RIETI Discussion Paper Series 20-E-075

The Relationship between Product Complexity and Exchange Rate Elasticities: Evidence from the People's Republic of China's Manufacturing Industries

THORBECKE, Willem
RIETI

CHEN, Chen
Xi'an Jiaotong-Liverpool University. Suzhou

SALIKE, Nimesh
Xi'an Jiaotong-Liverpool University. Suzhou

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 20-E-075
September 2020

The Relationship between Product Complexity and Exchange Rate Elasticities: Evidence from the People's Republic of China's Manufacturing Industries [1]

Willem Thorbecke*
Research Institute of Economy, Trade and Industry

Chen Chen**
Xi'an Jiaotong-Liverpool University. Suzhou

Nimesh Salike***
Xi'an Jiaotong-Liverpool University. Suzhou

Abstract

More complex products are less substitutable in international trade and may therefore have lower price elasticities. We investigate this issue using 960 types of Chinese manufactured exports to 190 partner countries disaggregated at the Harmonized System 4-digit level. We measure complexity using Hidalgo and Hausmann's (2009) product complexity index. We find that price elasticities are lower for more complex goods. These results imply that the People's Republic of China can reduce its exporters' exposure to tariffs, trade wars, and exchange rate volatility by upgrading its export basket.

Keywords: Chinese exports, exchange rate elasticities, product sophistication

JEL codes: F10, F14, F13

[1] This study is conducted as a part of the research at the Research Institute of Economy, Trade and Industry (RIETI).

* Willem Thorbecke. Research Institute of Economy, Trade and Industry, Tokyo, Japan. Email: willem-thorbecke@rieti.go.jp

** Chen Chen. International Business School Suzhou, Xi'an Jiaotong-Liverpool University. Suzhou, China. Email: Chen.Chen02@xjtlu.edu.cn

*** Nimesh Salike. International Business School Suzhou, Xi'an Jiaotong-Liverpool University. Suzhou, China. Email: Nimesh.Salike@xjtlu.edu.cn

1. Introduction

The People's Republic of China (henceforth PRC) faces tariffs, trade wars, volatile exchange rates, and other challenges. How can Chinese firms sustain their exports in the face of these shocks?

Abiad et al. (2018) and Asian Development Bank (2018) noted that products with lower demand elasticities will be less affected by impediments to trade. They also observed that goods that are complex (in the sense of Hidalgo and Hausmann, 2009) are difficult to produce. Thus purchasers need time and effort to find substitutes for these goods. Since finding substitutes is difficult, microeconomic theory indicates that complex goods should have lower price elasticities. Simple goods, on the other hand, are like commodities and are more substitutable. Theory thus implies that they should have larger elasticities.

Only a few studies have examined the relationship between Hidalgo and Hausmann's product complexity index (PCI) and elasticities. Arbatli and Hong (2016) investigated whether more complex exports from Singapore have lower exchange rate elasticities. Employing a Mean Group estimator and annual data at the Harmonized System (HS) 4-digit level from 1989 to 2013, they reported that products with higher PCIs do have lower elasticities.

Thorbecke (2018) estimated elasticities for the PRC's exports to the U.S. disaggregated at the 2-digit or and 4-digit Harmonized System (HS) level. He employed dynamic ordinary least squares (DOLS) estimation and quarterly data over the 1992-2018 period. He reported that Chinese exports that are more complex according to Hidalgo and Hausmann's measure have lower exchange rate elasticities.

We investigate elasticities not only for the PRC's exports to the U.S. but for its exports to the world. Examining trade elasticities for the PRC's exports to the world obviates misspecification issues that can arise when examining elasticities for the PRC's exports to a single country (see, Ahmed, 2009). We estimate elasticities for the PRC's exports of 960 manufactured goods to 190 countries over the 1995-2018 period. We then investigate whether there is a relationship between products' exchange rate elasticities and their PCIs. For all goods, we report an export elasticities of -0.67, implying that a 10 percent renminbi appreciation will reduce exports by 6.7 percent. We also find lower elasticities for more complex goods.

In previous work Cheung, Chinn, and Qian (2012) used DOLS to estimate elasticities for the PRC's exports to the world over the 1994Q3-2010Q4 period. Employing the IMF's

CPI-deflated real effective exchange rate, they reported that a 10 percent renminbi appreciation would reduce total exports by between 9 and 16 percent, manufacturing exports by between 9 and 15 percent, and primary exports by between 7 and 12 percent.

Kato (2015) used panel DOLS and annual data on Chinese exports to 26 countries over the 1995-2011 period to estimate elasticities. He examined Chinese exports of high skill & technology intensive manufacturing products and medium skill & technology intensive manufacturing products. He culled data on exports by skill level from the United Nations Conference on Trade and Development. He found that a renminbi appreciation reduced exports of high skill & technology intensive exports but not of medium skill & technology intensive exports.

Xing (2018) investigated how renminbi appreciations and rising wages affect the PRC's comparative advantage in labor-intensive assembly operations. He focused on processed exports, goods that are produced using imported parts and components. He examined two types of processed exports: pure assembly exports (PAE) and mixed assembly exports (MAE). PAE is dependent on low wage labor. According to Xing, PAE is the lowest value added segment of global value chains. Examining the PRC's exports to more than 100 countries over the 1993-2013 period, he found that a 10 percent appreciation of the nominal U.S. dollar/renminbi exchange rate would reduce PAE's share in the PRC's export basket by 24 percentage points and MAE's share by 15 percentage points. He also reported that a 10 percent wage increase in the PRC would reduce PAE's share by 16 percentage points and MAE's share by 11 percentage points. Thus exchange rate appreciations and wage increases would reduce exports more in the PRC's lower value-added regime.

Cheung, Chinn, and Qian (2015) examined the PRC's processed and ordinary exports to the U.S. over the 1994Q1 to 2012Q4 period. They employed the Pesaran, Shin, and Smith (2001) bounds testing approach that allows variables to have different orders of integration. Their exchange rate measures include both the CPI-deflated real exchange rate and the CPI-deflated real exchange rate corrected for feedback from the PRC's trade surplus. For both measures they reported larger price elasticities for ordinary exports than for processed exports. They noted that this could be because ordinary exports are more dependent on local factors of production than processed exports are.

Baiardi, Bianchi, and Lorenzini (2015) focused on one particular low-technology export, clothing. They disaggregated clothing exports into individual 4-digit Standard Industrial Trade Classification categories over the 1992-2011 period. They measured relative prices as the ratio of the PRC's export unit value for each 4-digit clothing category at time t to the average export unit value for other key exporters of the same good at time t. Using system Generalized Method of Moment estimation, they reported that a 10 percent increase in relative prices would reduce the PRC's clothing exports by between 8 and 9 percent.

It is not clear from these and other studies whether the PRC's exports of more complex products have lower elasticities. Our contribution is to investigate this issue systematically using data on the PRC's exports of 960 manufactured goods to 190 trading partners and Hidalgo and Hausmann's (2009) complexity measure.

The next section presents our data and methodology. Section 3 presents the results. Section 4 concludes.

2. Data and Methodology

The theoretical model informing this investigation is the imperfect substitutes model (see Chinn, 2004, 2005). In this framework imported goods are imperfect substitutes for domestic goods. Import demand is a decreasing function of the price of imports (in the importing country's currency) relative to the price of domestic goods. Export supply is an increasing function of the price of exports (in the exporting country's currency) relative to the price of goods in the exporting country. Equating import demand with export supply and using the real exchange rate to relate prices in the two currencies yields the following export function:

$$lnX_t = \beta_0 + \beta_1 lnRER_t + \beta_2 lnY_t \qquad (1),$$

where X_t represents exports, RER_t represents the real exchange rate (importing country's currency per unit of export country's currency), and Y_t represents importing country GDP. The parameter β_1 should be negative and larger in absolute value the more elastic import demand is to the relative price of imports and the parameter β_2 should be positive.

We follow Abiad et al. (2018) and Asian Development Bank (2018) in positing that purchasers require more time and effort to find substitutes for goods that are difficult to produce and thus that these goods should have lower import price elasticities. If import price elasticities are lower, then the imperfect substitutes model implies that exchange rate elasticities in equation (1) will be lower for these goods. We follow Abiad et al. and Asian

Development Bank in using the product complexity index (PCI) of Hidalgo and Hausmann (2009) as a way of measuring how difficult a good is to produce.

Felipe et al. (2012) explained Hidalgo and Hausmann's (2019) approach and how it builds on the literature that models development as a process of transforming a country's economic structure towards higher productivity activities.[2] Hidalgo and Hausmann emphasized the role of capabilities in determining the ability of economies to produce more complex goods. As a Scrabbble player with many letters can create more complicated words, an economy with many capabilities can produce more complex products. As Felipe et al. highlighted, capabilities are determined by human and physical capital, legal and institutional systems, tacit and codified know-how, organizational abilities and other factors.

The approach of Hidalgo and Hausmann (2009) involved employing copious export data to infer a country's capabilities. Building on the Scrabble analogy, they examined not the number of letters that the player has but the complexity of the words they create. To do this, they employed the method of reflections to measure the complexities of economies and products. For an economy, they measured complexity by its diversification. They defined diversification as the number of products that a country exports with revealed comparative advantage (RCA) greater than one. For a product, they measured complexity by its ubiquity. They defined ubiquity as the number of countries that export the product with RCA greater than one. Intuitively, an economy that exports more products with RCA greater than one is more diversified and a product that fewer countries export with RCA greater than one is less ubiquitous. Higher diversification implies that an economy has more capabilities and lower ubiquity implies that a product requires more capabilities to produce. Formally, diversification and ubiquity can be represented by:

$$\text{Diversification (Economic complexity): } k_{e,0} = \sum_{p} M_{ep} \qquad (2)$$

$$\text{Ubiquity (Product complexity): } k_{p,0} = \sum_{c} M_{ep} \qquad (3)$$

where e represents an economy, p represents a product, M_{ep} equals one if an economy e exports product p with RCA greater than one and M_{ep} equals zero otherwise. The method of reflections involves first calculating diversification and ubiquity from equations (2) and (3) and then solving equations (4) and (5) below iteratively:

[2]Contributors to this literature include Lewis (1955), Rostow (1959), Kuznets (1966), Kaldor (1967), and Chenery and Taylor (1968).

$$k_{e,n} = 1/k_{e,0} \sum_{p} M_{ep} \, k_{p,n-1} \qquad (4)$$

$$k_{p,n} = 1/k_{p,0} \sum_{c} M_{ep} \, k_{c,n-1} \qquad (5)$$

We use the PCI derived from this approach to measure complexity. The data come from the Atlas of Economic Complexity.[3] Since the index itself is volatile, we employ the ranking of products based on the PCI along with the index values themselves. We use average values of the PCI index and the PCI rankings over the 1995-2018 period and also combine exports into five sophistication categories based on their PCI index and PCI ranking values.[4] The HS 4-digit codes corresponding to high, medium high, medium, medium low, and low complexity goods are available on request. As a robustness check, we also use complexity values and rankings obtained from the MIT Observatory of Economic Complexity (OEC).[5] The OEC employs a similar method to the one used by Hidalgo and Hausmann (2009) to calculate PCI's. However, it uses data from Feenstra, Lipsey, Deng, Ma, and Mo (2005) and relies on researchers from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) to harmonize the trade data.

Why should China care if more complex products have lower exchange rate elasticities? Ilzetzki, Reinhart, and Rogoff (2020) argued that, while the exchange rates of the Chinese renminbi, the U.S dollar, the Japanese yen, and the euro have been eerily stable, volatility could reemerge. If this were to happen, exports of products with lower exchange rate elasticities would remain more stable relative to exports of products with higher elasticities. Stable export flows would allow producers to focus on upgrading their technology and satisfying consumer preferences rather than coping with volatile sales.

Further, protectionist pressures in the U.S. have exploded and led to tariffs on Chinese exports. In standard models, tariffs and exchange rates exert identical effects on export volumes (see, e.g., Krugman, 1979, and Eaton and Kortum, 2002). For example, Fontagné, Martin, and Orefice (2018) reported this correspondence in a model with constant elasticity

[3] The website for the Atlas of Economic Complexity is: https://atlas.cid.harvard.edu/ .
[4] Average PCI rankings of all 960 products over the 1995-2018 period are available on request.
[5] These data are available at: https://oec.world.

of substitution (CES) preferences. Because of this equivalence, House, Proebsting, and Tesar (2019) used exchange rate elasticities to calculate the effect of Chinese tariffs on the U.S. economy. Thus exports of products with lower exchange rate elasticities should also fall less when tariffs are imposed.

Many researchers have investigated empirically the relationship between exports and exchange rates (see, e.g., Eichengreen & Gupta, 2013; Freund & Pierola, 2012; Di Nino et al., 2012; Ahmed, Appendino & Ruta, 2015; Bénassy-Quéré et al., 2019). We follow the approach of Bénassy-Quéré et al. They modeled country *i*'s exports to country j of product p in year *t*, X_{ijpt} using a series of fixed effects:

$$lnX_{ijpt} = \lambda_{ipt} + \mu_{jpt} + \nu_{ij} + \epsilon_{ijpt} \qquad (6),$$

where λ_{ipt}, μ_{jpt} and ν_{ij} are fixed effects for exporter, product,time; importer,product,time; and importer,exporter respectively. The last variable ϵ_{ijpt} is a random error term. Benassy-Queré et al. added the bilateral real exchange rate between country *i* and country j, $BRER_{ijt}$, yielding the equation:

$$lnX_{ijpt} = \beta lnBRER_{ijt} + \lambda_{ipt} + \mu_{jpt} + \nu_{ij} + \epsilon_{ijpt} \qquad (7).$$

We can only estimate equation (7) with fixed effects along three dimensions (*j, p, t*) instead of four dimensions(*i, j, p, t*) because the PRC is the only exporting country. As Benassy-Queré et al. did, we also include the importing country's real GDP (Y_{jt}) as an additional control variable. We cannot include the PRC's real GDP since it is collinear with the time fixed effect (μ_t). We thus focus on the export equation:

$$lnX_{jpt} = \beta_0 + \beta_1 lnBRER_{jt} + \beta_2 lnY_{jt} + \lambda_{jp} + \mu_t + \epsilon_{jpt} \qquad (8).$$

We employ interaction terms to investigate whether exchange rate elasticities are different for the PRC's exports disaggregated into the five levels of sophistication:

$$lnX_{jpt} = \beta_0 + \beta_1 lnBRER_{jt} + \beta_2 lnY_{jt} + \beta_3 lnBRER_{jt} * D_1 + \beta_4 lnBRER_{jt} * D_2 + \beta_5 lnBRER_{jt} * D_3 + \beta_6 lnBRER_{jt} * D_4 + \lambda_{jp} + \mu_t + \epsilon_{jpt} \qquad (9),$$

where D_1 is a dummy variable equaling 1 if the export category p ranks in the most complex 20 percent (highly sophisticated) and 0 otherwise, D_2 is a dummy variable equaling 1 if the export category p ranks between the 60th and 80th percentile in the complexity rankings (medium highly sophisticated) and 0 otherwise, D_3 is a dummy variable equaling 1 if the export category p ranks between the 40th and 60th percentile in complexity ratings (medium sophisticated) and 0 otherwise, and D_4 is a dummy variable equaling 1 if the export category p ranks between the 20th and 40th percentile in complexity ratings (medium low sophisticated) and 0 otherwise. We also use an equation similar to (9) to investigate whether real GDP elasticities are different for the PRC's exports disaggregated into the five levels of sophistication

Following Benassy-Queré et al. (2019) we measure (X_{jpt}) as the value of exports. We obtain bilateral FOB export data from the PRC to 190 countries at the HS 4-digit level for 960 manufactured goods between 1995 and 2018 from the Atlas of Economic Complexity. The Atlas in turn collected these data from the UN Comtrade database.

We obtain data on the bilateral real exchange rate between the PRC and each importing countries from the CEPII-CHELEM database[6]. The exchange rate is defined so that an increase represents an appreciation of the Chinese renminbi. We obtain data on real GDP in the importing countries from the CEPII gravity database.[7] Table 1 provides descriptive statistics for the variables in equation (9).

3. Results

Table 2 presents the results from estimating equation (9). Column (2) presents results with exports sorted into five categories based on average rankings of the Hidalgo-Hausmann PCI index, column (3) with exports sorted based on values of the Hidalgo-Hausmann PCI index, column (4) with exports sorted based on average rankings of the MIT OEC PCI index, and column (5) with exports sorted based on values of the MIT OEC PCI index. All of the coefficients are of the expected signs and statistically significant at the 1 percent level. F-tests indicate that the coefficients on the interation terms between the exchange rate and complexity levels are also statistically different from each other at the one percent level, implying that the exchange rate elasticities differ across complexity levels.

In column (2) with exports sorted based on Hidalgo-Hausmann rankings, the exchange rate elasticity is -0.293 for the most sophisticated exports, -0.556 for the medium high sophisticated exports, -0.781 for the medium sophisticated exports, -0.936 for the medium low sophisticated exports, and -1.230 for the least sophisticated exports. In column (3) with exports sorted based on Hidalgo-Hausmann values, the exchange rate elasticity is -0.274 for the most sophisticated exports, -0.437 for the medium high sophisticated exports, -0.712 for the medium sophisticated exports, -0.831 for the medium low sophisticated

[6] It would be preferable to utilize relative individual prices of exports expressed in a common currency that differs between types of exports. Unfortunately we are unable to obtain these data across all of our export categories.

[7] The website for the gravity database is http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8.

exports, and -1.164 for the least sophisticated exports. In column (4) with exports sorted based on MIT OEC rankings, the exchange rate elasticity is -0.258 for the most sophisticated exports, -0.471 for the medium high sophisticated exports, -0.665 for the medium sophisticated exports, -0.868 for the medium low sophisticated exports, and -1.311 for the least sophisticated exports. In column (5) with exports sorted based on MIT OEC values, the exchange rate elasticity is -0.253 for the most sophisticated exports , -0.387 for the medium high sophisticated exports, -0.584 for the medium sophisticated exports, -0.733 for the medium low sophisticated exports, and -1.231 for the least sophisticated exports. Figures 1 through 4 plots the elasticities for these four cases. The figures, especially the first three, indicate that there is almost a linear relationship between sophistication levels and elasticities.

Taking averages of the elasticities across columns (2) through (5), the results indicate that a 10 percent renminbi appreciation is associated with a drop in exports of 2.5 percent for the most sophisticated exports, 4.5 percent for medium high sophisticated exports, 6.8 percent for medium sophisticated exports, 8.5 percent for medium low sophisticated exports, and 12.4 percent for the least sophisticated exports. Thus these findings indicate that sophisticated exports such as lubricants, zirconium, and titanium are less sensitive to exchange rates than unsophisticated exports such as natural rubber, sulphur,and prepared fish.

Table 2 presents results for exports divided into five sophistication categories. We also estimate equation (8) for each of the HS-4 digit level categories separately. Regressing the resulting exchange rate elasticities for each 4-digit export category *i* ($\beta_{BRER,i}$) on the corresponding PCI ranking for that 4-digit category ($PCI_{Ranking,i}$) yields:

$$\beta_{BRER,i} = \underset{(0.100)}{-0.466^{***}} - \underset{(0.000093)}{0.000319^{***}}\, PCI_{Ranking,i} \qquad (10)$$

No. of observations = 960, Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** = significant at 1% level. Adjusted R-squared = 0.315. Standard error of regression = 0.519. Durbin-Watson statistic = 2.00. Dummy variables included for each harmonized system 2-digit category.

The coefficient on $PCI_{Ranking}$ is negative and highly statistically significant. This implies that exports of more complex products are less responsive to exchange rate changes. There is a problem interpreting the coefficient in equation (10) because the regressand is a cardinal measure and the regressor is an ordinal measure. To circumvent this we use PCI values as the right-hand-side variable. We also use a log-log specification so that we can interpret the coefficient as an elasticity.[8] The results are:

$$\log(\beta_{BRER,i}) = \underset{(0.189)}{0.775^{***}} + \underset{(0.120)}{0.269^{**}} \log(PCI_{Value,i}) \qquad (11)$$

No. of observations = 960, Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** (**) = significant at 1% (5%) level. Adjusted R-squared = 0.133. Standard error of regression = 0.244. Durbin-Watson statistic = 2.12. Dummy variables included for each harmonized system 2-digit category.

The coefficient on PCI_{Value} is positive and statistically significant. This implies that exports of more complex products are less responsive to exchange rate changes. The coefficient indicates that a 10 percent increase in PCI values is associated with a 2.69 percent increase in the exchange rate elasticity.

As a sensitivity check we run a regression analogous to equation (11) using the PCI values obtained from the MIT Observatory of Economic Complexity:

$$\log(\beta_{BRER,i}) = \underset{(0.085)}{0.997^{***}} + \underset{(0.051)}{0.127^{**}} \log(PCI_{Value,i}) \qquad (12)$$

No. of observations = 817, Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** (**) = significant at 1% (5%) level. Adjusted R-squared = 0.343. Standard error of regression = 0.126. Durbin-Watson statistic = 1.90. Dummy variables included for each harmonized system 2-digit category.

The coefficient on PCI_{Value} is positive and statistically significant. This implies again that exports of more complex products are less responsive to exchange rate changes. The coefficient indicates that a 10 percent increase in PCI values is associated with a 1.27 percent increase in the exchange rate elasticity.

Table 3 presents the results from using interaction terms to allow GDP elasticities to vary across the five complexity categories. Column (2) sorts exports based on average rankings of the Hidalgo-Hausmann PCI index, column (3) based on values of the Hidalgo-Hausmann PCI index, column (4) based on average rankings of the MIT OEC PCI index, and column (5) based on values of the MIT OEC PCI index. F-tests indicate that all of the coefficients on the interaction terms between GDP elasticities and complexity levels are also statistically different from each other at the one percent level, implying that the GDP

[8] To avoid taking logarithms of negative values, we added 4.01 to the elasticity values and 5.00 to the Hidalgo-Hausmann and MIT OEC PCI values.

elasticities differ across complexity levels.

In column (2) with exports sorted based on Hidalgo-Hausmann rankings, the GDP elasticity is 1.24 for the most sophisticated exports, 0.919 for the medium high sophisticated exports, 0.569 for the medium sophisticated exports, 0.307 for the medium low sophisticated exports, and 0.048 for the least sophisticated exports. In column (3) with exports sorted based on Hidalgo-Hausmann values, the GDP elasticity is 1.146 for the most sophisticated exports, 1.081 for the medium high sophisticated exports, 0.599 for the medium sophisticated exports, 0.321 for the medium low sophisticated exports, and 0.127 for the least sophisticated exports. In column (4) with exports sorted based on MIT OEC rankings, the GDP elasticity is 1.582 for the most sophisticated exports, 1.364 for the medium high sophisticated exports, 1.050 for the medium sophisticated exports, 0.717 for the medium low sophisticated exports, and -0.247 for the least sophisticated exports. In column (5) with exports sorted based on MIT OEC values, the GDP elasticity is 1.393 for the most sophisticated exports, 1.412 for the medium high sophisticated exports, 1.012 for the medium sophisticated exports, 0.717 for the medium low sophisticated exports, and -0.097 for the least sophisticated exports.

Figures 5 through 8 plots the elasticities for these four cases. The figures indicate that more complex goods have higher GDP elasticities. This accords with conventional macroeconomic trade theory which suggests that more sophisticated goods and those with greater non-price competitiveness should have higher income elasticities.[9]

The GDP elasticities in Table 2 equal 0.775. This indicates that China's share of exports in the GDP of its trading partners is declining over time. However, there may be some aggregation bias when the income elasticities of demand are constrained to take on the same values for all exports. The results in Table 3 indicate that the income elasticities are typically greater than unity for the two most sophisticated export categories.

One important implication of the findings in this section is that more sophisticated exports from the PRC are less sensitive to exchange rates. This indicates that technological upgrading can help to maintain stability in the volume of the PRC's exports in the face of exchange rate fluctuations.

China's complexity rating based on the approach of Hidalgo and Hausmann (2009) rose from 46th place in 1995 to 18th place in 2018. As China's exports are becoming more sophisticated, the results in this paper imply that its exchange rate elasticity will fall. Taking average elasticities across columns (2) through (5) of Table 2 indicates that elasticities for the

[9] We are indebted to an anonymous referee for the discussion in this and the next paragraph..

two most complex categories are -0.45 and -0.25. Assuming that import elasticities are also small, then it seems likely that the Marshall-Lerner conditions will only just hold or not hold at all for China in the future. Thus, depreciations in the real exchange rate will have very limited impact in improving China's trade balance going forward.

4. Conclusion

Researchers at the International Monetary Fund, the Asian Development Bank, and other institutions have noted that complex products (in the sense of Hidalgo and Hausmann, 2009) have fewer substitutes (see, e.g., Arbatli and Hong, 2016, Abiad et al., 2018, and Asian Development Bank, 2018). For this reason complex goods should have lower price elasticities.

Albatli and Hong (2016) is one of the few studies that presents empirical evidence that products with higher product complexity indices have lower exchange rate elasticities. They found that more complex exports from Singapore decrease less when the exchange rate appreciates than less complex exports do.

We investigate this issue for the PRC's exports over the 1995-2018 period. We employ bilateral data on its exports of 960 products disaggregated to the HS 4-digit level to 190 partner economies. We find that a 10 percent appreciation of the Chinese yuan reduces total exports by 6.7%. We also find that more sophisticated exports as measured by their PCIs are less exposed to exchange rate appreciations.

There should be a relationship between how exchange rates affect exports and how tariffs affect them. In theory, exchange rates and tariffs exert identical effects on export volumes. The results in this paper thus imply that more complex products will be less exposed not only to exchange rates but also to tariffs and other factors affecting the PRC's export prices.

The PRC's manufacturers are buffeted by volatile exchange rates, tariffs, trade wars, and other factors. Producing more sophisticated products can help to stabilize the flow of manufacturing exports in the face of these shocks. The Chinese government has employed trade and industrial policies to upgrade its industries (Huang, Salike and Zhong, 2017). These policies helped the PRC's economic complexity ranking, as measured using the method of Hidalgo and Hausmann (2009), to increase from 46th in the world in 1995 to 18th in the world in 2018. To maintain stability, the PRC should continue upgrading its industrial structure and advancing towards the technology frontier.

Table 1. Summary Statistics

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Natural logarithm of exports	2,379,133	11.99	3.13	4.61	24.83
Natural logarithm of the bilateral real exchange rate	2,439,114	-0.15	0.53	-1.73	1.80
Natural logarithm of real GDP in importing countries	2,446,460	25.00	2.13	17.10	30.63

Table 2. Exchange Rate Elasticities for the PRC's Manufacturing Exports Sorted into Five Sophistication Categories.

(1)	(2)	(3)	(4)	(5)
Variable	Products Sorted by Hidalgo & Hausmann Product Complexity Rankings	Products Sorted by Hidalgo & Hausmann Product Complexity Values	Products Sorted by MIT Product Complexity Rankings	Products Sorted by MIT Product Complexity Values
Real Exchange Rate	-1.230*** (0.136)	-1.164*** (0.134)	-1.311*** (0.137)	-1.231*** (0.134)
Interaction Term Between Real Exchange Rate and Dummy Variable for Highly Sophisticated Products	0.937*** (0.114)	0.890*** (0.109)	1.053*** (0.124)	0.978*** (0.119)
Interaction Term Between Real Exchange Rate and Dummy Variable for Medium Highly Sophisticated Products	0.674*** (0.089)	0.727*** (0.098)	0.840*** (0.105)	0.844*** (0.108)
Interaction Term Between Real Exchange Rate and Dummy Variable for Medium Sophisticated Products	0.449*** (0.067)	0.452*** (0.064)	0.646*** (0.080)	0.647*** (0.081)
Interaction Term Between Real Exchange Rate and Dummy Variable for Medium Low Sophisticated Products	0.294*** (0.043)	0.333*** (0.043)	0.443*** (0.052)	0.498*** (0.059)
Real GDP	0.775*** (0.131)	0.775*** (0.131)	0.774*** (0.131)	0.774*** (0.131)
Number of Observations	2,361,964	2,361,964	2,361,964	2,361,964
Adjusted R-Squared	0.812	0.812	0.812	0.812

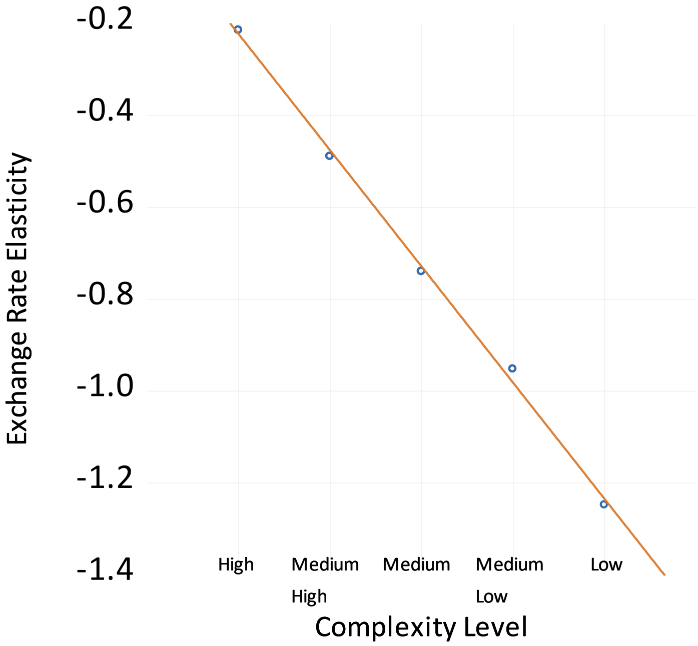
Notes: The table presents trade elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average ranking among 960 goods according to their Hidalgo and Hausmann (2009) Product Complexity Index rankings (column (2)), Hidalgo and Hausmann (2009) Product Complexity Index values (column (3)), MIT Observatory of Economic Complexity rankings (column (4)), MIT Observatory of Economic Complexity values (column (5)). The regressions include the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. These exports are divided into five complexity levels using the four methods listed above. The real exchange rate is interacted with dummy variables for four complexity levels. The regressions also include time and importer-product fixed effects. All variables are measured in natural logarithms.
*** denotes significance at the 1% level using clustered standard error at importing country level.

Table 3. GDP Elasticities for the PRC's Manufacturing Exports Sorted into Five Sophistication Categories.

(1)	(2)	(3)	(4)	(5)
Variable	Products Sorted by Hidalgo & Hausmann Product Complexity Rankings	Products Sorted by Hidalgo & Hausmann Product Complexity Values	Products Sorted by MIT Product Complexity Rankings	Products Sorted by MIT Product Complexity Values
Real Exchange Rate	-0.675*** (0.104)	-0.674*** (0.104)	-0.669*** (0.103)	-0.670*** (0.103)
Interaction Term Between Real GDP and Dummy Variable for Highly Sophisticated Products	1.239*** (0.096)	1.146*** (0.090)	1.582*** (0.101)	1.393*** (0.097)
Interaction Term Between Real GDP and Dummy Variable for Medium Highly Sophisticated Products	0.919*** (0.079)	1.081*** (0.079)	1.364*** (0.082)	1.412*** (0.084)
Interaction Term Between Real GDP and Dummy Variable for Medium Sophisticated Products	0.569*** (0.059)	0.599*** (0.055)	1.050*** (0.063)	1.012*** (0.062)
Interaction Term Between Real GDP and Dummy Variable for Medium Low Sophisticated Products	0.307*** (0.047)	0.321*** (0.044)	0.717*** (0.053)	0.732*** (0.050)
Real GDP	0.048 (0.145)	0.127 (0.140)	-0.247* (0.136)	-0.097 (0.133)
Number of Observations	2,361,964	2,361,964	2,361,964	2,361,964
Adjusted R-Squared	0.813	0.813	0.814	0.814

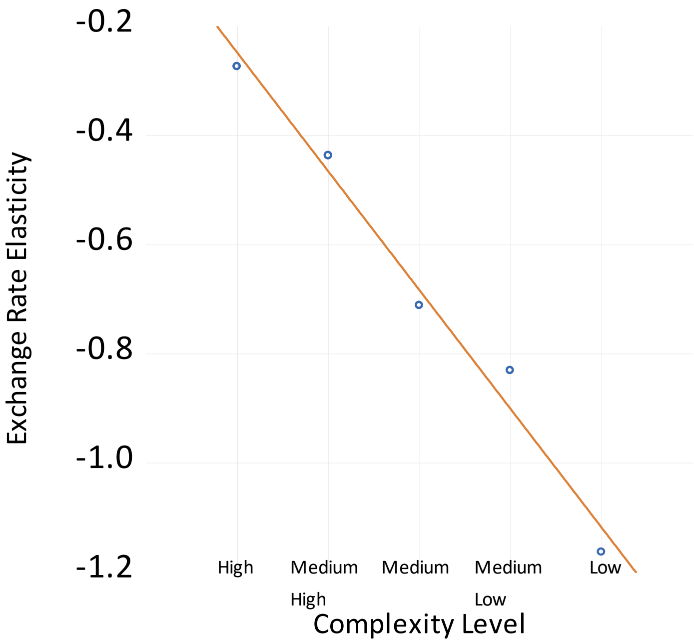
Notes: The table presents trade elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average ranking among 960 goods according to their Hidalgo and Hausmann (2009) Product Complexity Index rankings (column (2)), Hidalgo and Hausmann (2009) Product Complexity Index values (column (3)), MIT Observatory of Economic Complexity rankings (column (4)), MIT Observatory of Economic Complexity values (column (5)). The regressions include the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. These exports are divided into five complexity levels using the four methods listed above. Real GDP is interacted with dummy variables for four complexity levels. The regressions also include time and importer-product fixed effects. All variables are measured in natural logarithms.
*** denotes significance at the 1% level using clustered standard error at importing country level.

Figure 1. The Relationship between Product Complexity and Real Exchange Rate Elasticities for the PRC's Exports (complexity levels determined by product rankings based on Hidalgo and Hausman's Product Complexity Index).



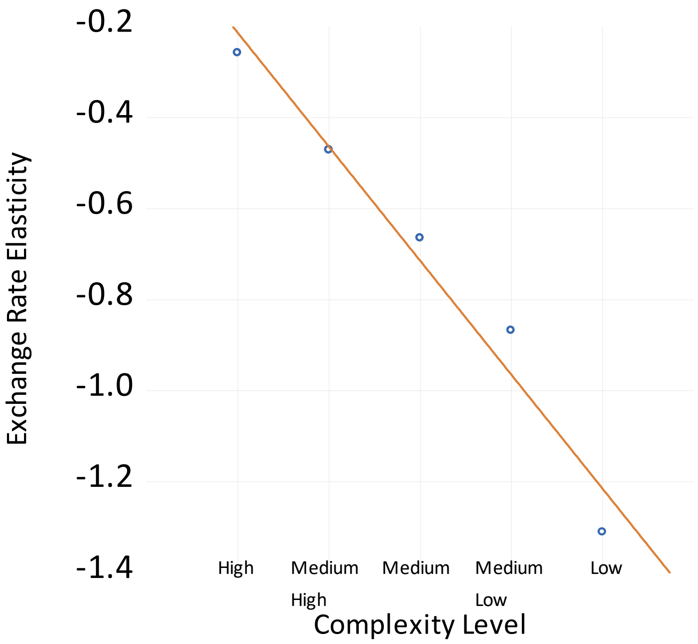
Notes: The figure presents real exchange rate elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average ranking among 960 goods according to the Product Complexity Index of Hidalgo and Hausmann (2009). The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. The real exchange rate is interacted with dummy variables for four complexity levels to find exchange rate elasticities for each level. The regressions also include importing country GDP and time and importer-product fixed effects.

Figure 2. The Relationship between Product Complexity and Real Exchange Rate Elasticities for the PRC's Exports (complexity levels determined by product values based on Hidalgo and Hausman's Product Complexity Index).



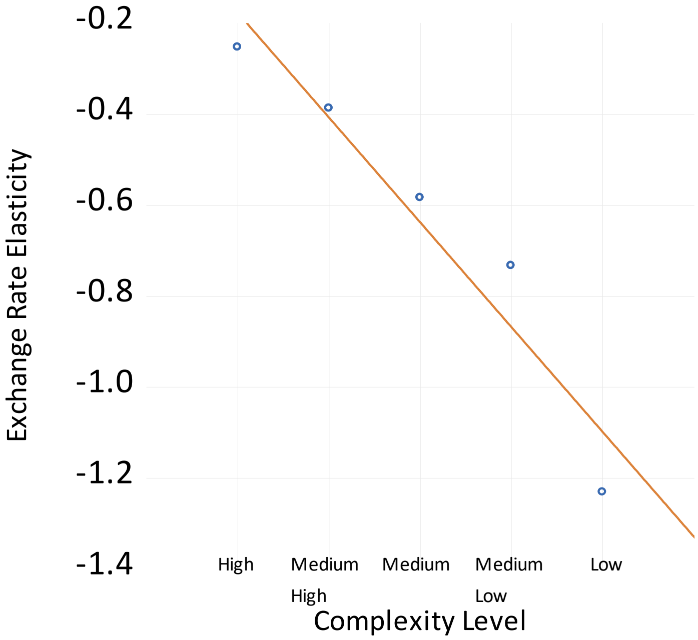
Notes: The figure presents real exchange rate elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average values among 960 goods according to the Product Complexity Index of Hidalgo and Hausmann (2009). The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. The real exchange rate is interacted with dummy variables for four complexity levels to find exchange rate elasticities for each level. The regressions also include importing country GDP and time and importer-product fixed effects.

Figure 3. The Relationship between Product Complexity and Real Exchange Rate Elasticities for the PRC's Exports (complexity levels determined by product rankings based on MIT Observatory of Economic Complexity data).



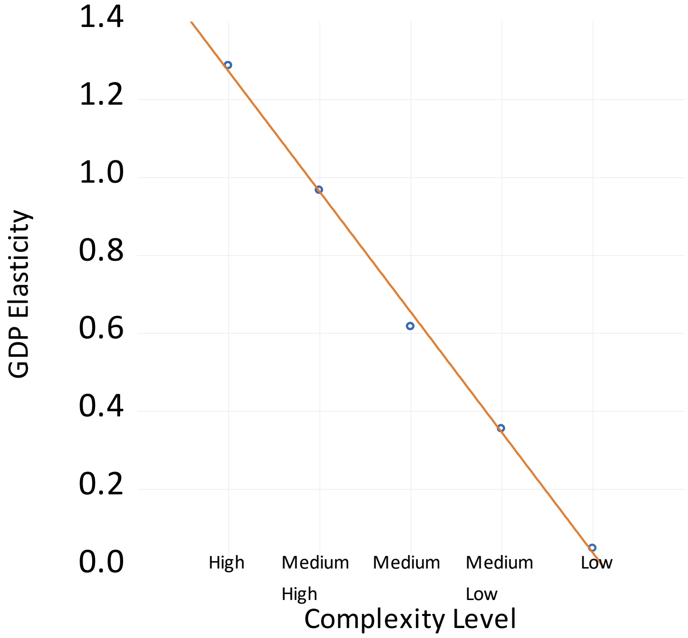
Notes: The figure presents real exchange rate elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average ranking among 960 goods according to data from the MIT Observatory of Economic Complexity. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. The real exchange rate is interacted with dummy variables for four complexity levels to find exchange rate elasticities for each level. The regressions also include importing country GDP and time and importer-product fixed effects.

Figure 4. The Relationship between Product Complexity and Real Exchange Rate Elasticities for the PRC's Exports (complexity levels determined by product values based on MIT Observatory of Economic Complexity data).



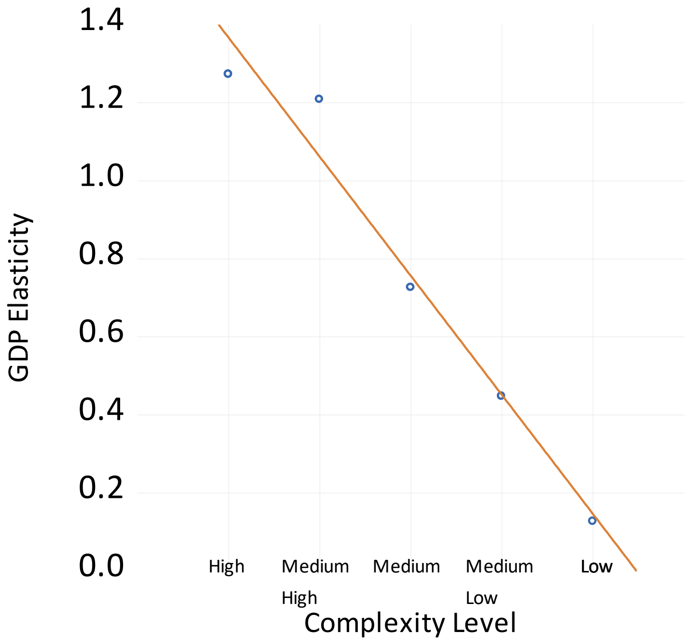
Notes: The figure presents real exchange rate elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average values among 960 goods according to data from the MIT Observatory of Economic Complexity. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. The real exchange rate is interacted with dummy variables for four complexity levels to find exchange rate elasticities for each level. The regressions also include importing country GDP and time and importer-product fixed effects.

Figure 5. The Relationship between Product Complexity and Real GDP Elasticities for the PRC's Exports (complexity levels determined by product rankings based on Hidalgo and Hausman's Product Complexity Index).



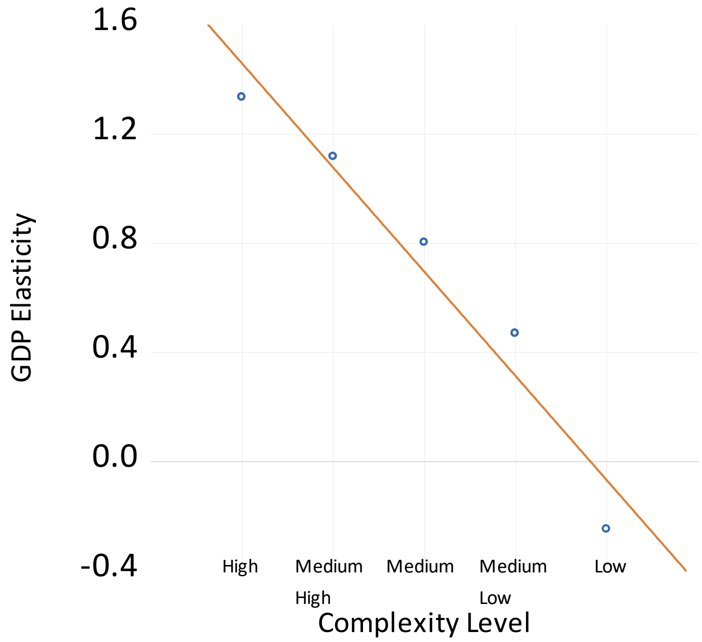
Notes: The figure presents real GDP elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average ranking among 960 goods according to the Product Complexity Index of Hidalgo and Hausmann (2009). The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. Real GDP rate is interacted with dummy variables for four complexity levels to find GDP elasticities for each level. The regressions also include bilateral real exchange rates and time and importer-product fixed effects.

Figure 6. The Relationship between Product Complexity and Real GDP Elasticities for the PRC's Exports (complexity levels determined by product values based on Hidalgo and Hausman's Product Complexity Index).



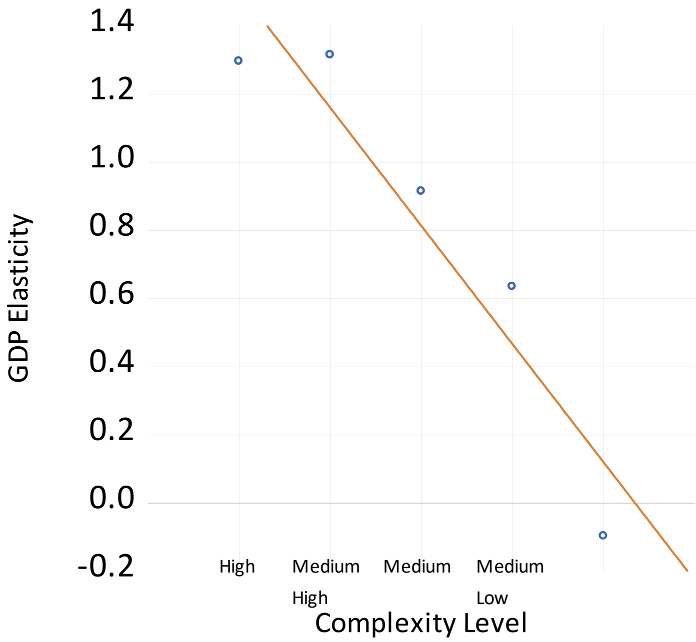
Notes: The figure presents real GDP elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average values among 960 goods according to the Product Complexity Index of Hidalgo and Hausmann (2009). The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. Real GDP is interacted with dummy variables for four complexity levels to find GDP elasticities for each level. The regressions also include bilateral real exchange rates and time and importer-product fixed effects.

Figure 7. The Relationship between Product Complexity and Real GDP Elasticities for the PRC's Exports (complexity levels determined by product rankings based on MIT Observatory of Economic Complexity data).



Notes: The figure presents real GDP elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average ranking among 960 goods according to data from the MIT Observatory of Economic Complexity. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. Real GDP is interacted with dummy variables for four complexity levels to find GDP elasticities for each level. The regressions also include bilateral real exchange rates and time and importer-product fixed effects.

Figure 8. The Relationship between Product Complexity and Real GDP Elasticities for the PRC's Exports (complexity levels determined by product values based on MIT Observatory of Economic Complexity data).



Notes: The figure presents real GDP elasticities for Chinese manufacturing exports. Harmonized System (HS) 4-digit level exports from the PRC are divided into 5 sophistication levels based on their average values among 960 goods according to data from the MIT Observatory of Economic Complexity. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 countries over the 1995-2018 period. Real GDP is interacted with dummy variables for four complexity levels to find GDP elasticities for each level. The regressions also include bilateral real exchange rates and time and importer-product fixed effects.

References

Abiad, A., Baris, K., Bertulfo, D., Camingue-Romance, S., Feliciano, P., Mariasingham, J., Mercer-Blackman, V., & Bernabe, J. (2018). The impact of trade conflict on developing Asia. (Working Paper No. 566). Manila: Asian Development Bank.

Ahmed, S. (2009). Are China's exports sensitive to changes in the exchange rate. (Working Paper No. IFDP-987). Washington, DC: Federal Reserve Board.

Ahmed,S., Appendino, M.,& Ruta, M. (2015). Global value chains and the exchange rate elasticity of exports. (Working Paper No. 15–252). Washington, DC: International Monetary Fund.

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). Washington, DC: International Monetary Fund.

Asian Development Bank. (2018). *Asian Development Outlook Update*. Manila: Asian Development Bank.

Baiardi, D., Bianchi, C., & Lorenzini, E. (2015). The price and income elasticities of the top clothing exporters: Evidence from a panel data analysis. *Journal of Asian Economics*, 38, 14-30.

Bénassy-Quéré, A., Bussière, M., & Wibaux, P. (2019). Trade and currency weapons. Mimeo, Paris School of Economics. Available at:
https://www.parisschoolofeconomics.eu/docs/benassy-quere-agnes/revisionrie_bbw_4.pdf

Chenery, H.B., & Taylor, L. (1968). Development patterns: among countries and over time. *Review of Economics and Statistics* 50, 391–441.

Cheung, Y. W., Chinn, M. & Qian, X. (2015). China–US trade flow behavior : the implications of alternative exchange rate measures and trade classifications. *Review of World Economics*, 152, 43-67.

Cheung, Y. W., Chinn, M., & Qian, X. (2012). Are Chinese trade flows different? *Journal of International Money and Finance*, 31, 2127–46.

Chinn, M. (2004). Incomes, exchange rates and the U.S. trade deficit, once again. *International Finance* 7, 451–469.

Chinn, M. (2005). Doomed to deficits? Aggregate U.S. trade flows revisited. *Review of World Economics* 141, 460-85.

Di Nino, V., Eichengreen, B., & Sbracia,M. (2012). Real exchange rates, trade and growth: Italy 1861-2011. (Economic History Working Paper No. 10). Rome: Bank of Italy.

Eaton, J., & Kortum, S. (2002). Technology, geography, and trade. *Econometrica*, 70, 1741-1779.

Eichengreen, B., & Gupta, P. (2013). The real exchange rae and export growth-are services different? (World Bank Policy Research Working Paper 6629). Washington: World Bank.

Feenstra, R., Lipsey, R., Deng, H., Ma, A., & Mo, H. (2005). World trade flows: 1962-2000. (Working Paper No. 11040). Cambridge, MA: National Bureau of Economic Research.

Felipe, J., Kumar, U., Abdon, A. & Bacate, M. (2012). Product complexity and economic development. *Structural Change and Economic Dynamics*. 23, 36-68.

Fontagné, L., Martin, P., & Orefice, G. (2018), The international elasticity puzzle is worse than you think. *Journal of International Economics*. 115, 115-129.

Freund, C., & Pierola, M.D. (2012). Export surges: The power of a competitive currency. *Journal of Development Economics,* 97, 387-395.

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

House, C., Proebsting, C., and Tesar, L. (2019). Regional effects of exchange rate fluctuations. (Working Paper No. 26071). Cambridge, MA: National Bureau of Economic Research.

Huang Y., Salike N., & Zhong F. (2017). Policy effect on structural change: A case of Chinese intermediate goods trade. *China Economic Review*, 44, 30–47.

Ilzetzki, E,, Reinhart, C., and Rogoff, K. (2020). Will the Secular Decline In Exchange Rate and Inflation Volatility Survive COVID-19? (Working Paper No. 28108). Cambridge, Mass.: National Bureau of Economic Research.

Kaldor, N. (1967). *Strategic Factors in Economic Development*. Ithaca NY: State School of Industrial and Labor Relations, Cornell University.

Kato, A. (2015). Effects of exchange rate changes on East Asian technology-intensive exports. *Journal of International Trade & Economic Development*, 24, 809-821.

Krugman, P. (1979). Increasing returns, monopolistic competition, and international trade. *Journal of International Economics*, 9, 469–79.

Kuznets, S., 1966. *Modern Economic Growth*. New Haven, CT: Yale University Press.

Lewis, A. (1955). *The Theory of Economic Growth*. Homewood, IL.: Irwin.

Pesaran, H., Shin, Y., & Smith, R.J. (2001) Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289-326.

Rostow, W.W. (1959). The stages of economic growth. *Economic History Review,* 12, 1–16.

Thorbecke, W. (2018). The exposure of U.S. manufacturing industries to exchange rates. *International Review of Economics and Finance*, 58, 538-549.

Xing,Y.(2018). Rising wages, yuan's appreciation and China's processing exports. *China Economic Review,* 48, 114-122.