CHAPTER 4

SERVICES, DIGITALLY DELIVERED TRADE, AND GLOBAL VALUE CHAINS IN ASIA

Ben Shepherd

4.1 Introduction and Motivation

Digital technology has become a major factor in global trade, and through it an engine of economic growth (Ferracane, Lee-Makiyama, and van der Marel 2018). The environment governing these transactions has seen substantial changes over recent years, involving policies, preferences, and technologies. Digitally delivered trade—that is to say, export and import transactions delivered using digital means—now provides benefits to producers and consumers alike, and is arguably helping drive productivity growth, which is the only reliable engine of long-run economic growth and increasing per capita incomes. As Ferracane, Lee-Makiyama, and van der Marel (2018) show, however, policies relating to digitally delivered sectors in Asia are mixed: some economies adopt relatively liberal stances, while others are among the most highly restrictive in the world.

The pandemic has accelerated the transformation toward digitally delivered trade. Not only have many activities—primarily services—that traditionally required in-person interaction moved online, but goods sectors have also increasingly shifted to online ordering and payment systems combined with advances in rapid delivery to keep crucial sectors afloat during a period where, in many economies, the protection of public health curtailed traditional retail interaction.

Conceptually, digital technology seems likely to play a major role in linking the large number of firms that participate in global value chains (GVCs). Lead firms depend on digital means to monitor production by suppliers and movement of goods within networked production structures. Similarly, digital payments make it possible for firms at different points in the chain to negotiate contracts and secure payments across borders, potentially at great distances. It is no coincidence that the "second unbundling" referred to by Baldwin (2011)—the geographic dispersion of production processes—coincides with the rise of information and communication technologies that began in the 1990s. Without such technologies, it would be difficult if not impossible to achieve the required degree of coordination in production.

An important policy issue is therefore the degree of linkage between the performance of goods market GVCs in sectors like electronics or apparel and in services, and the policy environment governing digitally delivered trade. If restrictive policies increase price and decrease availability of services provided digitally, then those services will be correspondingly less used as inputs in the production of manufactured goods and other services—potentially undermining trade performance and production efficiency. This analysis makes plain the importance of embodied services trade in the understanding of GVCs—i.e., the proportion of gross exports by sector that is made up of value added sourced in the services sector. It raises the question of the extent to which services provided digitally are used as inputs in the production of exports in other sectors. These backward and forward perspectives can be used in different contexts to better understand the role of input–output linkages, including those relating to services delivered digitally, in driving GVC performance and expansion.

Amid this trading environment, we seek to add to the literature in three ways. First, we identify digitally delivered services based on analysis by the Organisation for Economic Co-operation and Development (OECD) and use the ADB Multi-Regional Input–Output Tables (MRIOT) to produce consistent measures of their use within GVCs. We track this across economies and through time, focusing on Asia. Second, we analyze recently collected data on policy measures affecting digitally delivered trade. Finally, we build a quantitative general equilibrium model of world trade based on the ADB MRIOT for 2019. We use it to conduct counterfactual simulations based on plausible goals for policy liberalization and deregulation across economies affecting digitally delivered sectors. The model shows not only how policy changes affect trade flows and aggregate real income, but also how they influence GVC linkages. In other words, we are able to pinpoint the potential for the liberalization of digitally delivered trade to promote GVC integration across an economy, in other services sectors, and in goods. We also assess the ways in which this liberalization can promote structural change, by looking at the distribution of exports across primary, secondary, and tertiary aggregates.

After looking conceptually at digitally delivered trade and how it has trended through time, this chapter covers its effect on sectors, GVC linkages, and policies. We then develop a general equilibrium model of trade that incorporates GVC linkages and use this to conduct counterfactual simulations based on liberalization and deregulation of digitally delivered trade. The chapter ends by discussing the policy implications of the simulation findings.

4.2 Digitally Delivered Trade: Sectors, Linkages, and Policies

This section lays the groundwork for the rest of the chapter by developing a framework for understanding digitally delivered trade in terms of standard aggregates in the national accounts. Those insights help in measuring the degree of GVC integration exhibited by digitally delivered trade, focusing on Asian economies over 2000–2019. Finally, the section presents data on policies affecting digital trade for 2019, the most recent year for which data are available.[1]

4.2.1 Conceptualizing Digitally Delivered Trade

National accounts do not recognize "digital" as a sector or aggregate. Similarly, they do not identify ways in which other services are delivered, such as distinguishing between in-person versus digital provision. Services trade data do not distinguish provision by digital means from other means. In particular, they do not identify which of the four modes of supply recognized by the General Agreement on Trade in Services (GATS) is involved in particular cases. Standard services trade data are derived from the Balance of Payments, which mixes elements of GATS modes 1, 2, and 4. As such, it includes digitally delivered trade—which is relatively similar to the concept of GATS mode 1, or pure cross-border service provision—but also trade involving in-person interactions, either through movement of the consumer (mode 2) or the service provider (mode 4). Chapter 2 provides an overview of these issues, along with an identification of services that are digitally delivered, which is followed in this section.

Statisticians from the World Trade Organization (WTO) have made progress in moving beyond this by compiling data on Trade in Services by Mode of Supply (TISMOS). Since economies do not yet collect data by GATS mode of supply, the approach taken is to use information from surveys and external sources to construct first estimates of trade by mode. As such, TISMOS data are not directly observed, but instead are modeled estimates. They will be refined over time, but for the time being provide the best available information.

The TISMOS data make it possible to rank sectors according to the percentage of exports provided through GATS mode 1. This mode of supply is pure cross-border services trade, and essentially captures service provision by digital means. In other words, this mode is services trade that takes place by

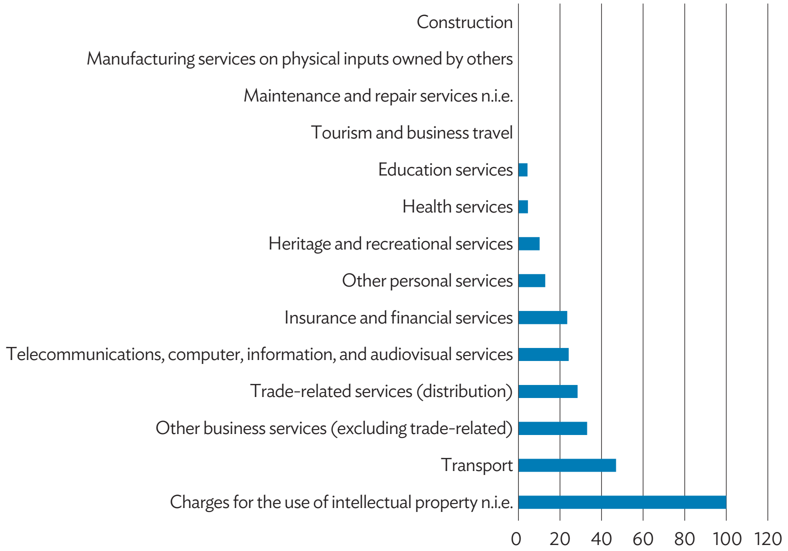
[1] No baseline year is free from external shocks to trade performance and GVC integration. For example, 2019 has the variable of the United States–People's Republic of China (PRC) trade conflict, but its effects were most keenly felt in goods markets rather than services. Nonetheless, this conflict primarily affects only two economies in the database, and is not a reason for preferring historical rather than current data.

phone, e-mail, data flows, and similar technologies, rather than in-person. A high proportion of mode 1 relative to other modes suggests that a significant proportion of a sector's trade is delivered digitally, and so the sector as a whole can be regarded as "digitally delivered."

Figure 4.1 shows results for this calculation using the major TISMOS aggregates. Results vary widely across sectors, with some services entries in TISMOS traded exclusively by mode 1, while others are not traded at all using that mode. Results differ somewhat among economies, but the pattern generally reflects the limited available information on the extent of pure cross-border trade in the total.

In interpreting the results, it is important to note that some pure cross-border services trade is not digital. Transport is a good example. Figure 4.1 shows it is heavily traded by mode 1, but clearly it is not digitally delivered; rather, the data capture the nature of transport movements in a physical sense. Putting royalties to one side, the key sectors are business services, telecommunications, financial services, and other personal services.

Figure 4.1: Global Mode 1 Exports, 2017
(% of total exports)



n.i.e. = not included elsewhere.

Source: World Trade Organization and Directorate-General for Trade of the European Commission. Trade in Services Data by Mode of Supply (TISMOS). https://www.wto.org/english/res_e/statis_e/trade_datasets_e.htm (accessed June 2021).

Mapping these aggregates to sectors in national accounts is not straightforward, as the classifications involved are slightly different. However, in a general sense, the following ADB MRIOT sectors can be considered as digitally delivered,[2] on a broad reading:

- Post and telecommunications;
- Financial intermediation;
- Real estate activities;
- Renting of machinery and equipment, and other business activities; and
- Other community, social, and personal services.

While the analysis is necessarily approximate, given the extent of data available, this list presents a selection of sectors where digitally delivered trade is expected to account for an important share of total trade, and where, therefore, policy reforms could be expected to have the most significant impact on trade flows and input sourcing.

4.2.2 Measuring Global Value Chain Integration

Standard trade data are ill-suited to measuring GVC integration. The reason is that they include a large measure of double counting because they are recorded on the basis of gross shipments rather than value added. For example, if the Republic of Korea ships a cellphone component worth $100 to the People's Republic of China (PRC), which then adds a further $500 worth of components from other regional sources and $100 of assembly services, then ships the cellphone to the United States, the transaction is recorded as an export of $100 from the Republic of Korea to the PRC, and of $700 from the PRC to the United States. The value-added origins of the cellphone are lost in the standard accounting systems used for customs valuation.

Wang, Wei, and Zhu (2013) provide a consistent methodology for decomposing gross value trade data into value-added components by combining them with information from input–output tables. The methodology is set out in detail from the next paragraph. Intuitively the decomposition is split into three main aggregates: domestic value added (DVA), foreign value added (FVA), and pure double counting (PDC). DVA records the part of gross exports that can be sourced to industries located within the exporting economy, while FVA is that part attributable to imported intermediate goods and services. Finally, PDC records the part of gross exports that is double counted due to having moved across borders multiple times during production.

2 ADB MRIOT sectors do not correspond exactly to TISMOS aggregates. Concordance is based on visual inspection, and matching to nearest categories, as well as information provided by the OECD Secretariat.

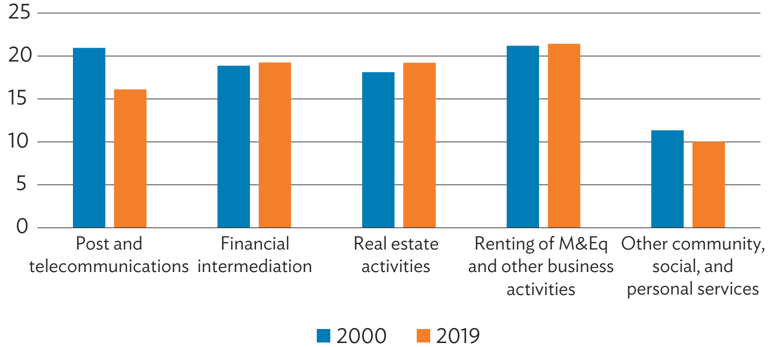
FVA as a proportion of gross exports gives a backward measure of GVC integration: the proportion of exports that is accounted for by imports of intermediate goods and services. To see the opposite perspective, it is necessary to zero in on a particular component of DVA that Wang, Wei, and Zhu (2013) term DVA_INTRex. This equates to production by domestic industries that is exported and used by other economies in the production of their own exports, and it is a typical measure of forward GVC participation from the perspective of industries in the exporting economy. We focus on it here, as we are interested in tracking forward linkages from the perspective of the sectors identified as digitally delivered—that is, we are interested in how other sectors use digitally delivered trade to produce their exports (forward linkages), not in how digitally delivered sectors use inputs from other sectors, by definition not digitally delivered, to produce their exports (backward linkages).

ADB provides a decomposition of gross exports from the MRIOT using the Wang, Wei, and Zhu (2013) methodology. Figure 4.2 shows results by sector, aggregating by summing all Asian economies in the database. For four of the five sectors, GVC forward linkages account for reasonably similar proportions of gross exports, at about 15%–20%. The exception is other community, social, and personal services, which is considerably lower at around 10%. In a static sense, there is clear evidence of significant GVC integration in digitally delivered sectors, focusing on forward linkages. However, the direction of change is also important: for three of the five sectors, forward integration between 2000 and 2019 increases only slightly; for the remaining two sectors, the proportion decreases, significantly so for post and telecommunications. The direction of change suggests that digitally delivered sectors are generally maintaining their importance in regional GVCs in a forward integration sense, but that importance is not really growing.

To provide a comparison, we can consider the sum of all forward integration across all sectors in the economy, goods and services combined. Again, considering Asian economies only, results indicate that forward linkages accounted for 16.9% of gross exports in 2000 and 18.4% in 2019. So aggregate GVC integration has been generally increasing over time, though more slowly than gross exports as a whole. For three of the five digitally delivered sectors—finance, real estate, and other business services—forward integration is generally higher than for all sectors taken together, while for the remaining sectors it is either slightly lower (telecom) or significantly lower (other community, social, and personal services). Moreover, in interpreting growth, it is important to note that forward GVC integration for the economy as a whole grew from 16.9% to 18.1% between 2000 and 2008, then decreased markedly because of the global financial crisis, returning to growth, though slow-paced, in the years after. So, the 2019 figure, although only a couple of percentage points higher than the 2000 figure, highlights the depth of the shock to production structures that occurred in 2009, as indicated by relatively slow growth in trade and GVC integration since then.

Figure 4.2: Global Value Chain Forward Linkages for Digitally Delivered Sectors—Asia and the Pacific

(% of gross exports)



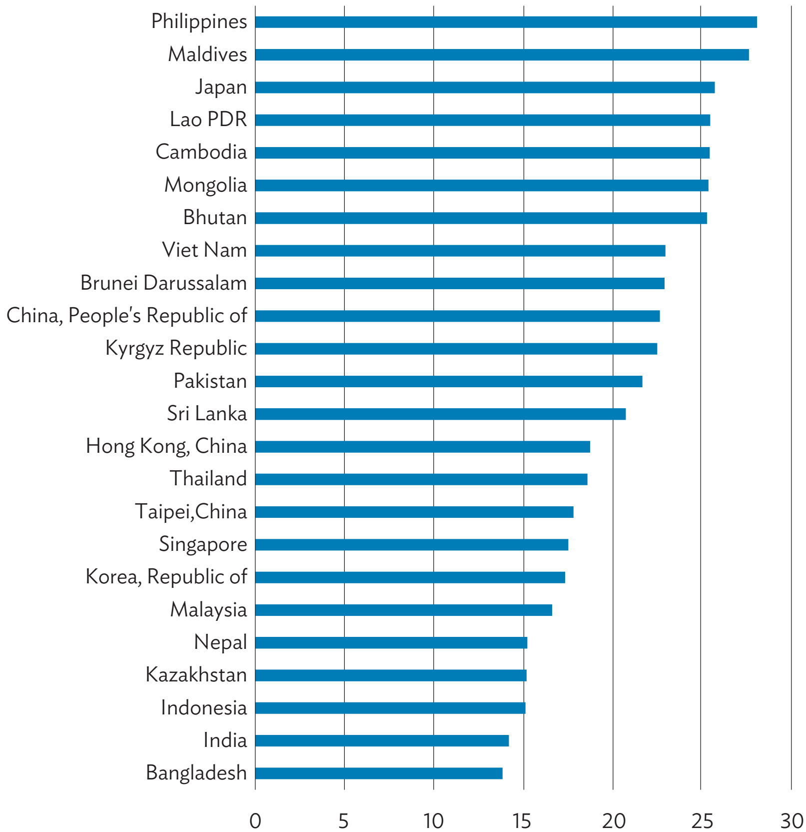
M&Eq = machinery and equipment.

Source: ADB. Multi-Regional Input–Output Tables.

Figure 4.3 looks at the data in a different way, retaining only the five digitally delivered sectors identified in Figure 4.2, and aggregating by exporting Asian economy. It shows that the digitally delivered sectors display substantial forward GVC integration in all economies for which data are available, although with considerable variation across economies. Interestingly, economies at a variety of income levels—not just high incomes—are well represented among those with the strongest forward GVC integration in digitally delivered sectors. Although results for some of the smaller economies have to be taken as indicative only (given the difficulties inherent in data collection and treatment), it is also generally true that both small and large economies can have relatively high forward GVC integration in digitally delivered sectors.

Figures 4.4 and 4.5 show the results of the analysis for backward linkages, again focusing on the five digitally delivered sectors. Backward linkages here capture the use of imported intermediates in these sectors. Figure 4.4 shows that much greater growth in backward linkages than forward linkages occurred over the sample period in post and telecommunications and in financial services. So, these sectors have developed overseas sourcing arrangements substantially over this period, while the other sectors have seen remote sourcing diminish or remain fairly steady. The contrast is clear when comparing with forward linkages, where changes were relatively small over time in all sectors. It is also evident in economy results for 2019 (Figure 4.5), where there is more dispersion in the proportion of backward linkages in gross exports than forward linkages. Levels of backward integration range from very low (Japan, for example) to very substantial (Singapore). Economy variation is also evident in forward linkages, but it is greater looking at use of imported intermediates in digitally delivered sectors. Otherwise, the patterns of integration differ substantially at this level of aggregation, depending on the direction of linkage. This result is typical in GVC analysis, as economies tend to specialize in different parts of the value chain, which implies different relationships to input sourcing and supply across borders.

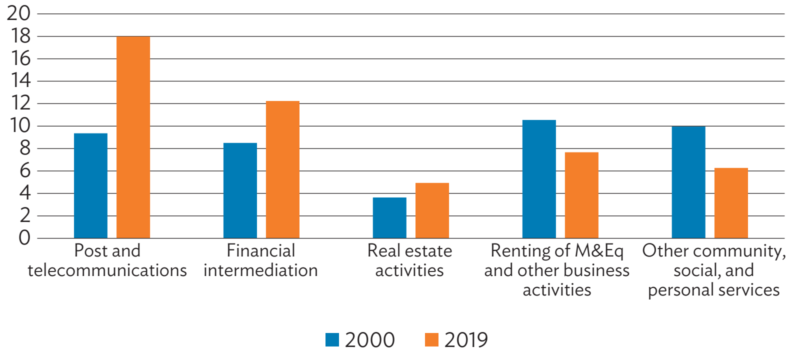
Figure 4.3: Forward Global Value Chain Integration of Digitally Delivered Sectors by Asian Economy, 2019
(% of gross exports)



Lao PDR = Lao People's Democratic Republic.

Source: ADB. Multi-Regional Input–Output Tables.

Figure 4.4: Global Value Chain Backward Linkages for Digitally Delivered Sectors—Asia and the Pacific
(% of gross exports)



M&Eq = machinery and equipment.

Source: ADB. Multi-Regional Input–Output Tables.

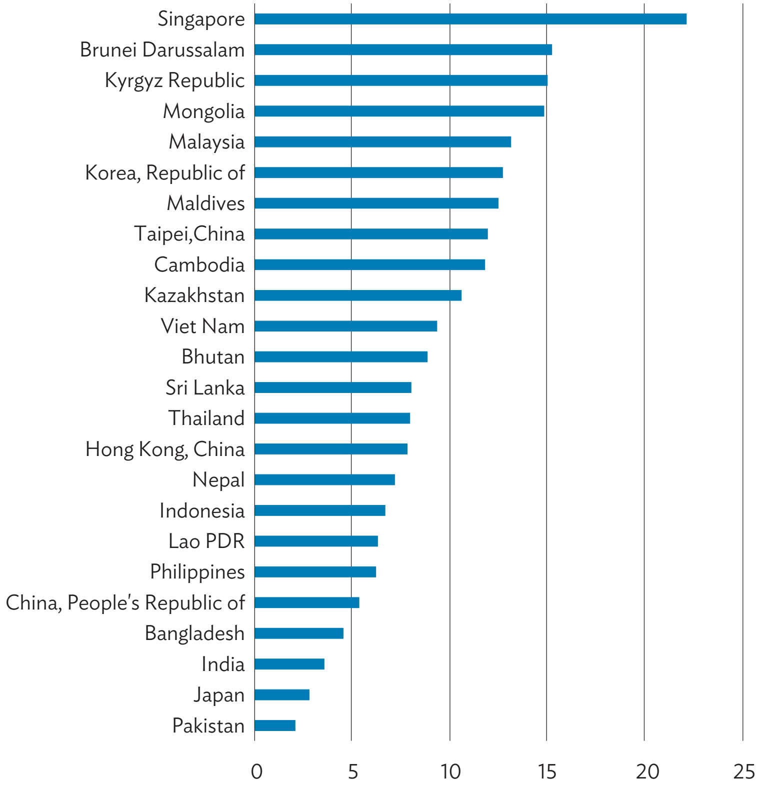
Overall, the picture that emerges from this brief review is that digitally delivered sectors are an important part of the GVC landscape in Asia. This point is important from a policy perspective, because development policy in Asia often focuses on manufacturing as the engine of growth, even as evidence is compelling that economies that have grown rapidly in recent decades have not only developed their manufacturing but have also seen services production and trade increase significantly (Shepherd 2019).

4.2.3 Quantifying Policies Affecting Digitally Delivered Trade

Conceptually, it is clear that policy is one factor affecting the ability of firms to use digital technologies for international transactions. During the initial development of digital technologies, the sector itself was not particularly burdened by specific regulations. But as governments have come to recognize its economic importance and strategic potential, they have taken different approaches to facilitating or restricting both the activities of digital firms that provide the infrastructure for transactions, and the nature and extent of certain transactions.

To a large extent, work on quantifying policies affecting digitally delivered trade is more advanced than for digitally delivered trade itself. National accounts do not yet track digitally delivered trade flows, and therefore rely on estimates, inferences, and proxies; the same is not true of policies: they can be measured directly, using the general set of techniques developed for assessing trade restrictions in services more broadly (Dee 2005).

Figure 4.5: Backward Global Value Chain Integration of Digitally Delivered Sectors by Asian Economy, 2019
(% of gross exports)



Lao PDR = Lao People's Democratic Republic.

Source: ADB. Multi-Regional Input–Output Tables.

Whereas tariffs in goods markets are already stated in ad valorem terms, policy restrictions in services sectors—including those affecting digitally delivered trade—typically affect either the ability to contest markets or the cost of doing business once in a market. As such, they need to be quantified in a fundamentally different way from tariffs. The first step is to develop a regulatory questionnaire, typically based on consultations with sector experts and the private sector. The questionnaire, which can have a large number of individual questions, identifies policy measures that are believed to affect the ability of firms to trade, in this case digitally. The next step is to code restrictions quantitatively by assessing national regulations relevant to each question along a sliding scale from completely open (usually coded as the minimum value) to completely closed (usually coded as the maximum value). The third step is then to weigh and aggregate the individual data points for each question in the questionnaire to produce a single summary index of restrictiveness. An optional fourth step is to use an econometric model to relate restrictiveness to some measure of economic performance, such as trade values or trade costs, often with the objective of producing ad valorem equivalents of the bundle of policies captured by the index.

The European Centre for International Political Economy (Ferracane, Lee-Makiyama, and van der Marel 2018) and OECD apply variations on this approach to produce trade restrictiveness indexes for digitally delivered trade. We focus on the OECD version because it is publicly available in panel data format—i.e., over a number of years, which is important for the econometric estimations conducted in this chapter.

The OECD Digital Services Trade Restrictiveness Index (DSTRI) covers all OECD members and a selection of nonmembers, for the years 2014 through 2020 inclusive. Figure 4.6 shows 2020 results for Asian economies, to give an idea of how restrictiveness varies in a cross-sectional sense. Given that the DSTRI is an index number, the interpretation is ordinal only, not cardinal. That is, a score of 0.2 is more restrictive than a score of 0.1 (on a range of zero to one), but it is not "twice as restrictive"—that is an issue that can only be examined with further econometric modeling, as per the last analytical stage, which was referred to as an optional fourth step.

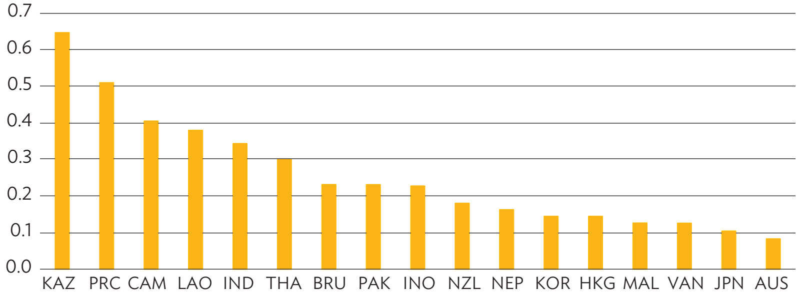
Figure 4.6 shows that patterns of restrictiveness in Asian economies vary substantially. Kazakhstan is the most restrictive economy in the dataset, followed by the PRC and Saudi Arabia (considered in the dataset as part of West Asia). Other economies are typically substantially less restrictive, with the lowest scores recorded in Japan, the Republic of Korea, and Malaysia.

Figure 4.7 looks at the data dynamically, focusing on the percentage change in the DSTRI between 2014 and 2020. The overwhelming takeaway is that policy regimes that have changed most have increased in restrictiveness, not liberalization. The change in the DSTRI is 50% or more in Japan, Kazakhstan, and Saudi Arabia. Only one economy in the sample, Indonesia, has witnessed major liberalization, with a fall in its DSTRI of 26% over 2014 to 2020. By and large, then, the Asian region has seen an emerging policy approach of greater restrictions to digitally delivered trade over the past half dozen years.

Another way of looking at the data is through the lens of heterogeneity. From this perspective, it is not only the restrictiveness of an economy's policies that matter for trade costs, but also how similar or different its policies are from those of trading partners. Data is perhaps an area, like services trade more broadly, where regulatory heterogeneity plays a significant part in determining the pattern of flows (Nordas 2016). For example, if one economy in a trading pair has strong

Figure 4.6: Digital Services Trade Restrictiveness Index, 2020—Selected Asian Economies

(index score)



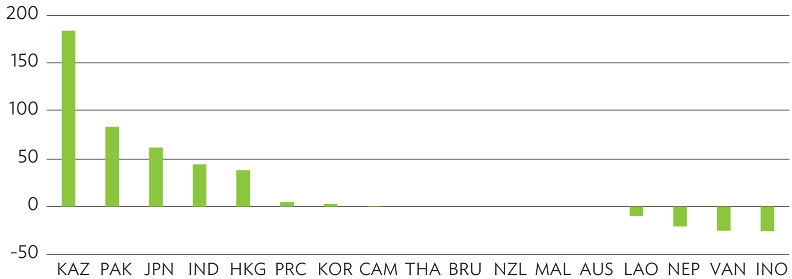
AUS = Australia; BRU = Brunei Darussalam; CAM = Cambodia; HKG = Hong Kong, China; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; LAO = Lao People's Democratic Republic; MAL = Malaysia; NEP = Nepal; NZL = New Zealand; PAK = Pakistan; PRC = People's Republic of China; THA = Thailand; VAN = Vanuatu.

Notes: Given that the Digital Services Trade Restrictiveness Index is an index number, the interpretation is ordinal only, not cardinal. That is, a score of 0.2 is more restrictive than a score of 0.1 (on a range of zero to one), but it is not "twice as restrictive."

Source: Organisation for Economic Co-operation and Development. OECD.Stat. https://stats.oecd.org/Index.aspx?DataSetCode=STRI_DIGITAL (accessed October 2021).

Figure 4.7: Change in Digital Services Trade Restrictiveness Index, 2014–2020—Selected Asian Economies

(%)



AUS = Australia; BRU = Brunei Darussalam; CAM = Cambodia; HKG = Hong Kong, China; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; LAO = Lao People's Democratic Republic; MAL = Malaysia; NEP = Nepal; NZL = New Zealand; PAK = Pakistan; PRC = People's Republic of China; THA = Thailand; VAN = Vanuatu.

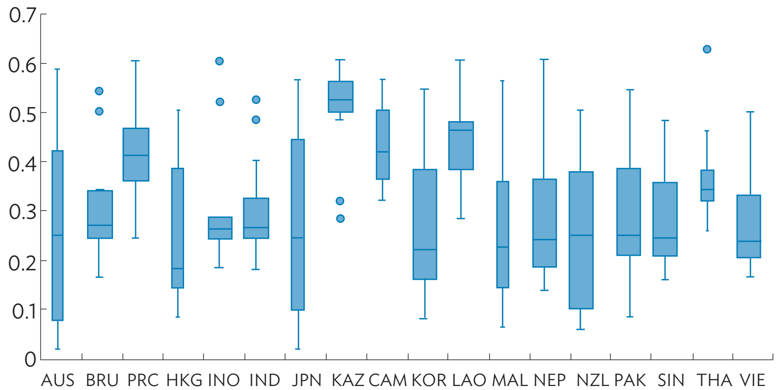
Note: No change in Australia, Brunei Darussalam, Malaysia, New Zealand, and Thailand.

Source: Author's calculations using data from Organisation for Economic Co-operation and Development. OECD.Stat. https://stats.oecd.org/Index.aspx?DataSetCode=STRI_DIGITAL (accessed October 2021).

rules about data privacy and the other does not, it may be difficult or impossible to move data in that direction as part of a broader economic transaction. Localization of data and servers may also impose additional costs in a case where those rules differ between economies, for instance, inside and outside a trade bloc. So, in addition to restrictiveness, there is good reason to believe that regulatory heterogeneity can play a role in driving trade costs.

Figure 4.8 shows results from a regulatory heterogeneity measure calculated by the OECD using the DSTRI. A higher score indicates a greater level of heterogeneity. The figure shows average levels (horizontal lines) and ranges for Asian economies, looking at intra-Asian trading relationships only. Economies differ substantially in the heterogeneity they exhibit with their partners. Kazakhstan, which had the most restrictive regime, also has the highest average heterogeneity with respect to other Asian economies, followed by the PRC. The lowest levels are in the Republic of Korea and Japan. To some extent, the more liberal economies also tend to display lower heterogeneity with trading partners but, as the chart shows, dispersion in scores is also substantial for most economies.

Figure 4.8: Digital Services Trade Restrictiveness Index Heterogeneity for Intra-Asian Trade, 2019



AUS = Australia; BRU = Brunei Darussalam; CAM = Cambodia; HKG = Hong Kong, China; IND = India; INO = Indonesia; JPN = Japan; KAZ = Kazakhstan; KOR = Republic of Korea; LAO = Lao People's Democratic Republic; MAL = Malaysia; NEP = Nepal; NZL = New Zealand; PAK = Pakistan; PRC = People's Republic of China; SIN = Singapore; THA = Thailand; VIE = Viet Nam.

Source: Author's calculations using data from Organisation for Economic Co-operation and Development. OECD.Stat. https://stats.oecd.org/Index.aspx?DataSetCode=STRI_DIGITAL (accessed October 2021).

Given the overall change in regional policy stance that emerges from the data, the time is ripe to look at the economic impacts of restrictions to digitally delivered trade. Broadly speaking, that is this chapter's objective. The next section introduces a general equilibrium trade model that provides a framework for analyzing empirically the effects of policies in the digital arena on trade flows by sector, as well as on GVC integration.

4.3 Results and Interpretation

The model set out in section 4.2 can serve as a framework for conducting counterfactual simulations.[3] We use it here to examine the trade and GVC impacts of trade liberalization and deregulation on digitally delivered sectors and define both terms. The exercise takes the form of a "thought experiment" because DSTRI data are available only for a small number of Asian economies; as a result, detailed policy simulations are not possible.

Defining trade liberalization is straightforward in terms of the framework set out in section 4.2: it is a reduction in trade costs that applies only to economy pairs that are not the same. For example, Australia reduces its trade costs in a particular way compared with other economies, but its internal trade costs remain constant. This definition allows us to contrast trade liberalization with deregulation, in which domestic trade costs also fall.

Taking this approach, we define two counterfactual simulations:

- Scenario 1 (Trade liberalization): All economies reduce international iceberg trade costs in digitally delivered sectors by 10% but leave intranational trade costs unchanged.
- Scenario 2 (Deregulation): All economies reduce international and intranational iceberg trade costs in digitally delivered sectors by 10%.

The data for the simulation model come from the ADB MRIOT, so we use the same sector classification as section 4.2.1. Digitally delivered sectors are therefore the following five: telecommunications, finance, real estate, other business services, and other community services.

Table 4.1 shows how intra-Asian trade flows change by sector under the two scenarios. Most goods sectors see a slight contraction under Scenario 1: the cost-decreasing effect of liberalization of digitally delivered sectors, which promotes trade by reducing the cost of an input bundle, is dominated by a substitution effect that draws resources into the digitally delivered sectors. This

[3] Details about the conceptional underpinnings of the model can be found in Appendix A4.1.

intuition is confirmed by figures for the digitally delivered sectors, which show very large rises. By contrast, in Scenario 2 trade shrinks more substantially in all goods sectors, and expands more modestly in the digitally delivered sectors. The intuition is that deregulation lowers both internal and external trade costs. Given the size of the internal market, a substantial amount of sourcing switches as a consequence: the substitution effect is stronger as the domestic market in digitally delivered sectors sees substantial increases. Table 4.1 does not show changes in real income. These are typically positive but modest in both scenarios; however, the real income changes are larger in Scenario 2 than in Scenario 1, which is a standard result in the trade literature: lowering intranational trade costs creates more "trade" because of the larger internal market, and therefore increases the possibilities of consumption since prices tend to fall when trade costs are reduced.

Table 4.1: Counterfactual Changes in Total Intra-Asian Exports by Sector
(% of baseline)

Sector	Scenario 1	Scenario 2
Agriculture, hunting, forestry, and fishing	-1.131	-4.301
Mining and quarrying	-0.045	-3.644
Food, beverages, and tobacco	-0.480	-4.752
Textiles and textile products	-0.335	-5.454
Leather, leather products, and footwear	-0.523	-5.715
Wood and products of wood and cork	-0.305	-3.995
Pulp, paper, paper products, printing, and publishing	0.319	-1.394
Coke, refined petroleum, and nuclear fuel	-0.513	-2.824
Chemicals and chemical products	-0.243	-3.001
Rubber and plastics	0.657	-3.197
Other nonmetallic minerals	-0.507	-3.817
Basic metals and fabricated metals	0.009	-3.767
Machinery, n.e.c.	0.335	-4.187
Electrical and optical equipment	-0.130	-3.164
Transport equipment	0.266	-4.800
Manufacturing, n.e.c.; recycling	0.192	-4.205
Electricity, gas, and water supply	-0.084	-1.559
Construction	-1.877	-4.266
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	0.627	-0.661

continued on next page

Table 4.1 *continued*

Sector	Scenario 1	Scenario 2
Wholesale trade and commission trade, except of motor vehicles and motorcycles	-0.656	-3.189
Retail trade, except of motor vehicles and motorcycles; repair of household goods	0.188	-2.163
Hotels and restaurants	-2.179	-4.226
Inland transport	-0.883	-2.012
Water transport	-0.523	-2.873
Air transport	-0.342	-4.085
Other supporting and auxiliary transport activities; activities of travel agencies	-1.585	-3.769
Post and telecommunications	**63.769**	**9.299**
Financial intermediation	**60.782**	**8.300**
Real estate activities	**54.791**	**9.948**
Renting of M&Eq and other business activities	**48.385**	**9.872**
Public administration and defense; compulsory social security	-2.114	-2.490
Education	3.734	-1.602
Health and social work	-0.271	-4.428
Other community, social, and personal services	**57.360**	**5.644**
Private households with employed persons	1.786	8.328

M&Eq = machinery and equipment, n.e.c. = not elsewhere classified.

Notes: Boldface indicates sectors subject to a change in trade costs. In Scenario 1 (Trade Liberalization), all economies reduce international iceberg trade costs in digitally delivered services by 10% but leave intranational trade costs unchanged. In Scenario 2 (Deregulation), all economies reduce international and intranational iceberg trade costs in digitally delivered services by 10%. Sector definitions are based on ADB Multi-Regional Input–Output Tables.

Source: Author's calculations.

Table 4.2 looks in more detail at GVC integration. As in Wang, Wei, and Zhu (2013), we first focus on forward linkages (DVA_INTRex). Both scenarios see increases in GVC forward integration as a percentage of gross exports, but the effect is typically more pronounced in Scenario 1 than Scenario 2. The reason is that forward linkages are measured on an international basis, so the emphasis is on effects in traded markets, not domestic ones. The five digitally delivered sectors see substantial increases in their GVC forward linkages, which means that other sectors are using them more intensively in the production of their own traded output. Even the deregulation scenario shows an increase in forward GVC integration for the sectors of interest relative to the baseline, due to the changed incentives to engage in international sourcing. From the perspective of value chains in the region, Table 4.2 suggests that liberalizing digitally delivered sectors can increase their breadth and depth, both in the affected sectors and elsewhere in the economy. The effect is to deepen value chain trade, not only in digitally delivered services but also in goods sectors and other services sectors.

Table 4.2: Forward Global Value Chain Participation by Sector—Intra-Asia (% of gross exports, baseline and counterfactuals)

Sector	Baseline	Scenario 1	Scenario 2
Agriculture, hunting, forestry, and fishing	14.645	14.805	14.618
Mining and quarrying	25.735	25.979	25.935
Food, beverages, and tobacco	6.779	6.873	6.876
Textiles and textile products	12.637	12.636	12.730
Leather, leather products, and footwear	5.583	5.605	5.690
Wood and products of wood and cork	15.585	15.828	15.818
Pulp, paper, paper products, printing, and publishing	20.383	20.905	20.757
Coke, refined petroleum, and nuclear fuel	21.409	21.237	21.260
Chemicals and chemical products	22.456	22.613	22.617
Rubber and plastics	24.210	24.581	24.497
Other nonmetallic minerals	13.805	13.932	14.004
Basic metals and fabricated metals	21.909	21.930	21.993
Machinery, n.e.c.	11.734	11.848	11.991
Electrical and optical equipment	20.880	21.057	21.231
Transport equipment	8.837	8.873	8.950
Manufacturing, n.e.c.; recycling	10.490	10.822	10.783
Electricity, gas, and water supply	17.740	18.080	18.052
Construction	6.942	7.146	7.227
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	23.041	23.099	23.187
Wholesale trade and commission trade, except of motor vehicles and motorcycles	16.948	16.967	17.162
Retail trade, except of motor vehicles and motorcycles; repair of household goods	20.571	20.549	20.636
Hotels and restaurants	3.960	4.261	4.205
Inland transport	17.345	17.599	17.482
Water transport	20.346	20.080	19.996
Air transport	13.479	13.550	13.696

continued on next page

Table 4.2 *continued*

Sector	Baseline	Scenario 1	Scenario 2
Other supporting and auxiliary transport activities; activities of travel agencies	28.604	29.031	29.023
Post and telecommunications	**17.431**	**18.043**	**17.784**
Financial intermediation	**22.533**	**23.006**	**22.737**
Real estate activities	**21.284**	**21.980**	**22.014**
Renting of M&Eq and other business activities	**21.271**	**21.782**	**21.829**
Public administration and defense; compulsory social security	11.633	11.910	12.155
Education	4.219	4.232	4.534
Health and social work	2.150	2.102	2.225
Other community, social, and personal services	**5.529**	**6.044**	**5.833**
Private households with employed persons	20.469	21.280	22.337

M&Eq = machinery and equipment; n.e.c. = not elsewhere classified.

Notes: Boldface indicates sectors subject to a change in trade costs. In Scenario 1 (Trade Liberalization), all economies reduce international iceberg trade costs in digitally delivered services by 10% but leave intranational trade costs unchanged. In Scenario 2 (Deregulation), all economies reduce international and intranational iceberg trade costs in digitally delivered services by 10%. Sector definitions are based on ADB Multi-Regional Input–Output Tables.

Source: Author's calculations.

Moving to backward linkages, Table 4.3 shows that both scenarios result in modest increases in backward GVC integration across the board. These changes are largest in the five digitally delivered sectors, which is in line with the fact that the two scenarios include only shock trade costs in those sectors. Given that backward GVC integration, like forward integration, changes only slowly in proportional terms over time, the sector results are significant in the shocked sectors, as well as in some others. The general picture is similar to the one that emerged for forward linkages, in the sense that value chains generally deepen in the region, and this extends not only to the shocked sectors but to other parts of the economy (value chains for services and goods).

Table 4.4 takes a different approach, breaking out the results by economy. It reports changes in total intra-Asian exports and shows that all economies, except Cambodia and Viet Nam, see increases in total exports (summing over all sectors) under Scenario 1, but the changes are generally modest except in Hong Kong, China and Nepal. The first result is driven by the importance of the finance sector, while the second is driven by the "other community services" sector. The former is highly intuitive, but the latter is not: it stems directly from the data in the ADB MRIOT, but there may be errors for this relatively aggregate sector for a small economy like Nepal, so we do not place any particular stress on this result.

Table 4.3: Backward Global Value Chain Participation by Sector—Intra-Asia
(% of gross exports, baseline and counterfactuals)

Sector	Baseline	Scenario 1	Scenario 2
Agriculture, hunting, forestry, and fishing	7.984	8.160	8.129
Mining and quarrying	6.998	7.195	7.141
Food, beverages, and tobacco	13.902	14.217	14.138
Textiles and textile products	12.185	12.530	12.500
Leather, leather products, and footwear	15.745	16.069	16.053
Wood and products of wood and cork	11.290	11.449	11.447
Pulp, paper, paper products, printing, and publishing	12.236	12.461	12.393
Coke, refined petroleum, and nuclear fuel	26.888	27.198	27.103
Chemicals and chemical products	18.999	19.144	19.023
Rubber and plastics	14.676	14.725	14.683
Other nonmetallic minerals	19.890	20.208	19.991
Basic metals and fabricated metals	18.639	18.844	18.717
Machinery, n.e.c.	15.766	16.020	15.840
Electrical and optical equipment	19.043	19.178	19.003
Transport equipment	18.598	18.929	18.775
Manufacturing, n.e.c.; recycling	14.757	15.042	15.015
Electricity, gas, and water supply	12.409	12.759	12.584
Construction	23.500	23.880	23.458
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel	9.197	10.121	9.687
Wholesale trade and commission trade, except of motor vehicles and motorcycles	11.053	11.633	11.656
Retail trade, except of motor vehicles and motorcycles; repair of household goods	8.656	9.662	9.166
Hotels and restaurants	12.874	13.448	13.100
Inland transport	11.571	11.884	11.740
Water transport	25.088	25.722	25.769
Air transport	22.478	23.131	22.767
Other supporting and auxiliary transport activities; activities of travel agencies	9.526	9.976	9.730
Post and telecommunications	**11.774**	**12.765**	**12.538**
Financial intermediation	**9.203**	**10.235**	**9.845**
Real estate activities	**3.400**	**3.658**	**3.694**
Renting of M&Eq and other business activities	**10.801**	**11.579**	**11.014**

continued on next page

Table 4.3 *continued*

Sector	Baseline	Scenario 1	Scenario 2
Public administration and defense; compulsory social security	10.777	11.162	11.265
Education	6.145	6.546	6.341
Health and social work	15.431	15.699	15.420
Other community, social, and personal services	**5.944**	**6.579**	**6.359**
Private households with employed persons	7.039	7.410	7.170

M&Eq = machinery and equipment, n.e.c. = not elsewhere classified.

Notes: Boldface indicates sectors subject to a change in trade costs. In Scenario 1 (Trade Liberalization), all economies reduce international iceberg trade costs in digitally delivered services by 10% but leave intranational trade costs unchanged. In Scenario 2 (Deregulation), all economies reduce international and intranational iceberg trade costs in digitally delivered services by 10%. Sector definitions are based on ADB Multi-Regional Input–Output Tables.

Source: Author's calculations.

Table 4.4: Counterfactual Changes in Intra-Asian Exports by Economy (% of baseline)

Economy	Scenario 1	Scenario 2
Bangladesh	1.356	-2.950
Bhutan	2.478	-3.150
Brunei Darussalam	1.961	-3.078
Cambodia	-0.360	-3.258
China, People's Republic of	2.148	-3.101
Hong Kong, China	19.466	1.209
India	4.081	-3.098
Indonesia	2.663	-2.626
Japan	1.113	-4.102
Kazakhstan	3.981	-3.096
Korea, Republic of	2.746	-2.743
Kyrgyz Republic	3.431	1.911
Lao People's Democratic Republic	2.239	-3.801
Malaysia	4.251	-2.351
Maldives	2.104	-3.660
Mongolia	1.892	-1.321
Nepal	24.852	-3.292

continued on next page

Table 4.4 *continued*

Economy	Scenario 1	Scenario 2
Pakistan	6.465	-3.396
Philippines	5.356	-3.702
Singapore	2.826	-0.836
Sri Lanka	4.133	-4.473
Taipei,China	1.283	-3.653
Thailand	1.725	-2.292
Viet Nam	-0.353	-3.770

Notes: In Scenario 1 (Trade Liberalization), all economies reduce international iceberg trade costs in digitally delivered services by 10% but leave intranational trade costs unchanged. In Scenario 2 (Deregulation), all economies reduce international and intranational iceberg trade costs in digitally delivered services by 10%.

Source: Author's calculations.

Under Scenario 2, results are more mixed due to the substitution logic. Total exports decrease in some economies, while smaller increases are recorded in those where digitally delivered sectors play a large role in total exports, like Hong Kong, China. That noted, the position for changes in real income is largely the opposite of what is seen in the trade data: deregulation tends to have larger (positive) real income effects than trade liberalization, as is standard in the literature.

We can also look at GVC integration at the economy level. Focusing again first on forward integration, Table 4.5 shows results. Changes are generally positive but small for economies. The reason for these modest results is that economy-level results aggregate over all sectors, whereas changes in trade patterns primarily affect the sectors where trade costs were assumed to change. As such, the initial importance of those sectors in total exports is determinative of changes in total forward linkages. Changes at a disaggregated level tend to be more substantial, especially in digitally delivered sectors, but also in those other sectors that use those services intensively as inputs.

Table 4.6 presents results for backward linkages. Results are comparable to those for forward linkages: in most cases, economies see an increase in backward linkages in both scenarios relative to the baseline, although there are some cases where the opposite is true. Changes are relatively modest, because the larger sector changes discussed in this section are only part of each economy's overall trade patterns, so sector patterns of specialization influence the final result. As with forward linkages, however, the overall picture is that trade liberalization and deregulation affecting digitally delivered sectors can boost GVC integration in the region, albeit with differences in nature and extent across economies.

Table 4.5: Forward Global Value Chain Participation by Economy—Intra-Asia
(% of gross exports, baseline and counterfactuals)

Economy	Baseline	Scenario 1	Scenario 2
Bangladesh	15.368	15.679	15.439
Bhutan	10.839	11.240	10.910
Brunei Darussalam	27.443	27.369	27.529
Cambodia	11.821	12.012	11.988
China, People's Republic of	17.087	17.373	17.494
Hong Kong, China	16.265	16.896	16.239
India	15.989	15.496	16.137
Indonesia	21.987	21.982	22.135
Japan	21.122	21.435	21.516
Kazakhstan	21.608	21.300	21.552
Korea, Republic of	16.725	16.769	16.857
Kyrgyz Republic	10.891	11.439	12.992
Lao People's Democratic Republic	30.102	30.182	30.381
Malaysia	27.038	26.581	26.886
Maldives	12.991	13.418	13.138
Mongolia	17.482	17.426	17.500
Nepal	10.489	10.57	10.487
Pakistan	20.563	20.604	20.454
Philippines	14.407	15.193	14.813
Singapore	14.537	14.260	14.492
Sri Lanka	13.643	13.660	13.710
Taipei,China	18.110	18.206	18.237
Thailand	13.749	13.819	13.969
Viet Nam	10.624	10.719	10.699

Notes: In Scenario 1 (Trade Liberalization), all economies reduce international iceberg trade costs in digitally delivered services by 10% but leave intranational trade costs unchanged. In Scenario 2 (Deregulation), all economies reduce international and intranational iceberg trade costs in digitally delivered services by 10%.

Source: Author's calculations.

Table 4.6: Backward Global Value Chain Participation by Economy
(% of gross exports, baseline and counterfactuals)

Economy	Baseline	Scenario 1	Scenario 2
Bangladesh	19.997	19.630	20.074
Bhutan	15.956	16.030	16.133
Brunei Darussalam	10.119	10.614	10.306
Cambodia	21.658	21.688	21.543
China, People's Republic of	9.281	9.461	9.386
Hong Kong, China	23.684	22.923	24.123
India	13.753	13.387	13.791
Indonesia	10.583	10.687	10.622
Japan	13.921	13.906	13.903
Kazakhstan	9.339	10.195	9.717
Korea, Republic of	24.064	24.323	24.300
Kyrgyz Republic	19.987	20.041	19.204
Lao People's Democratic Republic	8.106	8.180	8.022
Malaysia	16.935	17.407	17.214
Maldives	28.229	28.395	28.459
Mongolia	19.242	20.346	19.864
Nepal	18.063	16.441	18.029
Pakistan	7.907	7.686	7.932
Philippines	21.328	20.436	20.989
Singapore	33.446	33.608	33.708
Sri Lanka	11.660	11.933	11.895
Taipei,China	27.138	27.122	27.140
Thailand	20.280	20.453	20.209
Viet Nam	27.216	27.623	27.238

Notes: In Scenario 1 (Trade Liberalization), all economies reduce international iceberg trade costs in digitally delivered services by 10% but leave intranational trade costs unchanged. In Scenario 2 (Deregulation), all economies reduce international and intranational iceberg trade costs in digitally delivered services by 10%.

Source: Author's calculations.

4.4 Conclusion and Policy Implications

This chapter has shown that digitally delivered services are an important part of the trade landscape in Asia. Available evidence also suggests that trade costs, including those due to regulatory heterogeneity, are a significant determinant of the observed pattern of trade and GVC integration across economies.

In light of these realities, it is not surprising that a "thought experiment" in which trade costs are reduced for digitally delivered sectors, either through trade liberalization (foreign partners only) or deregulation (all partners, including domestic trade), typically has a substantial impact on the regional economy. Generally speaking, deregulation has a larger impact on real incomes than trade liberalization because it affects price in the internal market more strongly: reducing internal trade costs through deregulation increases consumption possibilities more strongly than only when deregulation involves external partners. By contrast, trade effects are stronger for trade liberalization, because there is no switch to increased domestic sourcing (which reduces trade) but rather a shift away from the domestic market. Both policy approaches therefore have significant economic effects.

In addition, the experiment shows that a reduction in trade costs of digitally delivered services can have spillover effects on other sectors. While impacts on forward GVC integration are not large in absolute terms, they are significant when set against the slow pattern of change set out in section 4.2: trade liberalization and deregulation have clear potential to promote increased use of digitally delivered services as inputs into the production and export of other goods and services, which cements their already important role in regional GVCs.

A significant area for future research is to attempt to relate policy restrictiveness as measured by the DSTRI to bilateral trade flows and trade costs. Identification is challenging, because the DSTRI primarily varies across economies rather than within economies across time periods. But expanding the thought experiment approach to relate it more closely to concrete policy changes would be an important piece of value added.

Turning to the policy implications, the analysis here points to three major conclusions. First, from a welfare perspective, it is important to consider nondiscriminatory policy changes in addition to trade policy reforms. While both are important from a purely trade flow perspective, changes in real income tend to be dominated by reforms that also influence conditions in the domestic market. This result is highly intuitive: most economies source the bulk of their inputs domestically, and sell the bulk of their output there, in the sectors identified as digitally enabled. The price implications are maximized when domestic reforms occur, not just international. So, efforts to liberalize the policy environment should ensure that nondiscriminatory measures are also addressed.

Second, Asian economies have the scope to conduct policy reforms on the basis of regional models. The data show substantial variation within the region in policy stances, ranging from relatively liberal to relatively restricted. Reducing trade costs can therefore help put the focus on moving toward policy regimes more like those seen in the Asian markets with the least restrictions, such as Japan, the Republic of Korea, and Malaysia. A stock of good practices in the region could be shared through existing channels such as the Association of Southeast Asian Nations and the Asia-Pacific Economic Cooperation.

Finally, the evidence shows that liberalizing the policy environment for digitally delivered services can have spillover effects to other sectors, including through GVC linkages. As a result, ongoing policy discussions on GVC deepening in the region, as well as trade policy linkages more broadly, need to consider the digital dimension. Trade agreements are increasingly devoting specific text to digital issues, but a case exists for ensuring that schedules of specific commitments are similarly ambitious in the sectors identified here as digitally delivered. New generation trade agreements involving Asian economies, such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership and the Regional Comprehensive Economic Partnership, will be evaluated in part based on their ability to extend GVC linkages, including through supporting the application of digital technologies. Using trade agreements to reduce regulatory heterogeneity as well as liberalizing underlying policies could be a fruitful avenue for future regional integration efforts.

Bibliography

Aichele, R., and I. Heiland. 2018. Where Is the Value Added? Trade Liberalization and Production Networks. *Journal of International Economics.* 115 (C). pp. 130–144.

Anderson, J., and E. Van Wincoop. 2003. Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review*. 93 (1). pp. 170–192.

———. 2004. Trade Costs. *Journal of Economic Literature.* 42 (3). pp. 691–751.

Baldwin, R. 2011. Trade and Industrialization after Globalization's Second Unbundling: How Building and Joining a Supply Chain Are Different and Why It Matters. *NBER Working Paper.* No. 17716. Cambridge, MA: National Bureau of Economic Research.

Caliendo, L., and F. Parro. 2015. Estimates of the Trade and Welfare Effects of NAFTA. *Review of Economic Studies.* 82 (1). pp. 1–44.

Dee, P. 2005. A Compendium of Barriers to Services Trade. *Working Paper*. Canberra: Asia-Pacific School of Economics and Government.

Dekle, R., J. Eaton, and S. Kortum. 2007. Unbalanced Trade. *American Economic Review* 97 (2). pp. 351–355.

Eaton, J., and S. Kortum. 2002. Technology, Geography, and Trade. *Econometrica*. 70 (5). pp. 1741–1779.

Egger, P., and M. Larch. 2008. Interdependent Preferential Trade Agreement Memberships: An Empirical Analysis. *Journal of International Economics.* 76 (2). 384–399.

Egger, P., M. Larch, S. Nigai, and Y. Yotov. 2018. Trade Costs in the Global Economy: Measurement, Aggregation, and Decomposition. *WTO Working Paper.* ERSD-2021-2. Geneva: World Trade Organization.

Ferracane, M., H. Lee-Makiyama, and E. van der Marel. 2018. *Digital Trade Restrictiveness Index.* Brussels: European Centre for International Political Economy.

Heid, B., M. Larch, and Y. Yotov. 2021. Estimating the Effects of Non-Discriminatory Trade Policies Within Structural Gravity Models. *Canadian Journal of Economics.* 54 (1). pp. 376–409.

Johnson, R. and G. Noguera. 2012. Accounting for Intermediates: Production Sharing and Trade in Value Added. *Journal of International Economics.* 86 (2). pp. 224–236.

Koopman, R., Z. Wang, and S. J. Wei. 2014. Tracing Value-Added and Double Counting in Gross Exports. *American Economic Review.* 104 (2). pp. 459–494.

Liberatore, A. Forthcoming. Statistics on Digital Trade in Services. *Statistics Working Paper.* Paris: Organisation for Economic Co-operation and Development.

Nordas, H. 2016. Services Trade Restrictiveness Index (STRI): The Trade Effect of Regulatory Differences. *Trade Policy Paper.* No. 189. Paris: Organisation for Economic Co-operation and Development.

Ottaviano, G. 2015. European Integration and the Gains from Trade. In H. Badinger and V. Nitsch, eds. *Routledge Handbook of the Economics of European Integration.* London: Routledge.

Santos Silva, J. and S. Tenreyro. 2006. The Log of Gravity. *Review of Economics and Statistics.* 88 (4). pp. 641–658.

Shepherd, B. 2019. Productivity and Trade Growth in Services: How Services Helped Power Factory Asia. In M. Helble and B. Shepherd, eds. *Leveraging Services for Development: Prospects and Policies.* Manila: Asian Development Bank Institute.

Wang, Z., S. J. Wei, and K. Zhu. 2013 (Revised 2018). Quantifying International Production Sharing at the Bilateral and Sector Levels. *NBER Working Paper.* No. 19677. Cambridge, MA: National Bureau of Economic Research.

Appendix A4.1: A Quantitative Trade Model with Global Value Chain Linkages

Trade policy analysis has traditionally used computable general equilibrium (CGE) models to examine the economy-wide impacts of reform. This section takes a different approach, drawing on the literature on "new quantitative trade models" (Ottaviano 2015). The new generation of models incorporates insights from standard trade theory, such as Ricardian technology differences and trade flows governed by structural gravity equations. But it incorporates the full general equilibrium approach of earlier CGE literature, in the sense that macroeconomic constraints are respected, relative prices matter, and sectors exhibit input–output relationships. Model outputs are familiar from the literature, but a key contribution of the model in this chapter is that it makes it possible to identify global value chain (GVC) linkages at a disaggregated level, with the same Wang, Wei, and Zhu (2013) approach used in this chapter. In other words, a trade policy change maps both counterfactual changes in trade and welfare and counterfactual changes in, for example, forward GVC integration. The model is therefore ideally suited to examining the GVC implications of policy changes that affect digital trade.

A. Consumption Side

The consumption side of the model comes from Caliendo and Parro (2015). A measure Ln of representative households in n economies (subscript) maximize Cobb Douglas utility by consuming final goods in j sectors (superscript), with consumption shares α_n^j summing to unity.

$$(1)\, u(C_n) = \prod_{j=1}^{J} \left(C_n^j\right)^{\alpha_n^j}$$

B. Production Side

The production side of the model also comes from Caliendo and Parro (2015) via Aichele and Heiland (2018), which can be seen as a multisector generalization of Eaton and Kortum (2002). As in Aichele and Heiland (2018), there is provision for different shares in intermediate and final consumption. Each sector produces a continuum of intermediate goods $\omega^j \in [0,1]$. Each intermediate good uses labor and composite intermediate goods from all sectors. Intermediate goods producers have production technology as follows:

$$(2)\ q_n^j(\omega^j) = z_n^j(\omega^j)[l_n(\omega^j)]^{\beta_n^j} \prod_{k=1}^{J} [m_n^{k,j}(\omega^j)]^{\gamma_n^{k,j}}$$

where $z_n^j(\omega^j)$ is the efficiency of producing intermediate good ω^j in economy n; $l_n(\omega^j)$ is labor; $m_n^{k,j}(\omega^j)$ are the composite intermediate goods from sector k used for the production of intermediate good ω^j; and β_n^j is the cost share of labor and $(1-\beta_n^j)\gamma_n^{k,j}$ is the cost share of intermediates from sector k used in the production of intermediate good ω^j, with $\sum_{k=1}^{J}\gamma_n^{k,j} = 1$.

Production of intermediate goods exhibits constant returns to scale with perfect competition, so firms price at marginal cost. The cost of an input bundle can therefore be written as follows:

$$(3)\ c_n^j = \Upsilon_n^j w_n^{\beta_n^j} \left(\prod_{k=1}^{J} (P_n^{km})^{\gamma_n^{k,j}} \right)^{1-\beta_n^j}$$

where P_n^{km} is the price of a composite intermediate good from sector k; w is the wage; and Υ_n^j is a constant.

Producers of composite intermediate goods in economy n and sector j supply their output at minimum cost by purchasing intermediates from the lowest cost suppliers across economies, similar to the mechanism in the single sector model of Eaton and Kortum (2002).

Composite intermediate goods from sector j are used in the production of intermediate good ω^k in amount $m_n^{j,k}(\omega^k)$ in all sectors k, as well as final goods in consumption C_n^j. The composite intermediate is produced using constant elasticity of substitution (CES) technology:

$$(4)\ Q_n^j = \left[\int r_n^j(\omega^j)^{1-\frac{1}{\sigma^j}} d\omega^j \right]^{\frac{\sigma^j}{\sigma^j-1}}$$

where r is demand from the lowest cost supplier, and σ is the elasticity of substitution across intermediate goods within a sector.

Solving the producer's problem gives an expression for demand:

$$(5)\ r_n^j(\omega^j) = \left(\frac{p_n(\omega^j)}{P_n^j} \right)^{-\sigma^j} Q_n^j$$

where $p_n(\omega^j)$ is the lowest price of a given intermediate good across economies; and $P_n^j = \left[\int p_n(\omega^j)^{1-\sigma^j} d\omega^j \right]^{\frac{1}{1-\sigma^j}}$ is the CES price index.

C. Trade Costs and Equilibrium

Trade costs consist of tariff and nontariff measures as components as in Aichele and Heiland (2018), in the standard iceberg formulation for imports by economy n from economy i, with trade costs potentially differing by end use (intermediate, m, or final, f):

$$(6)\ \kappa_{ni}^{jv} = \left(1 + t_{ni}^{jv}\right) * \tilde{t}_{ni}^{jv}, v \ni (m, f)$$

where t is the ad valorem tariff, and $\tilde{t}$ is nontariff-measure-related trade costs, including potentially policy measures but also geographic and historical factors that drive a wedge between producer prices in the exporting economy and consumer prices in the importing economy (Anderson and Van Wincoop 2003). Unlike in Caliendo and Parro (2015), we assume that all sectors are tradable. This assumption accords with the reality in our data, where sectors are sufficiently aggregated that trade always takes place, at least to some degree.

With this definition of trade costs, the price of a given intermediate good in economy n is

$$(7)\ p_n^j\left(\omega^j\right) = \min_i \frac{c_i^j \kappa_{ni}^{jm}}{z_i^j\left(\omega^j\right)}$$

As in Eaton and Kortum (2002), the efficiency of producing ω^j in economy n is the realization of a Fréchet distribution with location parameter $\lambda_n^j \geq 0$ and shape parameter $\theta^j > \sigma^j - 1$. The intermediate price index can therefore be rewritten as follows:

$$(8)\ P_n^{jm} = A^j \left[\sum_{i=1}^{N} \lambda_i^j \left(c_i^j \kappa_{ni}^{jm}\right)^{-\theta^j}\right]^{-\frac{1}{\theta^j}}$$

where A^j is a constant.

Then from the utility function, prices are

$$(9)\ P_n^f = \prod_{j=1}^{N} \left(\frac{P_n^{jf}}{\alpha_n^j}\right)^{\alpha_n^j}$$

Bringing together these ingredients gives a relationship for bilateral trade at the sector level that follows the general form of structural gravity, but developed in an explicitly multisector framework and with different relations for intermediate and final consumption:

$$(10)\ \pi_{ni}^{jv} = \frac{X_{ni}^{jv}}{X_n^{jv}} = \frac{\lambda_i^j \left[c_i^j \kappa_{ni}^{jv}\right]^{-\theta^j}}{\sum_{h=1}^{N} \lambda_h^j \left[c_h^j \kappa_{nh}^{jv}\right]^{-\theta^j}}$$

For analytical purposes, a key feature of the gravity model in equation 10 is that the unit costs term depends through equation 3 on trade costs in all sectors and economies. This result is an extension of the multilateral resistance reasoning in Anderson and Van Wincoop (2003) to the case of cross-sector linkages.

Goods market equilibrium is defined as follows, where Y is the gross value of production:

$$(11)\ Y_n^j = \sum_{i=1}^{N} \frac{\pi_{in}^{jm}}{1+t_{in}^{jm}} X_i^{jm} + \sum_{i=1}^{N} \frac{\pi_{in}^{jf}}{1+t_{in}^{jf}} X_i^{jf}$$

with

$$X_n^{jm} = \sum_{k=1}^{J} \frac{\pi_{in}^{jm}}{1+t_{in}^{jm}} \gamma_h^{j,k} (1-\beta_h^k) Y_h^k$$

$$(12)\ X_n^{jf} = \alpha_n^j I_n$$

National income is the sum of labor income, tariff rebates, and the exogenous trade deficit:

$$(12)\ I_n = w_n L_n + R_n + D_n$$

The model is then closed by setting income equal to expenditure:

$$(13)\ \sum_{j=1}^{J} X_n^{jm} \sum_{i=1}^{N} \frac{\pi_{ni}^{jm}}{1+t_{ni}^{jm}} + \sum_{j=1}^{J} X_n^{jf} \sum_{i=1}^{N} \frac{\pi_{ni}^{jf}}{1+t_{ni}^{jf}} - D_n = \sum_{j=1}^{J} Y_n^j$$

where *I* represents final absorption as the sum of labor income, tariff revenue, and the trade deficit; *R* is tariff revenue, and trade deficits sum to zero globally and to an exogenous constant nationally. So aggregate trade deficits are exogenous, but sector deficits are endogenous.

Caliendo and Parro (2015) show that the system defined by equations 3, 8, 10, 11, and 13 can be solved for equilibrium wages and prices, given tariffs and structural parameters.

1. Counterfactual Simulation

Using exact hat algebra (Dekle, Eaton, and Kortum 2007), it is simpler to solve the model in relative changes than in levels. This process is equivalent to performing a counterfactual simulation in which a baseline variable v is shocked to a counterfactual value v', and the relative change is defined as $\hat{v} = \frac{v'}{v}$. Aichele and Heiland (2018) show that counterfactual changes in input costs are given by

$$(14)\ \hat{c}_n^j = \hat{w}_n^{\beta_n^j} \left(\prod_{k=1}^{J} \hat{P}_n^{km\,\gamma_n^{k,j}} \right)^{1-\beta_n^j}$$

The change in the price index is

$$(15)\ \hat{P}_n^{jv} = \left[\prod_{i=1}^{N} \pi_{ni}^{jv} \left[\hat{\kappa}_{ni}^{jv} \hat{c}_i^j \right]^{-\theta^j} \right]^{-\frac{1}{\theta^j}}$$

The change in the bilateral trade share is

$$(16)\ \hat{\pi}_{ni}^{jv} = \left[\frac{\hat{\kappa}_{ni}^{jv} \hat{c}_i^j}{\hat{P}_n^{jv}} \right]^{-\theta^j}$$

Counterfactual intermediate goods and final goods expenditure are given by

$$(17)\ X_n^{jm'} = \sum_{k=1}^{N} \gamma_n^{j,k} (1 - \beta_n^k) \left(\sum_{i=1}^{N} X_i^{km'} \frac{\pi_{in}^{km'}}{1 + t_{in}^{km'}} + X_i^{kf'} \frac{\pi_{in}^{kf'}}{1 + t_{in}^{kf'}} \right)$$

with

$$(18)\ X_n^{jf'} = \alpha_n^j I_n{}'$$

$$(19)\ I_n' = \hat{w}_n w_n L_n + \sum_{j=1}^{J} X_n^{jm'} \left(1 - F_n^{jm'}\right) + \sum_{j=1}^{J} X_n^{jf'} \left(1 - F_n^{jf'}\right) + D_n$$

The trade balance condition requires

$$(20) \sum_{j=1}^{J} F_n^{jm'} X_n^{jm'} + \sum_{j=1}^{J} F_n^{jf'} X_n^{jf'} - D_n = \sum_{j=1}^{J} \sum_{i=1}^{N} X_i^{jm'} \frac{\pi_{in}^{jm'}}{1 + t_{in}^{jm'}} + \sum_{j=1}^{J} \sum_{i=1}^{N} X_i^{jf'} \frac{\pi_{in}^{jf'}}{1 + t_{in}^{jf'}}$$

The change in welfare is given by the change in real income:

$$(21)\ \hat{W}_n = \frac{\widehat{I_n}}{\prod_{j=1}^{J} \left(\hat{p}_n^{jf}\right)^{\alpha_n^j}}$$

The relative change in trade costs is given by the definition of the counterfactual simulation, and in our specification can cover nontariff measures and tariffs. Solving the model using exact hat algebra makes it possible to conduct the counterfactual experiment without having data on productivity, and importantly, without trade costs data other than those being simulated. Because of the multiplicative form of iceberg trade costs, solution in relative changes means that trade cost components, such as geographic and historical factors, which are constant in the baseline and counterfactual, simply cancel out. The parameters β_n^j (cost share of labor), $(1-\beta_n^j)\gamma_n^{k,j}$ (cost share of intermediates), and α_n^j (share of each sector in final demand) can be calibrated directly from the baseline data, as can value added ($w_n L_n$). Egger et al. (2018) provide updated estimates of the trade elasticity θ^j at the same level of disaggregation used in our data.

Caliendo and Parro (2015) develop an iterative procedure for solving the model, which we follow here in the modified version developed by Aichele and Heiland (2018).

2. *Trade in Value Added*

We follow Aichele and Heiland (2018) in extending the Caliendo and Parro (2015) framework to consider value-added trade, which helps identify the proportion of gross value trade that is considered to take place within GVCs. We differ from them, however, in the concept of value-added trade. They use Johnson and Noguera (2012) and Koopman, Wang, and Wei (2014), but as Wang, Wei, and Zhu (2013) point out, the measures derived in those papers only provide consistent results at an aggregate level. We are interested in a bilateral and sector disaggregation, so we follow the same basic approach of Aichele and Heiland (2018), but then apply the key result from Wang, Wei, and Zhu (2013) when it comes time to decompose gross value trade into its value-added components.

Given the model setup described in the previous subsection, Aichele and Heiland (2018) derive input–output coefficients as follows:

$$(22)\ \left(1+t_{ih}^{km}\right)a_{ih}^{k,j} = \pi_{ih}^{km}\left(1-\beta_h^j\right)\gamma_h^{k,j}$$

where a is the input–output coefficient; and $\left(1-\beta_h^j\right)\gamma_h^{k,j}$ is the cost share of intermediates from sector k.

Equation (20) makes clear that if the model dataset includes a baseline input–output table (A), as is necessary, then it is straightforward to calculate a counterfactual input–output matrix (A'), using the outputs of the counterfactual solution defined above.

Wang, Wei, and Zhu (2013) show that gross exports can then be fully and consistently decomposed into value-added components at the bilateral level as follows (with sector superscripts suppressed for readability):

$$(23)\ \pi_{ni}^{j} = DVA + FVA + PDC$$

$$DVA = \left(V^{i}B^{ii}\right)' * Y^{ni} + \left(V^{i}L^{ii}\right)' * \left(A^{ni}B^{nn}Y^{nn}\right)$$
$$+\left(V^{i}L^{ii}\right)' * \left[A^{ni}\sum_{h\neq n,i}^{N} B^{hn}Y^{hh} + A^{ni}B^{nn}\sum_{h\neq n,i}^{N} Y^{hn} + A^{ni}\sum_{h\neq n,i}^{N} B^{hn}\sum_{k\neq n,i}^{N} Y^{kh}\right]$$
$$+\left(V^{i}L^{ii}\right)' * \left[A^{ni}B^{nn}Y^{in} + A^{ni}\sum_{h\neq n,i}^{N} B^{hn}Y^{ih} + A^{ni}B^{in}Y^{ii}\right]$$

$$FVA = \left(V^{n}B^{in}\right)' * Y^{ni} + \left[\left(\sum_{h\neq n,i}^{N} V^{h}B^{ih}\right)' * Y^{ni}\right]$$
$$+\left(V^{n}B^{in}\right)' * \left(A^{ni}L^{nn}Y^{nn}\right) + \left(\sum_{h\neq n,i}^{N} V^{h}B^{ih}\right)' * \left(A^{ni}L^{nn}Y^{nn}\right)$$

$$PDC = \left(V^{i}L^{ii}\right)' * \left(A^{ni}B^{in}\sum_{h\neq n,i}^{N} Y^{hi}\right) + \left(V^{i}L^{ii}\sum_{h\neq n,i}^{N} A^{hi}B^{ih}\right)' * \left(A^{ni}X^{n}\right)$$
$$+\left(V^{n}B^{in}\right)' * \left(A^{ni}L^{nn}E^{n*}\right) + \left(\sum_{h\neq n,i}^{N} V^{h}B^{ih}\right)' * \left(A^{ni}L^{nn}E^{n*}\right)$$

where E is exports to economy n from economy i, with a star indicating an economy total across all other partners; Y is final demand for economy i's output in economy n; and DVA is domestic value added, FVA is foreign value added, and PDC is pure double counting. A is an input-output matrix, with superscripts used to define submatrices by economy pair. B is the global Leontief inverse based on A, with superscripts again indicating submatrices. V is the matrix of value-added shares, calculated directly from A. Y is the matrix of final demand. X is the vector of gross output by economy. L is the local Leontief inverse, defined as follows for the three-economy case (n, i, and k):

$$(24)\ L = \begin{bmatrix} B_{11}^{nn} & B_{12}^{nn} & 0 & 0 & 0 & 0 \\ B_{21}^{nn} & B_{22}^{nn} & 0 & 0 & 0 & 0 \\ 0 & 0 & B_{11}^{ii} & B_{12}^{ii} & 0 & 0 \\ 0 & 0 & B_{21}^{ii} & B_{22}^{ii} & 0 & 0 \\ 0 & 0 & 0 & 0 & B_{11}^{kk} & B_{12}^{kk} \\ 0 & 0 & 0 & 0 & B_{21}^{kk} & B_{22}^{kk} \end{bmatrix}$$

The above presentation is at the economy-pair level for simplicity, but Wang, Wei, and Zhu (2013) show that it can be extended to the sector level. The decomposition can therefore show DVA, FVA, and PDC in, for example, the People's Republic of China's exports of electrical equipment to the United States.

The sum of FVA and PDC is typically understood as a measure of production sharing, and we adopt that interpretation here.

Our approach to analyzing value-added trade is straightforward. As per Wang, Wei, and Zhu (2013), the decomposition for the baseline case can be calculated directly from the observed input–output table. We then use A' as calculated above to conduct a second decomposition for the counterfactual input–output table. The difference between the two shows the extent of changes in GVC trade as a result of the change in trade costs assumed for the counterfactual.