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Abstract

Using difference-in-difference analysis, we examine how trade in GVC-based products may have responded to two previous health shocks - SARS and MERS. Our identification strategy exploits differences in the time period of severe incidence of each disease and in the coverage of trading partners that were more adversely affected than others. While we find no evidence for "reshoring" in response to each of these virus outbreaks, there is some evidence for "near-shoring" in the stylized facts on SARS. Empirical analysis also suggests geographical diversification of value chains - import shares from China and UAE declined during each outbreak, while MERS was accompanied by a fall in import concentration; these effects persisted over time for SARS suggesting that the associated value-chains were not resilient to these health shocks. The findings are observed at both the intensive (import value) and extensive (number of HS-6 products and export destinations) margins. The SARS effects are driven by lower-middle-income importers that were more integrated in GVCs, received more investment, were more competitive and were more reliant on the severely affected partners. We expect similar disruptions to GVC-trade from COVID-19, especially diversification away from China.

Keywords

GVC-trade; health shocks; COVID-19; reshoring; near-shoring; GVC-disruptions.

JEL-Classification: F1

1 Introduction[1]

COVID-19 is an unprecedented crisis with disastrous health and socio-economic concerns around the world. It has already affected over thirty-seven million lives since its outbreak in Wuhan, China in January 2020. A burgeoning literature has developed around analysing the epidemiological and economic impact of this pandemic (Smith, et al. 2019; Ivanov, 2020; Miroudot, 2020; Baldwin and Tomiura, 2020; World Bank, 2020). The crisis also has significant implications for trade and investment due to disruption of global value chains (GVCs).

While these disruptions clearly emanate from the demand shock that lockdowns and stalled economic activity have caused, there is also a supply shock emanating from temporary or permanent disruptions in supply networks and execution of a plan B to import from alternative sources. Moreover, the pandemic has affected many locations simultaneously and the high level of interconnectedness of the global economy has amplified the impact, especially on the global hubs (World Bank, 2020).

Extant literature has studied the effects of health crises and natural disasters in the last two decades on both economic and non-economic outcomes, but not much work has been done exploring the GVC response to these events as observed in actual trade and investment data. Previous research suggests that overall output was disrupted more by health crises than by natural disasters (for instance see Raddatz, 2009). Recent work provides both historical evidence (Ceylan et al. 2020) and empirical analysis (Fernandes and Tang, 2020) but does not focus on GVCs.

This is a major gap in research given that trade in intermediate goods and services accounts for over 60 percent of total international trade (Strange, 2020). Moreover, multinational enterprises (MNEs) are involved as exporters, importers or as lead firms in GVCs in 80 percent of global trade worth around USD 20 trillion in 2019 (Contractor, 2020). In fact, the same MNE acted as both exporter and importer in close to 40 percent of world trade, highlighting the close links between FDI and GVC-trade.

We aim to bridge this research gap by studying GVC responses to two major health epidemics as observed in actual trade data. In doing so, we explore the following hypotheses: one, the disease outbreaks were associated with a rise in domestic production at the expense of total imports ("reshoring"); two, there was a tendency to reduce the share of imports from disease epicentres during the epidemics ("geographical diversification of value-chains"); three, the

[1]We would like to thank Rupa Chanda, Bernard Hoekman, Peter Holmes, Sebastien Miroudot and Ben Shepherd for excellents comments and suggestions on a previous version of this paper.

disease outbreaks were associated with a rise in the number of suppliers for each GVC-based product that was imported ("GVC-widening"); four, there was a tendency to import more from suppliers in the geographical neighbourhood at the expense of the disease epicentres ("near-shoring"); and five, disruptions to GVCs coincided with the time period of the virus outbreaks but dissipated over time ("GVC-resilience").[2]

To do so, we use difference-in-difference analysis to examine changes in patterns of GVC-based imports from the worst-affected countries in Asia during SARS - China, Hong Kong, Singapore and Vietnam - and from the worst-affected countries during MERS - Saudi Arabia, South Korea and the UAE[3] - over 2001-2005 and 2011-2018, respectively.[4] We focus on SARS and MERS for reasons that are common to the current pandemic - both outbreaks originated at an epicentre but spread around quickly; the diseases are characterized by flu-like symptoms; and manufacturing value-chains were likely disrupted by both episodes.[5] Our identification strategy exploits differences in the time period of severe incidence of each disease and in the samples covering trading partners that were more adversely affected than others. The objective of the analysis is not just to understand how GVCs may have responded to these crises, but also to draw lessons for the current COVID-19 outbreak.

We aggregate bilateral trade data from BACI (Gaulier and Zignago, 2010), disaggregated at the HS 6-digit level over the 2000-2018 period, for over 200 countries (see Annex table 1). The HS 6-digit products, used in disaggregated analysis, are classified as intermediate and

[2]In the international business literature, 'reshoring' and 'near-shoring' are defined more on the basis of the location of production of MNEs and whether they create foreign or domestic affiliates (or affiliates in neighbouring countries for near-shoring). In that sense, we use these terms differently. The actual reshoring or near-shoring would only be observed well after the shock, when firms change the organisation of their value-chains (something that takes time). Moreover, in the event that trade in intermediates were to recover after the crisis, it would suggest that the organisation of GVCs did not change structurally but that there was only a temporary change during the shock.

[3]These countries reported the largest number of cases and amongst the highest case fatality rates according to data from the WHO (https://www.who.int/csr/sars/country/table2004_04_21/en/; https://www.who.int/emergencies/mers-cov/en/). For instance, the number of SARS cases in China (the disease epicentre) and Hong Kong during January-June 2003 were 5327 and 1755, respectively, while the case fatality rate was 17% in Hong Kong and Canada (251 cases), 14% in Singapore (238 cases) and 7% in China. Vietnam reported 63 SARS cases and a case fatality rate of 8%. Similarly, Saudi Arabia, where MERS originated, had 158, 662, 454, 249 and 233 cases during each of 2013-2017, followed by 185 cases in South Korea in 2015 and 86 cases in the UAE in 2014. While Saudi Arabia has again witnessed a spike in MERS cases in 2019, there was a distinct break in trend in 2018, which we exploit in our identification strategy. Significantly, this break is also consistent with the stylized facts observed in Section 3 (see Figure 3 for details), where the decline in imports of GVC-based intermediates from Saudi Arabia in some sectors seems to have been arrested in 2018.

[4]The time periods span severe incidence of the virus outbreaks in the worst-affected countries in each case (2003 for SARS and 2013-2017 for MERS).

[5]We do not look at Zika (sporadic occurrence through 2000-18), Ebola (localized in West Africa, with the region significantly less integrated in GVCs) and H1N1 (concurrence with the global financial crisis makes identification challenging).

final products in GVCs in the apparel, automobiles, electronics, footwear, pharmaceuticals and textiles sectors, following Sturgeon and Memedovic (2010) and the World Bank WITS classification (see Annex table 2).

The baseline difference-in-difference model suggests a decline in cumulative imports from the worst-affected countries during SARS, though a similar effect is not observed in the case of the MERS outbreak. The results are found to be robust to controlling for possible violation of the parallel trends assumption by including unit-specific linear trends in estimation (Mora and Reggio, 2012) and in matrix completion (Athey, 2017; Xu, 2017) analysis.

There is also no evidence of a rise in domestic production at the expense of total imports ("reshoring") during these health shocks in the empirical analysis. Results also provide evidence for geographical diversification of value-chains - import shares of GVC-based products from China and UAE may have declined during SARS and MERS, respectively, while MERS was accompanied by a decline in the import concentration Hirschmann-Herfindahl indices at the disaggregated HS6-product level. The value-chains also seem to not have been resilient to the SARS outbreak - the adverse effects seem to have have been accentuated over time in the case of China in particular.

There is also some evidence for "near-shoring" in the stylized facts - the SARS epidemic, for instance, may have been associated with an increase in US imports from Mexico; Australian imports from Vietnam; and EU15 and Swiss imports from Poland, all at the expense of Chinese exports. The stylized facts also provide suggestive evidence for GVC-widening - six major importers seem to have diversified the source distribution of their imports at the product-level during each disease outbreak.

The findings are observed at both the intensive (import value) and extensive (number of HS-6 products and export destinations) margins. The SARS effects are found to be driven by lower-middle-income and non-OECD importers and countries that were more heavily reliant on the worst-affected suppliers; were more integrated in GVCs; received more investment; were more competitive; less capital-intensive and less technology-intensive in the production of intermediate goods, all of which are expected results. We expect similar disruptions to GVC-trade from COVID-19, especially diversification away from China.

The rest of the paper is organized as follows. Section 2 provides a comprehensive review of related literature. Section 3 provides descriptive statistical evidence on changes in trade patterns in the immediate aftermath of past epidemics. Section 4 discusses the empirical methodology used to examine the impact of previous health crises on GVC-based trade. Section 5 discusses the results from estimation while Section 6 explores the likely drivers of the results for SARS. Section 7 concludes with some implications for the COVID-19 pandemic.

2 Related literature

2.1 Robustness and resilience of supply-chains to global shocks

The world has witnessed several virus outbreaks in the last two decades. There is a large literature examining the effects of these epidemics on health and economic outcomes. Although the direct cost of an epidemic outbreak on health services can be extensive, the indirect economic cost may be larger (Smith, 2006). Nonetheless, the health consequences of a pandemic greatly outweigh the long-term economic impact (Wren-Lewis, 2020).

Specific to the operation of GVCs, the location of supply bases in severely affected regions is likely to create disruptions in supply networks; suppliers may close their plants or may be unable to deliver their products (Ivanov, 2020; Miroudot, 2020). For example, a supply-side contagion in East Asia's (Japan, Korea, Taiwan and China) manufacturing sectors may hurt manufacturing sectors of other countries as well due to supply linkages, especially in automobile, textiles and ICT goods sectors (Baldwin and Tomiura, 2020). Similarly, the decrease in domestic output in Thailand due to COVID-19 is attributed to increasing trade costs and under-utilization of capital, especially in the ICT goods industry that has the highest level of fragmentation of production in that country (Maliszewska et al. 2020).

Infectious disease outbreaks thus have a profound impact on GVCs, simultaneously affecting multiple countries and industries, with the fear of contagion resulting in unanticipated changes in demand and supply of products (Sheffi, 2015). This fear can lead to under-reporting of an outbreak, especially if the country fears an ex-post application of trade sanctions against it by non-outbreak countries (Brahmbhatt and Dutta, 2008). It is believed that epidemic outbreaks are a unique type of supply-chain risk characterized by long-term disruption in demand, supply and logistics as well as unpredictable ripple effects. The scope and timing of disruptions play a vital role in determining the impact of an epidemic outbreak on supply chains. For example, the asynchronous opening and closing of facilities creates uncertainty at the firm-level, necessitating a guided framework for better decision-making (Ivanov, 2020).

Building resilience during a pandemic is the topmost priority for firms integrated in supply chains. Brandon Jones et al. (2014) and Miroudot (2020) distinguish between building robustness and resilience in supply chains - the ability to recover in the post-crisis period is resilience, while the ability to continue firm operations during a crisis is robustness. Extant literature proposes two opposing solutions to build resilience. One, insurance against a disruption by diversifying the supplier base, albeit at an additional cost, to reduce excess dependence on one country and compensate loss from a few supplier breakdowns (Henriet et al. 2012; Baldwin and Tomiura, 2020); and two, isolation from any disruption through reshoring manufacturing firms back home (Henriet et al. 2012; di Mauro, 2020).

Exclusive reliance on suppliers from only one or a few countries can be detrimental and can expose the country to localized risks from health crises or natural disasters. Hence diversifying to alternative suppliers or locations of production during a crisis is more of a robustness strategy as compared to reshoring manufacturing back home to a localized setting (Miroudot, 2020). However, long-term firm-to-firm relationship with a single supplier can assist in an easy bounce-back in the post-crisis period (Antras, 2019), besides avoiding sunk costs from diversification at the eleventh-hour. Hence, there is an apparent downside to diversification vis-à-vis recovery, as supplier diversification is associated with slower recovery from interruptions (Jain et al., 2016).

On this subject, Strange (2020) recommends diversification over reshoring citing increased firm costs, reduced competitiveness and foreign sale of goods due to reshoring of firms closer to home. The negative sentiment around reshoring of supply chains is also corroborated by firms - 32 percent of the executives interviewed through an UNCTAD survey thought reshoring of manufacturing functions to be associated with a significant decline in global FDI (UNCTAD, 2015).

Against this background, we explore the following hypotheses in the analyses that follow. One, the disease outbreaks were associated with a rise in domestic production at the expense of total imports ("reshoring"). Two, there was a tendency to reduce the share of imports from disease epicentres during the epidemics ("geographical diversification of value-chains"). Three, the disease outbreaks were associated with a rise in the number of suppliers for each GVC-based product that was imported ("GVC-widening"). Four, there was a tendency to import more from suppliers in the geographical neighbourhood at the expense of the disease epicentres ("near-shoring"). Five, disruptions to GVCs coincided with the time period of the virus outbreaks but dissipated over time ("GVC-resilience").

2.2 Empirical evidence: impact of natural disasters

Evidence suggests GVC-disruptions due to natural disasters. The volcanic eruption in Iceland halted supplier transportation in the region for a week and stalled production based on imported inputs (Saltmarsh, 2010), while Hurricane Katrina in 2005 had widespread economic consequences in the United States and beyond (Henriet et al. 2012). The 2011 earthquake in Japan resulted in output losses and coerced companies to make their supply chains shorter and less complex (de Backer and Miroudot, 2014). The aftermath of the earthquake (and tsunami) witnessed a shift in suppliers in the automobile industry away from Japan (Todo et al. 2014; Freund et al. 2020) and halting of global production (especially in the United States) due to inability in obtaining parts and components from Japanese suppliers (Boehm et al. 2015; Ip, 2020; Javorcik, 2020). Firms in the affected areas in Japan even resorted to greater offshoring activities in the aftermath of the earthquake (Zhu et al. 2017). A similar effect was also felt by the hardware industry in Thailand after the floods of 2011 (Miroudot, 2020).

Measuring firm-level exposures to natural disasters, Carvalho et al. (2017) exploit the heterogenous exposure of Japanese firms to the 2011 earthquake, to examine the extent of shock propagation along supply chains. A negative firm-level shock is expected to travel both upstream and downstream affecting customers as well as suppliers of the firm. This was found to be true for the Japanese earthquake that led to an overall collapse in industrial production and manufacturing activity in Japan. Further evidence from Barrot and Sauvagnat (2016) supports these findings. In other work, Raddatz (2009) investigated the contribution of various external shocks in explaining output fluctuations showing larger output losses being associated with epidemics relative to natural disasters, but with qualitatively similar overall impacts. Notably, the estimated output responses are conditional upon the endogenous responses taken by a government or the international community to alleviate the consequences of a health or natural disaster.

2.3 Empirical evidence: impact of disease outbreaks

A number of studies have examined the economic cost of epidemics like SARS (Lee and McKibbin, 2004; Hai et al. 2004; Hanna and Huang, 2004; Smith, et al. 2019). The SARS outbreak that struck East Asia in 2003 resulted in a huge disruption in high-tech manufacturing in the region and around the world (Burleigh, 2009). It predominantly led to increased production costs due to supply-side disruptions and a large negative demand shock (World Bank, 2020). The threat to manufacturing sectors in China was to the extent that new orders were placed on hold and investors halted expansion plans for the year. The overall impact was felt across sectors, as diverse as seafood to microchips (ADB, 2003; National Intelligence Council, 2003; IMF, 2004). SARS deterred global FDI in industrial production in China (Bell and Lewis, 2005; Hanna and Huang, 2004; Fan, 2003) as well as in Hong Kong and Japan (Keogh-Brown and Smith, 2008).

Lee and McKibbin (2004) show that Hong Kong and China experienced the largest shocks to their GDPs from the SARS outbreak compared to Taiwan and Singapore, primarily due to their greater reliance on trade.[6] In fact, Taiwan may have faced a wave of delayed shocks to its trade and investment due to linkages with mainland China (Chou et al. 2004). In recent work, Fernandez and Tang (2020) show that firms in the affected regions of China experienced a YoY decline in export and imports for three consecutive quarters during the outbreak. Moreover, they continued to experience unfavorable growth as late as 2014-2015, supporting the claim that the SARS outbreak had a medium-term impact on Chinese trade such that aggregate exports and imports did not regain the pre-SARS levels even a decade later.[7]

Other East Asian countries were also affected by the SARS epidemic. APEC (2004) notes that Singapore's Purchasing Manufacturers' Index remained low in 2003, indicating that the manufacturing sector was contracting. Factories in Taiwan also faced falling levels of production, especially those in the electrical and electronic machinery sector, textiles and clothing and plastic products (Chou et al. 2004).

A similar contagion fear was felt soon after the outbreak of MERS in South Korea in 2015 that contracted overall export activity (Smith et al. 2019; Barua, 2020). Although the MERS outbreak infected less than 200 individuals in South Korea, its economic impact reverberated far beyond the original outbreak's footprint (WEF, 2019). In fact, recent evidence suggests that the impact of MERS may have been more severe than that of SARS (Ceylan and Ozkan, 2020).

Similarly, many countries such as Russia, China and Jordan banned all swine meat imports from Mexico and the southern US states and several countries issued travel bans to Mexico during the H1N1 outbreak in 2009, worsening supply chain connectivity that echoed throughout the world (Rassy and Smith, 2013; Turner and Akinremi, 2020). The outbreak also forced factories to shut down especially in high-tech and heavy manufacturing sectors (Field, 2009) and contributed to fear-driven reduction in consumer demand (Risk Management Solutions, 2010; Rassy and Smith, 2013).

Amongst other health crises, Kostova et al. (2019) assess the link between the Ebola outbreak in West Africa in 2014 and US exports. The study reported a loss of USD 1.08 billion during

[6] In contrast, Ceylan and Ozkan (2020) note that Hong Kong's external trade sector, made up of exports and re-exports from mainland China, performed quite well even during the peak of the SARS outbreak. Moreover, no major production disruptions were reported in the Pearl River Delta - the manufacturing hub of Hong Kong - during the epidemic as firms continued to function normally. Thus, the overall impact of SARS may not have been as catastrophic as anticipated.

[7] In contrast, Hong Kong returned to pre-SARS GDP levels by the end of 2003, while 2004 showed slight growth over the previous year (Keogh-Brown and Smith, 2008).

the peak of the epidemic that could have been higher had the virus spread to larger US trade partners. The foot-and-mouth disease outbreak in South America in 2000 led to a ban on exports to the EU, US and some Asian countries for several years (Fernandez-Stark, Bamber and Gereffi, 2014). In general, agri-food chains are found to be more severely affected by outbreaks of zoonotic diseases (Fernandez-Stark et al. 2014).

3 Stylized facts

One likely effect of major health shocks and natural disasters can manifest itself in a decline in the share of GVC-based intermediate imports by value from countries worst affected by such crises ("the intensive margin effect") as well as a fall in the number of intermediate products or destinations that the latter export to ("the extensive margin effect"). To reduce dependence on previous import sources and increase resilience to localized or region-specific shocks (Baldwin and Tomiura, 2020; di Mauro, 2020), these episodes can also induce a preference for the value-chains to be brought home ("reshoring"), widened (increase the number of suppliers) or be located in geographical proximity ("near-shoring").

In this section, we use disaggregated data at the HS-6 digit-level to look at the pattern of GVC-based intermediate import shares from China, Hong Kong, Singapore and Vietnam; and Saudi Arabia, South Korea and the UAE, before, during and after the incidence of the SARS and MERS outbreaks, respectively, to explore the hypotheses outlined in Section 2.1. We also see if these episodes were associated with a fall in the number of intermediate products or export destinations of these countries. Our analysis covers imports of intermediate products in the following sectors: apparel, automobiles, electronics, footwear and pharmaceuticals.

We begin with the reshoring hypothesis by looking at the trend of mean total imports and domestic production of intermediate and final products over 2000-2017, with the period covering the two virus outbreaks.[8] Figure 1 shows that mean imports of GVC-based intermediate and final products may not have declined during the SARS outbreak suggesting an absence of reshoring in the wake of that epidemic. In contrast, these imports seem to have witnessed a clear decline during the MERS outbreak across sectors but especially in automotives and electronics, pharmaceuticals and textiles. This decline in imports seemed to have been accompanied by a rise in domestic output in the auto and electronics sector for

[8]Disaggregated data on domestic output for GVC-based products included in our analysis are only available from UNIDO's Indstat database according to the ISIC Rev. 3 and Rev. 4 classification. The HS6 products in the data were thus "converted" to four-digit ISIC Rev. 3 codes using concordance tables in United Nations (2002) for the purpose of this analysis.

both intermediate and final products, which is thus suggestive of reshoring in these sectors during the MERS outbreak.

<Insert Figure 1 here>

Figure 2 shows the intensive and extensive margin trends of GVC-based intermediate imports from suppliers located in China and South-east Asia (Hong Kong, Singapore and Vietnam), which were the worst affected countries during the SARS epidemic. Figure 3 looks at the MERS outbreak in Saudi Arabia (the epicenter), United Arab Emirates (UAE) and South Korea that had the largest number of cases outside the Middle-east.

<Insert Figures 2-3 here>

Figure 2 suggests a consistent decline in the share of intermediate imports by value across sectors for Hong Kong, Singapore (barring auto and pharma) and Vietnam (except for auto and electronics) in the wake of the SARS outbreak. This said, imports seem to have recovered for most sectors by 2005-2006 with the exception of Hong Kong, where in contrast to the findings in Ceylan and Ozkan (2020), it seems that SARS had a medium-term impact on producers and exporters of intermediate products in the apparel, footwear, auto and electronics sectors. Hong Kong also seems to have exported intermediate products to fewer destinations in the apparel sector and fewer number of intermediate exports in the auto and electronics sectors in the wake of the SARS outbreak. A similar trend was observed for Singapore and Vietnam across sectors; both countries exported fewer number of intermediate products during the outbreak and in the case of Singapore, even in the period that followed.

Korea and UAE also witnessed a decline in the share of intermediate imports by value across sectors (barring footwear and pharma) during the MERS epidemic (see Figure 3); for Saudi Arabia, a decline was observed in auto and electronics. These countries also seem to have witnessed a decline in the number of their trading partners and in the number of products exported across GVC-based intermediate goods sectors in the wake of the MERS outbreak.

Figures 4a and 4b plot the Hirschmann-Herfindahl indices (HHI[9]) of import concentration at the HS6-digit level for six major importers (Australia, Canada, EU15, Japan, Switzerland, USA) of GVC-based intermediate and final products, respectively, over time by sector. The first six charts show the variance in the HHI during SARS and the next six during the MERS outbreak.

[9]The HHI ranges in value from 0 (several suppliers) to 1 (unitary supplier).

There is a substantial decline in the HHI for intermediate products in Australia, Canada and EU15 across sectors that suggests widening of supply chains during the SARS outbreak. Similar results were also observed for the automotives sector in Japan and for the automotives and electronics sectors in Switzerland and the United States. In contrast, during the MERS outbreak, a clear widening of supply chains across sectors was observed in the case of Japan and Switzerland only. This suggests that the SARS epidemic may have had a larger impact on trade in intermediate products along global supplier networks compared to the MERS outbreak.

In terms of imports of GVC-based final goods, Figure 4b indicates a slight widening of supply chains in Canada, EU15, Japan and Switzerland during the SARS outbreak in the electronics, auto and electronics, automotives and, automotives and textiles sectors, respectively; a decline in HHI during MERS also suggests widening of final-goods value-chains in the apparel and footwear sectors in all countries except Switzerland.

Thus, there is suggestive evidence for a clear disruption of GVCs in the data along different dimensions and it may well have been the case that importing countries were bringing the value-chains closer home. Figure 5 explores this "near-shoring" hypothesis by examining if the US, Australia, EU15 and Switzerland may have imported more GVC-based intermediate (top panel) and final (bottom panel) products from Mexico, Vietnam and Poland, respectively, at the expense of China in the wake of the SARS epidemic by observing changes in the ratios of the import shares over time.

Descriptive statistical evidence in Figure 5[10] suggests that the US may have switched imports of auto, electronics and pharmaceutical interemediates to Mexico; Australia may have switched intermediate imports of apparel and footwear and final imports of textiles to Vietnam; and the EU15 and Switzerland may have preferred Poland for intermediate imports of automotives and pharmaceuticals and final products of automotives and textiles; all at the expense of Chinese exports (this can be seen from the spike in the respective sectoral ratios for the US, Australia, EU15 and Switzerland in 2004, one year after the SARS outbreak).

<Insert Figures 4-5 here>

While these stylized facts are suggestive of a reconfiguration of GVCs in response to these disease outbreaks, they do not provide conclusive evidence of the "impact" of these health

[10]Significantly, the figure also highlights that two decades ago, the US was hugely reliant on Mexico (and not China) as a supplier of all GVC-based intermediate-goods sectors except footwear and in the automotives sector for final products. Likewise, the EU15 and Switzerland were significantly more reliant on Poland (than on China) for their intermediate imports of automotives and pharmaceuticals, respectively.

crises on GVC-trade. The identification of these effects thus requires more rigorous causal inference, which is the subject of the following section.

4 Empirical strategy

Our empirical strategy employs a difference-in-difference (DiD) estimator. A DiD estimate is the difference between the change in the outcome variable before and after treatment (difference one) in the treatment versus control group (difference two). To examine the suitability of the data for DiD analysis, Figure 6 plots the mean values of total imports from the more adversely affected and non-affected countries for SARS and MERS, over 2000-2006 and 2010-2018, respectively, with the time span covering the period of severe incidence in each case. The figure shows that mean total imports from the SARS- and MERS-affected countries were consistently lower than those from the unaffected countries during the respective time periods. This inference is corroborated by statistical tests on differences in means of the two variables in each case (see Annex table 3).

<Insert Figure 6 here>

An essential pre-condition for DiD analysis is the existence of parallel trends between treated and control groups in the pre-treatment period (see Meyer, 1995; Angrist and Pischke, 2009). To examine this pre-condition, we implement the 'common pre-dynamics test' proposed by Mora and Reggio (2012, 2015).[11] Results suggest that the assumption of parallel trends between treated and control groups in the pre-treatment period may have been met (see Annex table 4).

4.1 Baseline DiD

In examining the effects of the SARS outbreak, we prefer using the canonical difference-in-difference (DiD) estimator to the 2FE estimator for causal inference for the reasons outlined in Imai and Kim (2020).[12] In the case of MERS, however, variation in the timing of treatment

[11] This was implemented in STATA using the didq package.

[12] While the 2FE estimator is used to adjust for unobserved unit- and time-specific confounders simultaneously, this depends on the modeling assumptions, especially those of linear additive effects. Moreover, the equivalence between the 2FE and the DiD estimator does not hold when treatment timing varies for different units, as is the case with the MERS epidemic.

means that we have to use the 2FE estimator. The baseline DiD equations thus take the following forms:

$$ln(M_{jt}^{SARS}) = \alpha_1 DiD_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \tag{1}$$

$$ln(M_{jt}^{NonSARS}) = \alpha_1 DiD_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \tag{2}$$

$$ln(M_{jt}^{MERS}) = \alpha_1 DiD_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \tag{3}$$

$$ln(M_{jt}^{NonMERS}) = \alpha_1 DiD_{jt} + \mu + \gamma_j + \epsilon_{jt} \tag{4}$$

where $M_{jt}^{SARS/NonSARS/MERS/NonMERS}$ is the value of country j's cumulative imports of GVC-based intermediate and final products at time t from SARS-affected and unaffected countries, and MERS-affected and unaffected countries; μ_t and γ_j are the year and destination fixed effects; and ϵ_{jt} is the error term. In equations (1) and (2), the variable DiD_{jt} is the interaction between variables $Post_t$ and $Treated_j$; these variables, subsumed in the fixed effects in these equations, are binary coded according to the time period of severe incidence and sample coverage of worst affected countries during each episode, based on publicly-available information from the WHO. Thus, $Post_t = (0, 1)$ for $t(<, >)2003$ and $Treated_j = \{$China (epicentre), Hong Kong, Canada, Singapore and Vietnam$\}$; we thus model SARS as a distinct break in the year 2003 and compare outcomes before and after this year. In equations (3) and (4), DiD_{jt} is a binary dummy variable that takes the value one for Saudi Arabia (epicentre) over 2013-2017, for UAE during 2014, and for South Korea in the year 2015 (and zero otherwise).Under the parallel trends assumption, the estimate of α_1 identifies the average treatment effect on the treated.

An augmented version of equations (1)-(4) includes $Z_{\mathbf{z}jt}$ which is a vector of importer-time varying control variables. The control vector, Z_{zjt}, comprises a measure of country size – the log of population [ln(POP_{jt})]; and a measure of geographic distance to global markets – the log of market penetration [ln(MP_{jt})] computed as a distance (d_{ij}) weighted measure of other countries' GDP (GDP_{it}) i.e. $MP_{jt} = \sum_i (GDP_{it}/d_{ij})$. In specifications using disaggregated data, the control vector also includes the log of tariffs [$ln(1 + \tau_{jpt})$] with the latter computed as the average tariff levied by importer j on product p across all exporters. We expect population and market penetration to be positively correlated with imports, and tariffs to be inversely related.[13]

The equations are estimated separately for cumulative imports from SARS-affected and unaffected countries, and MERS-affected and unaffected countries, over the time periods 2001-2005 and 2011-2018, respectively, to examine the effects of the SARS and MERS outbreaks. A priori, we expect estimated $\alpha_1 < 0$ for cumulative imports from SARS- and MERS-affected countries.[14]

4.2 Reshoring hypothesis

To examine the "reshoring" hypothesis, we estimate the baseline and augmented versions of the following equations for SARS and MERS separately:

$$ln(M_{jt}) = \alpha_1 DiD_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \quad (5)$$

$$ln(Y_{jt}) = \alpha_1 DiD_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \quad (6)$$

where M_{jt} is the value of country j's total imports of GVC-based intermediate and final products from all countries at time t; Y_{jt} is the value of country j's total domestic output of GVC-based intermediate and final products at time t; and DiD_{jt} is as defined in equations (1) and (2). Estimated $\alpha_1 < 0$ for imports together with estimated $\alpha_1 > 0$ for domestic output would empirically support the reshoring hypothesis by suggesting a rise in domestic production at the expense of imports during each of the disease outbreaks.[15]

[13]Data on GDP and population are sourced from World Bank's World Development Indicators and those on tariffs from UNCTAD Trains. Geographical distance, used to construct the market penetration variable, is sourced from CEPII (Head et al, 2010).

[14]In sensitivity analysis, despite evidence to the contrary in the results reported in Annex table 4, we also control for any possible difference in trends before and after treatment by including unit-specific linear trends in estimation. The results from these regressions were found to be qualitatively similar and are available upon request. We also used matrix completion (Athey, 2017; Xu, 2017) analysis that nests synthetic control and unconfoundedness in a generalized approach and was implemented in R using the Gsynth package; these estimates were also found to be qualitatively similar and are available upon request.

[15]Note that this analysis was carried out at the ISIC level as data on domestic output sourced from UNIDO's Indstat database are reported according to that classification. Since the four-digit ISIC classification is more aggregate than the HS6 classification, the same ISIC code is allocated to several HS6 products in the concordance tables. It was thus more feasible to "aggregate" the HS6 products to the ISIC four-digit level for empirical analysis.

4.3 Geographical diversification of value-chains

Baseline and augmented variants of equations (1) and (3) are also used to examine empirically if (i) the SARS epidemic was associated with a decline in import shares coming from each of China, Hong Kong, Singapore and Vietnam; and (ii) the MERS outbreak was associated with a decline in import shares coming from each of South Korea, Saudi Arabia and the UAE. Estimated $\alpha_1 < 0$ would provide evidence for geographical diversification of value-chains in each case.

4.4 Extensive margin analysis

Variants of equations (1) and (3) are also used to examine empirically if the epidemics were associated with a decline in (i) the number of trading partners; and (ii) the number of HS-6 products imported. Estimated $\alpha_1 < 0$ would provide evidence for the adverse effects of SARS and MERS at the extensive margin, along two separate dimensions, in each case.

4.5 Widening of value-chains

To examine if the disease outbreaks were associated with a widening of value-chains, we estimate the baseline versions of the following equation at the disaggregated HS6-product level for SARS and MERS separately:

$$HHI_{jpt} = \alpha_1 DiD_{jt} + \mu_t + \gamma_{jp} + \epsilon_{jpt} \quad (7)$$

where HHI_{jpt} is the Hirschmann-Herfindahl index of import concentration for country j at the HS6-digit level (p) at time t; γ_{jp} are the destination-HS6 fixed effects; and ϵ_{jpt} is the error term. All other variables are as defined in equation (1). Estimated $\alpha_1 < 0$ would provide evidence for widening of value-chains.

All equations in this section are estimated using OLS with the standard errors clustered by destination-year in aggregate analysis and by destination-product-year in disaggregated analysis. Results from the Mora and Reggio (2012, 2015) 'common pre-dynamics test', available upon request, suggest that the parallel trends assumption may have been met in all cases. The DiD estimate, thus, identifies the average treatment effect on the treated in each case.

5 Results and analysis

5.1 Baseline DiD

The results from estimating equations (1)-(4) and their augmented versions are reported in Table 1. These results suggest that SARS had an adverse effect on cumulative imports of GVC-based products from the worst-affected countries though a similar finding was not observed for the MERS outbreak. Coefficient estimates suggest that the SARS outbreak was associated with a 13.4 to 20.7 perent decline in cumulative GVC-based imports from the worst-affected countries; for MERS, the estimate was statistically indifferent from zero . Encouragingly, the diseases outbreaks report a statistically insignificant effect on cumulative imports of GVC-based products from the unaffected countries. The additional control variables used generally lack statistical significance.

<Insert Table 1 here>

5.2 Reshoring

The results from estimating equations (5) and (6) and their augmented versions are reported in Table 2. The disaggregated trade data from BACI at the HS6 digit level are "aggregated" to the ISIC four-digit level for the purpose of this analysis; the domestic output data from UNIDO's Indstat are already at the ISIC four-digit level.

These results provide no evidence for reshoring in response to the SARS and MERS outbreaks. The DiD estimate of SARS is found to be positive on total imports of GVC-based products in the results reported in columns (1) and (2) but lacks statistical significance in columns (5) and (6) in the domestic output regressions. Meanwhile, the DiD estimate of MERS is found to be positive in the import regressions in columns (3) and (4) but could not be implemented for domestic output for lack of observations. The additional controls used again lack statistical significance.

<Insert Table 2 here>

5.3 The SARS effect on import shares from East Asian countries

Breaking down the results reported in columns (1) and (2) of Table 1 by South-east Asian countries worst-affected by SARS reveals that the average treatment effect may have been the most pronounced for China, which was the epicentre of the virus outbreak. Coefficient estimates, precisely estimated at the 1% level, suggest that SARS may have been associated with a 24.2 to 26.4 percentage point decline in the import share from China, which is consistent with the findings from firm-level analysis in Fernandes and Tang (2020).

<Insert Table 3 here>

In contrast, import shares from Hong Kong seem to have been largely unaffected by this outbreak - the coefficient estimates in columns (3) and (4) are statistically indifferent from zero - thus, corroborating the findings in Ceylan and Ozkan (2020). Meanwhile, Singapore and Vietnam seem to have witnessed an increase in their exports to the rest of the world despite the epidemic, which is not entirely inconsistent with their recent performance in managing the COVID-19 pandemic. The additional control variables again lack statistical significance in all cases.

5.4 MERS and the impact on imports from South Korea and the Middle-east

While the countries worst-affected by MERS collectively did not seem to witness a decline in their cumulative GVC-based exports to the rest of the world in the results reported in Table 1, their exports of GVC-based products seemed to have suffered individually in the case of the UAE. Coefficient estimates in columns (3) and (4) of Table 4, precisely estimated at the 1% level, suggest that import shares of GVC-based products from that country witnessed a 93.1 percentage point decline as a result of the MERS outbreak.

<Insert Table 4 here>

However, MERS did not seem to have been associated with an adverse effect on import shares from the two other badly-affected countries; the coefficient estimates reported in columns (1)-(2) and (5)-(6) of Table 4 are statistically indifferent from zero, as are the additional control variables used in these specifications.

5.5 Extensive margin analysis

The intensive margin effect in the results reported in Table 1 also seems to be corroborated at the extensive margin - both in terms of number of trading partners and products.

<Insert Table 5 here>

Coefficient estimates reported in columns (1) and (2) of Table 5 suggest that SARS may have been associated with a 28.6 percent decline in the number of suppliers and a 25.8 decline in the number of products (defined at the ISIC 4-digit-level) for the worst-affected countries; both results are precisely estimated. In contrast, while MERS may have been associated with a 32.2 percent decline in the number of suppliers for the worst affected countries, the coefficient estimate is only significant at the 10% level, and the estimate for the number of products lacks statistical significance.

5.6 Widening of value-chains

There is also some evidence for widening of value-chains in response to these outbreaks, especially in the case of MERS. Results reported in columns (4)-(6) of Table 6 suggest that MERS may have been associated with a decline in the Hirschmann-Herfindahl index of import concentration and that this effect may have persisted regardless of the choice of the pre-treatment period. Coefficient estimates suggest that MERS may have been associated with a 0.8 to 1.1 percent decline in importer concentration over the period spanning 2010-2018.

<Insert Table 6 here>

The SARS outbreak, in contrast, seems to have been associated with a rise in importer concentration as can be seen in the results reported in columns (1)-(3) of Table 6, though the magnitude of the effect is again small - ranging from a 0.6 to 1.1 percent rise in the HHI - and seems to have increased monotonically over time.

5.7 GVC-resilience

Since we would need data for 2019 and beyond to examine GVC-resilience to the MERS outbreak, we can only examine resilience of value-chains to the SARS epidemic. The results reported in Table 7 suggest that the adverse effects seemed to have have been accentuated over time for cumulative imports from the worst-affected countries and in the case of China in particular during the SARS outbreak.

<Insert Table 7 here>

On the whole, the results in this section suggest that there may have been a disruption to GVCs from the SARS outbreak, both by way of reducing reliance on the disease epicentre at both margins of trade and by diversifying the portfolio of trading partners, and the effects also seem to have persisted over time. This has implications for the current pandemic which we shall discuss in Section 7. In the following section, we dig deeper into the results for SARS to examine their likely drivers but before that we apply the Goodman-Bacon (2019) decomposition to the average treatment effect of the MERS outbreak as there is variation in treatment timing in this case.

5.8 Goodman-Bacon (2019) decomposition of the average treatment effect of the MERS outbreak

Goodman-Bacon (2019) shows that when there is variation in treatment timing, the 2FE DiD estimator is a weighted average of all possible two-group/two-period DiD estimators in the data. His decomposition shows that "when already-treated units act as controls, changes in their treatment effects over time get subtracted from the DD estimate. This does not imply a failure of the design, but it does caution against summarizing time-varying effects with a single-coefficient."

The results from the decomposition for the impact of MERS on cumulative imports from the worst-affected countries is shown in Figure 7.[16] The DiD estimate is found to be 0.052, which confirms that the MERS outbreak may not have had an adverse impact at the intensive margin. It also follows from the decomposition that the information contained in the different timing groups as well as the within estimate does not play a major role in the overall coefficient estimate; most of the weight (0.994) in the average is given to the estimate of the difference in outcome between units that were never treated, versus those that were treated at different times.

[16] The Goodman-Bacon (2019) decomposition was implemented in STATA using the bacondecomp package over the period 2011-2018. The bacondecomp implementation requires that the panel be strongly balanced, which meant that missing values for certain countries in the year 2018 needed to be extrapolated using their exponential growth rates over 2010-2017. In some cases, however, such extrapolation was infeasible and nine of the 227 countries (Antigua and Barbuda, Botswana, Luxembourg, Namibia, Netherlands Antilles, Saint Barthelemy, Serbia and Montenegro, South Sudan, and Wallis and Futuna Islands) were thus dropped from the sample.

6 What drives the SARS effects?

In this section, we examine the likely drivers of GVC-disruptions caused by the SARS epidemic using both aggregate and disaggregated data.

To examine the likely drivers of the results from aggregate analysis, we estimate the augmented version of equation (1) with an additional interaction term - $DiD_{jt} * Var_{j/jt}$ - where $Var_{j/jt} = \{LIC_{jt}, LMIC_{jt}, UMIC_{jt}, NonOECD_{j}, LFDI_{jt}, LGVC_{jt}, LGVC^{POS}{}_{jt}, REG_{j}\}$. These variables denote, respectively, belonging to the low-income, lower-middle-income and upper-middle-income groups according to the World Bank income classification; not belonging to the group of OECD countries; dummy variables that are unity when the level of inward FDI and measures of GVC participation and GVC position are less than the respective median values for the country sample by year; and belonging to one of 16 geographical regions[17].

<Insert Table 8 here>

Trade in GVC-based products is predominantly executed amongst MNEs. Since most MNEs are located in high and upper middle-income countries, more GVC-disruptions are expected for these groups of countries in response to macroeconomic shocks like disease outbreaks. However, these countries are also likely to manage crises better due to the effectiveness of their institutions compared to counntries at lower levels of economic development. This inference seems to be corroborated by the results reported in columns (1) and (2) of Table 8. The sum of the DiD estimate and the interaction term is strongly negative for lower middle-income countries (based on the World Bank's income classification of countries over time) for imports sourced from the worst-affected SARS countries. The coefficient estimate suggests that SARS may have reduced imports of LMICs by 29.7 to 30.7 percent.

The results reported in column (3) and (4) of Table 8 corroborate the above findings for the group of OECD vs non-OECD importers. Thus, SARS only seems to have affected non-OECD importers; the coefficient estimate translates into an average treatment effect ranging from -26.1 to -24.3 percent.

Since there is a strong nexus between FDI and GVC-trade, larger recipients of FDI are also likely to witness more GVC-disruptions. Columns (5) and (6) of Table 8 show that the DiD estimates, which references countries for whom inward FDI flows are in excess of the

[17] These regions include North America, Central America, South America, Caribbean, EU15, Rest of EU, EFTA , Transition economies, the CIS countries, Africa, West Asia, South Asia, ASEAN, East Asia, Australia and New Zealand, and the Pacific islands.

sample median, are strongly negative. The coefficient estimates suggest that SARS may have reduced imports of above-median FDI recipients by 13.5 to 20.7 percent.

Since our analysis covers trade in GVC-based products, the extent of disruption in GVCs is likely to be positively correlated with the extent of countries' GVC-participation (based on data sourced from the World Bank's World Development Report 2020). Once again, this is borne by the results reported in columns (7) and (8) of Table 8. The DiD estimates, which reference countries for whom integration into GVCs is in excess of the sample median, are strongly negative. The coefficient estimates suggest that the outbreak may have reduced imports of above-median GVC-integrated countries by 20.5 to 25.2 percent. In contrast, the sum of the DiD estimate and the interaction term is positive, suggesting that countries less-integrated into GVCs may not have observed a decline in their imports in the wake of that epidemic.

Results reported in columns (9) and (10) of Table 8 further suggest that importing countries more upstream in the value-chains may have been adversely affected by SARS, which seems to contradict the findings in Fernandes and Tang (2020). The DiD estimates, which reference countries whose position is more upstream in GVCs (based on data sourced from the World Bank's World Development Report 2020) are strongly negative. The coefficient estimates translate into average treatment effects ranging from -13.4 to -20.7 percent.

Not surprisingly, we find that only importers in ASEAN and East Asia were adversely affected by SARS. The coefficient estimates translate into average treatment effects of -15.3 and -34.8 percent, respectively, for countries in these regions in the augmented specifications in Table 8, column (12).

To examine the likely drivers of the results using disaggregated product-level data, we estimate the baseline version of equation (1) with an additional interaction term - $DiD_{jt} * Var_{p/jpt}$ - where $Var_{p/jpt} = \{H_{jpt},\ LRCA_{jpt},\ LIIT_{jpt},\ LKL_{jpt},\ TECH_p,\ SECTOR_p\}$. These variables denote, respectively, dummy variables that are unity when import share from affected countries in total imports; value of the normalized revealed comparative advantage index; value of the Grubel-Lloyd index; and capital-to-labour ratio are less than the respective median values for the country sample by year; belonging to the technology class classified as low- and medium-tech; and belonging to one of the seven sectors into which GVC-based intermediate and final products are categorized. The analysis at the disaggregated level further explores these likely drivers separately for intermediate and final products in odd and evenly numbered columns in Table 9.

<Insert Table 9 here>

To begin with, note that results reported in columns (1) and (2) of Table 9 corroborate the negative effects of the SARS epidemic observed in Table 1 for intermediate and final products, respectively, in analyses using disaggregated data . The coefficient estimates translate into average treatment effects of -24.9 and -37.9 percent for intermediates and final goods imports from the worst-affected countries, respectively.

Meanwhile, we expect importers more reliant on the worst-affected suppliers to be more adversely affected. This is what is observed in the results reported in columns (3) and (4) of Table 9 for intermediate and final products, respectively. The DiD estimates that reference heavily-reliant importers at the product-level suggest that the outbreak may have reduced their imports of intermediate and final goods by 24.1 and 35.6 percent, respectively.

More competitive economies are also more likely to reshore vvalue-chains in response to macroeconomic shocks. One product-level proxy of cost-competitiveness is the standardized/normalized revealed comparative advantage (RCA) indicator[18]. The expected decline in reliance on SARS epicentres for imports for most cost-competitive economies comes through in the results reported in columns (5) and (6) of Table 9, for intermediate and final products, respectively. The DiD estimates that reference more competitive countries at the product-level suggest that the outbreak may have reduced their imports of intermediate and final goods by 20.0 and 38.9 percent, respectively.

High levels of intra-industry trade[19] are indicative of greater diversification in production and potential for value-added trade. Countries exhibiting these characteristics are also likely to be more adversely affected by macroeconomics shocks. This inference is confirmed by the results reported in columns (7) and (8) of Table 9, for intermediate and final products, respectively. The DiD estimates that reference more IIT-intensive countries at the product-level suggest that the outbreak may have reduced their imports of intermediate and final goods by 30.0 and 35.9 percent, respectively.

More capital-intensive[20] and high-technology[21] products are also likely to be more sophisticated and less easily substitutable, and hence, prone to fewer disruptions (Fernandes and Tang, 2020). Results reported in columns (9) and (11) of Table 9 confirm these hypotheses in the context of changes in import reliance on SARS-affected countries for intermediate goods. In contrast, final goods observe an import decline for both capital-intensive import-

[18]Negative values of the standardized RCA indicate a comparative disadvantage in exporting while positive values indicate the converse.

[19]This is calculated using the Grubel-Lloyd Index (GLI). The GLI ranges in value from 0 to 1 with higher values indicating greater levels of intra-industry trade.

[20]This is measured by the ratio of GFKF to the number of employees in data sourced from UNIDO's Indstat database at the ISIC Rev 3. four-digit level.

[21]The technology classification of products is taken from UNCTAD.

ing countries and high-tech products. However, trade disruptions in both intermediate and final goods are more severe for countries importing low-tech products.

Finally, since different sectors may respond to the health shocks differently on the basis of their capital/technology-intensiveness or position in GVCs (Fernandes and Tang, 2020), we also exploit the sectoral breakup of our disaggregated data by further interacting the DiD_{jt} variable by sectoral dummies corresponding to the following sectors: apparel, automobiles, electronics, footwear, pharmaceuticals and textiles. This also enables a decomposition of the average treatment effect at the sector-level. The results reported in column (14) of Table 9 suggest that final goods imports of apparel and textiles (the reference sector) were more adversely affected by SARS; a similar adverse effect was not observed on intermediate imports at the sector-level.

7 Conclusion

Using difference-in-difference analysis and disaggregated data on trade in GVC-based intermediate and final products over 2000-2018, we examine how trade in these products may have responded to two previous health shocks - SARS and MERS. While we find no evidence for "reshoring" in response to each of these virus outbreaks, there is some evidence for "near-shoring" in the stylized facts on SARS. Empirical analysis also suggests geographical diversification of value chains - import shares from China and UAE declined during SARS and MERS, respectively, while MERS was accompanied by a fall in import concentration. The effects of SARS persisted over time suggesting that the associated value-chains were not resilient to that health shock. The findings are observed at both the intensive (import value) and extensive (number of HS-6 products and export destinations) margins. The SARS effects are especially pronounced for lower-middle-income importers that were more integrated in GVCs, received more investment, were more competitive and were more reliant on the severely affected partners.

While we expect similar disruptions to GVC-trade from COVID-19, it may be more relevant to compare SARS and COVID-19 given that both originated in China. In making this comparison, however, one must be mindful of China's participation in global GDP and trade. During SARS, China accounted for 4 percent of global output; today, that number has quadrupled. Thus, any slowdown in China today will impact the world much more severely than in 2003 (Bloom, 2020). Moreover, the overall impact of COVID-19 is likely to be worse than SARS because of three additional reasons; one, the current scale of the pandemic is much larger than that of SARS (less than ten thousand lives were affected during SARS versus thirty-seven million confirmed cases of COVID-19 as of 11 October 2020); two, the state-mandated social-distancing norms during COVID-19 have resulted in both an immediate supply and a subsequent demand shock; and three, services trade will be more severely impacted this time as three of the four modes of services delivery require physical proximity betweeen buyers and sellers (Shingal, 2020).

The impact of COVID-19 will also depend on the type of products being traded through supply networks. Fernandes and Tang (2020) found products that were capital and skill-intensive or upstream in production chains to have been more resilient to the export disruption caused by SARS. These results are also consistent with Furusawa et al. (2018) who found that sourcing of differentiated inputs is less vulnerable to trade-shocks. In contrast, findings from our analysis suggest that imports of capital-intensive and high-technology GVC-based final products from the worst-affected countries as well as countries more upstream in GVCs may have been more adversely affected by SARS.

Despite the obvious comparisons with SARS, the case of COVID-19 is different. The Chinese economy now specializes in a variety of products that are tech and skill-intensive, and it is possible that China may experience a faster recovery or a small disruption post-COVID owing to the inability of countries to find alternative sources for intermediates that are harder to substitute. However, the impact can be overwhelming for foreign buyers of Chinese intermediate products due to the dependence on China, such that a small disruption can cause large ripple effects (Fernandes and Tang, 2020). Hence, enhanced reshoring activity may be expected from this pandemic to cut risk from medical or even financial contagions. The pandemic has already spurred e-commerce but may also accelerate the fourth industrial revolution through adoption of automation, 3D printing and extreme customization (Bloom, 2020).

In recent work, Hassan et al. (2020) analyze the number of times the SARS and MERS epidemics were mentioned in firm-level conference calls to comment on the resilience of the corporate sector during various epidemics. Evidence suggests that discussions about diversifying supply chains during SARS peaked during the first quarter of 2003, clashing with the outbreak in China. The study also discusses the impact of prior epidemic experience in dealing with COVID-19. While sampled firms tend to overestimate their level of preparedness based on their familiarity with SARS, any prior epidemic experience is found to be significantly associated with a less negative sentiment towards COVID-19 (Hassan, et al. 2020).

This said, anecdotal evidence points to reshoring as well as nearshoring of manufacturing GVCs during the COVID-19 pandemic, especially aimed at reducing over-reliance on

China.[22] These plans are a part of a larger China+1 strategy that began in 2019 following the US-China trade war with the aim of diversifying away from China towards other low-cost Asian countries. These Asian economies offer access to the ASEAN free trade area as well as lower labor costs that are almost half of those in China. However, a second-order effect of the pandemic is expected to hit companies willing to reshore to ASEAN countries as these countries continue to be dependent on China for imports of raw materials. Hence any relocation of production to these countries is not really diversification away from China.

While Southeast Asian countries seem to be the most preferred destinations after China, Mexico is also emerging as a close favourite especially for American and Japanese firms. Trade data are beginning to show that US companies are opting for suppliers closer home, chiefly local suppliers and those based in Mexico, a trend that resonates with the stylized facts on SARS presented in this paper. It seems that the US has also used the pandemic as an excuse to move pharmaceutical production back home from China. Moreover, US companies have already begun relying on locally-sourced electronic parts rather than sourcing them from China. This has led to an increase in orders to local firms and to a few Mexican counterparts.

Many non-US firms are also seeking new markets to shock-proof their supply chains to remain competitive in the US market and not attract new US sanctions. There is also talk of nearshoring by companies in the Eurozone to Hungary, Czech Republic and Poland as a new manufacturing hub to move out of China following the pandemic. EU members have also urged automobile and pharmaceutical companies to strengthen local value chains as a way to reduce dependence on China. Japan is another country that has expressed concerns over reliance on China for imported inputs. As part of its COVID-19 stimulus package, the government set aside USD 2 billion to incentivize shifting production back home for high-tech manufacturing and in other sectors to Southeast Asian economies or India.

[22]For example, Apple, Google and Samsung have already begun diversifying away from China since February 2020. Apple will manufacture some mobile phones in Vietnam, India, Taiwan and Mexico and has already planned for an expansion into these new markets in the latter half of this year (https://www.bloomberg.com/news/articles/2020-03-27/iphone-makers-look-beyond-china-in-supply-chain-rethink; https://asia.nikkei.com/Spotlight/Coronavirus/Google-Microsoft-shift-production-from-China-faster-due-to-virus). Google smartphone unit is set to move to Northern Vietnam in the second half of the year, while it has already planned for Thailand for its smart-home product unit. Microsoft is also expected to start manufacturing in Vietnam soon. A similar trend is being observed in the textiles and clothing industry. During this pandemic, the Indonesian textiles industry has witnessed a 10 percent rise in the number of orders, primarily from global brands looking to substitute trade with China. Indonesia has been a preferred location because its supply chains in the industry remain localized and were unaffected by the outbreak in China (https://www.fibre2fashion.com/industry-article/8679/indonesian-textiles-industry-likely-to-pull-through-global-pandemic). Another favored destination for relocation of textiles manufacturing has been Vietnam (for instance, the Japanese megabrand UNIQLO has moved sourcing from China to Vietnam).

In sum, while value-chains may have exhibited selective resilience to previous health shocks despite disruptions, there may be more permanent changes this time around, including a conscious diversification away from China. It would be interesting to study these changes and their ramifications on different economic outcomes in future research on this subject.

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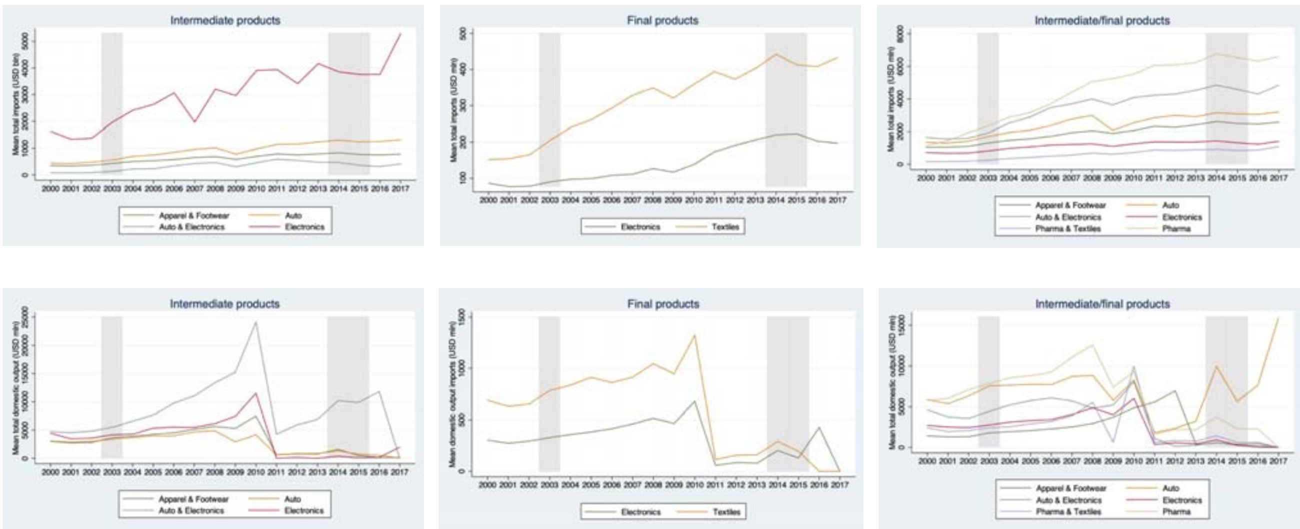
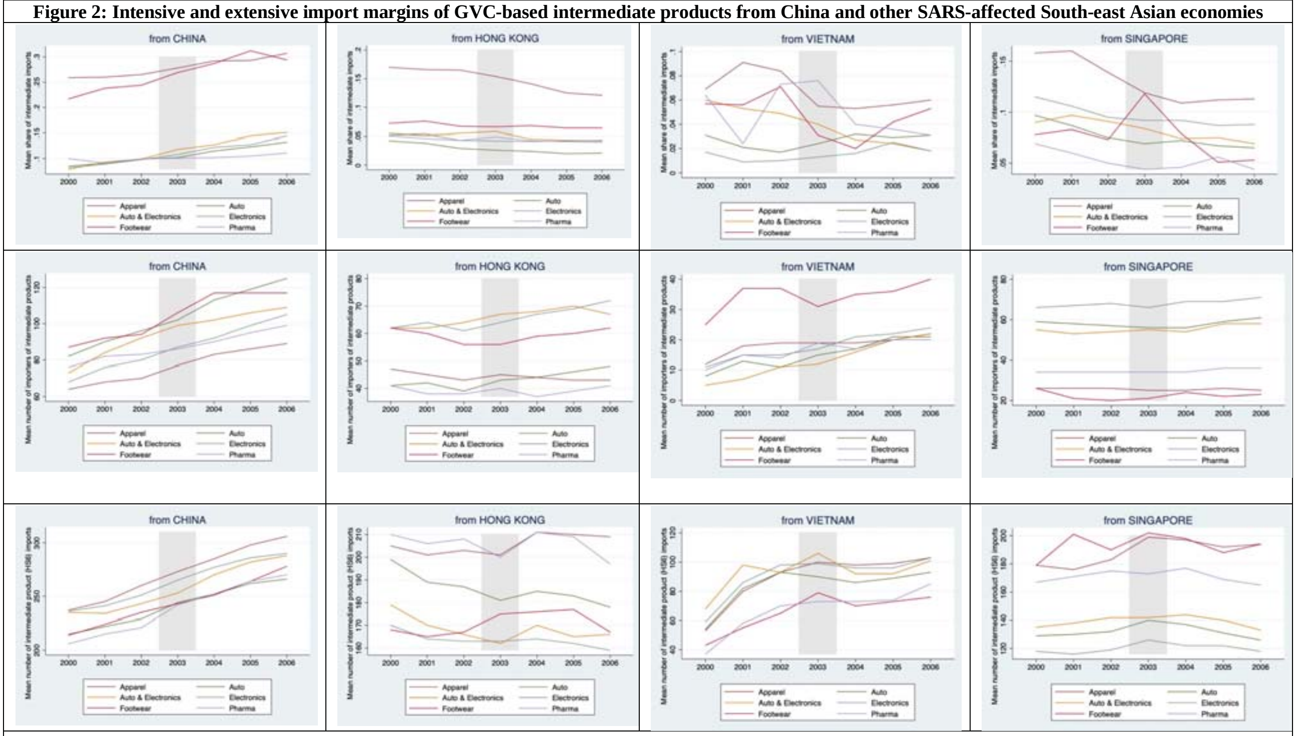
Figure 1: Imports (top panel) and domestic output (bottom panel) of GVC-based intermediate and final products overtime



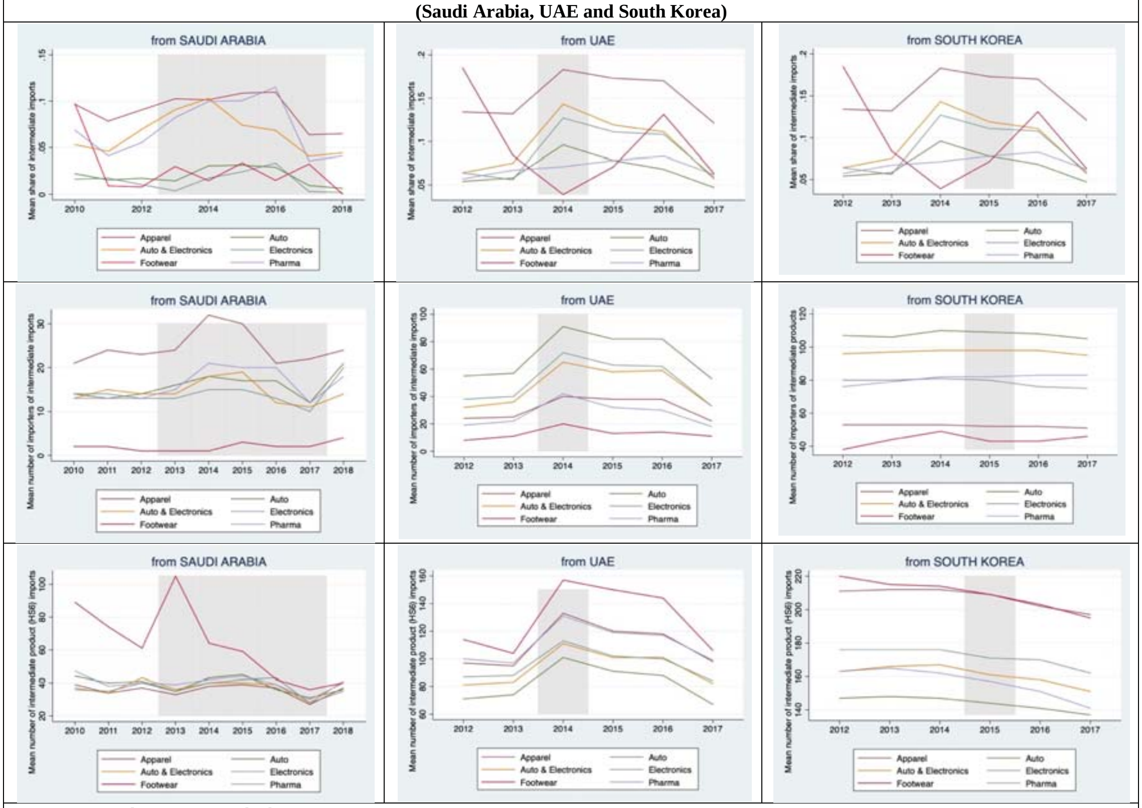
Source: UNIDO IndStat dataset; own calculations
Note: The two-coloured slabs denote the time periods corresponding to the incidence of SARS and peak cases in the three worst-affected countries during the MERS outbreak, respectively.

Figure 2: Intensive and extensive import margins of GVC-based intermediate products from China and other SARS-affected South-east Asian economies



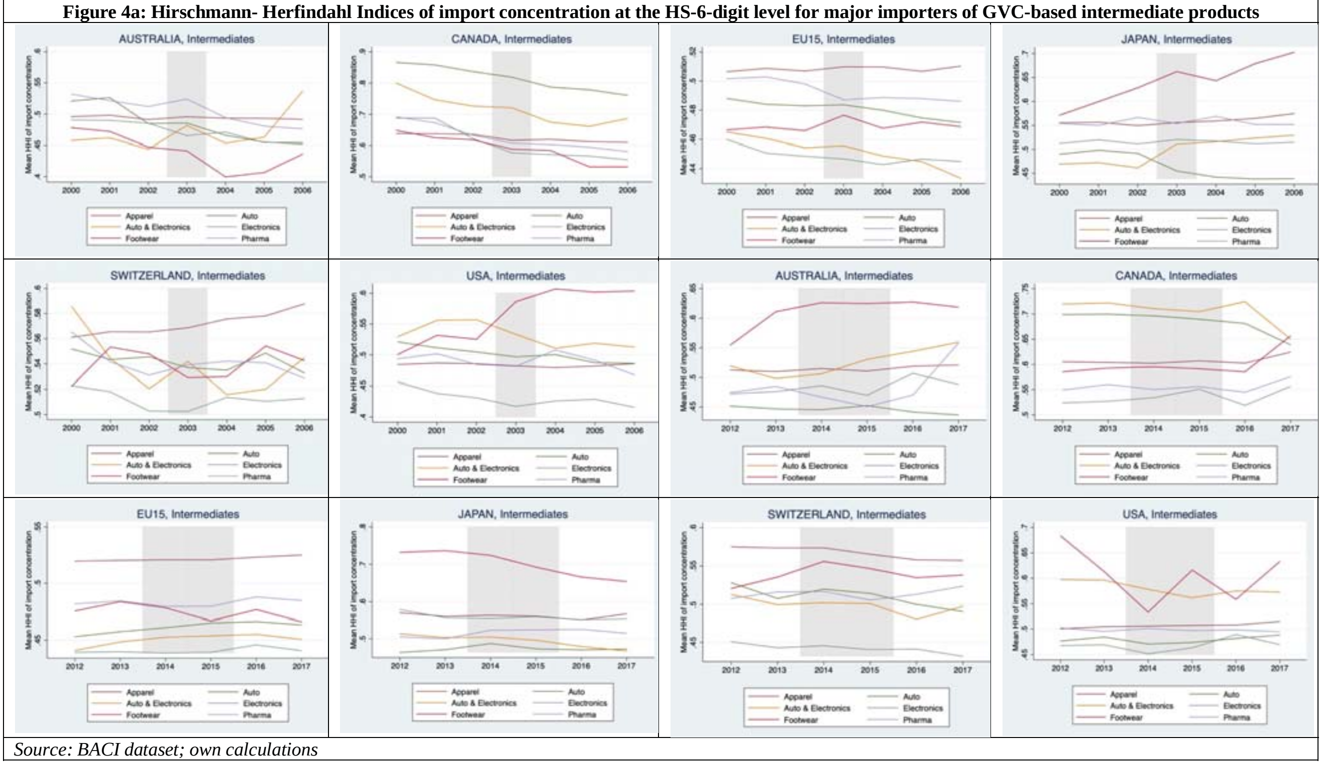
Source: BACI dataset; own calculations

Figure 3: Intensive and extensive import margins of GVC-based intermediate products from MERS-affected countries (Saudi Arabia, UAE and South Korea)



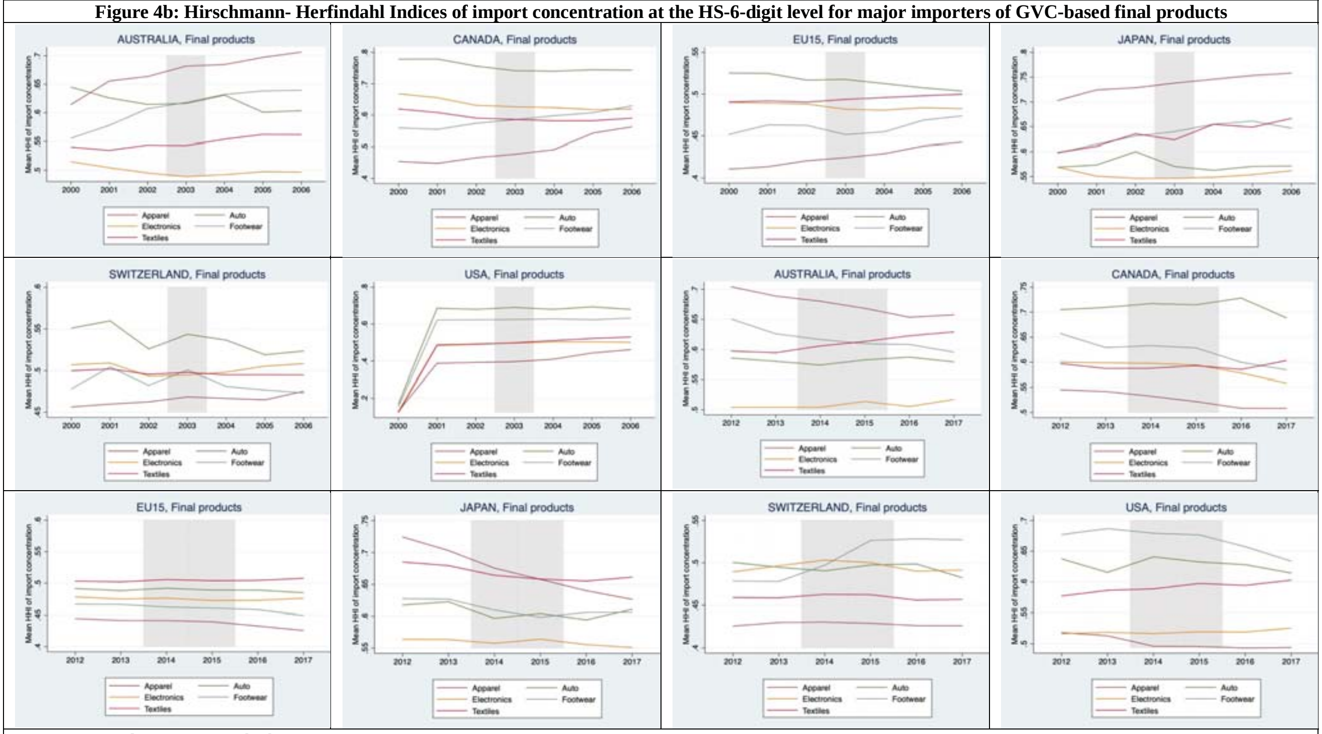
Source: BACI dataset; own calculations

Figure 4a: Hirschmann- Herfindahl Indices of import concentration at the HS-6-digit level for major importers of GVC-based intermediate products



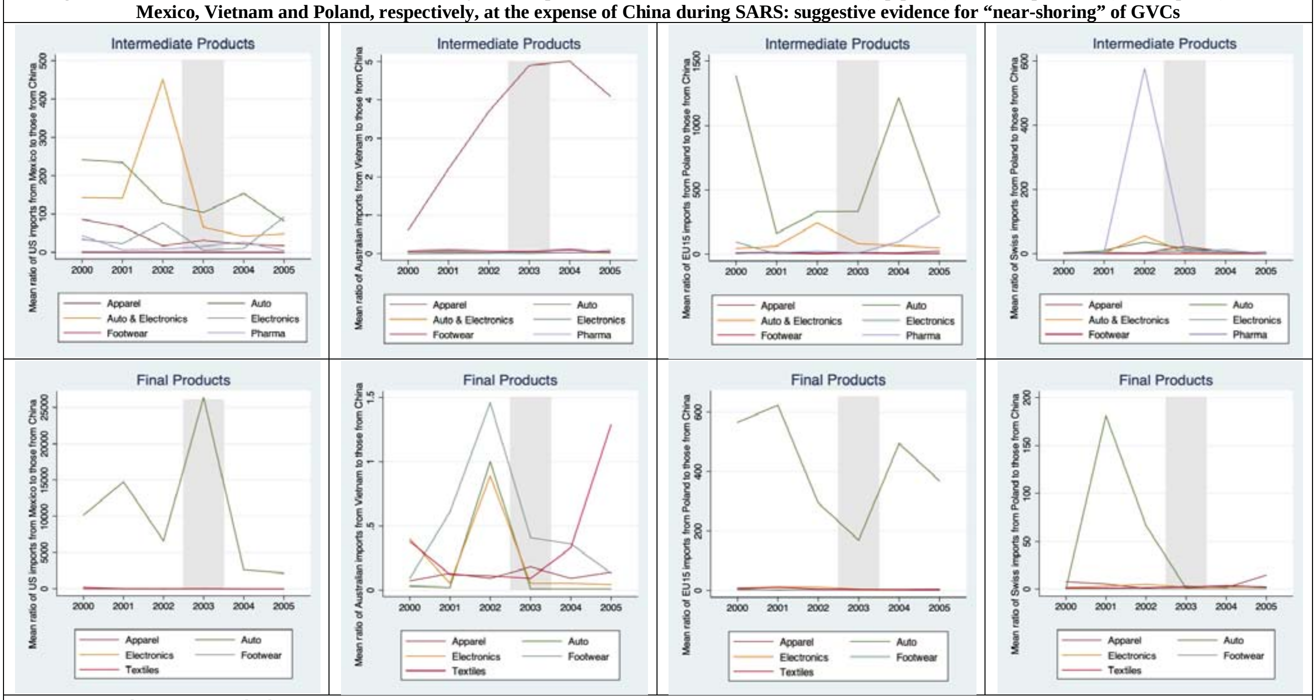
Source: BACI dataset; own calculations

Figure 4b: Hirschmann- Herfindahl Indices of import concentration at the HS-6-digit level for major importers of GVC-based final products



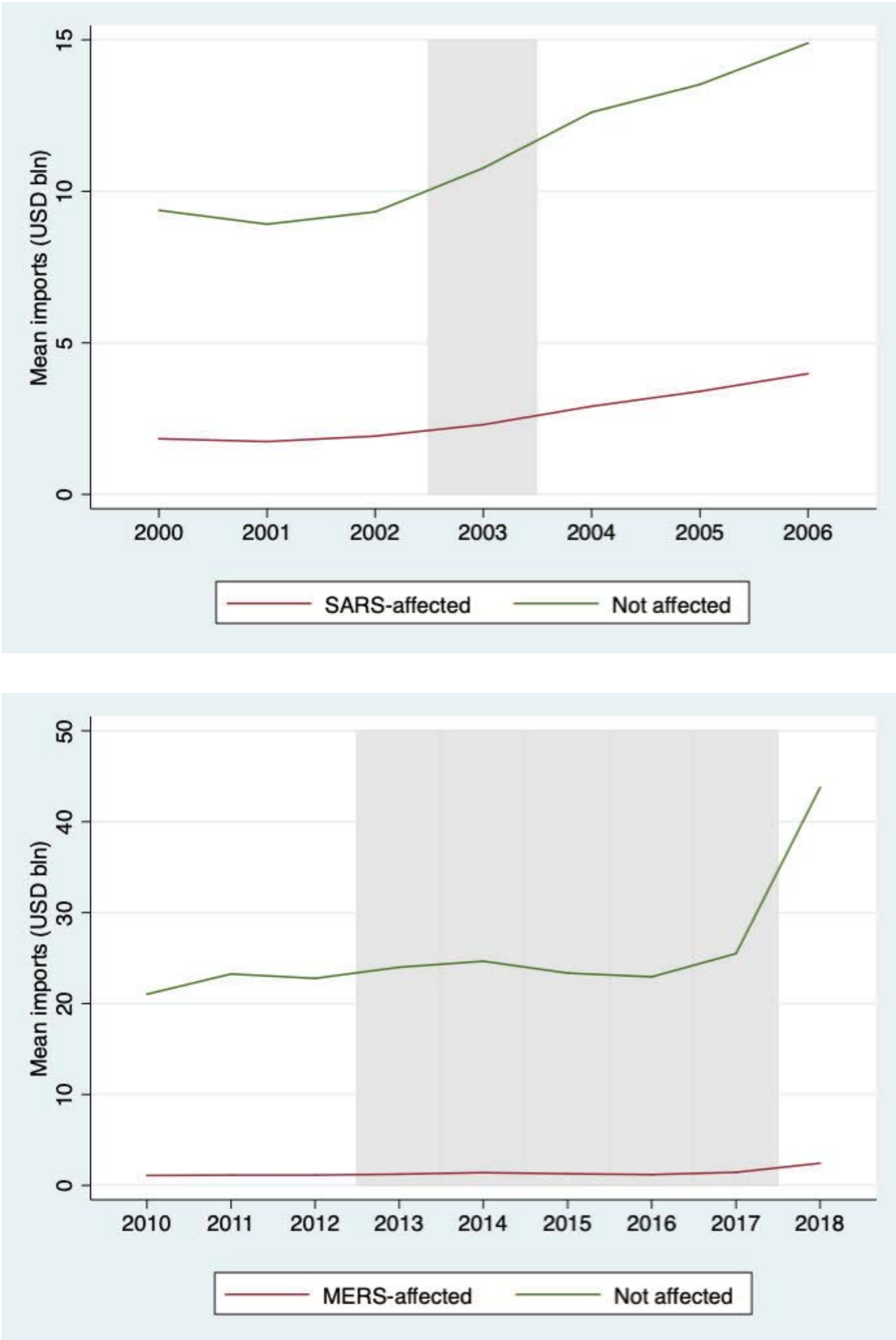
Source: BACI dataset; own calculations

Figure 5: USA, Australia, EU15 and Switzerland may have imported more GVC-based intermediates (top panel) and final products (bottom panel) from Mexico, Vietnam and Poland, respectively, at the expense of China during SARS: suggestive evidence for "near-shoring" of GVCs



Source: BACI dataset; own calculations

Figure 6: Mean cumulative imports of GVC-based products from worst-affected SARS (top panel), MERS (bottom panel) countries and unaffected countries overtime



Source: BACI dataset; own calculations
Note: The coloured slabs denote the time periods corresponding to the incidence of SARS and MERS, in the worst-affected countries, respectively. The worst-affected SARS countries include China (epicentre), Canada, Hong Kong, Singapore and Vietnam; countries worst-affected by MERS include Saudi Arabia (epicentre), UAE and South Korea.

Figure 7: Goodman-Bacon (2019) decomposition of average treatment effect of MERS

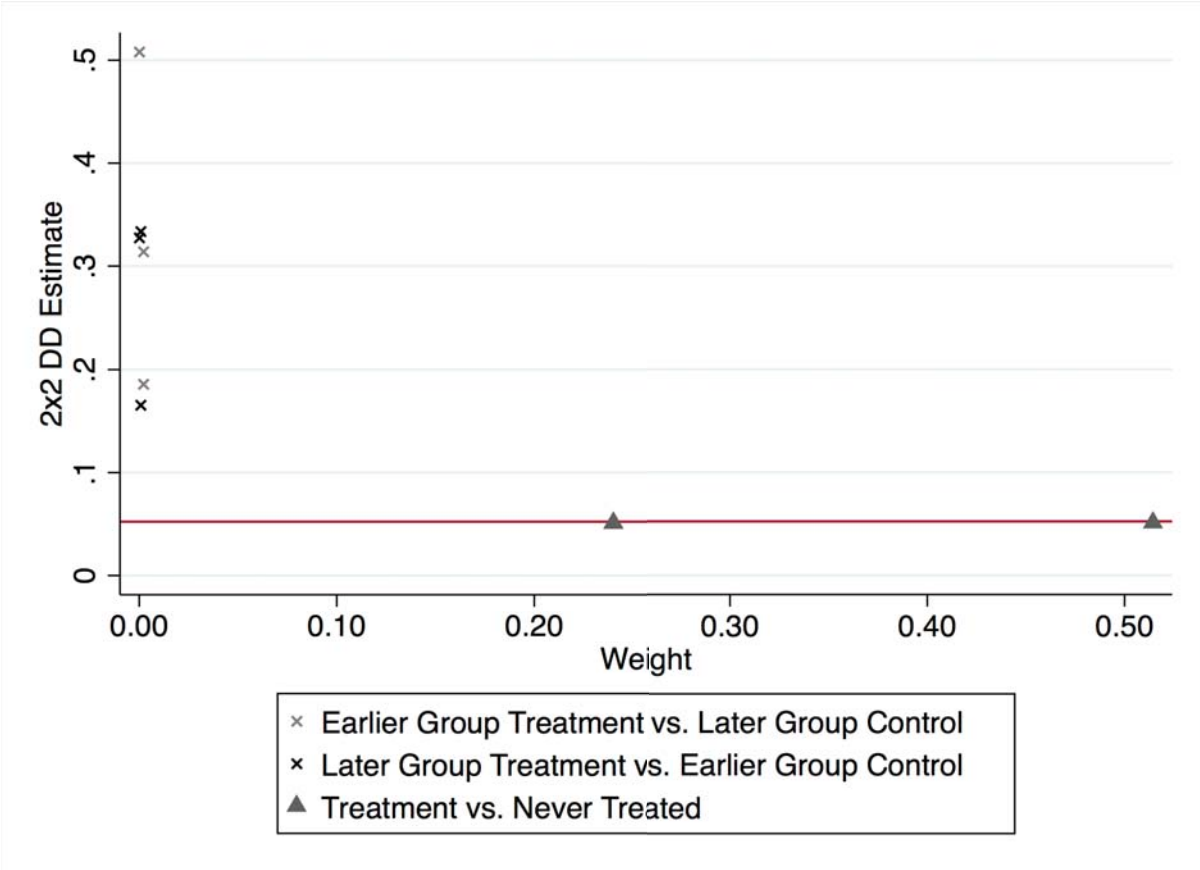


Table 1: Baseline DiD estimates

	$\ln(M^{SARS}_{jt})$		$\ln(M^{NonSARS}_{jt})$		$\ln(M^{MERS}_{jt})$		$\ln(M^{NonMERS}_{jt})$	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
VARIABLES	**2001-2005 (SARS)**				**2011-2018 (MERS)**			
DiD_{jt}	-0.144**	-0.232***	0.077	0.125*	0.051	0.074	0.094	0.083
	(0.069)	(0.078)	(0.067)	(0.075)	(0.096)	(0.114)	(0.086)	(0.087)
$\ln(Pop_{jt})$		-1.082		0.179		1.358*		-0.526
		(0.961)		(0.436)		(0.726)		(0.325)
$\ln(MP_{jt})$		0.003		0.005		-0.023**		-0.003
		(0.010)		(0.007)		(0.010)		(0.004)
Observations	855	727	864	727	1,664	1,381	1,744	1,389
R-squared	0.976	0.978	0.990	0.987	0.962	0.957	0.990	0.992
Destination FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-year in all specifications.
Levels of significance: *10%, **5%, ***1%.

Table 2: No evidence for reshoring in empirical analysis

	$\ln(M_{jt})$		$\ln(M_{jt})$		$\ln(Y_{jt})$	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
VARIABLES	**2001-2005 (SARS)**		**2011-2018 (MERS)**		**2001-2005 (SARS)**	
DiD_{jt}	0.285**	0.300*	0.209**	0.187*	0.006	-0.002
	(0.143)	(0.154)	(0.103)	(0.105)	(0.181)	(0.190)
$\ln(Pop_{jt})$		-0.850		-0.606*		-0.715
		(0.576)		(0.329)		(0.853)
$\ln(MP_{jt})$		-0.001		-0.005		0.004
		(0.009)		(0.004)		(0.010)
Observations	860	727	1,662	1,389	329	297
R-squared	0.989	0.986	0.992	0.992	0.994	0.994
Destination FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-year in all specifications. There were not enough observations to estimate the effect of MERS on $\ln(Y_{jt})$ using the DiD estimator.
Levels of significance: *10%, **5%, ***1%.

Table 3: SARS effect on import shares from affected countries

	Msh^{CHN}_{jt}		Msh^{HKG}_{jt}		Msh^{SGP}_{jt}		Msh^{VNM}_{jt}	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
VARIABLES	**2001-2005 (SARS)**							
DiD_{jt}	-0.277***	-0.306***	0.004	-0.068	0.279**	0.073***	0.109	0.043**
	(0.091)	(0.111)	(0.068)	(0.138)	(0.115)	(0.023)	(0.071)	(0.018)
$\ln(Pop_{jt})$		0.628		-2.534		-0.481		0.533*
		(0.915)		(2.378)		(0.321)		(0.310)
$\ln(MP_{jt})$		-0.002		0.005		0.004		-0.002
		(0.013)		(0.008)		(0.005)		(0.002)
Observations	864	727	864	727	864	727	864	727
R-squared	0.555	0.542	0.727	0.731	0.439	0.787	0.383	0.746
Destination FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-year in all specifications.
Levels of significance: *10%, **5%, ***1%.

Table 4: MERS effect on import shares from affected countries

	Msh^{SAU}_{jt}		Msh^{ARE}_{jt}		Msh^{KOR}_{jt}	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
VARIABLES	**2011-2018 (MERS)**					
DiD_{jt}	-0.005	-0.004	-0.072***	-0.071***	-0.046	0.015
	(0.005)	(0.003)	(0.025)	(0.026)	(0.052)	(0.020)
$\ln(Pop_{jt})$		0.017		0.547**		0.094
		(0.022)		(0.224)		(0.245)
$\ln(MP_{jt})$		-0.001		-0.007*		-0.002
		(0.001)		(0.004)		(0.003)
Observations	1,669	1,389	1,669	1,389	1,669	1,389
R-squared	0.248	0.415	0.442	0.478	0.333	0.724
Destination FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-year in all specifications.
Levels of significance: *10%, **5%, ***1%.

Table 5: Extensive margin analysis (DiD estimates)

	$\ln(\#Exporters^{SARS}_{jt})$	$\ln(\#Products^{SARS}_{jt})$	$\ln(\#Exporters^{MERS}_{jt})$	$\ln(\#Products^{MERS}_{jt})$
	(1)	(2)	(3)	(4)
VARIABLES	**2001-2005 (SARS)**		**2011-2018 (MERS)**	
DiD_{jt}	-0.337**	-0.299***	-0.389*	0.035
	(0.144)	(0.034)	(0.202)	(0.058)
Observations	333	2,492	665	1,593
R-squared	0.446	0.739	0.543	0.926
Destination-year contr	NO	NO	NO	NO
Destination FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-year in all specifications.
Levels of significance: *10%, **5%, ***1%.

Table 6: Effect of disease outbreaks on importer concentration overtime

	SARS effect on HHI_{jpt}			MERS effect on HHI_{jpt}		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	**2001-2004**	**2001-2005**	**2001-2006**	**2010-2018**	**2011-2018**	**2012-2018**
DiD_{jt}	0.006***	0.009***	0.011***	-0.011***	-0.010***	-0.008***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Observations	491,303	673,282	855,334	1,445,886	1,277,951	1,109,198
R-squared	0.808	0.780	0.763	0.746	0.755	0.764
Destination-year controls	NO	NO	NO	NO	NO	NO
Destination-HS6 FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-product-year in all specifications.
Levels of significance: *10%, **5%, ***1%.

Table 7: Value-chains not resilient to SARS

	Effect of SARS on:		
	(1)	**(2)**	**(3)**
	2001-2004	**2001-2005**	**2001-2006**
$\ln(M^{SARS}_{jt})$	-0.208**	-0.232***	-0.231***
	(0.095)	(0.078)	(0.084)
Msh^{CHN}_{jt}	-0.310***	-0.306***	-0.336***
	(0.090)	(0.111)	(0.099)
Msh^{HKG}_{jt}	-0.048	-0.068	-0.002
	(0.149)	(0.138)	(0.114)
Msh^{SGP}_{jt}	0.070**	0.073***	0.081***
	(0.030)	(0.023)	(0.022)
Msh^{VNM}_{jt}	0.045*	0.043**	0.040**
	(0.025)	(0.018)	(0.017)
Destination-year controls	YES	YES	YES
Destination-year FE	YES	YES	YES

Note: Table reports coefficients on DiD_{jt} obtained from augmented specifications with $\ln(Pop_{jt})$ and $\ln(MP_{jt})$. Coefficients on other variables, R-squared values and number of observations not reported. Robust standard errors are clustered by destination-year in all specifications. Levels of significance: *10%, **5%, ***1%.

Table 8: Drivers of SARS effect on imports from the worst-affected countries (based on aggregate data over 2001-2005)

	WBIC		OECD		FDI		GVC		GVC^{POS}		Regions	
						$\ln(M^{SARS}_{jt})$						
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
DiD_{jt}	-0.077	-0.127	0.078*	0.028	-0.145**	-0.232***	-0.230***	-0.290***	-0.144**	-0.232***	0.024	0.025
	(0.066)	(0.082)	(0.042)	(0.065)	(0.069)	(0.078)	(0.082)	(0.082)	(0.069)	(0.078)	(0.041)	(0.067)
DiD_{jt}*LIC_{jt}	-0.124*	-0.095										
	(0.065)	(0.074)										
DiD_{jt}*$LMIC_{jt}$	-0.367***	-0.352***										
	(0.075)	(0.084)										
DiD_{jt}*$NonOECD_j$			-0.278***	-0.303***								
			(0.059)	(0.060)								
DiD_{jt}*L_GVC_{jt}							0.307***	0.316***				
							(0.071)	(0.066)				
DiD_{jt}*$ASEAN_j$											-0.149***	-0.166***
											(0.052)	(0.056)
DiD_{jt}*EA_j											-0.407***	-0.428***
											(0.058)	(0.064)
LIC_{jt}	1.028	1.128										
	(1.026)	(1.134)										
$LMIC_{jt}$	1.219	1.341										
	(1.006)	(1.114)										
$UMIC_{jt}$	1.488	1.616										
	(0.993)	(1.103)										
L_FDI_{jt}					-0.049	-0.059						
					(0.078)	(0.083)						
L_GVC_{jt}							-0.116	-0.053				
							(0.085)	(0.079)				
$L\_GVC^{POS}_{jt}$									-0.021	-0.014		
									(0.083)	(0.084)		
$\ln(Pop_{jt})$		-1.338*		-1.085		-1.083		-1.107		-1.079		-0.670
		(0.735)		(0.962)		(0.963)		(0.968)		(0.962)		(0.969)
$\ln(MP_{jt})$		-0.000		0.003		0.003		0.003		0.003		0.001
		(0.010)		(0.010)		(0.010)		(0.010)		(0.010)		(0.010)
Observations	768	707	855	727	855	727	855	727	855	727	775	705
R-squared	0.976	0.979	0.976	0.978	0.976	0.978	0.976	0.978	0.976	0.978	0.979	0.978
Destination FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-year in all specifications. Interaction terms of the variable Did_{jt} with $UMIC_{jt}$, L_FDI_{jt}, $L\_GVC^{POS}_{jt}$ and the remaining 13 regions were dropped during estimation, as were the OECD and the regional dummy variables as they were collinear with the fixed effects. Levels of significance: *10%, **5%, ***1%.

Table 9: Drivers of SARS effects on GVC-based intermediate and final goods imports from the worst-affected countries (based on disaggregated data over 2001-2005)

	Baseline		**High-importers**		**RCA**		**IIT**		**K/L**		**TECH**		**SECTOR**	
	$\ln(M_{I\,jpt}^{SARS})$	$\ln(M_{F\,jpt}^{SARS})$	$\ln(M_{I\,jpt}^{SARS})$	$\ln(M_{F\,jpt}^{SARS})$	$\ln(M_{I\,jpt}^{SARS})$	$\ln(M_{F\,jpt}^{SARS})$	$\ln(M_{I\,jpt}^{SARS})$	$\ln(M_{F\,jpt}^{SARS})$	$\ln(M_{I\,jpt}^{SARS})$	$\ln(M_{F\,jpt}^{SARS})$	$\ln(M_{I\,jpt}^{SARS})$	$\ln(M_{F\,jpt}^{SARS})$	$\ln(M_{I\,jpt}^{SARS})$	$\ln(M_{F\,jpt}^{SARS})$
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
DiD_{jt}	-0.286***	-0.477***	-0.276***	-0.440***	-0.223***	-0.492***	-0.357***	-0.445***	-0.172	-0.603***	-0.021	-0.213**	-0.218	-0.480***
	(0.037)	(0.040)	(0.033)	(0.032)	(0.054)	(0.060)	(0.041)	(0.037)	(0.190)	(0.099)	(0.100)	(0.101)	(0.194)	(0.079)
$DiD_{jt}*L_{jpt}$			0.252***	0.108										
			(0.068)	(0.075)										
$DiD_{jt}*L\_RCA_{jpt}$					0.057	-0.011								
					(0.044)	(0.033)								
$DiD_{jt}*L\_IIT_{jpt}$							0.029	-0.151***						
							(0.022)	(0.030)						
$DiD_{jt}*L\_K/L_{jpt}$									0.795*	-0.151				
									(0.418)	(0.105)				
$DiD_{jt}*LOW\_TECH_p$											-0.363***	-0.343***		
											(0.107)	(0.113)		
$DiD_{jt}*MED\_TECH_p$											-0.261**	-0.058		
											(0.112)	(0.164)		
$DiD_{jt}*APPAREL_p$													-0.198	-0.256***
													(0.196)	(0.096)
$DiD_{jt}*AUTO_p$													0.019	0.278
													(0.236)	(0.237)
$DiD_{jt}*AUTO\_ELEC_p$													0.621**	0.251**
													(0.288)	(0.108)
$DiD_{jt}*ELEC_p$													0.124	0.305*
													(0.210)	(0.174)
$DiD_{jt}*FOOTWEAR_p$													0.046	
													(0.368)	
L_{jpt}			-1.236***	-1.125***										
			(0.021)	(0.013)										
L_RCA_{jpt}					-0.008	0.004								
					(0.009)	(0.005)								
L_IIT_{jpt}							-0.008	-0.004						
							(0.006)	(0.004)						
L_K/L_{jpt}									-0.095*	0.034				
									(0.053)	(0.079)				
Observations	757,691	1,358,993	757,691	1,358,993	609,813	1,097,633	667,858	1,179,762	2,072	731	694,368	1,018,380	757,691	1,358,993
R-squared	0.942	0.949	0.951	0.959	0.957	0.961	0.949	0.955	0.966	0.967	0.942	0.943	0.942	0.950
Destination-product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: Robust standard errors are clustered by destination-product-year in all specifications. The product is defined at the HS6-digit in all but columns (9) and (10) where it is defined at ISIC Rev.3, which also accounts for the much lower number of observations in those columns. The variable DiD_{jt} and its interaction terms with L_RCA_{jpt} and L_K/L_{jpt} were dropped during estimation in columns (6) and (10). The sectoral dummy variables and those for TECH were also dropped as they were collinear with the fixed effects. Levels of significance: *10%, **5%, ***1%.

Annex table 1: Country coverage

Afghanistan, Albania, Algeria, American Samoa, Andorra, Angola, Anguilla, Antarctica, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bhutan, Bolivia, Bonaire, Bosnia and Herzegovina, Botswana, British Indian Ocean Territory, British Virgin Islands, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Cayman Islands, Central African Republic, Chad, Chile, China, Hong Kong, Macao, Christmas Islands, Cocos Islands, Colombia, Comoros, Congo, Cook Islands, Costa Rica, Croatia, Cuba, Curácao, Cyprus, Czech Republic, Cote d'Ivoire, Democratic People's Republic of Korea, Democratic Republic of the Congo, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, FS Micronesia, Falkland Islands, Fiji, Finland, Fr. South Antarctic Terr., France, French Polynesia, Gabon, Gambia, Georgia, Germany, Ghana, Gibraltar, Greece, Greenland, Grenada, Guam, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Dem. Rep., Latvia, Lebanon, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Mongolia, Montenegro, Montserrat, Morocco, Mozambique, Myanmar, N. Mariana Islands, Namibia, Nauru, Nepal, Neth. Antilles, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Niue, Norfolk Islands, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Pitcairn, Poland, Portugal, Qatar, South Korea, Republic of Moldova, Romania, Russia, Rwanda, Saint BarthÇlemy, Saint Helena, Saint Kitts and Nevis, Saint Lucia, Saint Maarten, Saint Pierre and Miquelon, Saint Vincent and the Grenadines. Samoa, San Marino, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Solomon Islands, Somalia, South Sudan, Spain, Sri Lanka, State of Palestine, Sudan, Suriname, Sweden, Switzerland, Syria, TFYR of Macedonia, Tajikistan, Thailand, Timor-Leste, Togo, Tokelau, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Turks and Caicos Islands, Tuvalu, USA, Uganda, Ukraine, United Arab Emirates, United Kingdom, United Rep. of Tanzania, Uruguay, Uzbekistan, Vanuatu, Venezuela, Viet Nam, Wallis and Futuna Islands, Yemen, Zambia, and Zimbabwe.

Annex table 2: Product coverage (HS-6 digits by sector and type)

Apparel (intermediates): 382490 392010 392020 392030 392041 392042 392043 392049 392051 392059 392061 392062 392063 392069 392071 392072 392073 392079 392091 392092 392093 392094 392099 392111 392112 392113 392114 392119 392690 500400 500710 500720 500790 510610 510620 510710 510720 510810 510820 511000 511111 511119 511120 511130 511190 511211 511219 511220 511230 511290 511300 520411 520419 520511 520512 520513 520514 520515 520521 520522 520523 520524 520526 520527 520528 520531 520532 520533 520534 520535 520541 520542 520543 520544 520546 520547 520548 520611 520612 520613 520614 520615 520621 520622 520623 520624 520625 520631 520632 520633 520634 520635 520641 520642 520643 520644 520645 520811 520812 520813 520819 520821 520822 520823 520829 520831 520832 520833 520839 520841 520842 520843 520849 520851 520852 520853 520859 520911 520912 520919 520921 520922 520929 520931 520932 520939 520941 520942 520943 520949 520951 520952 520959 521011 521012 521019 521021 521022 521029 521031 521032 521039 521041 521042 521049 521051 521052 521059 521111 521112 521119 521120 521121 521122 521129 521131 521132 521139 521141 521142 521143 521149 521151 521152 521159 521211 521212 521213 521214 521215 521221 521222 521223 521224 521225 531100 540110 540120 540231 540232 540233 540234 540239 540241 540242 540243 540244 540245 540246 540247 540248 540249 540251 540252 540259 540261 540262 540269 540320 540331 540332 540333 540339 540341 540342 540349 540410 540411 540412 540419 540490 540500 540741 540742 540743 540744 540751 540752 540753 540754 540761 540769 540771 540772 540773

540774 540781 540782 540783 540784 540791 540792 540793 540794 540821 540822 540823 540824 540831 540832 540833 540834 550810 550820 550911 550912 550921 550922 550931 550932 550941 550942 550951 550952 550953 550959 550961 550962 550969 550991 550992 550999 551011 551012 551020 551030 551090 551211 551219 551221 551229 551291 551299 551311 551312 551313 551319 551321 551322 551323 551329 551331 551332 551333 551339 551341 551342 551343 551349 551411 551412 551413 551419 551421 551422 551423 551429 551430 551431 551432 551433 551439 551441 551442 551443 551449 551511 551512 551513 551519 551521 551522 551529 551591 551592 551599 551611 551612 551613 551614 551621 551622 551623 551624 551631 551632 551633 551634 551641 551642 551643 551644 551691 551692 551693 551694 580421 580429 580430 580620 580631 580632 580639 580710 580790 600210 600220 600230 600240 600241 600242 600243 600249 600290 600291 600292 600293 600299 600310 600320 600330 600340 600390 600410 600490 600510 600521 600522 600523 600524 600531 600532 600533 600534 600541 600542 600543 600544 600590 600610 600621 600622 600623 600624 600631 600632 600633 600634 600641 600642 600643 600644 600690 650100 650200 650700

Apparel (final): 420310 420329 420330 420340 610110 610120 610130 610190 610210 610220 610230 610290 610310 610311 610312 610319 610321 610322 610323 610329 610331 610332 610333 610339 610341 610342 610343 610349 610411 610412 610413 610419 610421 610422 610423 610429 610431 610432 610433 610439 610441 610442 610443 610444 610449 610451 610452 610453 610459 610461 610462 610463 610469 610510 610520 610590 610610 610620 610690 610711 610712 610719 610721 610722 610729 610791 610792 610799 610811 610819 610821 610822 610829 610831 610832 610839 610891 610892 610899 610910 610990 611010 611011 611012 611019 611020 611030 611090 611110 611120 611130 611190 611211 611212 611219 611220 611231 611239 611241 611249 611300 611410 611420 611430 611490 611510 611511 611512 611519 611520 611521 611522 611529 611530 611591 611592 611593 611594 611595 611596 611599 611610 611691 611692 611693 611699 611710 611720 611780 611790 620111 620112 620113 620119 620191 620192 62 0193 620199 620211 620212 620213 620219 620291 620292 620293 620299 620311 620312 620319 620321 620322 620323 620329 620331 620332 620333 620339 620341 620342 620343 620349 620411 620412 620413 620419 620421 620422 620423 620429 620431 620432 620433 620439 620441 620442 620443 620444 620449 620451 620452 620453 620459 620461 620462 620463 620469 620510 620520 620530 620590 620610 620620 620630 620640 620690 620711 620719 620721 620722 620729 620791 620792 620799 620811 620819 620821 620822 620829 620891 620892 620899 620910 620920 620930 620990 621010 621020 621030 621040 621050 621111 621112 621120 621131 621132 621133 621139 621141 621142 621143 621149 621210 621220 621230 621290 621310 621320 621390 621410 621420 621430 621440 621490 621510 621520 621590 621600 621710 621790 650300 650400 650500 650510 650590 650692 650699

Auto (intermediates): 830230 840710 840731 840732 840733 840734 840820 840991 840999 850750 850760 851110 851120 851130 851140 851150 851180 851190 851210 851220 851230 851240 852721 852729 853910 854430 870600 870710 870790 870810 870821 870829 870830 870831 870839 870840 870850 870860 870870 870880 870891 870892 870893 870894 870895 870899 871410 871411 871419 871690 910400 940120

Auto (final): 860900 870120 870210 870290 870310 870321 870322 870323 870324 870331 870332 870333 870390 870410 870421 870422 870423 870431 870432 870490 870510 870520 870530 870540 870590 871110 871120 871130 871140 871150 871190 871200 871610 871620 871631 871639 871640 871680

Electronics (intermediates): 844360 844390 844399 847310 847321 847329 847340 847350 851770 851790 851829 851890 852210 852290 852351 852352 852359 852390 852491 852499 852910 852990 853290 853310 853321 853329 853331 853339 853340 853390 853400 854011 854012 854020 854040 854050 854060 854071 854072 854079 854081 854089 854091 854099 854110 854121 854129 854130 854140 854150 854160 854190 854210 854212 854213 854214 854219

854221 854229 854230 854231 854232 854233 854239 854240 854260 854290 854381 900990 900991 900992 900993 900999 901490 902490 902890 902990 903090 903290 903300

Electronics (final): 841990 842191 842489 842490 842839 842890 843139 844312 844331 844332 844339 844351 845690 845699 846599 846610 846620 846630 846691 846692 846693 846694 846900 846911 846912 846920 846930 847010 847021 847029 847030 847040 847050 847090 847110 847130 847141 847149 847150 847160 847170 847180 847190 847210 847220 847230 847290 847710 847740 847759 847790 847989 847990 848071 848640 848690 850890 851490 851519 851521 851529 851580 851590 851711 851712 851718 851719 851721 851722 851730 851750 851761 851762 851769 851780 851810 851821 851822 851830 851840 851850 851910 851920 851921 851929 851930 851931 851939 851940 851950 851981 851989 851992 851993 851999 852010 852020 852032 852033 852039 852090 852110 852190 852510 852520 852530 852540 852550 852560 852580 852610 852691 852692 852712 852713 852719 852731 852732 852739 852790 852791 852792 852799 852812 852813 852821 852822 852830 852841 852849 852851 852859 852861 852869 852871 852872 852873 900610 900620 900630 900640 900651 900652 900653 900659 900810 900830 900850 900911 900912 900921 900922 900930 901090 901110 901120 901190 901210 901290 901410 901420 901480 901600 901720 901790 901811 901812 901813 901814 901819 901820 902110 902111 902119 902121 902129 902130 902131 902139 902140 902150 902190 902212 902213 902214 902219 902221 902229 902230 902290 902410 902480 902710 902720 902730 902740 902750 902780 902790 902810 902820 902830 902910 902920 903010 903020 903031 903032 903033 903039 903040 903082 903083 903084 903089 903210 903220 903281 903289 910111 910112 910119 910121 910129 910191 910199 910211 910212 910219 910221 910229 910291 910299 910310 910390 910511 910519 910521 910529 910591 910599 920110 920120 920190 920300 920410 920420 920510 920590 920600 920710 920790 920810 920890

Auto and electronics (intermediates): 720421 720429 720430 720449 740400 750300 780200 790200 810710 850710 850720 850730 850740 850780 854250 854270 854810 854890

Footwear (intermediates): 640610 640620 640690 640691 640699

Footwear (final): 640110 640191 640192 640199 640212 640219 640220 640230 640291 640299 640312 640319 640320 640330 640340 640351 640359 640391 640399 640411 640419 640420 640510 640520 640590

Pharma (intermediates): 300110 300120 300190 300210 300220 300230 300290 300310 300320 300331 300339 300340 300390 300410 300420 300431 300432 300439 300440 300450 300490 300510 300590 300610 300620 300630 300640 300650 300660 300670 300680 300691 300692

Textiles (final): 500600 510910 510990 520420 520710 520790 540210 540211 540219 540220 540310 540600 540610 540620 540710 540720 540730 540810 551110 551120 551130 560110 560121 560122 560129 560130 570110 570190 570210 570220 570231 570232 570239 570241 570242 570249 570250 570251 570252 570259 570291 570292 570299 570310 570320 570330 570390 570500 580110 580122 580123 580125 580126 580127 580132 580133 580135 580136 580137 580190 580211 580219 580220 580230 580300 580310 580390 580410 580500 580610 580640 580810 580890 580900 581010 581091 581092 581099 581100 600110 600121 600122 600129 600191 600192 600199 630120 630130 630140 630190 630210 630221 630222 630229 630231 630232 630239 630240 630251 630252 630253 630259 630260 630291 630292 630293 630299 630311 630312 630319 630391 630392 630399 630411 630419 630491 630492 630493 630499 630510 630520 630532 630533 630539 630590 630611 630612 630619 630621 630622 630629 630630 630631 630639 630640 630641 630649 630690 630691 630699 630710 630720 630790 630800

Apparel and textiles (final): 961900

Annex table 3: t-test of difference in means for treated and control variables

t-test of difference in means for variables ln(M^{SARS}_{jt}) and ln($M^{NonSARS}_{jt}$)
2000-2006

Year	Treated	Control	Difference
2000	3.61 (0.213)	6.082 (0.188)	-2.472**(0.087)
2001	3.562 (0.225)	6.127 (0.185)	-2.566** (0.099)
2002	3.787 (0.217)	6.197 (0.184)	-2.411** (0.089)
2003	4.043 (0.221)	6.331 (0.185)	-2.287**(0.087)
2004	4.335 (0.225)	6.507 (0.188)	-2.172** (0.089)
2005	4.624 (0.213)	6.666 (0.186)	-2.042** (0.079)
2006	4.746 (0.23)	6.752 (0.188)	-2.006** (0.096)

t-test of difference in means for variables ln(M^{MERS}_{jt}) and ln($M^{NonMERS}_{jt}$)
2012-2018

Year	Treated	Control	Difference
2012	3.851 (0.223)	7.463 (0.183)	-3.612** (0.085)
2013	3.879 (0.219)	7.465 (0.189)	-3.586** (0.08)
2014	4.29 (0.209)	7.595 (0.182)	-3.306** (0.093)
2015	4.08 (0.209)	7.643 (0.179)	-3.463** (0.089)
2016	3.959 (0.213)	7.467 (0.181)	-3.508** (0.094)
2017	3.668 (0.224)	87.536 (0.184)	-3.868** (0.096)
2018	4.933 (0.234)	8.618 (0.206)	-3.686** (0.094)

*Note: Standard errors in parentheses. Levels of significance ***1%, **5% and *10%*

Annex table 4: Mora and Reggio (2012, 2015) common pre-treatment dynamics test

Ho: Common pre-treatment dynamics

Variable	Observations	Test statistic	p-value	Result
ln(M^{SARS}_{jt})	1069	0.00166	0.9675	NR
ln($M^{NonSARS}_{jt}$)	1081	0.00156	0.9685	NR
ln(M^{MERS}_{jt})	1598	0.00032	0.9857	NR
ln($M^{NonMERS}_{jt}$)	1673	0.03678	0.8479	NR

Note: Standard model estimated, representing equations (1)-(4) in the text.
NR = Not rejected.

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