand to local products – if local firms are producing a good substitute to the imports – or shortages if local producers cannot replace the imports (as in the case of some imported manufactured parts).

World trade, however, is not simple anymore. Since the mid to late 1980s, international supply chains – also known as global value chains (GVCs) – have multiplied. This complicates the propagation of shocks. The ripple effects in manufacturing will depend on nations' exposure to other nations' manufacturing sectors – both direct and indirect. The direct part of this is clear. When a Mini Cooper is made in Britain, for example, the company buys tyres from, say, China, and the engine from Japan. This is direct exposure. The Japanese engine, however, might involve parts that were sourced from China, so the Mini maker is exposed indirectly to any disruption in China through its Japanese imports from China. This is indirect exposure.

A convenient way of visualising this is to use social network analysis (Figure 3). The top panel shows the trade pattern for value-added trade in final goods (value-added exports, for example, are exports that net out the value of any imported inputs). The size of the bubbles shows the magnitude of value-added exports, the thickness of the connectors shows the importance of the bilateral flows, and the arrows indicate the net direction of the flow. Minor bilateral trade flows are set to zero for clarity of presentation.

Figure 3 Network of exports in final goods (top) vs. GVC trade (bottom), 2017



Source: WTO (2019), Figure 1.15.
Note: Country nations show with standard ISO-3 alpha codes.

The key point is that GVC trade (bottom panel) is far more regionalised than trade in final goods. Indeed, there are no major linkages between the three industrial giants – at least at this level of abstraction. This suggests that supply chain contagion will be mostly regional, not global.

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The top panel of Figure 3 clearly shows the dominance of the three manufacturing giants, China, the US, and Germany. It also shows the highly regionalised nation of world trade in final goods. The main links are within Europe, within Asia, or within North America. The only really important inter-regional flows are among the three manufacturing giants.

The demand shock is likely to spread via trade in final goods

As this top panel focuses on the exports of final goods, it gives a good indication of how the demand shocks might spread. The 'COVID concussion' first knocked China's income on the head in January and February 2020. That surely reduced China's imports of final goods from the rest of the world. The concussion next hit Germany, and is just now hitting the US, just as China is starting to recover slowly.

The bottom panel of Figure 3 focuses on the supply-side linkages. This shows trade in intermediate goods that cross borders more than once – for example, exports of American computer chips that are embedded in electronic components that are then reimported into the US. In Baldwin and Lopez-Gonzalez (2012) this is called 'importing to export'. The key point is that GVC trade (bottom panel) is far more regionalised than trade in final goods. Indeed, there are no major linkages between any of the three industrial giants – at least of this back-and-forth type of supply chain trade. What this suggests is that in terms of disrupting complex production networks, the main transmission will be regional, not global.

While useful for illustrating the basic idea of demand-linked contagion (top panel) and supply chain contagion (bottom panel), Figure 3 radically simplifies the trade flows to clarify concepts. What do the more detailed linkages look like when it comes to what Baldwin and Tomiura (2020) call supply chain contagion? Figure 3 only looks at final goods trade (top panel) or complex, back-and-forth trade. What matters for contagion is the total dependency, i.e. exposure, of one nation's supply side (production) to the production of other nations.

How connected are nations' manufacturing sector to one another?

On the supply side, the disruption to countries' domestic production depends on the countries' exposure – both direct and indirect – to foreign production. As multi-country production networks have grown more complex, indirect exposure has become an increasingly important consideration. Imported parts and components from, say, Korea are very likely to contain parts from China, which in turn may comprise parts made in the US. Thus, in the short run, a disruption to US, Korean, or Chinese manufacturing could, in turn, disrupt production of the goods using the part that is nominally made in Korea.

Using the OECD's inter-country input-output (ICIO) tables – and applying a few linear algebra tricks – we can compute countries' total exposure (i.e. direct and indirect exposure) to each other. Looking at each countries' manufacturing sector production and aggregating exposure across all manufacturing sector inputs gives the total exposure of each nation's manufacturing sector to the manufacturing sector of other nations.[2] The results of this exercise are shown in Figure 4.

The numbers in the figure are shares that show the percentage of the row nation's manufacturing output that is made up by the value-added of manufacturing inputs from the column nation. This takes the whole manufacturing sector together. For example, the 4.8% number in GBR (the UK's) row under the CHN (China) column means that 4.8% of total British manufacturing production relies upon Chinese manufacturing direct and indirect inputs. The colouring is a sort of 'heat map' scheme where the largest numbers in the matrix are dark red, while the smallest are light green, and intermediate numbers are in yellow (small numbers are zeroed for clarity's sake).

Figure 4 Total exposure of row nations to column nation's manufacturing sectors.

		Factory North America			Factory Europe								Factory Asia									
		usa	can	mex	deu	gbr	fra	ita	esp	tur	nld	che	chn	jpn	kor	ind	twn	aus	idn	bra	rus	sau
Factory North America	**usa**		1.6	1.6	1.0								6.5	1.2	1.0							
	can	14.1		1.4	1.2	0.5							7.2	1.2	1.1		0.5					
	mex	15.5	1.0		1.7			0.6	0.6				14.3	2.3	2.6	0.7	1.1			0.6		
Factory Europe	**deu**	1.6				1.0	2.0	1.9	1.1	0.6	1.3	1.0	4.6	0.9	0.6						0.8	
	gbr	2.6	0.5		3.9		1.6	1.2	1.0	0.6	1.0		4.8	0.6	0.6	0.6						
	fra	2.4			5.7	1.2		2.3	1.9		0.8	0.6	4.1	0.6							0.5	
	ita	1.1			4.9	0.8	2.3		1.6	0.8	0.8	0.6	4.6		0.7	0.6					1.2	
	esp	1.2			4.5	1.2	3.3	2.3		0.6	0.8		4.6	0.6	0.6	0.6						
	tur	1.1			2.1	0.6	0.8	1.2	0.8				5.0		1.3	1.0					2.0	
	nld	1.8			5.0	1.2	1.2	0.9	0.7				3.7	0.7							0.9	
	che	2.4			8.2	1.6	1.9	3.1	1.1	0.6	0.7		5.2	0.9		0.5						
Factory Asia	**chn**	1.5			0.9									1.9	3.0		1.9					
	jpn	1.4			0.7								6.3		1.2		0.6					
	kor	2.9			1.8			0.5					16.4	4.4		0.6	1.8				0.6	
	ind	2.1			0.9	0.5							7.2	0.9	1.5		0.5				0.7	0.5
	twn	2.7			1.3								13.8	6.4	3.4	0.6			0.8		0.6	
	aus	1.8			1.0								7.1	2.2	1.5		0.5					
	idn	0.9			0.5								7.4	2.1	1.9	0.6	0.7					
	bra	2.2			1.0								4.6	0.5	0.6	0.6						
	rus	1.0			1.9		0.6	0.8					5.7	0.8	0.8							
	sau	1.3			1.8	0.9	0.5						3.8	0.6	1.0	1.0						

Source: Authors' elaboration of OCED Inter-Country Input Output Tables (available online at https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm).
Notes: The figures are the value-added share of direct and indirect inputs from the column nation in the row nation's total manufacturing output. Shares below 0.5% are zeroed for clarity as are 'own provisions' on the diagonal. For example, 4.8% of the GBR (the UK's) total manufacturing production relies upon Chinese manufacturing inputs (direct and indirect).

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The first fact that jumps out from the figure is China's dominance when it comes to imported manufacturing intermediates. China really is the workshop of the world – it is central to the entire global network of trade and production. Manufacturing inputs from China make up over 3.6% of every major nation's manufacturing output. For Korea, the number rises to over 16%. Plainly, the COVID shut down of Chinese manufacturing will clearly have a big impact on manufacturing sectors globally.

Second, German manufacturing inputs are important to all the other nations in Europe but also in Korea, and Taiwan, as shown by the many yellow cells in Germany's column (DEU). Note that Germany is also dependent on manufacturing inputs from a wide range of nations including the US and China. Inputs from the US are important in as many nations as China, but to a lower level. Only for Canada and Mexico are US manufacturing inputs highly critical.

Finally, the regionalisation of supply chain trade is clear from the figure. Many of the cells inside the three regional boxes (Factory North America, Factory Europe, and Factory Asia) are coloured, while most of the cells outside these boxes are not. The importance of Russia and Saudi Arabia (the two bottom rows) are obviously due to processed petroleum products.

The obvious implication of these facts is that supply disruption in the US, Germany, China, Korea, and Japan will have large effects on consumers and firms in all the major economies. The same is true, but to a lesser extent, for the UK, France, and Italy.

Supply chain 'contagion' and 'reinfection'

COVID-19 hit China first and hard. Importantly, the worse affected region, Hebei province, is the centre of many GVCs (Huang et al. 2020). But for January and February, COVID-19 was a Chinese disease which was dealt with in what struck many at the time as a very Chinese approach. Authorities quickly and firmly shut down the whole province to reduce the spread of the disease. Subsequently, that shut down production and/or shipment of the intermediate inputs that are so important to world manufacturing (as shown by the CHN column in Figure 3).

The impact of China's supply side disruption on the manufacturing output of other nations is what we call 'supply chain contagion'. The supply-side disruption in China is being transmitted to other nations. The chapter on Korea's COVID experience in Baldwin and Weder di Mauro (2020b) reports that the supply-side contagion was severe for Korean industry. "South Korea's industry is also deeply integrated with Chinese industry, so the disruption of parts and supplies from China was felt particularly hard in the country. Many corporations have already been weakened due to the failure of international logistics," according to Cheong (2020).

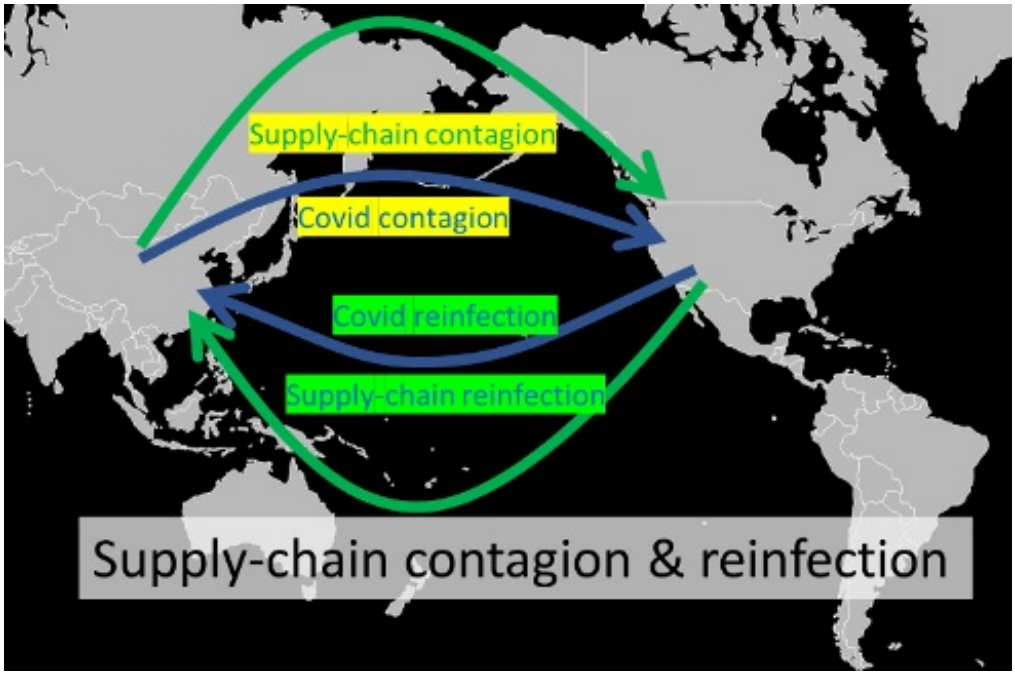
Figure 4 indicates that the disruption to other nation's manufacturing will be important especially for Mexico and Taiwan, for whom Chinese inputs account for a double-digit share of the value of production. Other nations will be hit, but not as strongly.[3]

But this first round contagion is not the end of the story. According to official figures, China's seemingly extreme lockdown worked in a medical sense. China has worked its way through the acceleration phase, peak, and deceleration phase of its epidemic. China is now recovering from the medical shock; the European Centre for Disease Control, for example, presents data that shows China has actually contained the disease for now. As the containment policies are relieved, China also seems to be recovering from the economic shock – or so early signs suggest (FT 2020). This should revive China's imports from other nations and relax the containment policies that hampered its exports.

But just as Chinese manufacturing is getting back on its feet, European and especially US manufacturing are being shuttered in an attempt to bring down the infection rate. In Europe, which began containment policies far later than China, there are some signs – at least in Italy which was first hit – that the containment is working. The US, by contrast still has not fully reacted to the threat. The daily load of new verified cases was in the tens of thousands at the end of March.

In a sense, the medical shock and thus the supply shock moved from China to the US and Europe, so now the supply chain contagion is working in reverse. The supply-side shock which emanated in China, is now 'reinfecting' Chinese industry, as inputs that it imports from the US and Europe are being constrained by anti-COVID containment policies. This is illustrated in Figure 5.

Figure 5 Illustration of medical and supply-chain contagion and reinfection.



Source: Authors' elaboration of OECD TiVA data on gross manufacturing production.

Summary and concluding remarks

COVID-19's impact on world manufacturing is unlike the impact caused by other pandemics over the last 100 years. Compounded by the complex nature of supply networks today, global manufacturing is particularly exposed. Trade-linked contagion will ripple through to nations whose output relies - both directly and indirectly- on each other's manufacturing inputs.

Unlike previous crises, first round contagion is unlikely to be the end of the story. As COVID-19 hits major global value chain hubs sequentially, supply chain contagion is working in reverse: the supply side shock which first originated in China is now working its way back via China's dependence on other countries' inputs.

International coordination on containment exceptions could help. All nations make exceptions to lockdown policies for essential goods. Realising the extent to which trade partners are dependent upon key inputs should broaden the definition of 'essential'. This would be a matter of enlighten self-interest. The US may need China and India to keep their 'active pharmaceutical ingredient' plants open, while China and India may need the US to keep its semiconductor plants open.

References

Baldwin, R and B Weder Mauro (2020a), *Economics in the Time of COVID-19*, a VoxEU.org eBook, CEPR Press.

Baldwin, R and B Weder di Mauro (2020b), *Mitigating the COVID economic crisis: Act fast and do whatever it takes*, a VoxEU.org eBook, CEPR Press.

Baldwin, R and E Tomiura (2020). "Thinking ahead about the trade impact of COVID-19," Chapter 5 in Baldwin and Weder di Mauro (2020a).

Baldwin, R and J Lopez-Gonzalez (2012). "Supply-chain trade: A portrait of global patterns and several testable hypotheses," NBER Working Paper, No. 18957 (published in 2015 in *The World Economy* 38(11): 1682-1721 https://doi.org/10.1111/twec.12189).

Cheong, I (2020). "The experience of South Korea with COVID-19", in Baldwin and Weder di Mauro (2020b).

FT (2020), "Coronavirus tracked: the latest figures as the pandemic spreads," Financial Times newspaper, accessed 31 March 2020.

Huang, Y, C Lin, P Wang and Z Xu (2020). "Saving China from the coronavirus and economic meltdown: Experiences and lessons," Chapter 9 in Baldwin and Weder di Mauro (2020b).

World Trade Organisation (2019), *Global Value Chain Development Report 2019: Technological Innovation, Supply Chain Trade, and Workers in a Globalized World* (English).

Endnotes

1 Number taken from WHO COVID-19 Situation Report 70.

2 Calculations available from the authors upon request to rbaldwin@cepr.org and rebecca.freeman@graduateinstitute.ch.

3 Note that Figure 4 shows the average figures for all of manufacturing, including some sectors with very low GVC involvement and others with very high involvement, so the impact for particular firms will be heterogenous.