How did trade in GVC-based products respond to previous health shocks? Lessons for COVID-19*

Anirudh Shingal† and Prachi Agarwal‡

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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. Empirical analysis also suggests geographical diversification of value chains - imports from the disease epicentres declined during each outbreak accompanied by a fall in import concentration; these effects persisted overtime suggesting that the associated value-chains were not resilient to these health shocks. These findings are observed at both the intensive (import value) and extensive (number of HS-6 products and export destinations) margins. We expect similar disruptions to GVC-trade from COVID-19, especially diversification away from China.

JEL classification: F1

Key words: GVC-trade; health shocks; COVID-19; reshoring; near-shoring; GVC-disruptions

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*The data that support the findings of this study are available from the corresponding author upon reasonable request.

†Corresponding author. Indian Council for Research on International Economic Relations, New Delhi; European University Institute, Florence and World Trade Institute, University of Bern (ashingal@icrier.res.in).

‡PhD in Economics, JNU, New Delhi (prachi86_ssa@jnu.ac.in).

1 Introduction

COVID-19 is an unprecedented crisis with disastrous health and socio-economic concerns around the world. It has already affected over thirty 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 (people consume less because of the fear of the pandemic or lower income), there is also a supply shock emanating from temporary/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 particular, 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 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, these disruptions to GVCs coincided with the time period of the virus outbreaks but dissipated overtime ("GVC-resilience").[1]

To do so, we use difference-in-difference analysis to examine changes in patterns of GVC-based imports from severely affected exporters - China, Hong Kong, Singapore and Vietnam; and from Saudi Arabia, South Korea and the UAE - before, during and after the incidence of SARS (2002) and MERS (2014-15) outbreaks, respectively.[2] 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 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 each disease episode, though there is no evidence of a rise in domestic production at the expense of total imports ("reshoring") in the empirical analysis. Results also provide evidence for geographical diversification of value-chains - imports of GVC-based products from the disease epicentres - China and Saudi Arabia - may have declined during each outbreak, accompanied by a decline in the import concentration Hirschmann-Herfindahl indices at the disaggregated HS6-product level, especially during the MERS outbreak. The value-chains also seem to have been selectively resilient to the disease episodes - the adverse effects seem to have dissipated overtime for most major MERS-affected suppliers but seem to have been accentuated in the case of China during the SARS outbreak.

[1] 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.

[2] 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. 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).

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.

These findings are observed at both the intensive (import value) and extensive (number of HS-6 products and export destinations) margins, especially in the case of the SARS epidemic. 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 the literature that has examined past economic outcomes of epidemics with some focus on GVCs. 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 these results. 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 viral 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, these disruptions to GVCs coincided with the time period of the virus outbreaks but dissipated overtime ("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) exploited 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.[3] 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.[4]

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

[3] 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.

[4] 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).

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) assessed 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 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 European Union, United States 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 SARS (2002) and MERS (2014-15) 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.[5] 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 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

[5] 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.

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[6]) 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, overtime by sector. The first six charts show the variance in the HHI during SARS (2003) and the next six during the MERS outbreak (2014-15).

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

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

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[7] 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 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) analysis. 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 2012-2018, 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 statistcal tests on differences in means of the two variables in each case (see Annex table 3).

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). Results suggest that the assumption of parallel trends

[7]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.

between treated and control groups in the pre-treatment period may have been met (see Annex table 4).

4.1 Baseline DiD[8]

The baseline DiD equations takes the following form:

$$ln(M_{jt}^{SARS}) = \alpha_1 Post_t + \alpha_2 Treated_j + \alpha_3 Post * Treated_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \qquad (1)$$

$$ln(M_{jt}^{NonSARS}) = \alpha_1 Post_t + \alpha_2 Treated_j + \alpha_3 Post * Treated_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \qquad (2)$$

$$ln(M_{jt}^{MERS}) = \alpha_1 Post_t + \alpha_2 Treated_j + \alpha_3 Post * Treated_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \qquad (3)$$

$$ln(M_{jt}^{NonMERS}) = \alpha_1 Post_t + \alpha_2 Treated_j + \alpha_3 Post * Treated_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \qquad (4)$$

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. The variables $Post_t$, $Treated_j$ and their interaction term vary for SARS and MERS 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. In the case of SARS, $Post_t = (0,1)$ for $t(<,>)2003$ and $Treated_j = \{$China (epicentre), Hong Kong, Canada, Singapore and Vietnam$\}$. For MERS, $Post_t = (0,1)$ for $t(<,>)2014-2015$ and $Treated_j = \{$Saudi Arabia (epicentre), UAE and South Korea$\}$.[9]

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

[8]We prefer using the difference-in-difference estimator to the 2FE estimator for causal inference for the reasons outlined in Imai and Kim (2020).

[9]Saudi Arabia accounted for almost 80% of MERS cases, followed by the UAE and South Korea which were also majorly affected, especially in 2014-15.

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, justifying their choice as controls.

The equations are estimated separately for cumulative imports from SARS-affected and unaffected countries, and MERS-affected and unaffected countries, over the time periods, 2000-2006 and 2012-2017, to examine the effects of the SARS and MERS outbreaks, respectively. A priori, we expect estimated $\alpha_3 < 0$ only for cumulative imports from SARS- and MERS-affected countries.

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:

$$ln(M_{jt}) = \alpha_1 Post_t + \alpha_2 Treated_j + \alpha_3 Post * Treated_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \tag{5}$$

$$ln(Y_{jt}) = \alpha_1 Post_t + \alpha_2 Treated_j + \alpha_3 Post * Treated_{jt} + \mu_t + \gamma_j + \epsilon_{jt} \tag{6}$$

where M_{jt} is the value of country j's cumulative imports of GVC-based intermediate and final products from all countries at time t and Y_{jt} is the value of country j's total domestic output of GVC-based intermediate and final products at time t. Estimated $\alpha_3 < 0$ for imports together with estimated $\alpha_3 > 0$ 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.[10]

4.3 Geographical diversification of value-chains

Baseline and augmented variants of equation (5) are also used to examine empirically if (i) the SARS epidemic was associated with a decline in imports coming from each of China, Hong Kong, Singapore and Vietnam; and (ii) the MERS outbreak was associated with a

[10]Note that this analysis is 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 is thus more feasible to "aggregate" the HS6 products to the ISIC four-digit level for empirical analysis.

decline in imports coming from each of South Korea, Saudi Arabia and the UAE. Estimated $\alpha_3 < 0$ would provide evidence for geographical diversification in each case.

4.4 Widening of value-chains

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

$$HHI_{jpt} = \alpha_1 Post_t + \alpha_2 Treated_j + \alpha_3 Post * Treated_{jt} + \mu_t + \gamma_{jp} + \epsilon_{jpt} \tag{7}$$

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 $\alpha_3 < 0$ would provide evidence for widening of value-chains.

All equations are estimated using OLS with the standard errors clustered by destination-year in aggregate analysis and by destination-HS6/product-year in disaggregated analysis.

5 Results and analysis

5.1 Baseline DiD

The results from estimating equations (1)-(4) and their augmented versions are reported in Table 1. Both SARS and MERS had an adverse effect on cumulative imports from the respective worst-affected countries; the coefficients on the interaction terms are negative and statistically significant in each case. Coefficient estimates suggest that the SARS outbreak was associated with a 13.5 to 20.7 perent decline in cumulative imports from the worst-affected countries; for MERS, the decline ranged from 31.3 to 32.8 percent. Encouragingly, the diseases outbreaks report a statistically insignificant effect on cumulative imports from the unaffected countries.

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 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 on domestic output could not be implemented for lack of observations and is found to be statistically indifferent from zero in the import regressions in columns (3) and (4).

<Insert Table 2 here>

5.3 The SARS effect on imports 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 viral outbreak. Coefficient estimates suggest that SARS may have been associated with a 25.6 to 27.7 percent decline in imports from China, which is consistent with the findings from firm-level analysis in Fernandes and Tang (2020).

<Insert Table 3 here>

In contrast, imports from Hong Kong and Singapore seem to have been largely unaffected by this outbreak - the respective coefficient estimates in columns (3)-(6) are weakly significant or statistically indifferent from zero - while Vietnam seems to have witnessed an increase in its exports to the rest of the world.

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

The countries worst-affected by MERS collectively also seemed to have seen their exports suffer individually in the results reported in Table 4. Once again, the disease epicentre - Saudi Arabia - seeemed to have been the most severely affected; coefficent estimates in columns (1) and (2) suggest that imports from that country witnessed a 94.9 to 95.2 percent decline as a result of the MERS outbreak.

<Insert Table 4 here>

Unlike for SARS, MERS seems to have been associated with an adverse effect on imports from other badly-affected countries as well. Coefficient estimates reported in columns (3)-(6) suggest that the outbreak may have been associated with a 36.4 to 39.4 percent decline in imports from the UAE and a 12.7 to 17.0 percent decline in imports from South Korea.

5.5 Extensive margin analysis

The intensive margin effect in the results reported in columns (1)-(2), (5)-(6) of Table 1 also seems to be corroborated at the extensive margin - both in terms of number of trading partners and products - especially for the SARS outbreak.

<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. While MERS may have been associated with a much larger decline (50 percent) in the number of suppliers for the worst affected countries, the latter seem to have exported a much larger number of products.

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 overtime. Coefficient estimates suggest that MERS may have been associated with a 2.4 percent decline in importer concentration over 2012-2016.

<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 small - ranging from a 0.6 to 1.1 percent rise in the HHI - and seems to have increased monotonically overtime.

5.7 GVC-resilience

GVCs seem to have been selectively resilient to the disease episodes - the adverse effects seemed to have dissipated overtime for most major MERS-affected suppliers but seem to have been accentuated in the case of China during the SARS outbreak (see Table 7).

<Insert Table 7 here>

On the whole, the results in this section suggest that there may have been a disruption to GVCs from each of the disease outbreaks, both by way of reducing reliance on the disease epicentres at both margins of trade and by diversifying the portfolio of trading partners, though the effects did not always persist overtime.

6 What drives these results? (TO BE COMPLETED)

7 Conclusion

Using difference-in-difference analysis and disaggregated data on bilateral 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. Empirical analysis also suggests geographical diversification of value chains - imports from the disease epicentres declined during each outbreak accompanied by a fall in import concentration; these effects persisted overtime suggesting that the associated value-chains were not resilient to these health shocks. These findings are observed at both the intensive (import value) and extensive (number of HS-6 products and export destinations) margins.

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 over twenty-five million confirmed cases of COVID-19 as of the end of August 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. Specifically, products that were capital and skill-intensive or upstream in production chains may have been more resilient to the export disruption caused by SARS (Fernandes and Tang, 2020). These results were consistent with Furusawa et al. (2018) who found that sourcing of differentiated inputs is less vulnerable to trade-shocks, but not to the findings from our analysis where Chinese exports of GVC-based intermediates in both apparel and electronics were adversely affected by SARS.

In any event, the case with COVID-19 is slightly different. China has moved upstream in GVCs and specializes in a variety of products that are tech and skill-intensive, and may therefore, be hard to substitute. Perhaps China will experience a faster recovery or a small disruption post-COVID owing to the inability of countries to find alternative sources. However, for foreign buyers of Chinese intermediate products, the impact can be overwhelming 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 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 on 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. For example, Apple, Google and Samsung have already begun diversifying away from China since February 2020.[11] 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 was a preferred location because its supply chains in the industry remain localized and were unaffected by the outbreak in China.[12] Another favored destination for relocation of textiles manufacturing has been Vietnam.[13]

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.[14] 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.[15] 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.[16]

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.[17] 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.[18] 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

[11] 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.

[12] https://www.fibre2fashion.com/industry-article/8679/indonesian-textiles-industry-likely-to-pull-through-global-pandemic.

[13] Japanese megabrand UNIQLO has moved sourcing to Vietnam from China.

[14] https://www.washingtonpost.com/world/asia_pacific/chinas-next-challenge-coronavirus-breaks-the-links-in-the-worlds-supply-chain/2020/03/11/175f391e-6270-11ea-8a8e-5c5336b32760_story.html.

[15] https://www.forbes.com/sites/wadeshepard/2020/03/26/covid-19-undermines-chinas-run-as-the-worlds-factory-but-beijing-has-a-plan/#4e2ab3c2459a.

[16] https://investors-corner.bnpparibas-am.com/economics/decoupling-from-china-easier-said-than-done/; https://www.bruegel.org/2020/02/companies-must-move-supply-chains-further-from-china/.

[17] https://www.japantimes.co.jp/news/2020/03/17/business/japan-auto-suppliers-shift-china-mexico/#.X0yecWdLgWp.

[18] https://www.forbes.com/sites/kenrapoza/2020/05/21/face-it-china-led-globalization-is-over/#27af7a355aa3.

counterparts.[19]

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.[20] 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.[21]

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.

[19] https://www.forbes.com/sites/annashedletsky/2020/02/07/coronavirus-hits-electronics-manufacturing-hard-companies-are-scrambling/#2b3ab08e369c.

[20] https://www.forbes.com/sites/kenrapoza/2020/05/21/face-it-china-led-globalization-is-over/#27af7a355aa3.

[21] https://theaseanpost.com/article/japan-switching-manufacturing-asean; https://www.eria.org/news-and-views/reimagining-global-value-chains-after-covid-19/.

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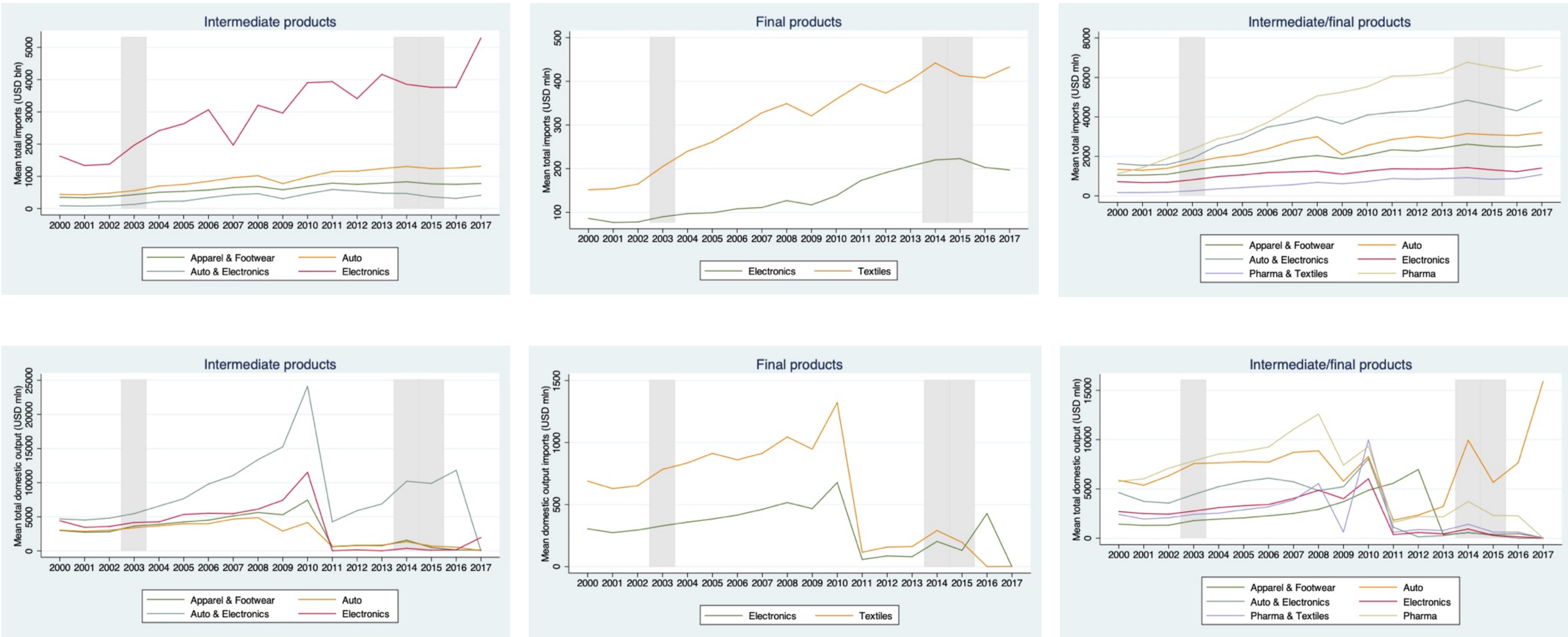
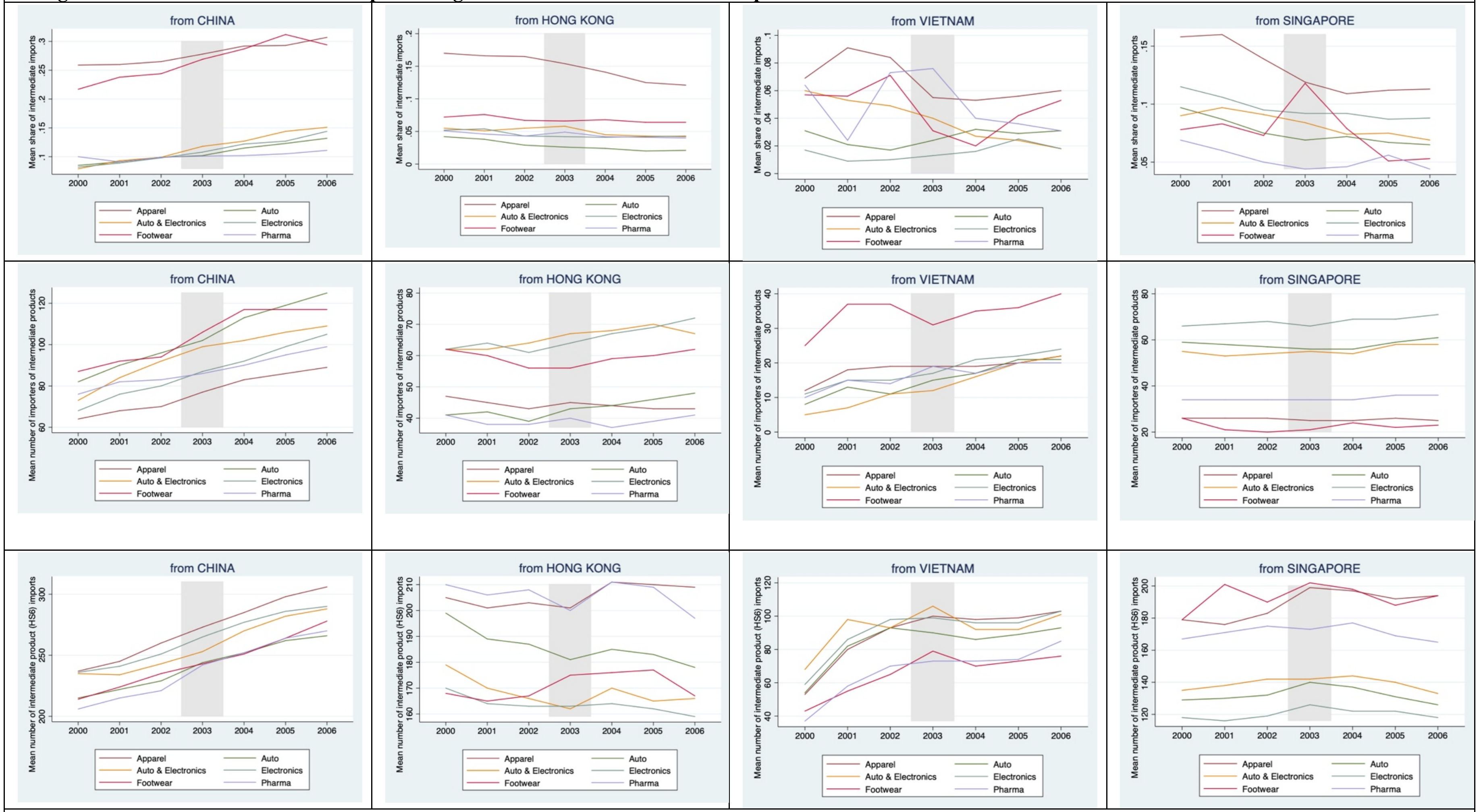
Figure 1: Imports (top panel) and domestic output (bottom panel) of GVC-based intermediate and final products overtime



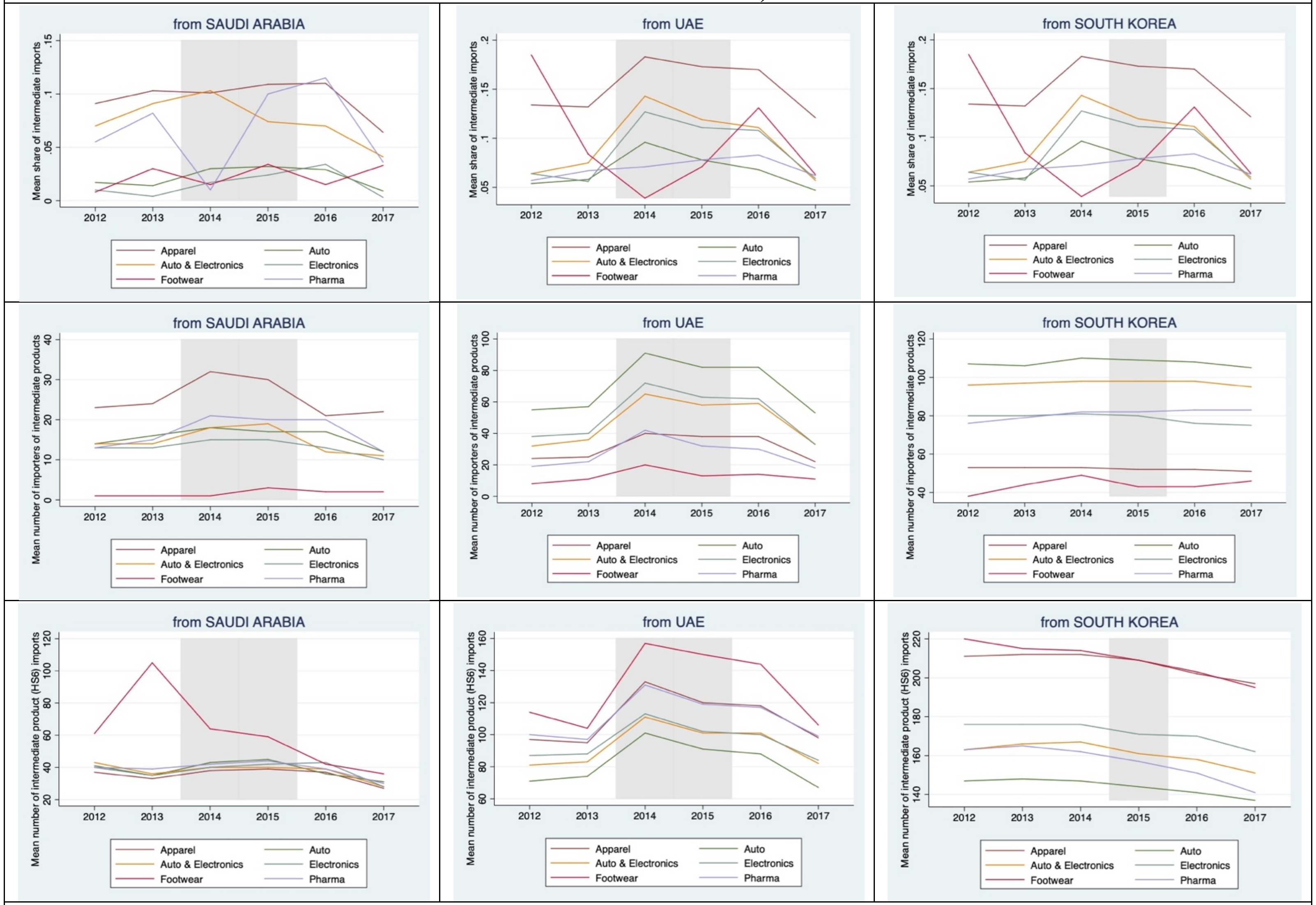
Source: UNIDO IndStat dataset; own calculations
Note: The two-coloured slabs denote the time periods corresponding to severe incidence of the SARS (2003) and MERS (2014-15) outbreaks, respectively.

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



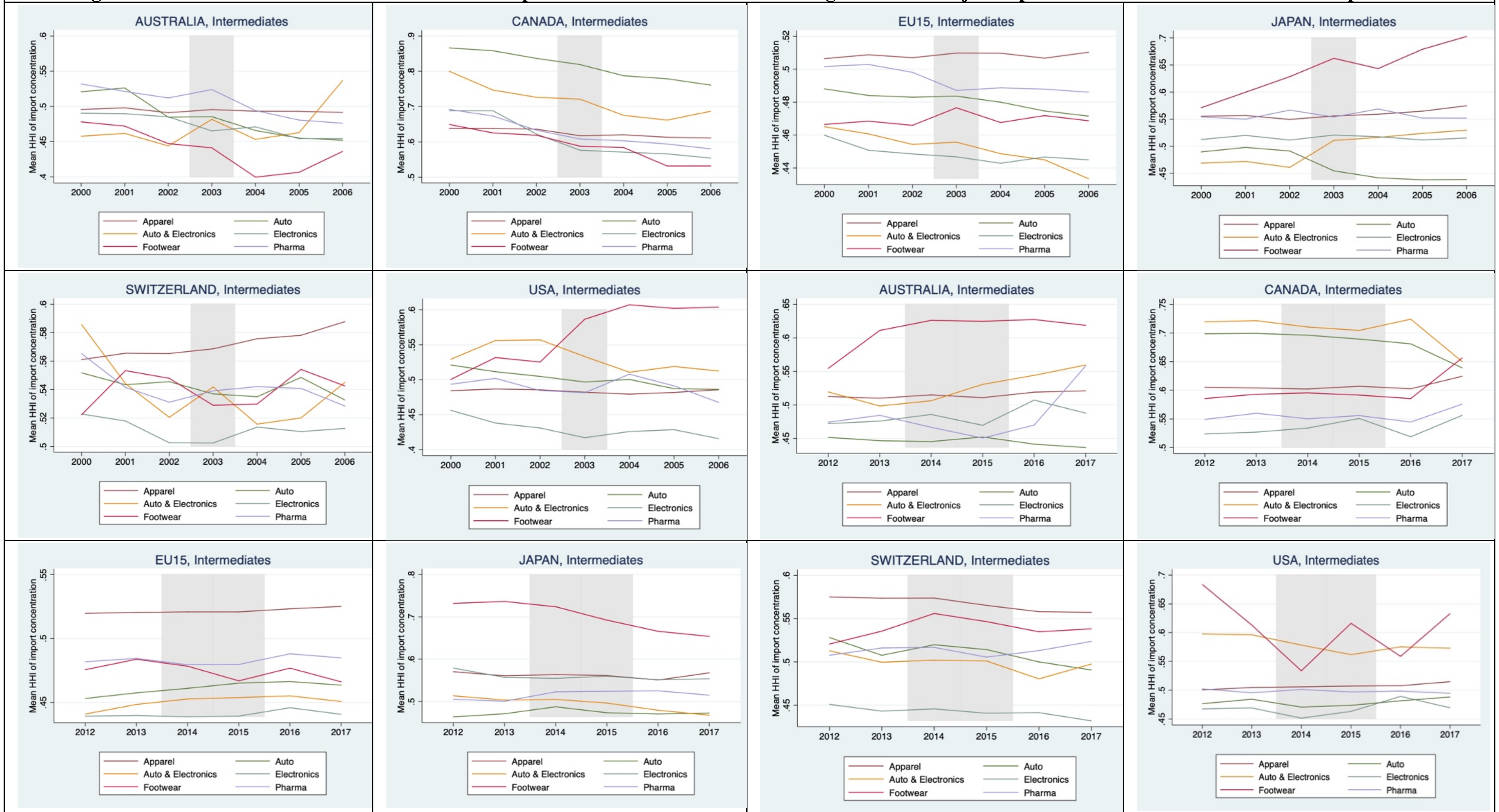
Source: BACI dataset; own calculations

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



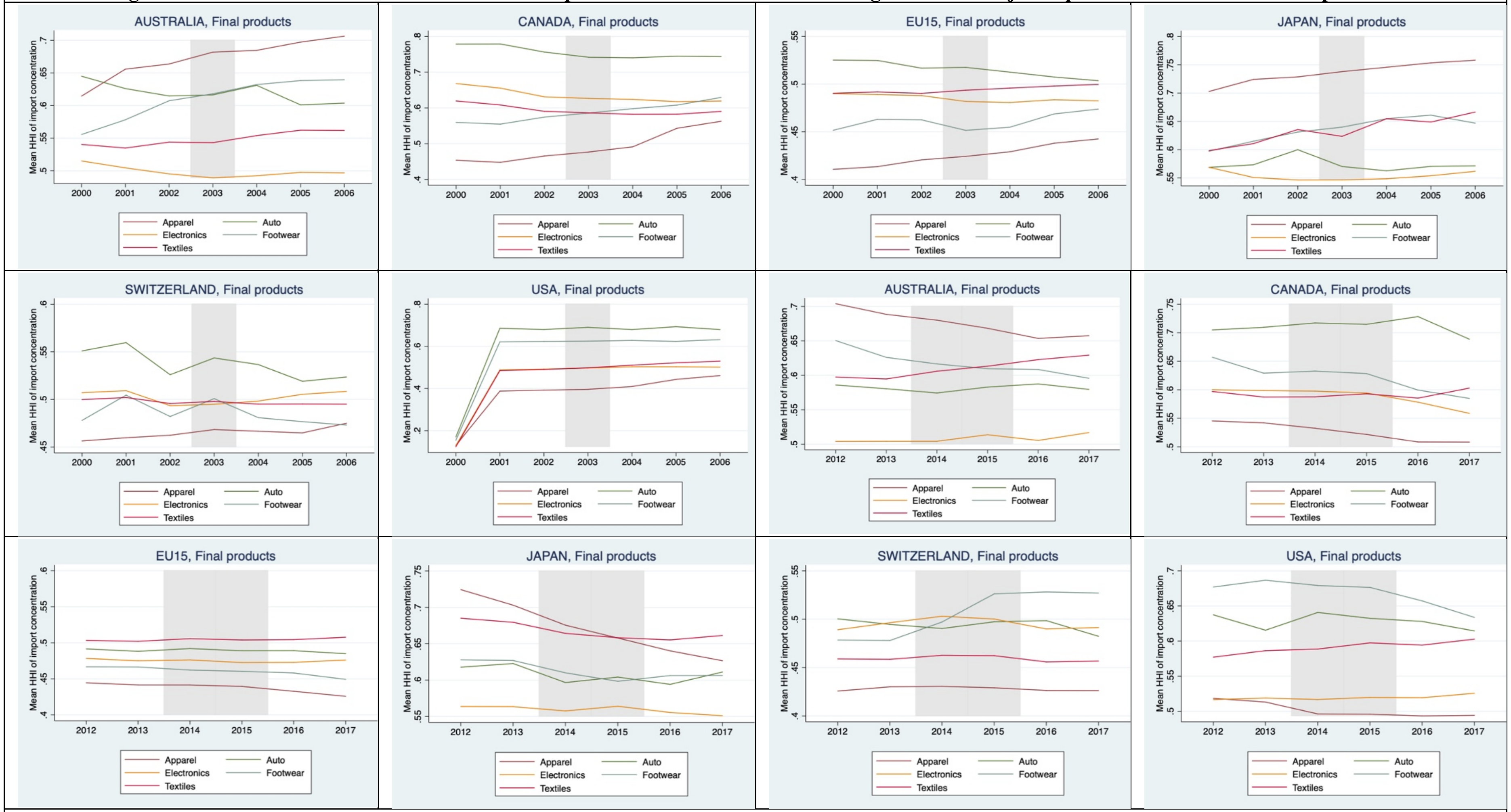
Source: BACI dataset; own calculations

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



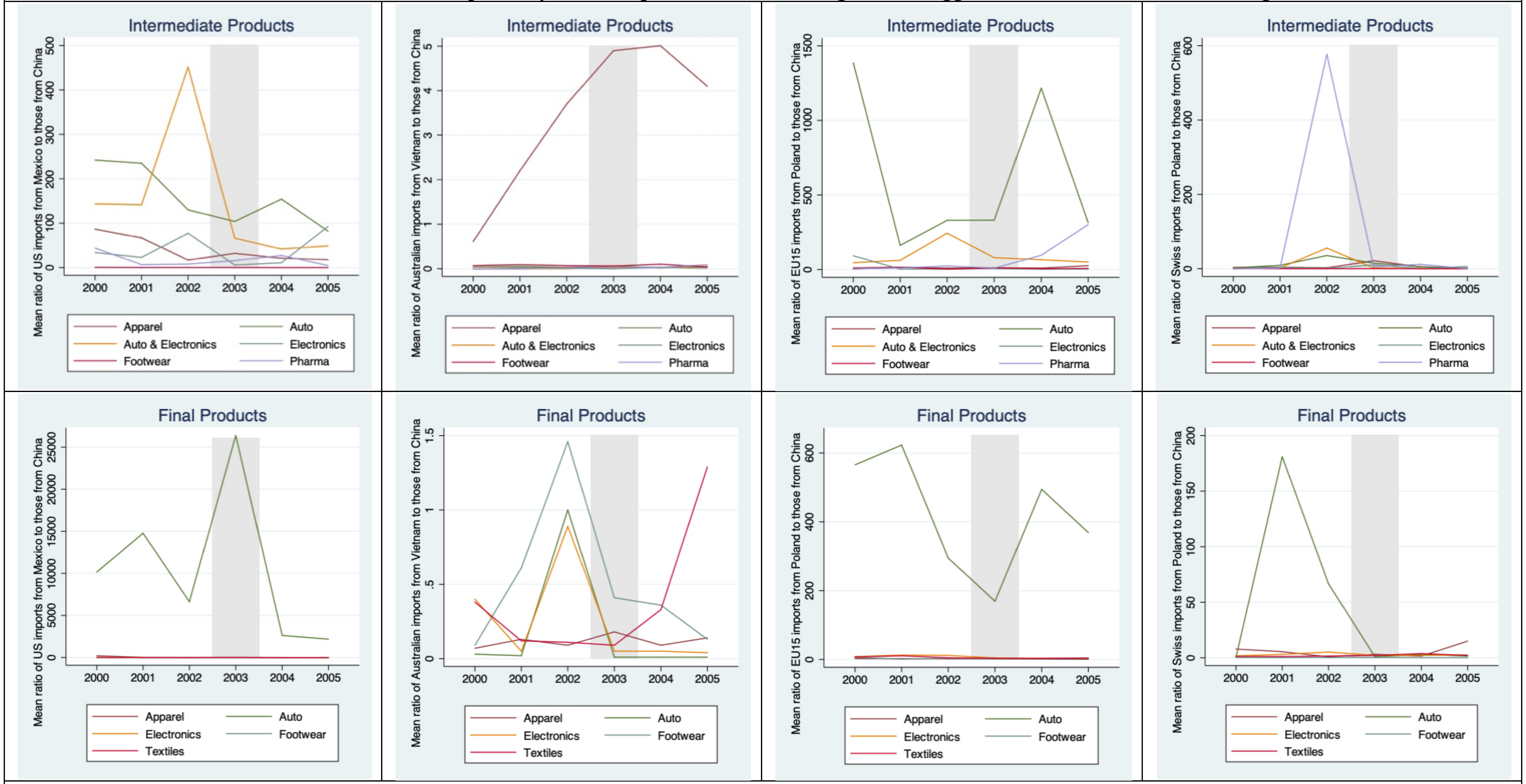
Source: BACI dataset; own calculations

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



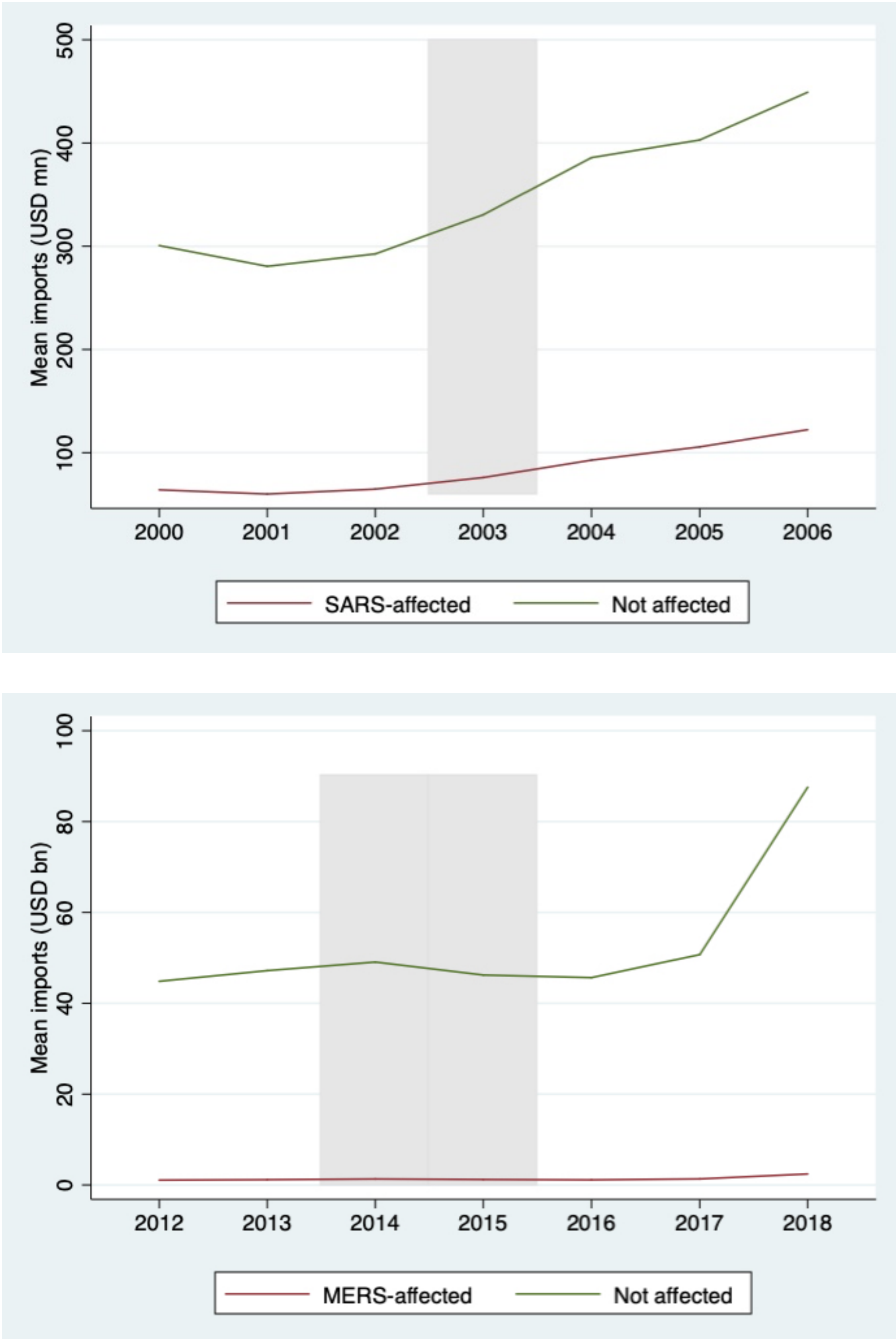
Source: BACI dataset; own calculations

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 severe incidence of SARS (2003) and MERS (2014-15). 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.

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)**				**2012-2016 (MERS)**			
$Treated*Post_{jt}$	-0.145**	-0.232***	0.052	0.110	-0.397***	-0.376***	-0.089	-0.091
	(0.069)	(0.078)	(0.068)	(0.076)	(0.113)	(0.064)	(0.075)	(0.076)
$\ln(Pop_{jt})$		-1.080		0.540		5.614***		-0.112
		(0.961)		(0.469)		(1.571)		(0.467)
$\ln(MP_{jt})$		0.003		0.004		-0.026		-0.001
		(0.010)		(0.007)		(0.017)		(0.007)
Observations	855	727	864	727	626	544	662	548
R-squared	0.976	0.978	0.990	0.987	0.976	0.973	0.994	0.994
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)**		**2012-2016 (MERS)**		**2001-2005 (SARS)**	
$Treated*Post_{jt}$	0.285**	0.300*	-0.016	-0.023	0.006	-0.002
	(0.143)	(0.154)	(0.086)	(0.087)	(0.181)	(0.190)
$\ln(Pop_{jt})$		-0.850		-0.049		-0.715
		(0.576)		(0.529)		(0.853)
$\ln(MP_{jt})$		-0.001		-0.002		0.004
		(0.009)		(0.008)		(0.010)
Observations	860	727	659	548	329	297
R-squared	0.989	0.986	0.994	0.995	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 model.
Levels of significance: *10%, **5%, ***1%

Table 3: SARS effect on imports from affected countries

	$\ln(M^{CHN}_{jt})$		$\ln(M^{HKG}_{jt})$		$\ln(M^{SGP}_{jt})$		$\ln(M^{VNM}_{jt})$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	2001-2005 (SARS)							
$Treated*Post_{jt}$	-0.295***	-0.325***	-0.116	-0.166	0.181*	0.162	0.318**	0.363**
	(0.079)	(0.090)	(0.152)	(0.167)	(0.104)	(0.101)	(0.130)	(0.146)
$\ln(Pop_{jt})$		-0.462		-2.843***		-3.074**		3.805**
		(0.885)		(0.960)		(1.255)		(1.485)
$\ln(MP_{jt})$		0.006		-0.009		0.001		-0.019
		(0.011)		(0.013)		(0.014)		(0.025)
Observations	785	709	746	681	720	636	708	625
R-squared	0.978	0.976	0.971	0.971	0.974	0.973	0.923	0.925
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 imports from affected countries

	$\ln(M^{SAU}_{jt})$		$\ln(M^{ARE}_{jt})$		$\ln(M^{KOR}_{jt})$	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	2012-2016 (MERS)					
$Treated*Post_{jt}$	-3.042***	-2.977***	-0.452**	-0.501*	-0.136*	-0.186**
	(0.144)	(0.232)	(0.193)	(0.266)	(0.075)	(0.076)
$\ln(Pop_{jt})$		7.401**		-2.328		0.684
		(3.032)		(1.821)		(1.381)
$\ln(MP_{jt})$		0.024		0.025		-0.013
		(0.039)		(0.025)		(0.013)
Observations	361	333	422	384	620	541
R-squared	0.915	0.928	0.945	0.946	0.981	0.981
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)**		**2012-2016 (MERS)**	
$Treated*Post_{jt}$	-0.337**	-0.299***	-0.692***	0.422***
	(0.144)	(0.034)	(0.044)	(0.116)
Observations	333	2,492	272	1,749
R-squared	0.446	0.739	0.477	0.572
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**	**2012-2016**	**2012-2017**	**2012-2018**
$Treated*Post_{jt}$	0.006***	0.009***	0.011***	-0.024***	-0.005**	-0.013***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Observations	491,303	673,282	855,334	484,063	650,609	766,745
R-squared	0.808	0.780	0.763	0.816	0.787	0.769
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: Adverse effects of disease outbreaks on imports dissipate overtime: summary of results

	Effect of SARS on:			Effect of MERS on:		
	(1)	(2)	(3)	(4)	(5)	(6)
	2001-2004	2001-2005	2001-2006	2012-2016	2012-2017	2012-2018
$\ln(M^{SARS}_{jt})$	-0.207**	-0.232***	-0.231***			
	(0.095)	(0.078)	(0.084)			
$\ln(M^{CHN}_{jt})$	-0.316***	-0.325***	-0.341***			
	(0.118)	(0.090)	(0.089)			
$\ln(M^{HKG}_{jt})$	-0.172	-0.166	-0.190			
	(0.181)	(0.167)	(0.179)			
$\ln(M^{SGP}_{jt})$	0.136	0.162	0.229**			
	(0.125)	(0.101)	(0.095)			
$\ln(M^{VNM}_{jt})$	0.448***	0.363**	0.312**			
	(0.171)	(0.146)	(0.132)			
$\ln(M^{MERS}_{jt})$				-0.376***	-0.114	-0.109
				(0.064)	(0.201)	(0.139)
$\ln(M^{SAU}_{jt})$				-2.977***	-1.750	-1.315
				(0.232)	(1.228)	(0.940)
$\ln(M^{ARE}_{jt})$				-0.501*	-0.275	-0.112
				(0.266)	(0.252)	(0.200)
$\ln(M^{KOR}_{jt})$				-0.186**	-0.158**	-0.158**
				(0.076)	(0.065)	(0.069)
Destination-year controls	YES	YES	YES	YES	YES	YES
Destination-year FE	YES	YES	YES	YES	YES	YES

Note: Table reports coefficients on Treated*$Post_{jt}$ 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%

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	3.654 (0.216)	6.739 (0.197)	-3.085** (0.083)
2001	3.580 (0.225)	6.171 (0.194)	-3.133** (0.091)
2002	3.787 (0.217)	6.741 (0.195)	-2.954** (0.083)
2003	4.091 (0.224)	6.995 (0.192)	-2.904**(0.081)
2004	4.378 (0.228)	7.162 (0.196)	-2.784** (0.083)
2005	4.660 (0.214)	7.325 (0.193)	-2.665** (0.075)
2006	4.773 (0.231)	7.378 (0.196)	-2.604** (0.089)

t-test of difference in means for variables $\ln(M^{MERS}_{jt})$ and $\ln(M^{NonMERS}_{jt})$ 2012-2018			
Year	**Treated**	**Control**	**Difference**
2012	3.812 (0.225)	8.096 (0.189)	-4.283** (0.082)
2013	3.879 (0.219)	8.130 (0.192)	-4.251** (0.078)
2014	4.245 (0.212)	8.230 (0.187)	-3.985** (0.092)
2015	4.053 (0.209)	8.168 (0.186)	-4.115** (0.089)
2016	3.893 (0.216)	8.079 (0.186)	-4.186** (0.091)
2017	3.610 (0.226)	8.140 (0.190)	-4.530** (0.095)
2018	4.932 (0.234)	9.307 (0.206)	-4.375** (0.094)

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

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

Ho: Common pre-treatment dynamics

Variable	**Observations**	**Test statistic**	**p-value**	**Result**
$\ln(M^{SARS}_{jt})$	1495	0.00341	0.9983	NR
$\ln(M^{NonSARS}_{jt})$	1514	0.04681	0.9769	NR
$\ln(M^{MERS}_{jt})$	1260	0.00067	0.9793	NR
$\ln(M^{NonMERS}_{jt})$	1325	0.1231	0.9117	NR

Note: Fully flexible model estimated in each case. NR = Not rejected.