RIETI Discussion Paper Series 18-E-061

Export Sophistication and Trade Elasticities

Willem THORBECKE
RIETI

Nimesh SALIKE
Xi'an Jiaotong-Liverpool University

RIETI
Research Institute of Economy, Trade & Industry, IAA
The Research Institute of Economy, Trade and Industry
https://www.rieti.go.jp/en/

RIETI Discussion Paper Series 18-E-061

September 2018

Export Sophistication and Trade Elasticities*

Willem THORBECKE†

RIETI

Nimesh SALIKEϒ

Xi'an Jiaotong-Liverpool University

Abstract

Does a country's export structure impact the way that exchange rates affect trade? Do more sophisticated products exhibit lower demand elasticities? Using panel data for major exporters over the 1992-2016 period and dynamic ordinary least squares techniques, we find that price elasticities are higher for low-technology goods such as textiles and footwear than for high-technology goods such as pharmaceuticals and medical equipment. We also find that elasticities are larger for less advanced countries such as China than for more advanced countries such as Switzerland. We draw policy implications from these findings for countries exposed to safe haven capital flows, for countries facing long-term appreciation pressures, and for countries that specialize in low-technology exports.

Keywords: Exchange rate elasticities; Export sophistication

JEL classification: F14, F10

*This study is conducted as a part of the project "East Asian Production Networks, Trade, Exchange Rates, and Global Imbalances" undertaken at Research Institute of Economy, Trade and Industry (RIETI). This research is supported by the JSPS Grants-in-Aid for Scientific Research (B, 17H02532). Any errors are our own responsibility. **Acknowledgments:** We thank Dario Diodato, Andres Gomez, Matté Hartog, Keiichiro Kobayashi, Masayuki Morikawa, Atsushi Nakajima, Frank Neffke, Sultan Orazbayev, Andre Ribeiro, Makoto Yano, Fernando Yu, and other colleagues for helpful suggestions.

† Senior Fellow, Research Institute of Economy, Trade and Industry. 1-3-1 Kasumigaseki, Chiyoda-ku Tokyo, 100-8901 Japan Tel.: + 81-3-3501-0230; Fax: +81-3-3501-8414; E-mail: willem-thorbecke@rieti.go.jp

ϒ International Business School Suzhou Xi'an Jiaotong – Liverpool University 111 Ren'ai Road, Dushu Lake Higher Education Town, Suzhou, China Tel.: + 86-512-8816-1700 Fax: + +86-512-8816-1899. E-mail: Nimesh.Salike@xjtlu.edu.cn

1 Introduction

Exchange rate changes, protectionism, and other factors impact export prices and cause dislocation. For instance, between 1985 and 1995 and again between 2007 and 2010 the Japanese yen soared and decimated exports. Similarly, before the Asia Crisis overvalued exchange rates reduced price competitiveness and led to current account deficits in Indonesia, Malaysia, the Philippines, South Korea, and Thailand that equaled 4-5 percent of GDP between 1995 and 1997. How can countries insulate themselves from these effects? One way may be to progress technologically. More sophisticated products may exhibit lower demand elasticities. This is because more advanced goods may be valued more by buyers, making them less sensitive to price fluctuations in their buying decisions. If so, this means that producers of technologically advanced products have greater market power.

Arbatli and Hong (2016) investigated the relationship between product sophistication and exports from Singapore. They calculated product sophistication using the methods of Hidalgo and Hausmann (2009). They estimated export functions with product-specific fixed effects using the Mean Group estimator of Pesaran and Smith (1995) and annual data over the 1989-2013 period. They found that highly sophisticated goods such as pharmaceuticals have lower price elasticities.

Several studies have investigated whether elasticities of demand are lower for Swiss exports of advanced products. The IMF (2013, p. 18) stated that Swiss "…exporting industries may be built around production of very specific items, which are particularly valued for their brands or special characteristics and hence face limited price competition." Grossmann, Lein, and Schmidt (2016) estimated trade elasticities for Swiss exports using error correction techniques and panel data over the 1989Q1- 2014Q4 period and reported that exchange rate elasticities are smaller for sophisticated sectors such as pharmaceuticals, chemicals, and precision instruments than they are for sectors where many nations compete such as textiles, clothes, and leather. Auer and Sauré (2011) estimated exchange rate elasticities for bilateral exports between OECD countries using a gravity model and annual data between 1972 and 2000 and found that exchange rate responses are smaller for Swiss exports of high quality products such as centrifuges and milling machines than for exports of competitive products such as clothing and fish fillets. Thorbecke and Kato (2018) used panel dynamic ordinary least squares techniques and annual data over the 1989-2014 period and reported that exchange rate changes do not affect the volume of exports from Switzerland's most advanced sectors, pharmaceuticals and watches, but matter for exports of medium-high-technology products such as capital goods and machinery.

Chen and Juvenal (2016) demonstrated theoretically that the elasticity of demand facing exporters decreases with quality. This implies that there will be more pricing to market and smaller exchange rate elasticities for higher quality goods. They tested these implications using data on disaggregated Argentinean wine exports and experts' wine ratings to measure quality. For higher quality wines exported to high-income countries, they reported that a real depreciation causes firms to increase their markups more and their export volumes less.

On the other hand, Héricourt, Martin, and Orefice (2014) investigated whether high-end French exports are less sensitive to exchange rate changes. They used annual panel data over the 1995-2010 period and measured the quality of products using export unit values. They did not find that higher-end exports are less sensitive to exchange rates than other exports.

These studies examined the relationship between product sophistication and export elasticities for individual countries. We seek to fill a gap in the literature by examining the relationship between product sophistication and exchange rate elasticities for a panel of countries. Our goal is thus to focus on elasticities for products across countries. The results indicate that appreciations lead to large decreases in exports for low-technology goods such as textiles and apparel, footwear, and wood products but not for high-technology goods such as pharmaceuticals and medical equipment. Certain higher technology categories such as motor vehicles, however, remain exposed to appreciations.

We also examine the relationship between the sophistication of a country's overall export basket and its sensitivity to exchange rates. We report that exports from countries at the technological frontier such as Switzerland are not exposed to exchange rate appreciations whereas exports from less advanced countries such as China are very sensitive to appreciations

The next section investigates the relationship between product sophistication and price elasticities. Section 3 studies the relationship between country sophistication and price elasticities. Section 4 concludes.

2 PRODUCT SOPHISTICATION AND EXCHANGE RATE ELASTICITIES

2.1 Data and Methodology

To measure product sophistication we use the OECD's classifications. The OECD determines technology levels based on the ratio of R&D spending to value-added (see Hatzichronoglou, 1997). They assign goods into four categories: high technology (HT), medium high technology (MHT), medium low technology (MLT), or low technology (LT).

For each good in the four categories, we choose the four leading exporting countries and examine their exports to major importing countries.[1] We avoid countries that did not trade much with each other over part of the sample period, because these countries can have large percentage

[1] Flows of electronics goods such as computer, semiconductors, and cellphones have proven difficult to model (Gruber, McCallum, and Vigfusson, 2016). Cellphones and semiconductors have proven especially difficult because so much of the value-added comes from imported parts and components (see, e.g., Carton, Mongardini, and Li, 2018, and Cheung, Chinn, and Qian, 2012). We thus exclude cellphones and semiconductors from our estimation.

changes in trade due to idiosyncratic factors such as a trading company opening up a new branch in the country rather than due to the macroeconomic variables such as real exchange rates and real income. We find that using four exporting countries enables us to focus on trade driven by macroeconomic fundamentals rather than noise. [2]

We employ standard export functions, with exports depending on the real exchange rate and foreign income:

$$ex_t = \alpha_1 + \alpha_2 rer_t + \alpha_3 y_t^* + \varepsilon_t , \qquad (1)$$

where ex_t represents real exports, rer_t represents the real exchange rate, and y_t^* represents real foreign income.

Data on exports are measured in U.S. dollars and obtained from the CEPII-CHELEM database. For each product category, we deflate exports using trade price data for the corresponding category obtained from the U.S. Bureau of Labor Statistics (BLS). For example, we deflate Japanese motor vehicle exports measured in U.S. dollars by the U.S. import price deflator for motor vehicles. Trade prices from the BLS are available beginning in 1992 and the CEPII-CHELEM database extends to 2016. Our sample period thus stretches from 1992 to 2016.

Annual data on bilateral real exchange rates between the exporting and importing countries and real GDP in the importing countries are also obtained from the CEPII-CHELEM database. An increase in the real exchange rate represents an appreciation of the exporting country's currency.

Annual data on bilateral real exchange rates between the exporting and importing countries and real GDP in the importing countries are also obtained from the CEPII-CHELEM

[2] The major exporting countries for each commodity are listed in Table 1. We exclude China in many cases because its exports early in the sample period were small. The list of major importers for each exporting country is available on request.

database. An increase in the real exchange rate represents an appreciation of the exporting country's currency.

We perform a battery of panel unit root tests and Kao (1999) cointegration tests on the variables. The results often provide evidence of cointegrating relations among the variables. Therefore we employ the Mark-Sul weighted DOLS technique. This is a fairly robust estimator (see, e.g., Kao and Chiang, 2000, and Wagner and Hlouskova, 2010). To estimate equation (1) the model takes the form:

$$ex_{i,j,t} = \beta_0 + \beta_1 rer_{i,j,t} + \beta_2 y_{j,t}^{*} + \sum_{k=-p}^{p} \alpha_{1,j,k} \Delta rer_{i,j,t-k} + \sum_{k=-p}^{p} \alpha_{2,j,k} \Delta y_{j,t-k}^{*} + u_{i,j,t}, \qquad (2)$$
$$t = 1, \cdots, T; \qquad j = 1, \cdots, N.$$

where $ex_{i,j,t}$ represents real exports from country i to country j at time t, $rer_{i,j,t}$ represents the bilateral real exchange rate between country i and country j, and $y_{j,t}$ represents real GDP in country j.

Cross-section specific lags and leads of the first differenced regressors are included to asymptotically remove endogeneity and serial correlation.[3] A sandwich estimator is employed to allow for heterogeneity in the long-run residual variances. Country-pair fixed effects and country-pair time trends are included.

2.2 Results

Table 1a presents the results for low-technology exports, Table 1b for medium low-technology exports, Table 1c for medium high-technology exports, and Table 1d for high-technology exports. The model performs well, with almost all of the exchange rate and GDP coefficients of the expected signs and statistically significant. Only pharmaceutical exports do not have a statistically significant exchange rate coefficient. As Sauré (2015) noted, pharmaceutical

[3]One lag and one lead is included.

products are often essential and covered by employees' health insurance. Thus, the price elasticity of demand for these goods should be low. The exchange rate coefficient on computers is statistically significant but of the wrong sign. Previous researchers have found it difficult to explain trade in computers using exchange rates (see, e.g., Gruber, McCallum, and Vigfusson, 2016). One reason for this is that much of the value-added for computers comes from imported parts and components.

Figure 1 shows that less sophisticated exports tend to be more exposed to exchange rates. The exchange rate elasticities average -0.76 for low-technology exports, -0.38 for medium low-technology exports, -0.36 for medium high-technology exports, and 0.04 for high-technology exports.

Furniture exports in Table 1b and motor vehicle exports in Table 1c are more sensitive to exchange rates than other products in their categories. These high price elasticities could reflect the fact that these industries are competitive, with many close substitutes from different countries.

Figure 2 shows that the income elasticities tend to be larger for higher-technology items. This could reflect the fact that, as countries become wealthier, they purchase more advanced, cutting-edge products.

The important implication of these findings is that low-technology products such as textiles and apparel, footwear, and wood have high price elasticities. Exchange rate appreciations can thus deter exports of these products. On the other hand, appreciations would reduce exports of high-technology products such as pharmaceuticals and medical equipment only a little, if at all. For medium-technology exports, exchange rate appreciations would deter exports for motor vehicles and furniture. These high price elasticities probably arise because the markets for motor vehicles and furniture are very competitive with lots of substitutes available from different countries.

3 COUNTRY SOPHISTICATION AND EXCHANGE RATE ELASTICITIES

3.1 Data and Methodology

We again employ standard export functions to estimate aggregate trade elasticities. We focus on the leading exporters of manufacturing goods and examine their exports to importers over the 1992-2016 period. Minor importers are excluded because they can have large percentage changes in imports due to idiosyncratic factors.

Data on manufacturing exports come from the CEPII-CHELEM database. The export data are measured in U.S. dollars. Since exports from other countries represent imports by the U.S., they are deflated using the corresponding price deflators obtained from the U.S. Bureau of Labor Statistics. For example, exports from Japan are deflated using the price deflator for Japanese exports, exports from South Korea are deflated using the price deflator for the Asian Newly Industrialized Countries, exports from Malaysia are deflated using the price deflator for ASEAN countries, exports from Europe using the price deflator for European manufacturing exports, and so on. Data on bilateral real exchange rates between the exporting and importing countries and real GDP in the importing countries are obtained from the CEPII-CHELEM database.

Our focus is on the largest exporters of manufactured goods. We begin with Belgium, Canada, China, France, Germany, Italy, Japan, Malaysia, Mexico, the Netherlands, South Korea, Spain, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. Mexico and Canada's exports flow disproportionately to the U.S. Belgium, the Netherlands, and Spain's exports flow disproportionately to other Eurozone countries. This limits the cross-sectional variation in exchange rates for these five countries and makes it difficult to identify (in an econometric sense) the effect of exchange rates on exports. We thus exclude these countries from the estimation.

A battery of panel unit root tests and Kao and Pedroni cointegration tests indicate in most cases that there are cointegrating relations among the variables. We thus again use the Mark-Sul weighted DOLS technique. Country-pair fixed effects and country-pair time trends are again included.

To measure the sophistication of a country's export basket, we employ the export sophistication indexes (ESI) of Kwan (2002), Lall, Weiss, and Zhang (2006), and Hausmann, Hwang, and Rodrik (2007). These indexes assume that products exported by richer countries are more technologically sophisticated. The reason for this is that wealthy countries have higher labor costs. To compete in world markets, they thus need to employ more sophisticated technological processes (see Lall *et al.*, 2006).

Kwan (2002) and Lall *et al*. (2006) calculated a product sophistication index for a product k exported by country j using the formula:

$$PSI(k) \; = \; \frac{\sum_j x(jk)Y(j)}{X(k)}, \qquad (3)$$

where PSI(k) is the product sophistication index for product k, x(jk) represent exports of product k by country j, Y(j) is real per capita gross domestic product in country j, and X(k) equals total world exports of product k. Equation (3) is a weighted average of the per capita GDPs of product k's exporters, using the countries' shares of global exports of k as weights.

Kwan (2002) then used the following formula to calculate a country's ESI:

$$ESI(j) \; = \; \frac{\sum_k x(jk)PSI(k)}{X(j)}, \qquad (4)$$

where ESI(j) is the country sophistication index for country j, x(jk) are exports of product k by country j, PSI(k) is the product sophistication index for product k, and X(j) are total exports of country j to the world. Equation (4) is thus a weighted average of the product sophistication indexes of the goods that country j exports, using the percentage of country j's total exports in each good as weights.

Hausmann *et al*. (2007) argued that equation (3) assigns too much weight to large countries. In equation (3), they proposed weighting per capita GDP by each country's revealed comparative advantage in product k. They call the resulting measure the productivity level of product k:

$$PRODY(k) = \sum_j \frac{\left(\frac{x(jk)}{X(j)}\right)}{\sum_j \left(\frac{x(jk)}{X(j)}\right)} Y(j), \qquad (5)$$

where PRODY(k) is the productivity level of good k, x(jk)/X(j) is the share of commodity k in the country's overall export basket, $\sum_j$(x(jk)/X(j)) is the sum of the value shares across all countries j exporting product k, and Y(j) is per capita GDP in country j. Equation (5) thus weighs a country's per capita GDP by the country's revealed comparative advantage in product k.

Hausmann *et al*. (2007) used PRODY to calculate a country's sophistication index:

$$ESI(j) = \frac{\sum_k x(jk) PRODY(k)}{X(j)}, \qquad (6)$$

where ESI(j) is the sophistication level associated with country j's export basket, PRODY(k) is the productivity level of good k, and the other variables are defined after equation (5).

We calculate country sophistication indexes using both Kwan's (2002) method (equations (3) and (4)) and Hausmann *et al*'s (2007) method (equations (5) and (6)). To do this, we employ exports disaggregated at the four-digit International Standard Industrial Classification (ISIC) level. The data are measured in U.S. dollars. Real per capita GDP is measured in constant US dollars. These data are obtained from the CEPII-CHELEM database.

3.2 Results

Table 2 presents the results. The columns are ordered from the country whose exports are most exposed to exchange rate appreciations to the country whose exports are least exposed. Table 2 also presents values of the export sophistication indexes.

Figures 3a and 3b plot the relationship between countries' ESI and their export elasticities. Values above the regression line indicate that exports are less responsive to exchange rates than one would predict given the country's export sophistication and values below imply the opposite.

China's exports are the most exposed to exchange rate appreciations, with a 10 percent appreciation leading to a 12.6 percent drop in exports.   China is also the country with the lowest export sophistication index in the sample, reflecting the preponderance of textiles, apparel, footwear, and other labor-intensive goods in China's export basket.

Columns (2), (3), (5), and (7) of Table 2 combined with Figure 3 indicate that Germany, South Korea, Japan, and the U.S. have larger (in absolute value) price elasticities than one would predict given their levels of technological sophistication. For Germany, the price elasticity equals -0.68; for Korea -0.66; for Japan -0.31; and for the U.S. -0.35. For Germany over the 1992-2016 sample period, 20 percent of manufacturing exports were motor vehicles (ISIC code 34); for Korea 13 percent were motor vehicles; for Japan 22 percent were motor vehicles; and for the U.S. 10 percent were motor vehicles. Not only do motor vehicles make up a large share of their export baskets, these countries' automobile exports are also sensitive to exchange rates. As shown in Table 3, the exchange rate elasticity for automobile exports from Germany equals -0.76, from Korea -1.47, from Japan -1.11, and from the U.S. -0.65. Thus one reason why aggregate elasticities are high for these countries is that their price elasticities are large for automobile exports.

Switzerland has the highest export sophistication index in Table 2 according to both measures. Over our 1992-2016 sample period, 38 percent of Switzerland's manufacturing exports were high-technology goods according to the OECD classification. This is at least 10 percentage points higher than the values for any of the G7 countries. Thus, Switzerland's export structure is an outlier relative to other developed economies. There is also no evidence in Table 2 that exchange rate appreciations affect Switzerland's aggregate exports.

Several of the export elasticities reported in Table 2 are close to those found in previous work using time series data and DOLS estimation. Cheung, Chinn, and Qian (2012), using data over the 1994Q3-2010Q4 period, reported exchange rate elasticities for China's manufacturing exports of between -0.92 and -1.50. Thorbecke and Kato (2012), using data over the 1980Q4-2011Q1 period, reported exchange rate elasticities for Germany's exports of between 0.6 and 1.0. Chinn (2013), using data over the 1990Q1-2012Q3 period, reported elasticities for Japan's exports of between 0.29 and 0.66. Thorbecke and Kato (2018), using data over the 1989Q4-2015Q3 period, found no evidence that exchange rate appreciations decrease Switzerland's aggregate exports. Thus the estimates in Table 2 are consistent with previous findings.

The GDP elasticities in Table 2 are large for China, South Korea, Malaysia, and Thailand. This reflects the fact that exports from these countries have steadily increased, as has their trading partners' GDP. This tends to inflate the measured relationship between exports and importing countries' GDP.

Figure 3 shows that countries with more sophisticated export baskets tend to be less sensitive to exchange rates. At one extreme is Switzerland, with a technologically advanced export basket and no exposure of aggregate exports to exchange rates. At the other extreme is China, with many labor-intensive exports and high sensitivity of exports to exchange rates. Technological sophistication is not the only factor that matters, however, as major exporters of automobiles such as Germany and Korea have higher (in absolute value) price elasticities than would be predicted given the technological sophistication of their exports.

4 CONCLUSION

Intuitively, one would expect more sophisticated products to exhibit lower elasticities of demand. This paper investigates whether this is so using panel data on exports and imports of different technology levels. The results indicate that high-technology goods are less exposed to exchange rate changes than lower technology goods. Similarly, the analysis on country sophistication vis-à-vis export elasticity indicates that exports from more technologically advanced countries are less sensitive to exchange rates. The findings reported have implications for many economies.

Japan and Switzerland have safe haven currencies (see, e.g., Botman, de Carvalho Filho, and Lam, 2013, and Goldberg and Krogstrup, 2018). When global risk aversion increases, their currencies tend to appreciate. For instance, between the fourth quarter of 2007 and the third quarter of 2011, when the Global Financial Crisis and the Eurozone Crisis were generating uncertainty, the Bank for International Settlements broad real effective exchange rate measures increased 22 percent for the Japanese yen and 26 percent for the Swiss franc. While these appreciations devastated the Japanese economy, investment and consumption in Switzerland continued to grow apace and the trade surplus remained large (see Klein, 2017). One reason for this differential response is that 50 percent of Switzerland's exports between 2007 and 2016 were high-technology goods, while only 21 percent of Japanese exports were high-technology goods.[4] Switzerland's leading export category over this period was pharmaceuticals, whereas Japan's leading category was motor vehicles. The results in this paper indicate that pharmaceutical exports are insensitive to exchange rates while motor vehicle exports are highly exposed. These findings suggest that Japanese exports would be more stable if its export basket contained more high-technology goods.

For countries facing long-term appreciation pressure due to growing productivity and structural current account surpluses, the results indicate that industrial upgrading is important. Low-technology exports are especially vulnerable in the long run to stronger exchange rates.

For countries whose export baskets contain primarily low-technology goods, the findings indicate that there may be benefits to weaker exchange rates. Rodrik (2008) found that undervalued exchange rates can increase economic growth. He reported that exchange-rate undervaluations tend to increase the share of the tradeable sector in total output. He also found that government or market failures in developing countries cause the tradeable sector to be inefficiently small. Thus he argued that an undervalued exchange rate that increases the size of the tradeable sector will stimulate growth. The results in this paper indicate that countries that export low-technology goods will experience higher steady-state exports if their exchange rates are weaker.

Exchange rate changes, trade policies, and other factors produce exogenous changes in trade prices. This paper reports that, in general, higher technology goods are less exposed to

[4]This figure does not include gold bars that are imported into Switzerland, processed, and then re-exported. Little of the value-added of these bars comes from Switzerland.

these factors. These findings suggest that R&D policy that promotes upgrading may be useful in helping firms and economies to maintain stability in the volatile world economy.[5]

This paper assumed that exports in the same product category from different countries are similar. Future research should investigate whether exports of products from sophisticated countries (e.g., watches from Switzerland) have lower elasticities then exports of the same products from less sophisticated countries (e.g., watches from China).

[5] However, the results also indicate that high technology goods are more exposed to drops in their trading partners' GDP. The appropriate industrial structure for each country thus depends on more than just their industries' exposures to exchange rates.

TABLE 1a

Panel dynamic OLS estimates for low-technology manufacturing exports

	(1)	(2)	(3)	(4)	(5)
	Apparel & textiles (ISIC 17, 18)	Food, beverages & tobacco (ISIC 15, 16)	Footwear (ISIC 19)	Paper & printed products (ISIC 21, 22)	Wood & wood products exc. furniture (ISIC 20)
Real Exchange Rate	-0.69*** (0.06)	-0.68*** (0.05)	-0.88*** (0.06)	-0.59*** (0.08)	-0.95*** (0.07)
GDP	1.60*** (0.10)	1.55*** (0.13)	1.54*** (0.11)	0.95*** (0.16)	2.52*** (0.19)
Cross Sections Included	84	78	84	50	77
Number of Observations	2100	1950	2094	1250	1925
S.E. of Regression	0.177	0.211	0.273	0.184	0.286
Adjusted *R*-squared	0.983	0.975	0.970	0.977	0.962
Exporting countries	France, Germany, Italy, & U.S.	China, Germany, Nether-lands, & U.S.	China, France, Germany, & Italy	Canada, Germany, Sweden, & U.S.	Canada, Germany, Indo-nesia, & U.S.

Notes: The table reports export elasticities for manufacturing exports from the four leading exporters of each product category to major importers. The products are classified as low-technology goods by the OECD. The dependent variable is the level of manufacturing exports measured in U.S. dollars and deflated using price deflators for the corresponding product obtained from the U.S. Bureau of Labor Statistics. Data on bilateral real exchange rates and real GDP in the importing countries are obtained from the CEPII-CHELEM database. One lag and one lead of the first differenced variables are included. Standard errors are calculated using the Bartlett Kernel and the Newey-West fixed bandwidth method. The sample period extends from 1992 to 2016.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

TABLE 1b

Panel dynamic OLS estimates for medium-low technology manufacturing exports

	(6)	(7)	(8)	(9)	(10)	(11)
	Fab-ricated metals exc. ma-chinery (ISIC 28)	Furniture (ISIC 36)	Iron & steel (ISIC 271)	Mineral products (ISIC 26)	Non-ferrous metals (ISIC 272)	Rubber & plastic products (ISIC 25)
Real Exchange Rate	-0.32*** (0.05)	-0.78*** (0.05)	-0.30*** (0.07)	-0.42*** (0.05)	-0.32*** (0.08)	-0.11*** (0.04)
GDP	1.54*** (0.09)	2.67*** (0.11)	2.71*** (0.16)	1.68*** (0.12)	0.85*** (0.18)	1.61*** (0.09)
Cross Sections Included	86	84	86	86	71	86
Number of Observations	2150	2100	2150	2150	1775	2150
S.E. of Regression	0.174	0.255	0.294	0.189	0.381	0.154
Adjusted *R*-squared	0.979	0.965	0.961	0.976	0.921	0.986
Exporting Countries	China, Germany, Italy, & U.S.	China, Germany, Italy, & U.S.	Germany, Italy, Japan, & U.S.	Germany, Italy, Japan, & U.S.	Austra-lia, Canada, Ger-many, & U.S.	France, Germa ny, Japan, & U.S.

Notes: The table reports export elasticities for manufacturing exports from the four leading exporters of each product category to major importers. The products are classified as medium low-technology goods by the OECD. The dependent variable is the level of manufacturing exports measured in U.S. dollars and deflated using price deflators for the corresponding product obtained from the U.S. Bureau of Labor Statistics. Data on bilateral real exchange rates and real GDP in the importing countries are obtained from the CEPII-CHELEM database. One lag and one lead of the first differenced variables are included. Standard errors are calculated using the Bartlett Kernel and the Newey-West fixed bandwidth method. The sample period extends from 1992 to 2016.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

TABLE 1c

Panel dynamic OLS estimates for medium-high technology manufacturing exports

	(12)	(13)	(14)	(15)
	Chem-icals exc. pharma. (ISIC 241, 2421, 2422, 2424, 2429, 243)	Elec-trical mach. (ISIC 31)	Ma-chinery (ISIC 29)	Motor vehic. (ISIC 34)
Real Exchange Rate	-0.11*** (0.04)	-0.25*** (0.05)	-0.31*** (0.05)	-0.75*** (0.07)
GDP	1.93*** (0.08)	2.45*** (0.12)	2.64*** (0.12)	1.92*** (0.16)
Cross Sections Included	86	86	86	86
Number of Observations	2150	2150	2150	2150
S.E. of Regression	0.131	0.171	0.167	0.240
Adjusted *R*-squared	0.988	0.981	0.978	0.979
Exporting Countries	France, Germany, Japan, & U.S.	France, Germa ny, Japan, & U.S.	Germa ny, Japan, Italy, & U.S.	France, Germany, Japan, & U.S.

Notes: The table reports export elasticities for manufacturing exports from the four leading exporters of each product category to major importers. The products are classified as medium high-technology goods by the OECD. The dependent variable is the level of manufacturing exports measured in U.S. dollars and deflated using price deflators for the corresponding product obtained from the U.S. Bureau of Labor Statistics. Data on bilateral real exchange rates and real GDP in the importing countries are obtained from the CEPII-CHELEM database. One lag and one lead of the first differenced variables are included. Standard errors are calculated using the Bartlett Kernel and the Newey-West fixed bandwidth method. The sample period extends from 1992 to 2016.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

TABLE 1d

Panel dynamic OLS estimates for high-technology manufacturing exports

	(16)	(17)	(18)
	Computers (ISIC 30)	Medical equip. (ISIC 33)	Pharma-ceuticals (ISIC 2423)
Real Exchange Rate	0.40*** (0.09)	-0.19*** (0.04)	-0.08 (0.07)
GDP	6.35*** (0.20)	2.02*** (0.10)	2.35*** (0.14)
Cross Sections Included	80	79	80
Number of Observations	1999	1975	2000
S.E. of Regression	0.415	0.179	0.296
Adjusted R-squared	0.928	0.977	0.956
Exporting Countries	Germany, Japan, Nether-lands, & U.S.	Germany, Japan, Switzerland, & U.S.	Germany, Switzerland, UK, and U.S.

Notes: The table reports export elasticities for manufacturing exports from the four leading exporters of each product category to major importers. The products are classified as high technology goods by the OECD. The dependent variable is the level of manufacturing exports measured in U.S. dollars and deflated using price deflators for the corresponding product obtained from the U.S. Bureau of Labor Statistics. Data on bilateral real exchange rates and real GDP in the importing countries are obtained from the CEPII-CHELEM database. One lag and one lead of the first differenced variables are included. Standard errors are calculated using the Bartlett Kernel and the Newey-West fixed bandwidth method. The sample period extends from 1992 to 2016.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

TABLE 2

Panel dynamic OLS estimates for manufacturing exports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	China	Germany	South Korea	Italy	US	Malaysia	Japan	Thailand
Real Exchange Rate	-1.26*** (0.08)	-0.68*** (0.09)	-0.66*** (0.09)	-0.38*** (0.08)	-0.35*** (0.05)	-0.32** (0.15)	-0.31*** (0.09)	-0.30*** (0.08)
GDP	3.43*** (0.18)	1.75*** (0.18)	3.21*** (0.24)	2.07*** (0.13)	1.83*** (0.16)	3.44*** (0.33)	2.07*** (0.21)	3.60*** (0.28)
Cross Sections Included	18	22	22	22	22	17	20	18
Number of Observations	450	550	550	550	550	425	500	450
S.E. of Regression	0.179	0.111	0.202	0.126	0.124	0.217	0.142	0.162
Adjusted R-squared	0.985	0.987	0.977	0.985	0.984	0.966	0.980	0.978
Export Sophistication Index (Hausmann *et al.* measure)	19212	25271	22413	23951	24304	20117	25423	20339
Export Sophistication Index (Kwan measure)	24864	33520	29516	31917	33031	26646	32829	27561

Notes: The table reports export elasticities for manufacturing exports from the four leading exporters of each product category to major importers. The dependent variable is the level of manufacturing exports measured in U.S. dollars and deflated using corresponding price deflators obtained from the U.S. Bureau of Labor Statistics. Data on bilateral real exchange rates and real GDP in the importing countries are obtained from the CEPII-CHELEM database. One lag and one lead of the first differenced variables are included. Standard errors are calculated using the Bartlett Kernel and the Newey-West fixed bandwidth method. The sample period extends from 1992 to 2016.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

TABLE 2 (continued)

Panel dynamic OLS estimates for manufacturing exports

	(9)	(10)	(11)	(12)
	Taiwan	UK	France	Switzer-land
Real Exchange Rate	-0.23*** (0.08)	-0.08 (0.07)	-0.07 (0.08)	0.18 (0.13)
GDP	2.33*** (0.26)	2.16*** (0.15)	2.15*** (0.13)	0.45 (0.34)
Cross Sections Included	15	21	22	15
Number of Observations	375	525	550	375
S.E. of Regression	0.129	0.140	0.122	0.198
Adjusted R-squared	0.985	0.977	0.988	0.965
Export Sophistication Index (Hausmann *et al.* measure)	22352	22040	24262	29880
Export Sophistication Index (Kwan measure)	28870	30350	32899	37307

Notes: The table reports export elasticities for manufacturing exports from the four leading exporters of each product category to major importers. The dependent variable is the level of manufacturing exports measured in U.S. dollars and deflated using corresponding price deflators obtained from the U.S. Bureau of Labor Statistics. Data on bilateral real exchange rates and real GDP in the importing countries are obtained from the CEPII-CHELEM database. One lag and one lead of the first differenced variables are included. Standard errors are calculated using the Bartlett Kernel and the Newey-West fixed bandwidth method. The sample period extends from 1992 to 2016.

*** (**) [*] denotes significance at the 1% (5%) [10%] levels.

TABLE 3

Panel dynamic OLS estimates for automobile exports

	(1)	(2)	(3)	(4)
	Germany	Japan	South Korea	United States
Real Exchange Rate	-0.76*** (0.14)	-1.11*** (0.17)	-1.47*** (0.26)	-0.65*** (0.12)
GDP	2.48*** (0.26)	0.89** (0.40)	4.20*** (0.58)	1.20*** (0.41)
Cross Sections Included	22	20	22	22
Number of Observations	550	500	545	550
S.E. of Regression	0.185	0.332	0.564	0.263
Adjusted *R*-squared	0.975	0.948	0.895	0.974

Notes: The table reports export elasticities for automobile exports from Germany, Japan, South Korea, and the United States to major importers. The dependent variable is the level of automobile exports measured in U.S. dollars and deflated using the import price deflators for automobiles obtained from the U.S. Bureau of Labor Statistics (BLS) for exports from Germany, Japan, and South Korea and deflated using the BLS export price deflator for automobiles for exports from the U.S. Data on bilateral real exchange rates and real GDP in the importing countries are obtained from the CEPII-CHELEM database. One lag and one lead of the first differenced variables are included. Standard errors are calculated using the Bartlett Kernel and the Newey-West fixed bandwidth method. The sample period extends from 1992 to 2016.
*** (**) denotes significance at the 1% (5%) levels.

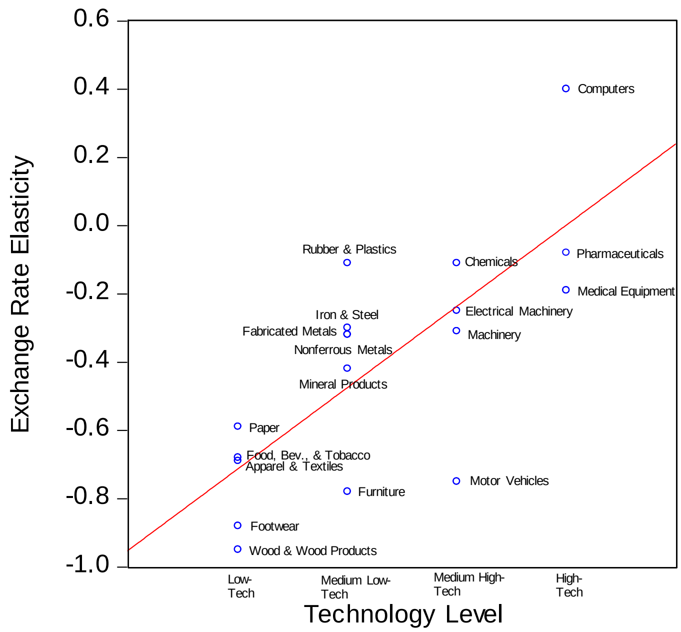

Figure 1. Exchange Rate Elasticities for Exports and Product Technology Levels

Note: The figure shows the relationship between a product's exchange rate elasticity (ERE) and its technology level (TL). The technology level is calculated by the OECD. The OECD determines technology levels based on the ratio of R&D spending to value-added (see Hatzichronoglou, 1997). The predicted relationship is positive. The line in the figure comes from the following regression (with heteroscedasticity and autocorrelation consistent standard errors in parentheses):

ERE = -0.95 + 0.24TL
(0.08) (0.03)
Adjusted R-squared = 0.526, Standard Error of Regression = 0.237,

where TL equals 1 for low-technology goods, 2 for medium-low technology goods, 3 for medium-high technology good, and 4 for high-technology goods.

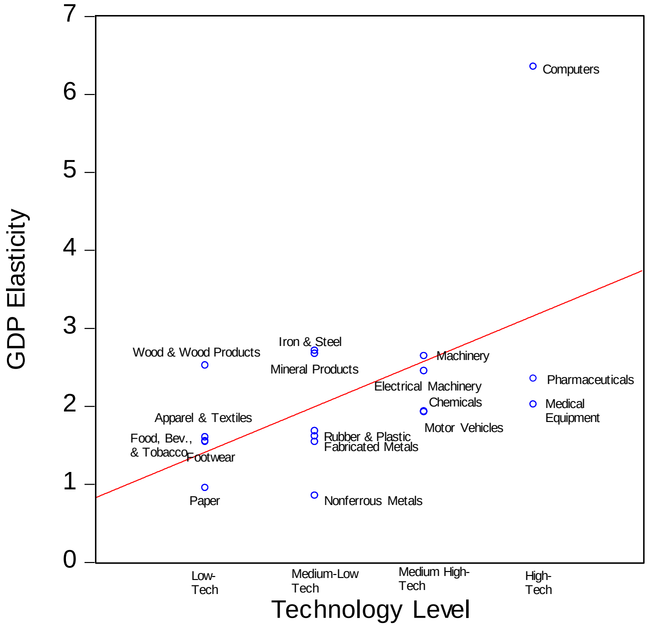

Figure 2. GDP Elasticities for Exports and Product Technology Levels

Note: The figure shows the relationship between a product's GDP elasticity (GDPE) and its technology level. The technology level is calculated by the OECD. The OECD determines technology levels based on the ratio of R&D spending to value-added (see Hatzichronoglou, 1997). The predicted relationship is positive. The line in the figure comes from the following regression (with heteroscedasticity and autocorrelation consistent standard errors in parentheses):

$$\underset{(0.46)}{GDPE = 0.83} + \underset{(0.24)}{0.58TL}$$

Adjusted R-squared = 0.233, Standard Error of Regression = 1.04,

where TL equals 1 for low-technology goods, 2 for medium-low technology goods, 3 for medium-high technology good, and 4 for high-technology goods.

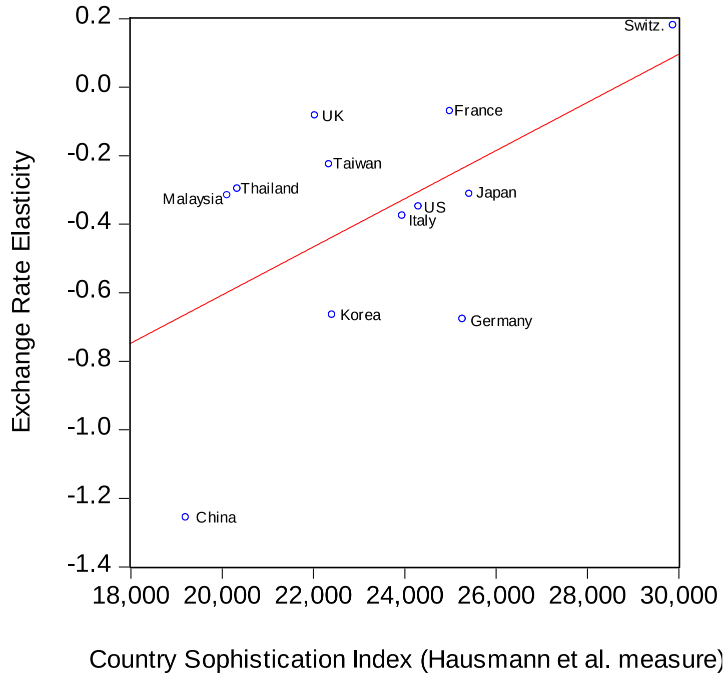

Figure 3a. Exchange Rate Elasticities for Exports and Country Sophistication Index

Note: The figure shows the relationship between the sophistication level of a country's export basket (ESI) and the exchange rate elasticity (ERE) for aggregate manufacturing exports. ESI is calculated using the method of Hausmann et al. (2007) and represents the average sophistication level over the 1992-2016 sample period. The predicted relationship is positive. The line in the figure comes from the following regression (with heteroscedasticity and autocorrelation consistent standard errors in parentheses):

ERE = -2.01 + 0.000070ESI
(0.47) (0.000019)
Adjusted R-squared = 0.250, Standard Error of Regression = 0.317,

.

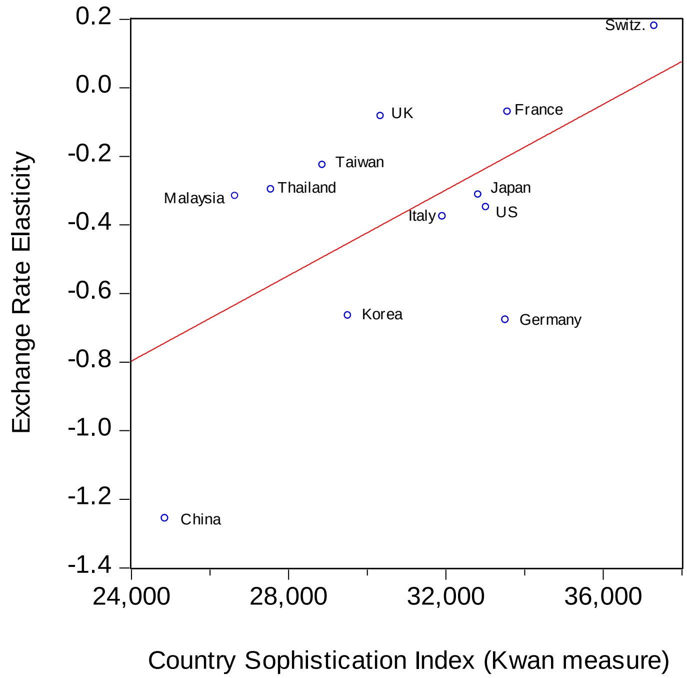

Figure 3b. Exchange Rate Elasticities for Exports and Country Sophistication Index

Note: The figure shows the relationship between the sophistication level of a country's export basket (ESI) and the exchange rate elasticity (ERE) for aggregate manufacturing exports. ESI is calculated using the method of Kwan (2002) and represents the average sophistication level over the 1992-2016 sample period. The predicted relationship is positive. The line in the figure comes from the following regression (with heteroscedasticity and autocorrelation consistent standard errors in parentheses):

$$\underset{}{ERE} = \underset{(0.51)}{-2.30} + \underset{(0.000016)}{0.000062}ESI$$

Adjusted R-squared = 0.296, Standard Error of Regression = 0.307,

References

Arbatli, E., & Hong, G.H. (2016). Singapore's export elasticities: A disaggregated look into the role of global value chains and economic complexity. Working paper No. 16-52, International Monetary Fund.

Auer, R., & Sauré, P. (2011). Export basket and the effects of exchange rates on export – Why Switzerland Is special. Working paper No. 77, Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute.

Botman, D., de Carvalho Filho, I., and Lam, W.R. (2013). The curious case of the yen as a safe haven currency: A forensic analysis. Working paper No. 13-228, International Monetary Fund.

Carton, B., Mongardini, J., and Li, Y. (2018). A new smartphone for every fifth person on earth: Quantifying the new tech cycle. Working paper No. 18-22, International Monetary Fund.

Chen, N., & Juvenal, L. (2016). Quality, trade, and exchange rate pass-through. *Journal of International Economics*, 2016(C), 61-80.

Cheung, Y.-W., Chinn, M., and Qian, X. (2012). Are Chinese trade flows different? *Journal of International Money and Finance,* 31(8), 2127-2146.

Chinn, M. (2013). Export and import elasticities for Japan: New estimates. Working paper No. 2013-004, La Follette School of Public Affairs.

Goldberg, L., & Krogstrup, S. (2018). International capital flow pressures. Working paper No. 18-30, International Monetary Fund.

Grossman, S.H., Lein. S.M., & Schmidt, C. (2016). Exchange rate and foreign GDP elasticities of Swiss exports across sectors and destination countries. *Applied Economics,* 48(57), 5546- 5562.

Gruber, J., McCallum, A., & Vigfusson, R. (2016). The dollar in the U.S. international transactions (USIT) model. Board of Governors of the Federal Reserve IFDP Notes, November 6. Available at: www.federalreserve.gov.

Hatzichronoglou, T. (1997). Revision of the high-technology sector and product classification. Science, Technology and Industry Working Paper No. 1997-02, Organization for Economic Cooperation and Development.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth,* 12(1), 1-25.

Héricourt, J., Martin, P., & Orefice, G. (2014). Les exportateurs français face aux variations de l'euro. *La Lettre du CEPII* 340. Centre D'Etudes Prospectives et D'Information Internationales.

Hidalgo, C.A., & Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the National Academy of Sciences*, 106(26), 10570-10575.

IMF (2013). Switzerland: Selected issues paper. *IMF Country Report*, No 13-129. Available at: http://www.imf.org/external/pubs/ft/scr/2013/cr13129.pdf.

Kao, C. (1999). Spurious regression and residual-based tests for cointegrated regression in panel data. *Journal of Econometrics* 90(1), 1-44.

Kao, C., & Chiang, M.-H. (2000). On the estimation and inference of a cointegrated regression in panel data. *Advances in Econometrics*, 15, 179-222.

Klein, M. (2017). Have the Swiss National Bank's currency interventions actually been good for Switzerland? *Financial Time*, 3 June.

Kwan, C.H. (2002). The rise of China and Asia's flying geese pattern of economic development: An empirical analysis based on US import statistics. RIETI Discussion Paper 02-E-009, Research Institute of Economy, Trade and Industry.

Lall, S., Weiss, J., & Zhang, J. (2006). The "sophistication" of exports: A new trade measure. *World Development* 21(2), 153-172.

Pesaran, M. H., & Smith, R.P. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, 68(1), 79-113.

Rodrik, D. (2008). The real exchange rate and economic growth. *Brookings Papers on Economic Activity*, 39, 365-412.

Sauré, P. (2015). The resilient trade surplus, the pharmaceutical sector, and exchange rate assessments in Switzerland. Working paper No. 15-11, Peterson Institute for International Economics

Thorbecke, W., & Kato, A. (2018). Exchange rates and the Swiss economy. *Journal of Policy Modeling,* forthcoming.

Thorbecke, W., & Kato, A. (2012). The effect of exchange rate changes on Germany's exports. RIETI Discussion Paper 12-E-081, Research Institute of Economy, Trade and Industry.

Wagner, M., & Hlouskova, J. (2010). The performance of panel cointegration methods: Results from a large scale simulation study. *Econometric Reviews,* 29(2), 182-223.