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Global Value Chains and Changing Trade Elasticities

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Abstract

The trade collapse of 2008-2009 and the anemic trade growth since then raise the question of whether trade elasticities may be undergoing fundamental structural change. A potential source of such change is the spread of global value chains (GVCs), which have brought a marked increase in the use of intermediate goods and changes in the nature of trade competition. We review the recent literature on the impact of GVCs on measured trade elasticities and the ways in which their emergence may affect how we estimate and interpret trade responsiveness. We then draw out a few implications of recent research for global modeling.

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1. INTRODUCTION

Global economic modelling depends on satisfactorily describing the flows of international trade in goods and services. Estimating trade equations therefore has a long history in macroeconometric modelling. Of particular interest has been the responsiveness of trade volumes to income and relative prices, the so-called trade elasticities.

Recent developments in the global economy have led modelers to question whether trade elasticities may be undergoing fundamental structural change. A first eye opener was the Great Trade Collapse in the wake of the global recession in 2008-2009. Compared to previous economic downturns, the drop in trade was unprecedentedly sudden, severe and synchronized, with world trade declining more than 30 percent in the first quarter of 2008 relative to a year earlier (Baldwin, 2009). This led to the question of whether the unusually large trade response reflected a structural increase in responsiveness of trade to income in comparison to previous periods (Freund, 2009).

There is substantial evidence that trade did indeed become more sensitive to income growth at the close of the 20th century. Cheung and Guichard (2009) find that the long-run income elasticity of world trade almost doubled from 1.3 in the period 1975-1986 to 2.5 in the 1986-2008 period. Escaith et al. (2010) find a similar increase in the income elasticity of trade in the 1990s, but suggest that it had stabilized by the early 2000s. Ceglowski (2014) finds evidence of the same pattern in a study of U.S. aggregate imports.

More recent events raise the possibility that income elasticities may once again have shifted, this time in the downward direction. After an initial bounce from the 2008-2009 recession, world trade growth has been unusually anemic, a development often referred to as the Great Trade Slowdown. For the first time in nearly half a century, global trade has grown more slowly than GDP. In 2011-2014, the value of merchandise exports expanded at an annual rate of just 3.3 percent, less than half the average of roughly 7 percent for the 1985-2007 period. This has led to an intense debate among scholars over whether income elasticities have started to come down, and what might be the cause (for a fairly comprehensive discussion, see the collection of papers in Hoekman, 2015).

Trade modelers have raised similar questions about price elasticities, following recent episodes where large depreciations appeared to have had little impact on exports. And there is some recent suggestive evidence of a downward trend in price elasticity. Ahmed et al. (2015) find that the responsiveness of manufacturing exports to changes in the real effective exchange rate has declined from an absolute elasticity of 1.1 in the first part of the 1996-2012 period to 0.6 by the end of the period. While this is by no means a settled fact (see, for example, the contrasting view of Leigh et al., 2015), a decline in the price sensitivity of trade would have important implications for exchange rate adjustment and related issues.

In the ongoing discussion about changing trade elasticities, global value chains (GVCs) are the elephant in the room. A key simplifying assumption implicit in workhorse trade models is that products have clear national identities, that is, their entire production process is concentrated within the borders of the home country. In this traditional view, each country produces differentiated products that compete against the products of other countries in destination markets. In this case, the quantity of exports demanded can be expressed as a function of demand in the destination market, own prices, and prices of competing products.

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This national view of production, however, is disconnected from today's reality. Thanks to reduced communication and transportation costs, many companies have long abandoned the practice of producing goods in a single country. Through offshoring, they have sliced up their supply chains and dispersed their production activities across many countries, leading to GVCs. A consequence of the emergence of GVCs is that countries increasingly specialize in adding value at a particular stage of production rather than producing entire finished products (Grossman and Rossi-Hansberg, 2008). Making final products requires them to connect with foreign value chain partners both upstream and downstream. Upstream, countries increasingly rely on foreign inputs for their exports. Johnson and Noguera (2014) provides evidence that the share of foreign value added embodied in a country's exports increased for virtually all countries between 1970 and 2008. Downstream, countries increasingly export intermediate goods that are used by foreign companies to make their respective exports. As a result, a significant portion of a country's exports is now ultimately consumed in a country other than where they were first exported.

The spread of GVCs, the increasing role of intermediate goods, and the changing nature of trade competition may have important implications for both income and price elasticities of trade. In this chapter, we review the recent literature on the impact of GVCs on measured trade elasticities and the ways in which their emergence may affect how we estimate and interpret trade responsiveness. We will then draw out a few implications of recent research for global modeling.

2. THE STANDARD TRADE MODEL

As we noted above, the traditional empirical model of trade rests on the idea of a national production paradigm, where exports are wholly produced within one country and then compete with those of other countries on international markets. The demand for a country's exports is therefore typically modeled as a function of income in the rest of the world, home export prices, and foreign prices measured in domestic currency. Following Goldstein and Khan (1985),[2]

$$X_t^d = g(Y_t^* e_t, PX_t, P_t^* e_t) \qquad (1)$$

where X_t^d is export demand at time t, Y_t^* is a measure of foreign income, PX_t is the home export price, P_t^* is the price of competing foreign goods, and e_t is the effective exchange rate in domestic currency per unit of foreign currency.

Equation (1) is consistent with consumer choice over domestic and foreign goods, which are assumed to be imperfectly substitutable (Armington, 1969), as is well supported by the data. Note that in this two-region formulation, the domestic country's exports to the rest of the world are also the rest of the world's imports from the domestic country, so the trade flow can equivalently be interpreted as a foreign import demand equation.

Under homogeneity, export demand is a function of real income abroad and relative export prices,

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[2] This model has been used so often in the literature that Goldstein and Khan refer to it as the "standard export model."

$$X_t^d = g\left(\frac{Y_t^*}{P_t^*}, \frac{PX_t}{P_t^* e_t}\right) \tag{2}$$

Empirical versions of equation (2) have most often been estimated in log-linear (double log) form (Houthakker and Magee, 1969),

$$logX_t^d = \alpha + \beta \cdot log\left(\frac{Y_t^*}{P_t^*}\right) + \gamma \cdot log\left(\frac{PX_t}{P_t^* e_t}\right) + \varepsilon_t \tag{3}$$

where β is the income elasticity of export demand and γ the relative price elasticity.

Empirical trade equations based on (2) and (3) have dominated trade modeling over the years. Examples extend back to the earliest days of applied econometric modeling, with income and relative price forms at least as early as Adler (1945), Hinshaw (1945), and Chang (1946).[3] The log-linear form (3) can be found as early as Chang (1946).

The standard trade model has played an enduring role in international macroeconomics and in macroeconometric modeling. Trade elasticities play a central role in discussions of exchange rate and balance of payment adjustment. Estimated trade equations represent important channels for external conditions to impact domestic economies and to condition policy responses, and in multi-country models, such as the Project LINK model pioneered by Lawrence Klein and others, they serve as a key linkage between national economies (Hickman, 1991). The precise form of trade equations has evolved over time, with early macro models (e.g. Klein-Goldberger, 1959) often adopting forms relating trade demand to income alone, without consideration of relative price effects. In part this may reflect the Keynesian preoccupation with the income determination of demand, but it may also reflect limited trade price data available at the time. Models including relative prices terms have been standard for many years and continue to play a role in both econometric and CGE trade models.

Despite its longevity, there are well-known limitations to the modeling approach in (2) and (3) and in its common application, including omission of trade determinants such as immigration, adjustment costs, trade regime changes, and supply-side developments.[4] Theory-based or ad hoc modifications have sometimes been made to address these issues (see, for example, Marquez, 2002; Gagnon, 1989; and Garcia-Herrero, 2007). When used as a single equation to determine trade volumes, the model ignores supply-side interactions. Effectively, this assumes infinite supply elasticities, something that is clearly not supported by the literature (Goldstein and Khan, 1985,

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[3] The canonical survey of trade elasticities is Goldstein and Khan (1985). Marquez (2002) provides a chronological listing of trade elasticity estimates for studies between 1941 and 2001. He cautions that his list may not be comprehensive. Hillberry and Hummels (2012) review a number of more recent papers, including research that applies cross-sectional and panel methods, with an eye to their use in computable general equilibrium models.

[4] Econometric concerns such as Orcutt's (1950) critique of bias in estimates of price elasticities or more recent concerns about nonstationarity and spurious regressions can typically be overcome by using appropriate empirical methodology.

1087-88). Of particular relevance for the current discussion, derived as it is from consumer demand theory, the standard trade model is not well suited for describing trade in intermediate goods[5].

The model in log-linear form (3) implies constant trade elasticities. In fact, by now there is compelling evidence that this is not the case and that elasticities can change significantly over time. Marquez (2002) is largely devoted to this question and what theory and practice can tell us about it. A recent google search turned up 2950 pages with "structural breaks" and "trade elasticity" or a similar term. The apparent shifts of the past two decades that was described above is but the most recent example.

Past attempts to deal with parameter instability have including applying more flexible functional forms, including other variables that may influence trade (see above), the introduction of dummy variables for known events or to capture unexplained shifts, estimation over shortened time periods (which amounts to the same thing), use of greater disaggregation, and so on (e.g., Patel et al., 2014). The hypothesis in question here is whether the recent evolution of measured trade elasticities may be linked directly to the emergence and changes in the manner of production associated with GVCs.

3. GLOBAL VALUE CHAINS

The introduction of GVCs fundamentally alters the nature and determinants of trade patterns. It has been widely documented that production chains for goods and services are not concentrated within single countries, but are now increasingly fragmented, with corporations dispersing activities across multiple countries and companies (Feenstra, 1998). As a consequence, countries increasingly specialize in the production and exports of slivers of the value chain, not of entire goods (Grossman and Rossi-Hansberg, 2008). Furthermore, countries increasingly connect with foreign value chain partners to make final goods and services. As a result, trade in intermediate inputs now accounts for roughly two-thirds of all international trade (Johnson and Noguera, 2012).

Countries can connect with foreign value chain partners in two directions to produce goods and services: upstream and downstream. Upstream, they can import intermediate goods from their foreign value chain partners which they then use for the production and export of their own goods. This is called *backward participation*. Downstream, countries can export intermediate goods to their foreign value chain partners which use them to make their own respective exports, i.e. *forward participation*.

A new TiVA dataset compiled by the OECD and the WTO allows us to gain insights into the extent of a country's backward and forward participation in GVCs (De Backer and Miroudot, 2014). By combining input-output data for multiple countries with trade statistics, the dataset

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[5] A limited number of models focused on intermediate goods have been developed over the years. These models derive the demand for imported intermediates as the result of a profit maximizing (alternatively cost minimizing) choice between imports and domestic inputs. Goldstein and Khan (1985) cite Burgess (1974) and Kohli (1982); Marquez (2002) cites Kohli (1991).

allows a country's gross exports to be decomposed into two parts: (1) *domestic value added* which is generated in the exporting country and (2) *foreign value added* which comes from outside the exporting country. As is shown in figure 1, foreign value added captures a country's backward participation in GVCs.

Domestic value added can be further decomposed into two subparts: *domestic value added consumed in the destination country* and *domestic value added embodied in a foreign country's exports*. The latter term captures a country's forward participation in GVCs. In the remainder of this section, we will use the TiVA dataset to document trends in countries' integration in GVCs.
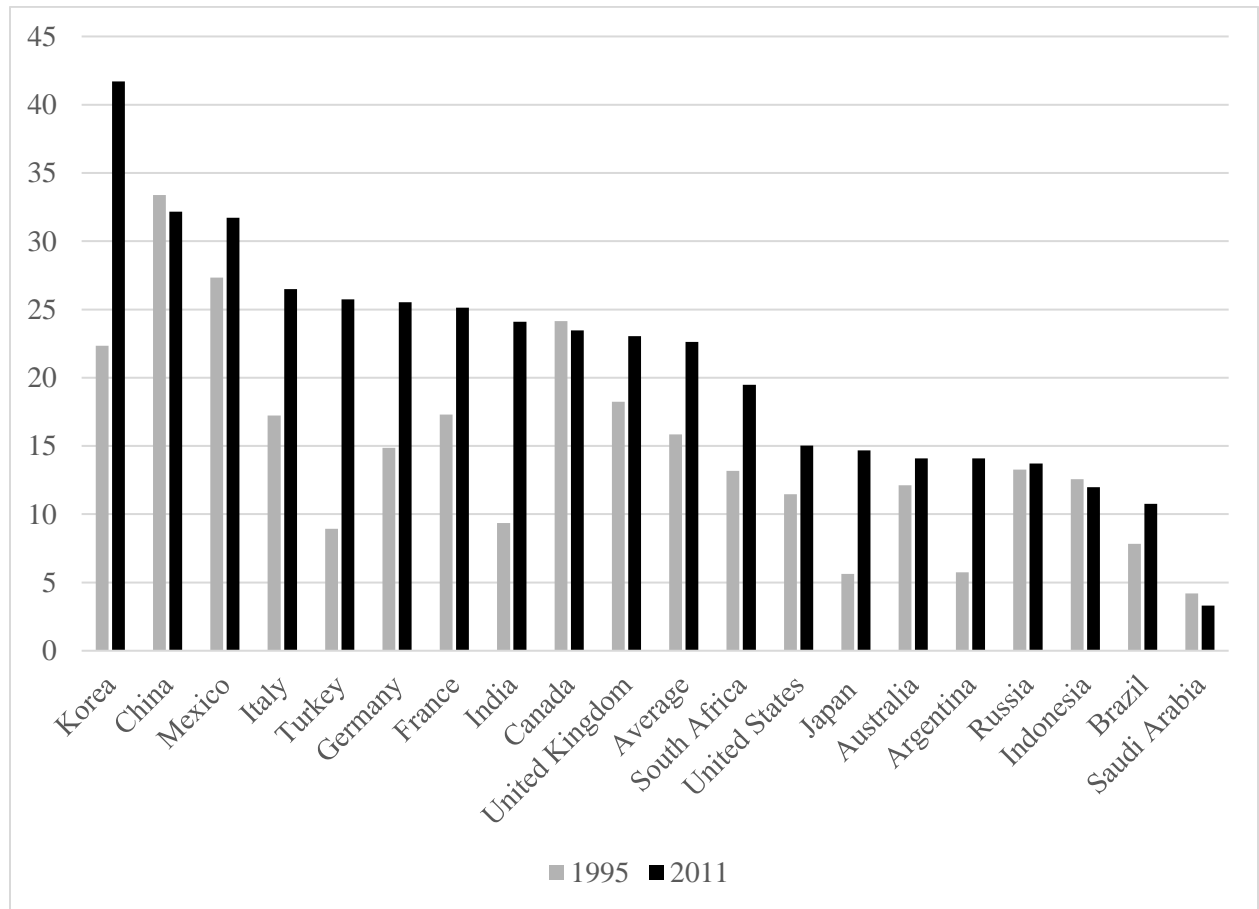
Figure 1: Decomposition of gross exports
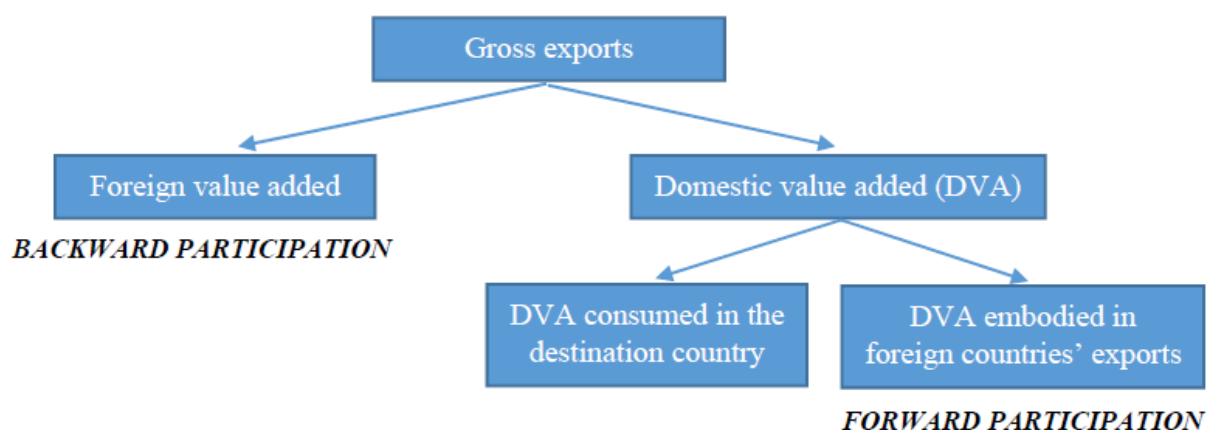
Backward participation

Starting with Hummels et al. (2001), scholars have used the foreign value added share embodied in gross exports as an indicator of a country's backward participation in GVCs, since it indicates how heavily a country relies on imported inputs to produce its exports (see also Johnson and Noguera, 2012). As figure 2 shows, foreign value added is responsible for a significant and growing share of G-20 countries' exports around the world. Between 1995 and 2011, the average share of foreign value added in gross exports for the G20 countries grew from 16 percent to 23 percent. This share varies across countries in a predictable fashion. It is substantially smaller for large economies such as the United States, since they have a large pool of intermediate inputs to draw on, and for countries with substantial natural resources such as Saudi Arabia, since mining activities require fewer intermediate goods in the production process. It is also smaller for countries that are located far from big markets and suppliers, such as Indonesia, since it is relatively more expensive for them to import inputs.

Figure 2: Share of foreign value added in gross exports, G-20 countries, 2011

The foreign value added share embodied in gross exports varies not only across countries, but also across industries (De Backer and Miroudot, 2014). Figure 3 depicts the foreign value added share embodied in gross exports for various Canadian industries in 2011. It exceeds 35 percent in the durable goods industries *Transport equipment* (motor vehicles, airplanes), *Electrical and optical equipment* (computers, telecommunication devices) and *Basic metals and fabricated metal products*. In contrast, it is less than 10 percent in the services sectors *Electricity, gas and water supply*, *Community, social and personal services,* and *Total business sector services,* as well as in *Mining and quarrying*.

Figure 3: Share of foreign value added in Canadian gross exports, by industry, 2011
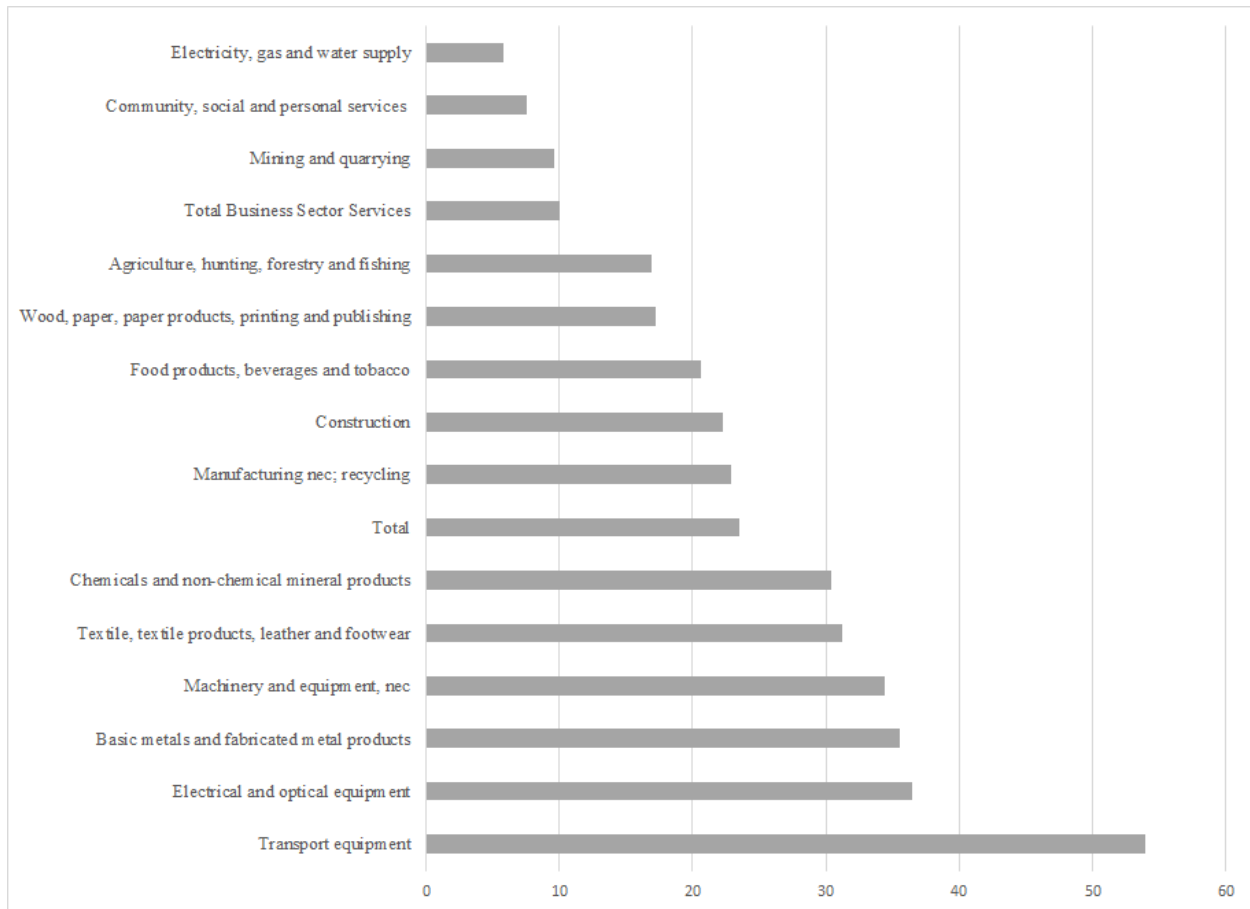
Source: authors' calculations using the OECD-WTO TiVA database

As we will see below, the variation across industries is important, because it implies that the composition of a country's exports may vary substantially when expressed in gross versus value added terms, and that this discrepancy can become larger as countries alter their backward participation in GVCs. Durable goods account for a larger share of G20 non-oil exports when expressed in gross terms than in value-added terms, and that the discrepancy has increased over time. In 2011, durable goods exports accounted for 38 percent of G20 non-fuel gross exports, but only 34 percent of G20 non-fuel value added exports.[6]

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[6] In this calculation, durable manufacturing goods includes *Basic metals and fabricated metal products* (C27T28), *Machinery and equipment* (C29), *Electrical and optical equipment* (C30T33), *Transport equipment* (C34T35). Non-mineral fuel exports are total exports minus *Mining and quarrying* (C10T14)

Forward participation

Countries also export intermediate goods to foreign value chain partners, who use them to produce their respective exports. For example, a Canadian aerospace company may export an intermediate good to Seattle, which Boeing then uses to produce and sell planes all around the world. As we noted above, to capture a country's *forward participation* in GVCs, the TiVA dataset allows a further decomposition of a country's domestic value added into two subcategories: (1) domestic value added consumed in the destination country; and (2) domestic value added embodied in foreign countries' exports. The latter term captures a country's forward participation in GVCs.

Figure 4 shows that the majority of G-20 countries have increased their forward participation in GVCs over the past few decades. Between 1995 and 2011, the average share of domestic value added embodied in foreign exports grew from 17.2 percent to 24.3 percent. Here again, the share varies across countries. It is larger for countries with substantial natural resources such as Saudi Arabia and Russia, since natural resources tend to be an important input embodied in foreign countries exports. It tends to be lower for countries such as China and Mexico that specialize in the final assembly of manufacturing exports.

Figure 4: Domestic value added embodied in foreign exports as share of gross exports, G-20 countries, 2011
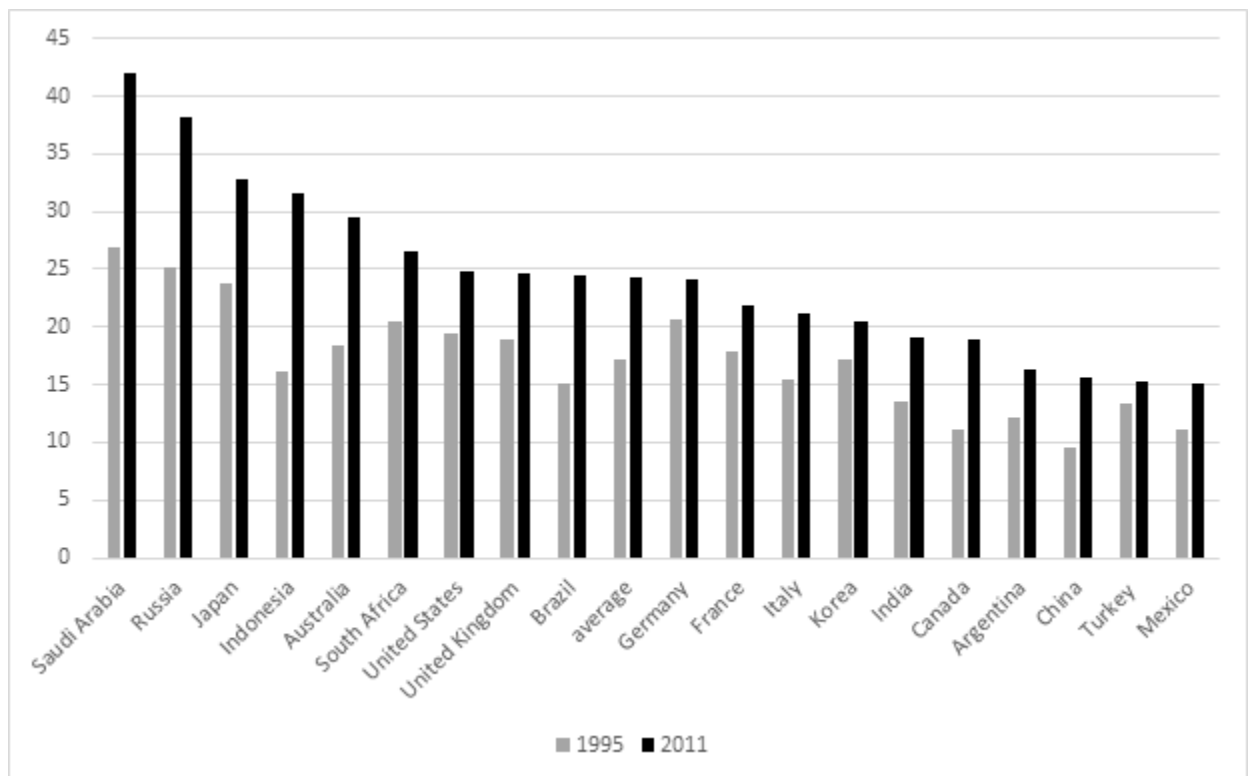
Source: Authors' calculation using the OECD-WTO TiVA database

A country's forward participation in GVCs means that its exports are not necessarily determined by demand conditions in the destination country, but rather in the country where they are ultimately consumed (Ma and Van Assche, 2013). Table 1 uses the example of Canadian exports to demonstrate the importance of taking this distinction into account. In gross terms, 66.7 percent of Canada's exports were destined for the United States in 2011. If we only consider the domestic value added that is embodied in Canada's gross exports (value added trade), the share of Canada's exports to the United States drops to 65.5 percent. If we then consider where Canada's domestic value added is ultimately consumed, the share of Canadian exports to the United States drops to 58.1 percent. The relative shares for other Canadian export destinations vary, depending on the nature of trade between Canada and each destination market. Note that the differences would be more dramatic for an exporting country more heavily specialized in intermediate goods trade.

**Table 1: Share of Canada's exports by destination country, 1995 and 2011**

	Gross exports		Domestic value added content of gross exports		Domestic value added in foreign final demand	
	1995	2011	1995	2011	1995	2011
United States	70.9	66.7	68.1	65.5	63.5	58.1
EU-15	8.3	8.4	9.2	8.9	10.4	10.1
China	1.1	4.9	1.2	5.1	0.9	4.4
Japan	5.7	3.0	6.4	3.2	7.4	3.9
Mexico	0.8	2.5	0.9	2.2	1.0	2.5

Source: Authors' calculation using the OECD-WTO TiVA database

Total participation

Combining the numbers for backward and forward participation allows us to obtain an estimate of the importance of GVCs in a country's total trade. Figure 5 shows that for the G20 countries the share of gross exports that takes place within GVCs has doubled from a bit more than 33 percent in 1995 to 46 percent in 2011. Clearly GVC production arrangements have become a key element of G-20 countries' exports over the past several decades.

Figure 5: GVC trade as a share of G20 countries' gross exports value, 1995-2011
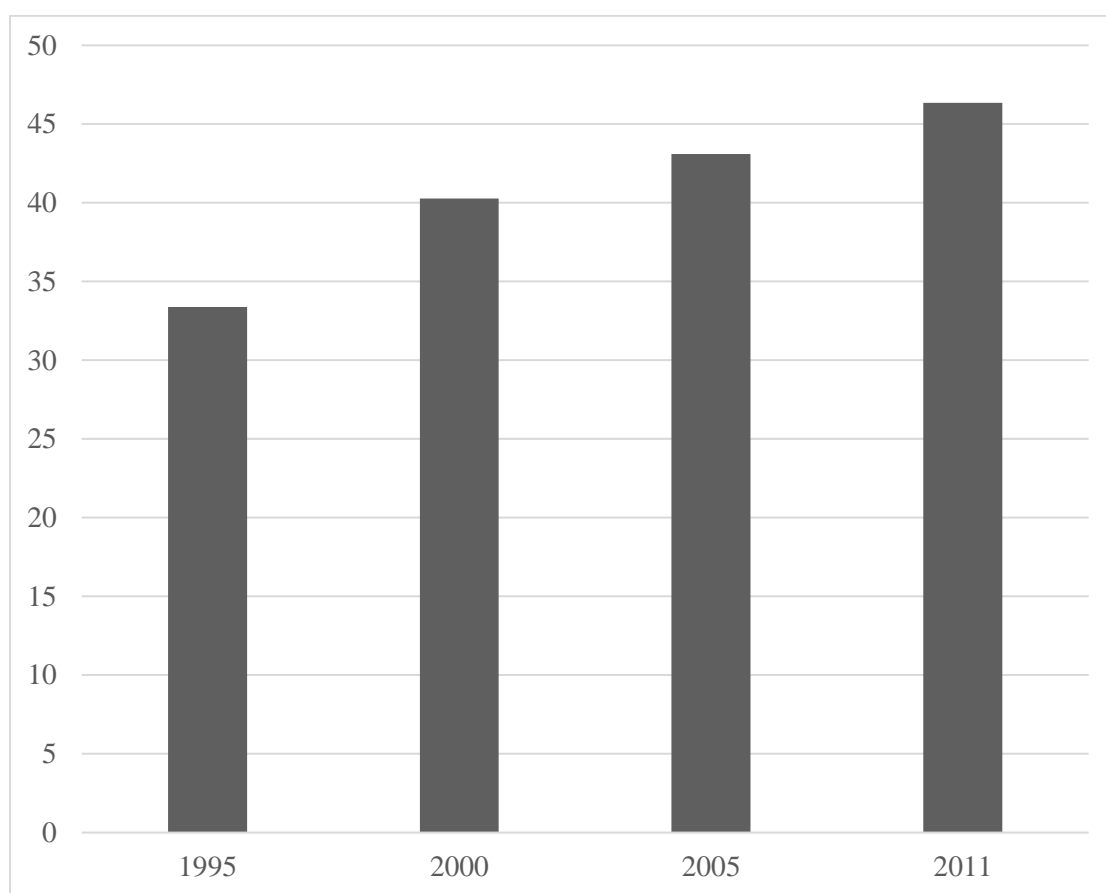
4. IMPLICATIONS FOR TRADE ELASTICITIES

Countries' growing integration in GVCs has potentially important implications for trade elasticities. Below we consider the impacts on price and income elasticities of the backward and forward participation in GVCs.

4.1. Price elasticity

The price elasticity of exports summarizes the effect of a change in the relative price of domestic and foreign goods on export volume. Traditionally the focus has been on the manner in which relative price change (often associated with currency appreciation or depreciation) alters the competitiveness of domestic and foreign producers on final demand. A country's participation in GVCs can alter the elasticity of its exports to relative price change in a number of ways (Arndt and Huemer, 2007; Ahmed et al. 2015).

We have seen in Figure 2 that G-20 countries increasingly rely on imported inputs to produce exports. Recent studies argue that this has important implications for the sensitivity of a country's exports to exchange rate fluctuations (Bems and Johnson, 2012). If a portion of the exporter's intermediate inputs are imported, and these costs are not denominated in the exporter's domestic currency, then an exporter's marginal cost of production will only be partly exposed to exchange rate fluctuations. All else equal, we should therefore expect that exports of country with a higher proportion of foreign value added will have a lower responsiveness to an exchange rate fluctuation.

The price elasticity of a country's exports should also depend on its degree of forward participation in global value chains. A currency fluctuation not only affects the competitiveness of domestic value added that is sold to foreign consumers, but also the domestic value added embodied in foreign countries' exports. For example, a depreciation of the Canadian dollar increases the competitiveness of Canadian aerospace components embodied in Boeing's planes. The effect on the price elasticity is complex. On the one hand, a depreciation may make downstream foreign producers (like Boeing) more competitive in third markets which could boost the responsiveness of a country's intermediate good exports to a currency fluctuation. On the other hand hand, the rising competitiveness of foreign downstream producers may dampen the export demand for their domestic competitors in the destination market.[7] For example, a rise in competitiveness of Boeing can dampen the rise in export demand for Canadian-based Bombardier planes.

Efforts have been made to calculate more accurate measures of the real effective exchange rate (REER) that take into account backward and forward participation in GVCs. Bayoumi et al. (2013) develop a measure of competitiveness based on the IMF REER, but which adjusts component price indices using new bilateral trade weights that reflect value-added trade. They find that competitiveness losses of emerging economies that rely heavily on imported inputs are significantly larger when value-added weights are used. Bems and Johnson (2015) devise a new method for calculating a country's "value added real effective exchange rate" by modifying both the price and trade-weight components. Similar to Bayoumi et al. (2013), they constructed new bilateral trade weights that reflect value-added trade rather than gross trade. They then replaced consumer prices with the GDP deflator to better reflect the value-added component of trade competitiveness. They find that this approach can yield very different paths for relative price change than traditional gross REER measures, as well as for measures of the degree of openness.

To our knowledge, there are very few papers that provide direct evidence of the effect of GVCs on price elasticities. Ahmed et al. (2015) find that the rise of participation in global value chains explains on average 40 percent of the recent fall in the elasticity, and that correction of the REER for participation in global value chains does not present the same decreasing pattern in elasticity. Athukorala and Khan (2016) find that while the price elasticity of import demand for final goods is large (greater than 2 in the long run), that of intermediate goods is not significantly

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[7] Athukorala and Khan (2016) describe other channels through which GVCs may affect the responsiveness of trade to relative price changes. On the one hand, the ability to outsource itself could make it easier for firms to move production in response to relative price changes. However, trade responsiveness could be limited by potentially high costs of setting up international production arrangements and limited substitutability of inputs sited in different locales.

different from zero. Arndt and Huemer (2007) find that the real exchange rate has greater explanatory power for non-manufactures US exports from Mexico than it does for manufacturing imports, where GVC arrangements are common; in the case of autos, the effect of real exchange rate change disappears altogether.

4.2 Income elasticity

The emergence of GVCs also has implications for the responsiveness of trade to changes in national income. Certainly, the coincidence of rapid GVC trade growth before the Great Recession and the documented rise of income elasticities suggests it may be a primary candidate for structural change in the trade-income relationship. Several existing studies find that the inclusion of proxies for GVC prevalence can in some cases reduce income elasticity estimates and/or eliminate structural breaks. (Cheung and Guichard, 2009; Ceglowski, 2014; Escaith et al., 2010.)

There are two primary ways by which a country's backward participation in a GVC may affect its income elasticity. First, it may increase the sensitivity of its exports to foreign income movements by making its export bundle more concentrated in durable goods industries (a *composition effect*). Second, it may increase the income elasticity due to features inherent to the GVC production structure (*supply chain effects*).

Countries that increase their reliance on imported inputs for their exports can see an increase in their income elasticity due to a composition effect. Durable goods tend to have a higher sensitivity to income shocks than do non-durables goods (see, among others, Ceglowski, 2014; Aziz and Li, 2008.) In economic downturns, for example, households and companies disproportionately delay purchases of durable and capital goods as they await clearer evidence that the economic climate is improving. If GVC trade growth is primarily centered in durable goods industries (see section 3, above), this will raise the weight of higher-income-elasticity goods in trade, potentially leading to an increase in the aggregate income elasticity.

Bems et al. (2011) use a global input-output table to show that the asymmetric expansion of GVCs in durable goods sectors has raised the weight of durable goods in world trade compared to their weight in world GDP. By 2008, durable goods had grown to nearly 40% of trade, but amounted to only 10% of final demand. Building on this stylized fact, Engel and Wang (2011) set up a two-country, two-sector model in which durable goods are tradable while nondurables are nontradable. They show that since durables expenditures are several times more volatile than GDP and international trade is highly concentrated in these durable goods, trade should also experience larger swings than GDP. This has also been used to explain the severity of the trade collapse during the Great Recession. Bems et al. (2011) and Eaton et al. (2011) estimate that the composition effect accounted for 70 to 80 percent of the global decline in the trade-to-GDP ratio during the crisis.

In Gangnes et al. (2014), we find evidence that China's growing backward integration into GVCs has led to a rise in the durable goods share of gross exports, and that this has led in turn to a higher measured income elasticity. To capture China's backward integration into GVCs, we exploit data from China′s Customs Statistics for the years 1992-2011 that distinguish between

trade under two distinct customs regimes: the processing trade regime and the ordinary trade regime. Under processing trade, firms enjoy duty-free importation of inputs that are used in production, but face restrictions on selling in the domestic market. As a result, firms use it almost exclusively if they rely heavily on imported inputs and export their products, that is, if they are integrated into GVCs. Under ordinary trade, firms face duties on imported inputs but can sell their output locally. Firms that export under the ordinary trade regime, therefore, have more extensive domestic value chains.

We first show that the share of processing trade (that is, GVC trade) in China′s exports increased rapidly in the 1990s before stabilizing in the early 2000s. Second, we demonstrate that GVCs have primarily emerged in durable goods sectors, therefore altering the composition of Chinese exports. As the data in table 2 indicate, in 2011 processing trade accounted for 84% of durable goods exports, but only 16% of non-durable goods exports. The rapid growth of durable goods processing trade raised the share of durable goods in total trade from 42% in 1995 to 69% by 2011.

Table 2: China's exports, by sector, various years

	HS Codes	Share of total exports		Annualized growth rate	Processing exports share	
		1995	2011	1995-2011	1995	2011
DURABLES						
Machinery, electrical	84-85	18.6	44.3	22.4	8.3	64.2
Misc. Manufacturing	90-97	9.6	9.2	15.6	3.7	8.9
Metals	72-83	8.1	7.0	14.9	8.0	2.2
Transportation	86-89	2.7	5.6	21.4	3.6	7.5
Stone and glass	68-71	3.0	2.5	14.7	2.0	1.6
Total durables	**68-97**	42.0	68.7	19.5	55.6	84.3
NON-DURABLES						
Textiles	50-63	24.2	12.7	11.3	20.9	4.9
Non-manufacturing	01-27	13.8	5.0	8.7	3.8	2.3
Chemicals	28-38	5.7	4.8	14.6	1.7	1.5
Plastics and rubbers	39-40	2.9	3.1	16.5	4.0	3.6
Footwear and headgear	64-67	5.5	2.8	11.1	8.1	1.7
Wood and wood products	44-49	2.2	1.5	13.2	1.2	1.0
Raw hides, skins, leathers & furs	41-43	3.8	1.5	9.2	4.7	0.7
Total non-durables	**01-67**	68.7	31.3	11.5	44.4	15.7
Total		**100.0**	**100.0**	**16.0**	**49.6**	**46.9**

Source: Gangnes et al. (2014).

Using panel data that varies across industries, customs regimes and years, we next estimate a standard export-demand model that relates trade volume to foreign income and relative prices (real exchange rates), with interaction terms for durable-nondurable goods and for processing

versus other trade.[8] Consistent with the literature, we find that Chinese exports of durables have substantially higher income elasticities than those of non-durable goods exports. The income elasticity for durables is nearly four times higher than for non-durables (see table 3, column 2). For non-durables, the elasticity on real GDP growth is 1.123; for durables it is 1.123 + 3.052= 4.175.

Table 3: Estimated income elasticities (impact), 1995-2009

Dependent variable:	(1)	(2)	(3)
Real GDP growth	1.831***	1.123***	1.072**
Durable goods		3.052**	3.608**
Processing trade			0.096

Source: Gangnes et al. (2014), page 484. The coefficients on real exchange rates, productivity, one-year time lags, cross-interaction terms and fixed effects are not shown. Significance: ***1% level, **5% level, * 10% level.

In addition to the role of GVCs in shifting the composition of trade toward higher-income durable goods, there may also be characteristics of the GVC structure itself that make exports relying heavily on imported inputs inherently more responsive to income movements, what we term *supply chain effects*. Suppose for example that the organization of global value chains allows companies to more rapidly ramp production up or down in the wake of a foreign demand fluctuation. In this case, it may be that—within a given industry—the income elasticity of demand is larger for GVC trade than for non-GVC trade.

Ma and Van Assche (2012) find preliminary evidence that GVC trade was more sensitive to demand fluctuations than non-GVC trade during the Great Recession of 2008-2009. As is shown in table 4, within HS 8-digit industries the share of processing exports in total exports declined between the first quarter of 2008 and the first quarter of 2009.

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[8] Our model is estimated in growth rates to avoid spurious regression, and it includes lagged terms of left and right-hand side variables, a proxy for productivity growth, and industry or industry-regime fixed effects. Because the model is estimated in growth rates, the fixed effects will capture secular trade growth due, for example, to adoption effects.

Table 4: China's processing exports as a share of total exports (HS 8-digit level)

Variables	Number of Observations	Mean	Standard error
Share of processing exports in total exports, 08Q1	4760	0.31	0.004
Share of processing exports in total exports, 09Q1	4760	0.29	0.004
Difference	**9520**	**0.020*****	**0.003**

Notes: * means significant at 10%; ** means significant at 5%; *** means significant at 1%.
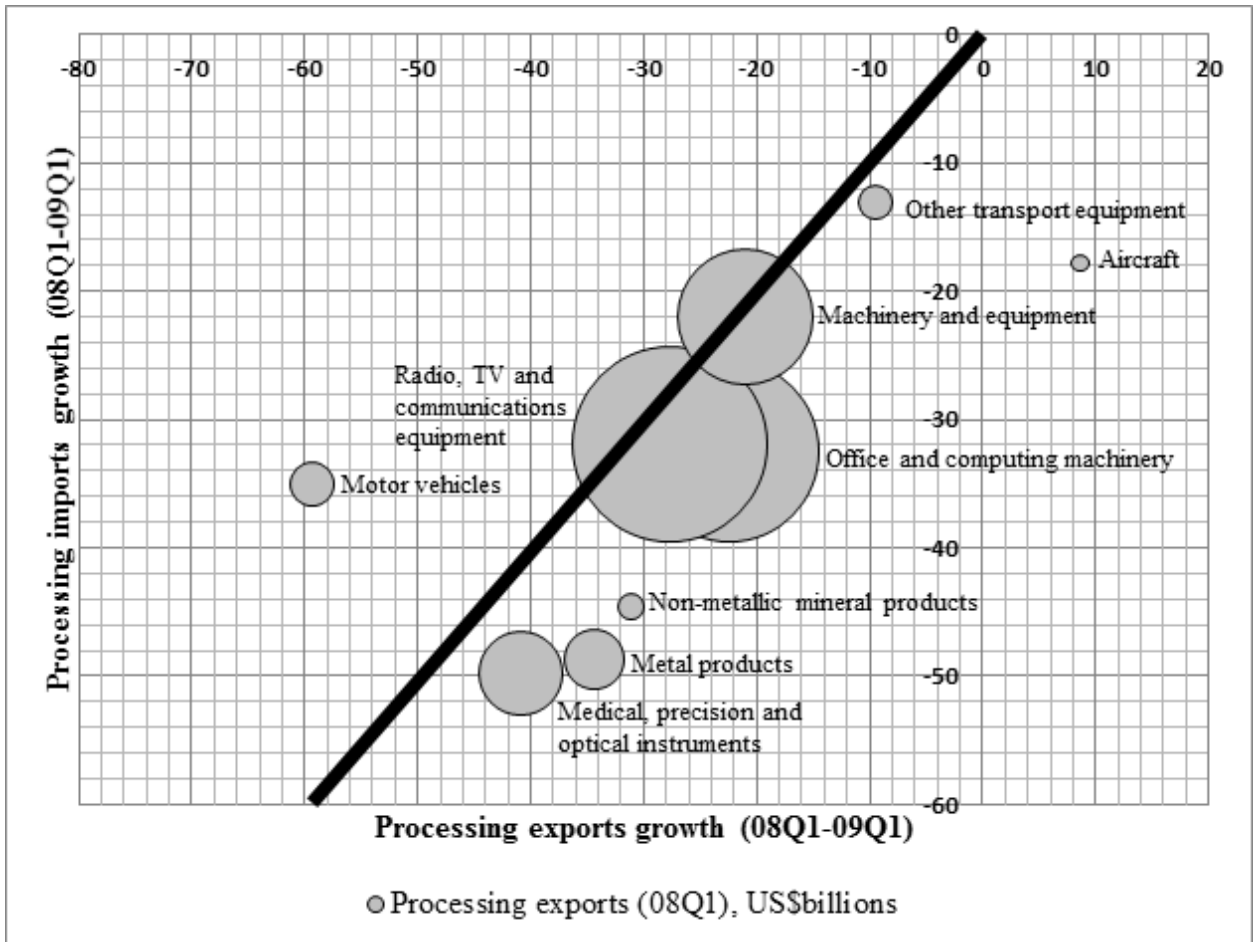
Source: Ma and Van Assche (2012)

Further analysis by Gangnes et al. (2014) suggests that this effect may have been particular to the Great Recession. Referring back to table 3, the addition of a processing trade interaction term to our panel analysis permits us to test whether processing trade has a higher income elasticity over and above the difference that can be explained by industry composition. The evidence in column 3 suggests that it does not. Once we adjust for the industrial composition of trade, the results fail to show that GVC trade has a higher income elasticity than trade taking place outside GVCs.[9]

What about the impact of forward participation in GVCs? Here, attention has been given to the role of inventory dynamics. The management of inputs by GVC firms may be one driver that amplifies the volatility of GVC trade to income movements (Alessandria et al., 2010; Altomonte et al., 2012). The logic for such a *bullwhip effect* is the following: businesses typically face errors in their sales forecasts against which they hedge by accumulating buffer stocks of inventories. When a downstream firm is confronted with an unexpected drop in demand, it may attempt to smooth production by running down its inventories and suspending new purchases of imported inputs, leading to potentially large declines in exports by upstream firms. This disproportionate falloff in trade in inputs may lead to a higher sensitivity of GVC trade to foreign income shocks compared to regular trade.

A number of scholars have found evidence of bullwhip effects in international trade during the Great Recession of 2008-2009. Alessandria et al. (2011) find that in the U.S. auto industry two-thirds of the decline in imports was due to firms running down their inventory stocks. Altomonte et al. (2012) use French firm-level data to show that imports of intermediate goods during the crisis overreacted to the final demand shock as firms ran down their inventory stocks. Ma and Van Assche (2011) find that China's processing imports across industries contracted more severely than processing exports in the first quarter of 2009 compared to a year earlier (see figure 6).

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[9] Cross interaction effects of processing on durables and real GDP, not shown here, also failed to show a positive effect.

Figure 6: Bullwhip effect in Chinese processing trade, 2008Q1-2009Q1

Source: Ma and Van Assche (2012)

Further analysis by Gangnes et al. (2012) suggests that this effect too may have been particular to the Great Recession. We find no evidence that foreign demand shocks are amplified as they move from processing exports to processing imports during the period 1988-2009. This may be because severe economic downturns such as the Great Recession create greater than usual demand uncertainty, which can create exceptionally large bullwhip effects in industries that do not normally see bullwhip effect behavior.

5. GVCS AND THE RECENT TRADE SLOWDOWN

As we noted in the introduction, after a period of apparent rise in income elasticities, the anemic pace of trade growth in recent years has led some scholars to look to GVCs as a potential source for an elasticity falloff. In the context of our discussion above, a lower measured income

elasticity could emerge if there has been shift away from the high share of durable goods that has emerged in the GVC era (a compositional effect), either for structural or cyclical reasons. A lower income elasticity could also emerge if there has been a general retreat from GVC production arrangements in the post-crisis world and if, contrary to our results for China, GVC trade is inherently more sensitive to income shocks than normal trade (supply side effects).

In Gangnes et al. (2015), we evaluate the recent trade slowdown in light of GVC-trade linkages, trying to tease out some insights from the limited experience to date. Looking first at composition effects, we find little evidence of a decline in the importance of durable goods trade in the recent period. Instead, we find that after accounting for a decline in low-elasticity mineral exports, the share of durable goods in world exports has remained roughly stable both in the past few years and in the period extending back to 2000. It does not appear that there has been a fundamental shift in the composition of non-mineral exports away from durables.[10]

Might the lower apparent sensitivity of trade to income reflect a pullback from GVC production arrangements? Some have argued that such a process of "reshoring" may be occurring as firms reconsider exposures and expenses associated with far-flung value chains, or because of changing regional cost conditions (Boz et al., 2014; Canadian Trade Commissioner, 2014). Again, a disproportionate retreat from GVCs is not evident in the data. The share of intermediate goods in both non-mineral exports and durable goods exports has remained stable over the past decade, contrary to what one would expect if a disproportionate pullback from GVC arrangements were to blame for the drop in income elasticities.[11]

What then might explain the anemic growth of trade relative to income in the post-crisis period? The main competing hypothesis is that it is primarily cyclical, the result of temporarily weak demand for those categories of goods that have the highest import propensities, consumer durable goods and investment goods, because of the disappointing pace of economic recovery. Among other explanations are a rise in protectionism and post-crisis constraints on trade finance. (See the various contributions in Hoekman, 2015.) One particularly interesting structural explanation is the potential effect on trade of heightened uncertainty in the post-recession era, which may have negatively affected overall trade. Taglioni and Zavacka (2013) show that there is a strong negative relationship between uncertainty and trade, and that this relationship is non-linear. When uncertainty is low, a marginal increase in uncertainty has little impact on trade. If it surpasses a threshold, however, it can lead to a significant decline in trade, both within and outside of GVCs. The heightened uncertainty is of course not likely to stay around forever. Each of these competing explanations, if true, would suggest that the trade slowdown is more likely temporary, rather than an indication of a permanently lower rate of trade growth.

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[10] This indication that the durable/non-durable composition has remained relatively stable stands in contrast to the evidence from Boz et al. (2014) that the composition of final demand has shifted away from import-intensive goods. According to Bussiere et al. (2013), the latter include investment goods that have relatively high durable good shares.

[11] It could be the case that measured elasticities have fallen because of a slowdown in the rate of adoption of new GVC production arrangements, which may have temporarily raised the growth rate of gross trade in recent decades.

6. LESSONS FOR MODELERS

We have focused in this chapter on the implications of GVCs for the measured responsiveness of trade to changes in income and relative prices. This may be of interest in its own right, but of course it has broader importance for macroeconomists. How trade responds to income has implications for how macro shocks in one country are transmitted abroad and how the domestic economy itself is affected by home-grown developments or policies that affect aggregate demand. Price elasticities are central to understanding exchange rate adjustment, and they play a role in assessing the impact of changes in competitiveness.

By now we know that aggregate trade elasticities can shift markedly and that the rise of global value chains may explain at least a part of the recent changes. At the same time, the staying power of the standard trade model suggests that in some form it will continue to play a central role in macroeconometric modeling.[12] Because production arrangements will continue to evolve, this presents a challenge for international economists. What's a modeler to do?

The most promising avenue is the ongoing development of new datasets that distinguish between gross trade and trade in value added. These data get at the heart of the problem posed by modern complex global production systems. For now, the data series are too short to be used in time-series econometrics, but they may still be useful as a tool for identifying trade flows where caution is particularly important. And as time series become longer, they will permit a much more satisfactory—and it is hoped more stable—identification of trade determinants.

In the meantime, there are some things that we can do. One is to match carefully the specification of trade equations to the nature of the flow being modeled. If trade is dominated by intermediate goods, then it makes little sense to try to "explain" the flow as a function of final demand and relative consumer prices. As we have shown for the case of China, a key part of the recent story has been the shift in the composition of trade toward durable goods, so attention to an appropriate level of disaggregation is important. Neither of these issues is new to trade modeling, although they are often ignored. Finally, there is some evidence that incorporating proxies for GVC development may help to achieve more stable estimates of traditional trade equations.

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[12] Indeed, as Marquez (2002) has noted, the simple constant-elasticity log-linear trade model often has greater explanatory power than more flexible functional forms.

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