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Singapore's Export Elasticities: A Disaggregated Look into the Role of Global Value Chains and Economic Complexity

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Singapore's Export Elasticities: A Disaggregated Look into the Role of Global Value Chains and Economic Complexity

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Abstract

Singapore is one of the world's most open economies, with the size of its trade reaching about 350 percent of its GDP. With the rise of highly diversified cross-border production networks, Singapore has come to play an integral role in the global supply chain with heavy reliance on foreign contents in its exports and production. It has also successfully moved up the value chain, exporting goods with high sophistication and economic complexity. Against this backdrop, in this paper, using disaggregate industry/product level trade data, we revisit Singapore's export elasticities and find that growing participation in global production chains and rising export complexity are important determinants.

JEL Classification Numbers: D57, F10, F14, F31

Keywords: Trade elasticities, trade structure, global supply chain, economic complexity

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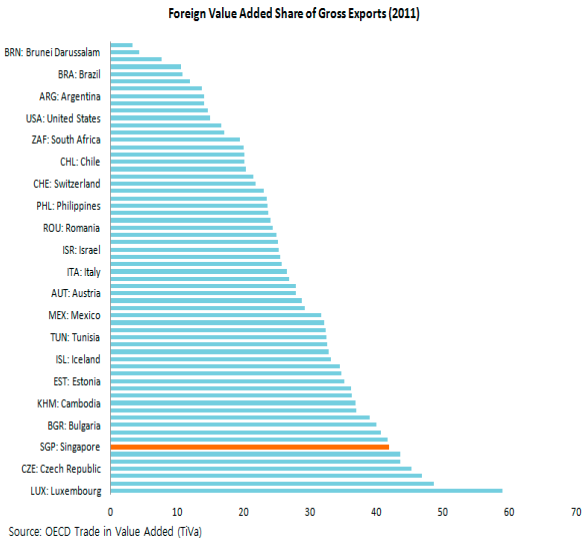
I. INTRODUCTION

Singapore is one of the world's most open economies, with the size of its trade (exports plus imports) reaching about 350 percent of its GDP. This reflects Singapore's role as a trading port and an oil and gas hub and its participation in regional supply chains, which has over time let to a significant increase in trade in intermediate goods. With the rise of highly diversified cross-border production, Singapore now plays an integral role in the regional and global supply chain with heavy reliance on foreign contents in its exports and production. Singapore has also successfully moved up the value chain, exporting products with ever increasing sophistication and complexity.[2]



Against this backdrop, this paper revisits the size and determinants of Singapore's export elasticities in light of growing trade in intermediate inputs and goods of growing complexity. The size of these elasticities are important for understanding the role of the exchange rate, competitiveness and external demand in the determination of output and trade balance. Export elasticities are also critical to understand the transmission of the exchange rate based monetary policy in Singapore. The Monetary Authority of Singapore (MAS) uses the nominal effective exchange rate as its monetary policy instrument given the relative importance of the exchange rate in the context of a very open economy. Exchange rate changes can affect profits and trade volumes differently, depending upon the price pass-through to import and export prices and the price elasticity of exports and imports. While fully recognizing the importance of the first channel – exchange rate pass-through to export prices -, in this paper, we focus on the price elasticity of exports.

The novelty of our empirical approach is that we explore the size of Singapore's export elasticities at the disaggregated industry/product level, using the mean group estimator (MG) of Pesaran and Smith (1995) and fixed-effects regressions. This allows us to consider the heterogeneity across different products and explore how product complexity and position in

[2] The economic complexity of a country's export product used in the paper follows Hidalgo and Hausmann (2009). The notion of economic complexity is related to the number of countries that export the product and the diversity of those countries' exports. If a product is produced by a small number of countries and if those countries have a diverse export product mix, the economic complexity of the product is measured to be higher. See section II.B for further details.

global value chains, or foreign value added in exports affect elasticities[3]. Product and industry level heterogeneity are important in the context of the ongoing structural change in Singapore's economy and the tilt of exports towards more sophisticated products, which allows Singaporean firms to capture a higher share of value added.

Our work contributes to recent theoretical and empirical studies that focus on the role of global value chains (GVCs) in global trade. The complex input-output linkages of the intermediate goods and output crossing borders multiple times motivate a new interpretation of the trade elasticities on several dimensions.[4] The fragmentation of production in global trade, points to the need to distinguish between gross versus value-added (net of imported inputs) trade data in estimating trade elasticities (Johnson and Noguera (2012a, 2012 b, 2014), Bems and Johnson (2015)). For instance, IMF (2015) empirically assesses the effect of real effective exchange rate changes on exports and imports distinguishing between GVC and non-GVC-related trade. They find that participation in GVCs and a country's position in GVCs (upstream versus downstream position), are important determinants of the size of trade elasticities.

Furthermore, as countries become more deeply integrated in global production chains, they demand more foreign value-added to use in their production and exports. This aspect is particularly relevant in understanding the trade elasticities of Singapore. In fact, Singapore is a country with one of the highest share of foreign value-added contents in its exports—40 percent in 2011 (OECD, Trade in Value-Added Data)—on par with countries such as Hong Kong and Taiwan, Province of China. Studies have found that as backward participation increases, exchange rate pass-through and trade elasticities decline (Koopman et al. (2010)). For instance, in a partial equilibrium simulation Riad et. al. (2012) find that a downstream position in GVCs, or a higher share of imported foreign inputs in exports, cushions the impact of relative price changes on exports and imports. This is due to the foreign content in a downstream country's exports, which mitigates the impact of exchange rate changes, given that an appreciation lowers exports but it also implies cheaper imports. Similar findings were reported for Belgium (Amiti et al. (2014)), Switzerland (Fauceglia et al. (2014)) and the US (Powers and Riker (2013)). Cheng et al. (2015) find that this effect is large, so much so that that a real appreciation (depreciation) could increase (decrease) the GVC-related exports for countries with high foreign-value added contents in their exports.

This study provides additional evidence, using Singapore and the heterogeneity of its export products as a case study, on how integration in GVCs affects trade elasticities. Consistent with IMF (2015), we find that at the product level, more upstream export products with a higher domestic value-added share tend to be more price elastic. As highlighted in IMF (2015), this

[3] We use position in GVCs and foreign value added in exports interchangeably in the paper.

[4] A recent work by Ahmed, Appendino and Ruta (2015) assess the implications of GVC participation on the price elasticities of trade. They find that the rise of GVC participation explains on average 40 percent of the fall in the price elasticity from 1996–2012.

could reflect the dampened impact of exchange rate adjustments on downstream exports due to their high import content.

We also explore whether the complexity of export products has an effect on price and demand elasticities. We find that economic complexity is related to export price elasticities: higher economic complexity is associated with lower price elasticity of exports. This is intuitive given the potentially higher market power enjoyed by producers of highly sophisticated products. This relationship is stronger within certain product segments such as pharmaceuticals.[5] The next section of this paper provides an overview of the structure and composition of Singapore's external trade. The consequent sections discuss the empirical strategy for estimating trade elasticities and results.

II. Structure and Role of Singapore's External Trade

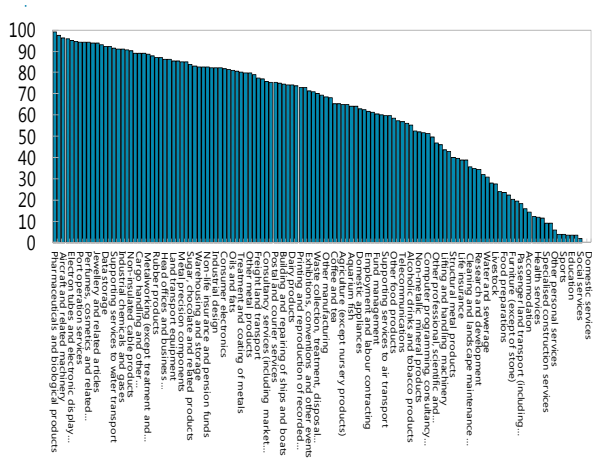
A. External Trade and Economic Structure.

Singapore is a highly export oriented economy. Although net exports have declined from 30.8 percent of GDP before the global financial crisis to 24.4 percent of GDP in2014, they are still one of the highest in the world. The export orientation of Singapore's economy can also be seen at the industry level. For instance, about 70 percent of all industries which produce 67 percent of Singapore's total output are export-oriented (Figure 1).[6] Singapore's output and exports are also highly dependent on imports. Most industries have a significant import input share, with the most import-intensive sector being the petroleum products industry (Figure 2). There is also a clear relationship between export orientation and import intensity at the industry level that becomes more significant for industries with an export share of output more than fifty percent (Figure 3). Looking at the relationship between export orientation and the share of labor compensation in value added, there also seems to be a negative relationship, with more export-oriented sectors having a lower labor share in value-added (Figure 4).

[5] Other studies have looked at the role of supply constraints in affecting trade elasticities. See Tulin and Raissi (2015) and Anand et al. (2015) for an application to India and South Africa respectively.

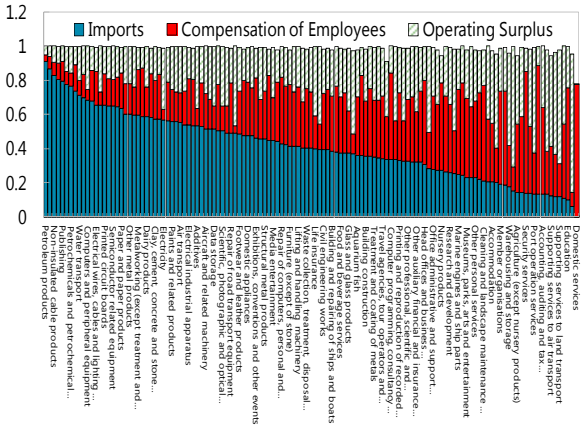
[6] Industries are classified as export-oriented when exports constituted more than 50 percent of final output. The calculations are based on Singapore's 2010 Input-Output Tables.

Figure1. Exports as Percent of Total Output by Industry
(percent)



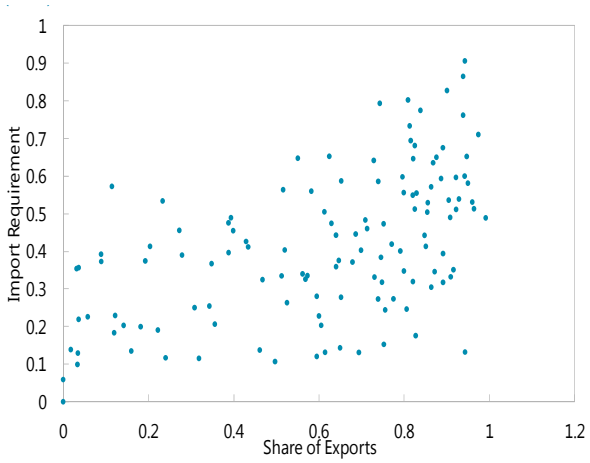
Sources: SingStat, Singapore 2010 Input-Output Tables

Figure2. Share of Value-added by Primary Inputs
(share)



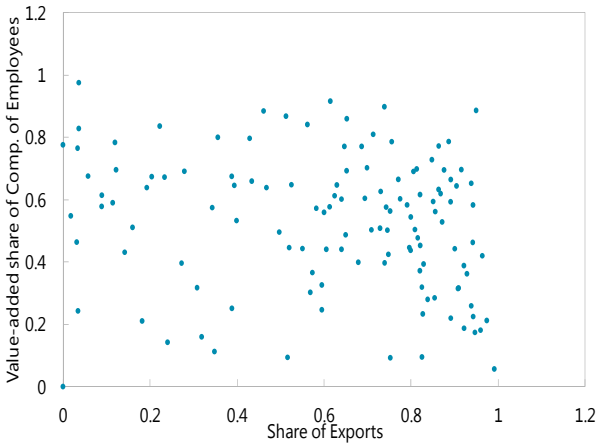
Sources: SingStat, Singapore 2010 Input-Output Tables

Figure3. Import Intensity and Export Orientation of Sectors
(share)



Sources: SingStat, Singapore 2010 Input-Output Tables

Figure4. Share of Employee Compensation and Export Orientation
(share)



Sources: SingStat, Singapore 2010 Input-Output Tables

Most export industries in Singapore have a relatively low value-added share of exports (i.e. large import content), but there is some heterogeneity across sectors (Figure 5). Unsurprisingly, petroleum products sector stands out in terms of its low value-added content, reflecting the high value of imported crude oil relative to the refining and processing that takes place in Singapore. Sectors with relatively high value added are mainly services sectors, which is also intuitive. However, there are some service sectors such as water transport that have a low value-added share, reflecting the reliance of the sector on imported petroleum products as input.

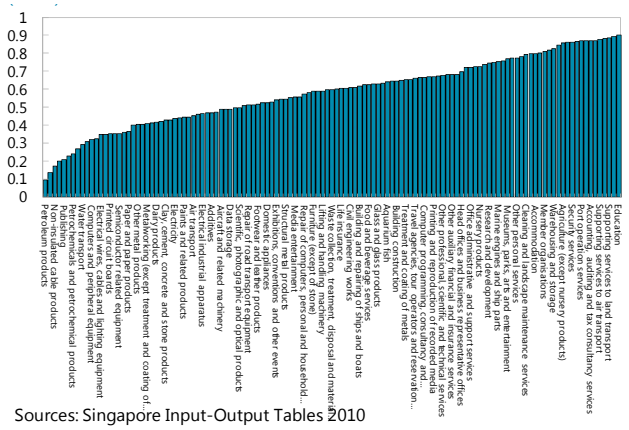
Singapore's exports of computers and electrical products also have relatively low value-added shares, reflecting Singapore's upstream position in global value chains.

B. Composition of Trade.

Singapore's exports have been dominated by the machinery and mechanical appliances, electrical machinery and equipment and mineral fuels and oils sectors (Figure 6). Over time, the share of organic chemicals, pharmaceuticals, plastics and measuring and checking, precision, medical or surgical instruments sectors have also increased.

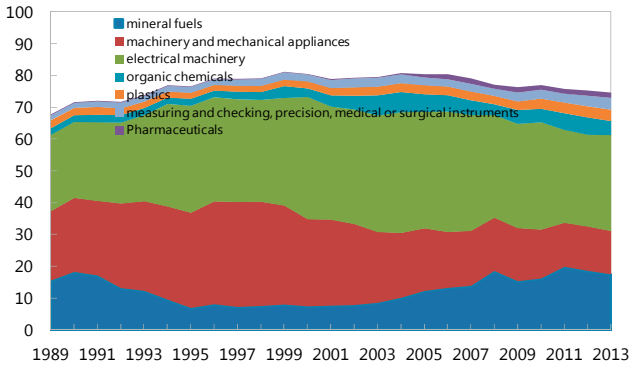
Important changes have taken place over time in the share of individual products under machinery and mechanical appliances and electrical machinery. For instance the share of computers in Singapore's gross goods exports declined from 14.1 percent in2000 to 2.4 percent in2013. Integrated circuits gained significant share in the1990 s, reached about20 percent of total goods exports in the early2000 s, and have remained an important export product since then. On the other hand, the export shares of radio receivers, monitors and projectors and related parts have declined since the1990 s. The composition of imports closely follows that of exports (Figure 7). Singapore's input-output tables confirm that a large share of imports is intermediate goods mainly imported by export-oriented sectors.

Figure 5. Value-added Share of Exports for Different Industries
(share)



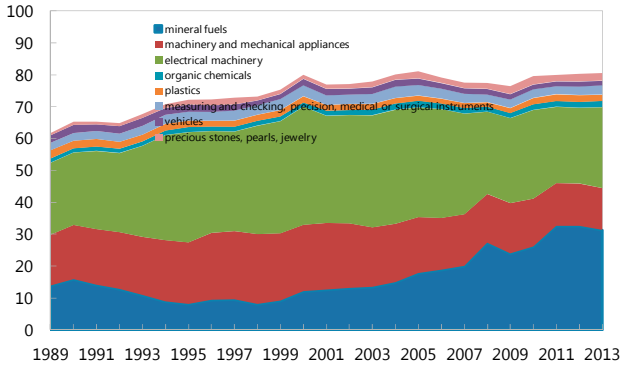
Sources: Singapore Input-Output Tables 2010

Figure 6. Composition of Singapore's Gross Goods Exports by Major Product Groups
(percent)



Sources: UN Comtrade Database and IMF staff calculations.

Figure 7. Composition of Singapore's Gross Goods Imports by Major Product Groups
(percent)

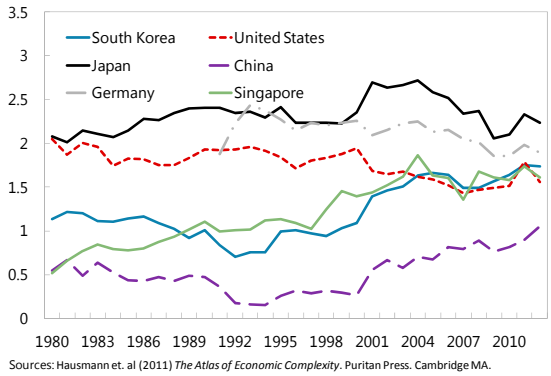


Sources: UN Comtrade Database and IMF staff calculations.

C. Economic Complexity.

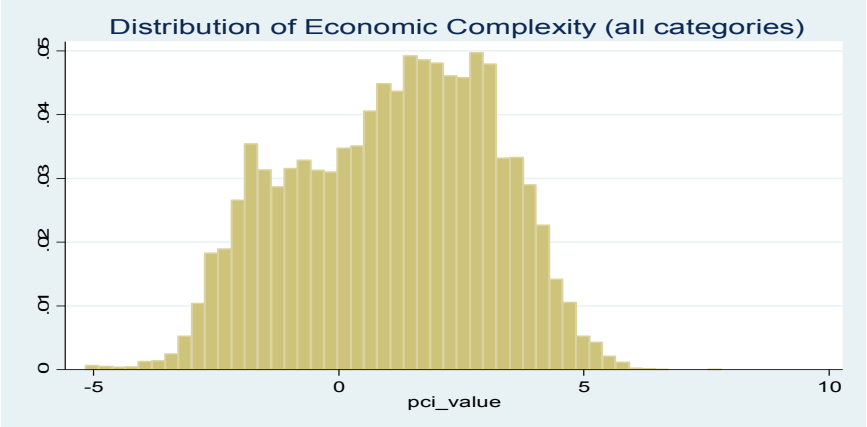
The notion of complexity of goods and services, originally described in Hidalgo and Hausmann (2009), is helpful in capturing the diversity and sophistication of a country's exports. Product complexity is captured by the fewness of the number of countries that export the product and the diversity of those countries' exports. If a product is produced by a small number of countries and if those countries have a diverse export product mix, the economic complexity of the product is measured to be higher. Economic complexity of Singapore is among the highest in the world and has increased steadily up until the mid-2000s, but has remained relatively flat since then (Figure 8). Although Singapore's export products have a high level of average complexity, there is significant variation across its export products (Figure 9).

Figure 8. Index of Economic Complexity–Selected Countries *(level)*



Sources: Hausmann et. al (2011) *The Atlas of Economic Complexity*. Puritan Press. Cambridge MA.

Figure 9. Distribution of Economic Complexity by Export Products



III. Export Elasticities

We estimate trade elasticities for export volumes using data from the UN Comtrade Database for about 1180 individual products for the 1989 –2013 period. We estimate the following specifications for export volumes using the Mean Group estimator of Pesaran and Smith (1995), allowing for product-specific fixed effects and price and demand elasticities.

$$\exp_{i,t} = c_{1,i} + \beta_i rp_{i,t} + \gamma_i y_{i,t}^{TP} + e_{i,t}$$

Where $\exp_{i,t}$ is the export volume for individual products at the level of 6-digit HS codes. The relative price variable is calculated as Singapore's export price divided by the average global import price of the same product that year. Each 6-digit price is calculated by dividing the total trade value (in USD) by total quantity[7].[8] Foreign demand ($y_{i,t}^{TP}$) is calculated as a weighted average of demand by Singapore's trading partners, whereby the weights are based on the share of Singapore's exports to different trading partners at the HS 2-digit product group level. Trading partners' demand is estimated by total imports of the country in U.S. dollars, divided by the U.S. GDP Deflator. All variables enter in log form.

In the second stage of our analysis, we explore how different product or industry characteristics affect export elasticities using interaction terms with relative price and demand variables and a fixed-effects panel regression model.

$$\exp_{i,t} = c_{1,i} + \beta rp_{i,t} + \gamma y_{i,t}^{TP} + \delta(IV_{i,t} * rp_{i,t}) + \theta(IV_{i,t} * y_{i,t}^{TP}) + e_{i,t}$$

We explore two factors: 1) value-added in exports and the global supply chains and 2) economic complexity, through interaction terms with relative price and demand variables ($IV_{i,t}$). To explore the role of domestic value added we link sector-specific information on the domestic value content of Singapore's exports from input-output tables to different export products, allowing us to have a product-specific measure of the domestic value-added content.[9][10] The economic complexity index described earlier is available for individual products at the HS 4-digit level for1995 –2012. We use this data to match Singapore's export products with economic complexity.[11]

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[7] Changes over time and across countries in the units used to measure volumes for a given product could be problematic for our measure of relative export prices. Conducting a scan of the products exported by Singapore (at the 6-digit level) we observe that over time the volume units are broadly fixed. Potential differences across countries are harder to tackle and could add noise to our measure of relative prices. We take comfort in the fact that this measurement error is not likely to be correlated with other economic indicators and hence would not bias our results.

[8] In other studies, the relative export price or the real effective exchange rate for individual product groups is estimated by using domestic export price multiplied by the nominal effective exchange rate and divided by the domestic price of the product in trading partners. The ability to match sector specific prices across trading partners has proven to be complicated, depending on the product group and data availability. This measure of relative price has the advantage of being product-specific at a much detailed level of disaggregation and capture Singapore's export price relative to its competitors.

[9] We match industries in Singapore's input-output tables with the HS 4-digit level product codes that are provided as part of the input-output tables. When there is a match between a certain product code and multiple input-output industry codes, we use a weighted average of the input-output industries with the exports of that industry used as weights.

[10] Another important caveat related to these measures of GVC integration is the fact that we use the Input-Output Tables for 2010 only and therefore do not account for potential changes over time in the extent to which a certain product is used in exports and the import content of exports.

[11] As mentioned earlier, the complexity index for individual products is available at the HS 4-digit level for 1995–2012, which allows us to match Singapore's export products with the index of complexity. We assume

(continued…)

IV. RESULTS

Baseline results and heterogeneity in export elasticities. Table1 presents estimates of export elasticities for Singapore. The average relative price and demand elasticities of Singapore's exports are estimated at -0.24 and 0.68 respectively, showing that export volumes are affected by changes in both relative prices and foreign demand. The estimates at the broad product groups show that there is significant variation (Figure 10). The price elasticity varies between 0 and -0.8, while the demand elasticity varies between 0 and 2.5.The distribution of both elasticities is in line with what we would expect.

Categories at HS 2-digit level that exhibit low price elasticity (in absolute terms) are the categories that involve sophisticated technology (for instance, man-made staple fibre, vegetable fibre and arms and ammunition). On the other hand, categories that exhibit high price elasticity are more labor-intensive, commodity products such as furniture, beddings, mattresses and live animals. Food related items were among the top 3 categories that show the highest demand elasticity such as miscellaneous edible preparations, beverages and preparation for meat. Some examples of the categories that exhibited low income elasticities are commodity goods, such as cork and woods.

Table1 a. Export Elasticities

	Mean-Group Estimator	Fixed-Effects
VARIABLES	log_export_volume	log_export_volume
log_relativeprice	-0.342***	-0.237***
	(0.007)	(0.004)
log_foreign_demand	0.602***	0.680***
	(0.015)	(0.010)
Constant	2.449***	1.615***
	(0.314)	(0.214)
Observations	93,280	93,494
R-squared		0.408

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table1 b. Export Elasticities

	Mean-Group Estimator	Machinery, computers	Electrical machinery Telecommunications equip.
VARIABLES		log(export volume)	log(export volume)
log_relativeprice		-0.448***	-0.553***
		(0.02)	(0.03)
log_foreign_demand		0.297***	0.661***
		(0.06)	(0.05)
Constant		5.352***	-0.612
		(1.31)	(1.00)
Observations		9,881	4,389
R-squared			0.617

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

that all 6-digit products under the same 4-digit product code have the same complexity. For years that we do not have the product-level economic complexity index we assume that it is the same as the closest available year.

Figure 10. Distribution of Export Elasticities

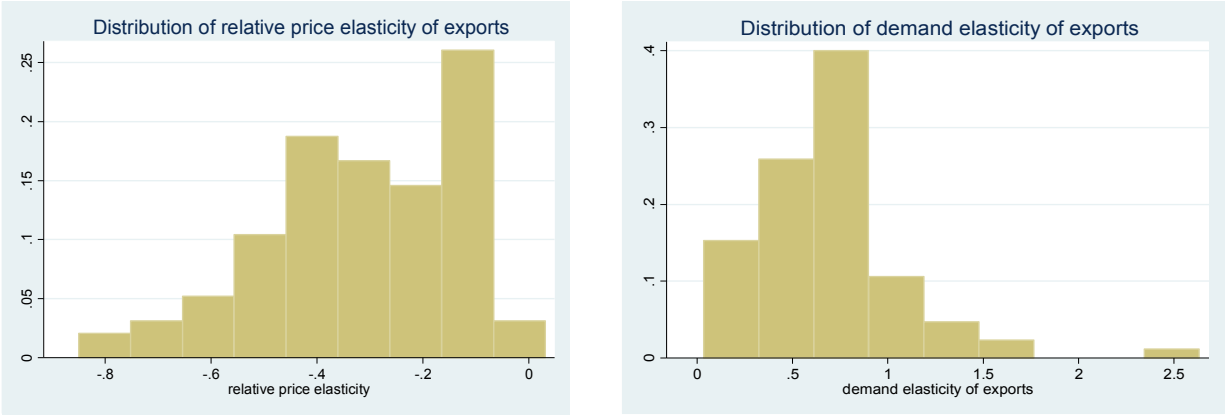
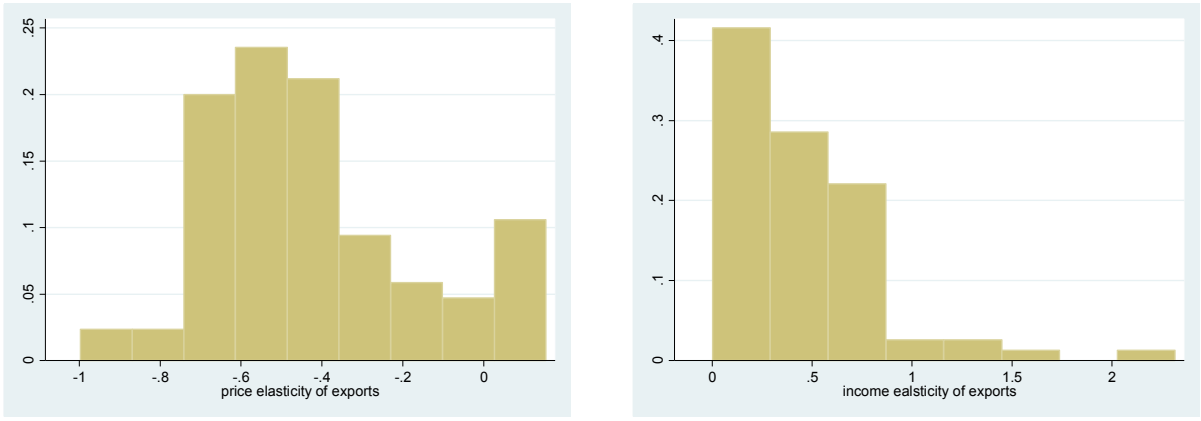


Table 1 also shows the estimates for two important export product groups for Singapore: HS 2-digit product category 84, related to machinery, mechanical appliances and computers and HS 2-digit category 85, related to electrical machinery, equipments and telecommunications equipments. Both sectors have higher price elasticity than the average reported in Table 1, but the demand elasticity of machinery and computers sector is lower than the average.[12]

Within these two sectors, the variance of trade elasticities is also quite substantial. This is relevant given the importance of these two sectors in Singapore's exports and the fact that broad product group averages can hide important product-level heterogeneity. The following charts show within category 84, the variation of price and income elasticities of 4-digit sub-sectors (Figure 11). The most important 4-digit subsector of category 84 is computers (HS category 8471), which constituted 2.4 percent of Singapore's total goods exports in 2013 (only third to refined petroleum and integrated circuits). This category shows a low price elasticity of -0.05 and a large income elasticity of 0.7.

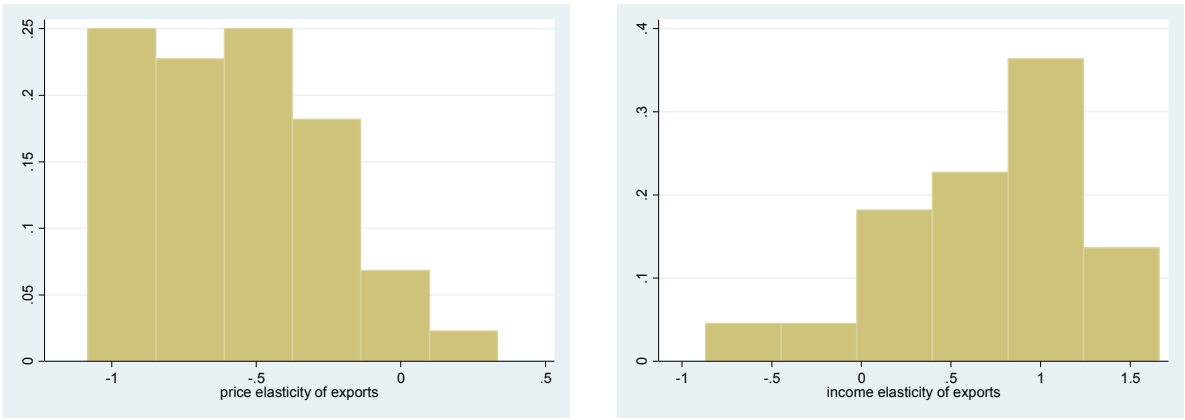
[12] The Mean Group Estimator (Pesaran and Smith (1995)) assumes cross-sectional independence of error terms. It is possible to relax this assumption by using the common correlated effects mean group (CCEMG) estimator (Pesaran (2006)). Alternatively, one can include trend in each group to estimate the elasticities. Our results based on CCEMG and including trend suggest that the estimates of price and demand elasticities remain reasonably close to the baseline results in Table 1. Export price elasticities for all sectors range from -0.285 to -0.313 with statistical significance. For the two selected sectors, the price elasticity ranges from -0.23 to -0.45 for category 84, while the elasticity ranges from -0.49 to -0.55 for the category 85. The coefficients also look close to the fixed-effect regressions with product category and time fixed effects: for the overall sectors, price elasticity -0.237 with statistical significance. For category 84, the price elasticity using the fixed-effects is -0.487and for category 85, -0.477.

Figure 11. Distribution of Price and Income Elasticities within Category HS 84



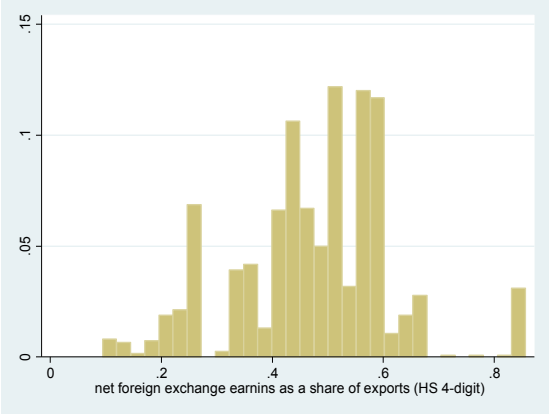
The following two charts reveal the variation of export elasticities for electrical machinery, equipments and telecommunication equipments sector (Figure 12). Integrated circuits (category 8542), which has accounted for20 percent of the SGP's total goods exports in 2013, shows an income elasticity of 0.89 and a price elasticity of -0.49.

Figure 12. Distribution of Price and Income Elasticities within Category HS 85



Explaining Export Elasticities. In this section we explore the relationship between export elasticities and product/industry characteristics. We first consider the impact of value-added in exports. As discussed earlier, Singapore's exports typically have high import content. However, there exists substantial heterogeneity in the import intensity, as shown in Figure 13 (at HS 4-digit level), which shows the share of domestic value-added in exports. The higher domestic valued-added or lower import content an exported product has, one can conjecture a higher sensitivity of export volume to changes in relative price.

Figure 13. Distribution of Domestic Value-added Share of Exports by Product



The regression results reported in Table 2 uses the domestic value-added share of different products, which we obtain by matching products with industry characteristics in Singapore's input-output tables, as an interaction variable. Consistent with our expectations, the higher is the domestic value-added share of exports, the higher is the absolute value of the price elasticity of exports. The impact of domestic value added share on demand elasticity is negative, indicating that products with higher domestic value added also demonstrate lower demand elasticity.

Table 2. Effect of Domestic Value-added Share on Export Elasticities

VARIABLES	log (export volume)
log_relativeprice	-0.179***
	(0.0249)
log_foreign_demand	0.262***
	(0.0221)
log_relativeprice*log_domestic value added	-0.0841*
	(0.0472)
log_foreigndemand*log_domestic value added	-0.122***
	(0.0170)
Constant	12.14***
	(0.450)
Observations	67,059
R-squared	0.404

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Given the importance of industries with high economic complexity in SGP's trade, we then assess the relationship between economic complexity and export elasticities. Table 3 below shows estimates of baseline regressions for export volumes, where we interact relative price and demand with the economic complexity index. The estimated coefficients are small, showing a limited impact of economic complexity on elasticities. For instance, based on the estimated coefficient, the difference in terms of export price elasticity between the most and the least complex product is about 0.1. When we look at how complexity is related to trade elasticities within individual product groups, we find a significant and large effect on price

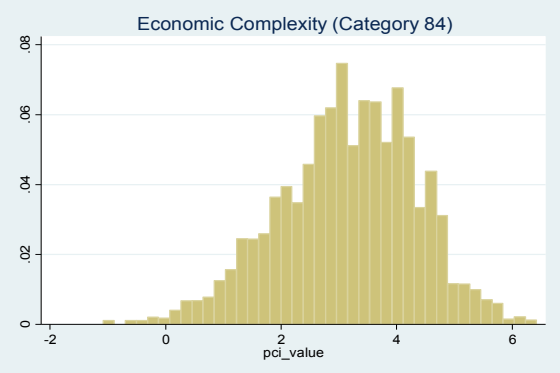
elasticities. It is important to look at the sensitivity of trade elasticities within individual groups because Singapore's trade is concentrated in a few major product groups and there is significant product heterogeneity within those product segments (Figure 14). For instance, within the pharmaceuticals groups, price elasticities decline with product complexity, consistent with our priors (Table 4). This relationship is somewhat weaker for the other three product groups. The relationship between complexity and demand elasticities is pretty small within individual product groups.

Table 3. Effect of Economic Complexity on Export Elasticities

VARIABLES	log (export volume)
log_relativeprice	-0.204***
	(0.00692)
log_foreign_demand	0.193***
	(0.0207)
log_relativeprice* complexity	-0.00811***
	(0.00246)
log_foreigndemand* complexity	-0.00786***
	(0.000914)
Constant	12.61***
	(0.451)
Observations	67,059
R-squared	0.403

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 14. Distribution of Complexity Index within Individual Product Groups



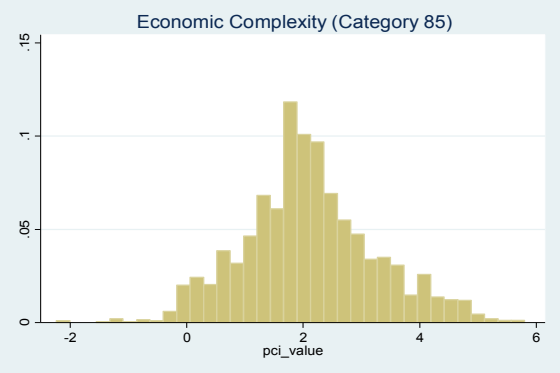


Table 4. Effect of Economic Complexity on Export Elasticities for Major Product Groups

VARIABLES	Machinery, computers log(export volume)	Electrical machinery Telecomm. equip. log(export volume)	Organic chemicals log(export volume)	Pharmaceuticals log(export volume)
log_relativeprice	-0.513***	-0.510***	-0.187***	-0.656***
	(0.0122)	(0.0196)	(0.0167)	(0.165)
log_foreign_demand	-0.933***	0.169***	0.639***	0.0996*
	(0.136)	(0.0595)	(0.0195)	(0.0573)
log_relativeprice* complexity	0.00781**	0.0176**	0.0235***	0.135**
	(0.00353)	(0.00718)	(0.00556)	(0.0541)
log_foreign_demand* complexity	0.00406**	0.00638**	0.00503***	0.0420**
	(0.00171)	(0.00280)	(0.00187)	(0.0171)
Constant	32.14***	10.87***	2.983***	10.46***
	(3.059)	(1.332)	(0.420)	(0.840)
Observations	7,269	3,195	4,502	226
R-squared	0.874	0.918	0.974	0.942

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Finally, we tried a specification which includes both GVC integration and economic complexity as interaction terms with foreign demand and relative prices. Estimated coefficients for both GVC integration and complexity are similar to the earlier results looking at their impact one at a time. The higher coefficient of GVC integration implies that GVC integration better explains the cross-sectional variation in Singapore's export elasticities.

Table 5. Effect of Domestic Value-added Share and Economic Complexity on Export Elasticities

VARIABLES	Log (export_volume)
log_relativeprice	-0.159***
	(0.025)
log_foreign_demand	0.268***
	(0.031)
log_relativeprice*log_domestic value added	-0.083*
	(0.049)
log_foreigndemand*log_domestic value added	-0.121***
	(0.017)
log_relativeprice* complexity	-0.009***
	(0.003)
log_foreigndemand* complexity	-0.008***
	(0.001)
Constant	12.107***
	(0.656)
Observations	66,904
R-squared	0.409

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

V. CONCLUSIONS

In this paper we study the role of growing participation in GVCs and of rising complexity in Singapore's external trade. As emphasized in previous studies, value-added in exports plays an important role in trade elasticities. We find evidence that this is indeed the case for

Singapore's export products using highly disaggregated product-level data. Products that have a higher domestic value-added share also tend to have higher export price elasticities. Economic complexity also matters for the size of Singapore's export price elasticities, where higher economic complexity is associated with lower price elasticity of exports. Compared to the domestic value-added share, economic complexity seems to matter less in explaining the cross-sectional variation in export elasticities, but economic complexity and export elasticities seem to have a stronger relationship within certain product segments such as the machinery, mechanical appliances and computers as well as the pharmaceuticals. We find that there is important product heterogeneity with respect to export elasticities; both across different product groups but also within individual product groups. This implies that structural changes in the product composition of trade can lead to sizable changes in Singapore's trade elasticities. Export elasticities are important to understand the transmission of Singapore's exchange rate-based monetary policy. Our results show that Singapore's downstream position in GVCs has indeed had a dampening effect on its price elasticities, requiring a higher relative price adjustment to achieve a given volume effect.

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