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

WILLEM THORBECKE, CHEN CHEN, AND NIMESH SALIKE*

More complex products are less substitutable in international trade and may therefore have lower price elasticities. We investigate this issue using 960 types of manufactured exports from the People's Republic of China (PRC) to 190 partner economies 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 PRC can reduce its exporters' exposure to tariffs, trade wars, and exchange rate volatility by upgrading its export basket.

Keywords: exchange rate elasticities, PRC exports, product sophistication

JEL codes: F10, F13, F14

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I. Introduction

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

Abiad et al. (2018) and Asian Development Bank (ADB) (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 United States (US) disaggregated at the 2-digit and 4-digit HS level. He employed dynamic ordinary least squares (DOLS) estimation and quarterly data over the 1992–2018 period. He reported that the PRC's 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 US but also 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, for example, Ahmed 2009). We estimate elasticities for the PRC's exports of 960 manufactured goods to 190 economies 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 elasticity of -0.67, implying that a 10% renminbi appreciation will reduce exports by 6.7%. 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 from the third quarter (Q3) of 1994 to the fourth quarter (Q4) of 2010. Employing the International Monetary Fund's Consumer Price Index (CPI)-deflated real effective exchange rate, they reported that a

10% renminbi appreciation would reduce total exports by between 9% and 16%, manufacturing exports by between 9% and 15%, and primary exports by between 7% and 12%.

Kato (2015) used panel DOLS and annual data on the PRC's exports to 26 economies over the 1995–2011 period to estimate elasticities. He examined exports of high skill- and technology-intensive manufacturing products and medium skill- and 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- and technology-intensive exports but not of medium skill- and technology-intensive exports.

Xing (2018) investigated how renminbi appreciation and rising wages affect the PRC's comparative advantage in labor-intensive assembly operations. He focused on processed exports, which are 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 economies over the 1993–2013 period, he found that a 10% appreciation of the nominal US 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% 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 appreciation 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 US from the first quarter (Q1) of 1994 to Q4 2012. 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 (RER) and the CPI-deflated RER 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 are processed exports.

Baiardi, Bianchi, and Lorenzini (2015) focused on one particular low-technology export, which is 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 moments estimation, they reported that a 10% increase in relative prices would reduce the PRC's clothing exports by between 8% and 9%.

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) product complexity measure.

The next section presents our data and methodology. Section III presents the results. Section IV concludes.

II. Data and Methodology

The theoretical model informing this investigation is the imperfect substitutes model (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 RER to relate prices in the two currencies yields the following export function:

$$\ln X_t = \beta_0 + \beta_1 \ln \mathrm{RER}_t + \beta_2 \ln Y_t, \tag{1}$$

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's gross domestic product (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 ADB (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. (2018) and ADB (2018) in using the 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 (2009) approach and how it builds on the literature that models development as a process of transforming a country's economic structure toward higher productivity activities.[1] Hidalgo and Hausmann emphasized the role of capabilities in determining the ability of economies to produce more complex goods. As a Scrabble player with many letters can create more complicated words, an economy with many capabilities can produce more complex products. As Felipe et al. (2012) 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 1. For a product, they measured complexity by its ubiquity. They defined ubiquity as the number of economies that export the product with RCA greater than 1. Intuitively, an economy that exports more products with RCA greater than 1 is more diversified, and a product that fewer economies export with RCA greater than 1 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 as follows:

$$\text{Diversification (Economic complexity): } k_{e,0} = \sum_p M_{ep}, \tag{2}$$

$$\text{Ubiquity (Product complexity): } k_{p,0} = \sum_e M_{ep}, \tag{3}$$

where e represents an economy, p represents a product, M_{ep} equals 1 if an economy e exports product p with RCA greater than 1, and M_{ep} equals 0 otherwise. The method of reflections involves first calculating diversification and ubiquity from equations (2) and (3) and then solving equations (4) and (5) iteratively as follows:

$$k_{e,n} = 1/k_{e,0} \sum_p M_{ep} k_{p,n-1}, \tag{4}$$

$$k_{p,n} = 1/k_{p,0} \sum_e M_{ep} k_{c,n-1}. \tag{5}$$

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

We use the PCI derived from this approach to measure complexity. The data come from *The Atlas of Economic Complexity*.[2] 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 and the PCI rankings over the 1995–2018 period, and also combine exports into five sophistication categories based on their PCI and PCI ranking values.[3] 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 Massachusetts Institute of Technology (MIT) Observatory of Economic Complexity (OEC).[4] The OEC employs a similar method to the one used by Hidalgo and Hausmann (2009) to calculate PCIs. However, it uses data from Feenstra et al. (2005) and relies on researchers from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) to harmonize the trade data.

Why should the PRC care if more complex products have lower exchange rate elasticities? Ilzetzki, Reinhart, and Rogoff (2020) argued that, while the exchange rates of the renminbi, US dollar, Japanese yen, and 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 US have exploded and led to tariffs on imports from the PRC. In standard models, tariffs and exchange rates exert identical effects on export volumes (Krugman 1979; Eaton and Kortum 2002). For example, Fontagné, Martin, and Orefice (2018) reported this correspondence in a model with constant elasticity of substitution preferences. Because of this equivalence, House, Proebsting, and Tesar (2019) used exchange rate elasticities to calculate the effect on the US economy of tariffs on imports from the PRC. 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, for example, Eichengreen and Gupta 2013; Freund and Pierola 2012; Di Nino, Eichengreen, and Sbracia 2012; Ahmed, Appendino, and Ruta 2015; and Bénassy-Quéré, Bussière, and Wibaux 2019). We follow the approach of Bénassy-Quéré, Bussière, and Wibaux (2019). They modeled country *i*'s exports to

[2]The website for *The Atlas of Economic Complexity* is https://atlas.cid.harvard.edu/.

[3]Average PCI rankings of all 960 products over the 1995–2018 period are available upon request.

[4]These data are available at https://oec.world.

country j of product p in year t, X_{ijpt}, using a series of fixed effects:

$$\ln X_{ijpt} = \lambda_{ipt} + \mu_{jpt} + \nu_{ij} + \epsilon_{ijpt}, \tag{6}$$

where λ_{ipt}, μ_{jpt}, and ν_{ij} are fixed effects for exporter, product, time; importer, product, time; and importer, exporter, respectively. The last term ϵ_{ijpt} is a random error term. Bénassy-Quéré, Bussière, and Wibaux (2019) added the bilateral real exchange rate (BRER) between country i and country j at time t, BRER_{ijt}, yielding the following equation:

$$\ln X_{ijpt} = \beta \ln \text{BRER}_{ijt} + \lambda_{ipt} + \mu_{jpt} + \nu_{ij} + \epsilon_{ijpt}. \tag{7}$$

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 Bénassy-Quéré, Bussière, and Wibaux (2019) did, we also include the importing country's real GDP (Y_{jt}) as an additional control variable. We thus focus on the following export equation:

$$\ln X_{jpt} = \beta_0 + \beta_1 \ln \text{BRER}_{jt} + \beta_2 \ln Y_{jt} + \lambda_{jp} + \mu_t + \epsilon_{jpt}. \tag{8}$$

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

$$\begin{aligned} \ln X_{jpt} = &\beta_0 + \beta_1 \ln \text{BRER}_{jt} + \beta_2 \ln Y_{jt} + \beta_3 \ln \text{BRER}_{jt} * D_1 + \beta_4 \ln \text{BRER}_{jt} * D_2 \\ &+ \beta_5 \ln \text{BRER}_{jt} * D_3 + \beta_6 \ln \text{BRER}_{jt} * D_4 + \lambda_{jp} + \mu_t + \epsilon_{jpt}, \end{aligned} \tag{9}$$

where D_1 is a dummy variable equaling 1 if the export category p ranks in the most complex 20% (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 Bénassy-Quéré, Bussière, and Wibaux (2019), we measure X_{jpt} as the value of exports. We obtain bilateral free-on-board export data from the PRC to 190 economies 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 United Nations Comtrade database.

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 economies	2,446,460	25.00	2.13	17.10	30.63

GDP = gross domestic product.
Source: Authors' calculations.

We obtain data on the BRER between the PRC and each importing economy from the CEPII-CHELEM database.[5] The exchange rate is defined so that an increase represents an appreciation of the renminbi. We obtain data on real GDP in the importing economies from the CEPII gravity database.[6] Table 1 provides descriptive statistics for the variables in equation (9).

III. 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, column (3) with exports sorted based on values of the Hidalgo–Hausmann PCI, column (4) with exports sorted based on average rankings of the MIT OEC PCI, and column (5) with exports sorted based on values of the MIT OEC PCI. All of the coefficients are of the expected signs and statistically significant at the 1% level. F-tests indicate that the coefficients on the interaction terms between the exchange rate and complexity levels are also statistically different from each other at the 1% 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,

[5]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.

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

Table 2. **Exchange Rate Elasticities for the People's Republic of China's Manufacturing Exports Sorted into Five Sophistication Categories**

Variable (1)	Products Sorted by Hidalgo and Hausmann Product Complexity Rankings (2)	Products Sorted by Hidalgo and Hausmann Product Complexity Values (3)	Products Sorted by MIT Product Complexity Rankings (4)	Products Sorted by MIT Product Complexity Values (5)
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)

Continued.

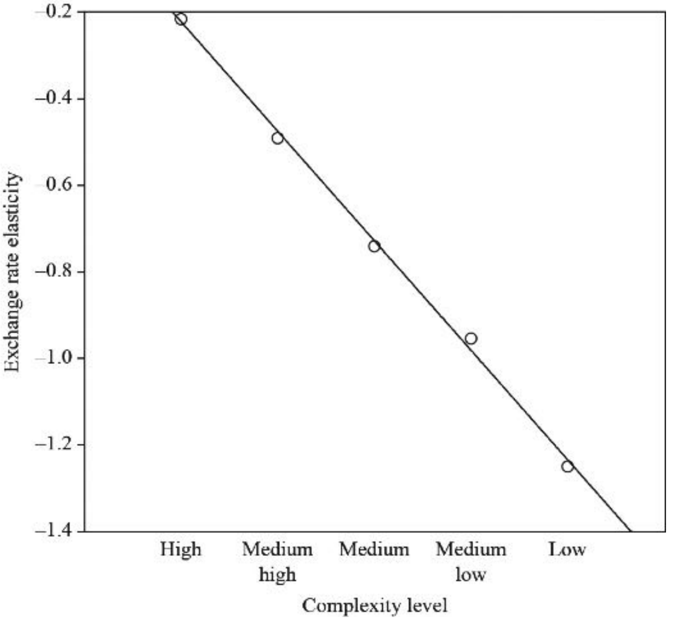
Table 2. *Continued.*

Variable (1)	Products Sorted by Hidalgo and Hausmann Product Complexity Rankings (2)	Products Sorted by Hidalgo and Hausmann Product Complexity Values (3)	Products Sorted by MIT Product Complexity Rankings (4)	Products Sorted by MIT Product Complexity Values (5)
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

GDP = gross domestic product, MIT = Massachusetts Institute of Technology.
Notes: The table presents trade elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five 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]), and 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 economies 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 the importing-economy level.
Source: Authors' calculations.

−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 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 1–4 plot

Figure 1. **The Relationship between Product Complexity and Real Exchange Rate Elasticities for the People's Republic of China's Exports**

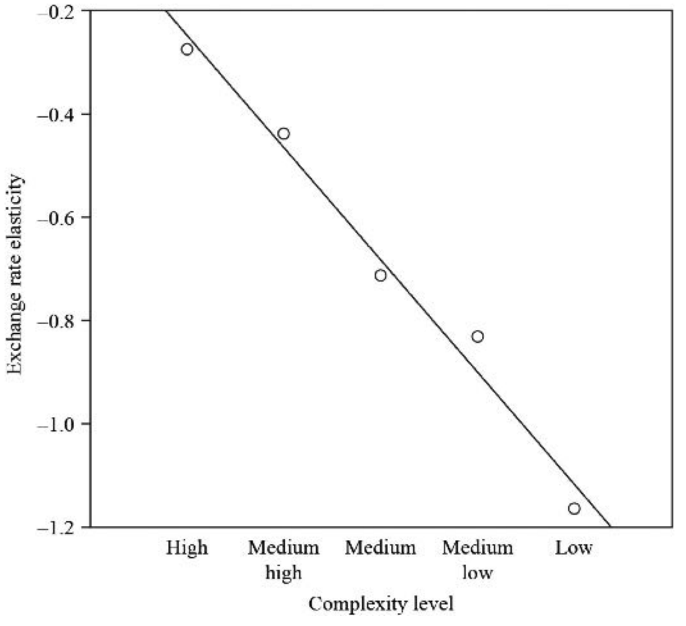


Notes: Complexity levels are determined by product rankings based on Hidalgo and Hausmann's Product Complexity Index. The figure presents real exchange rate elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five 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 economies 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-economy gross domestic product and time and importer-product fixed effects.
Source: Authors' calculations.

the elasticities for each of 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)–(5), the results indicate that a 10% renminbi appreciation is associated with a drop in exports of 2.5% for the most sophisticated exports, 4.5% for medium-high sophisticated exports, 6.8% for medium sophisticated exports, 8.5% for medium-low sophisticated exports, and 12.4% 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, sulfur, and prepared fish.

Figure 2. **The Relationship between Product Complexity and Real Exchange Rate Elasticities for the People's Republic of China's Exports**



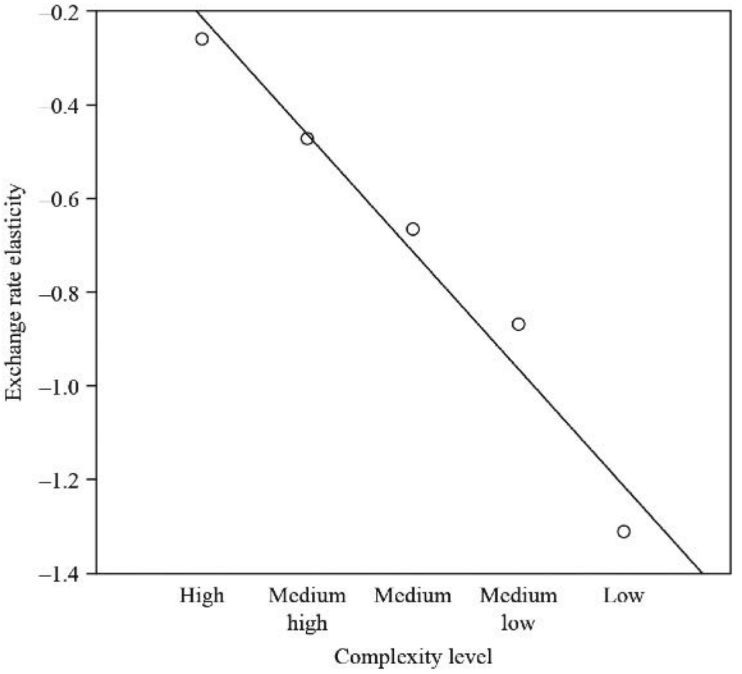
Notes: Complexity levels are determined by product values based on Hidalgo and Hausmann's Product Complexity Index. The figure presents real exchange rate elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five 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 economies 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-economy gross domestic product and time and importer-product fixed effects.
Source: Authors' calculations.

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 ($\beta_{\mathrm{BRER},i}$) on the corresponding PCI ranking for that 4-digit category ($\mathrm{PCI}_{\mathrm{Ranking},i}$) yields the following:

$$\beta_{\mathrm{BRER},i} = \underset{(0.100)}{-0.466^{***}} - \underset{(0.000093)}{0.000319^{***}}\mathrm{PCI}_{\mathrm{Ranking},i}. \tag{10}$$

Number of observations = 960. Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** = significant at 1% level. Adjusted R-squared = 0.315. Standard

Figure 3. **The Relationship between Product Complexity and Real Exchange Rate Elasticities for the People's Republic of China's Exports**

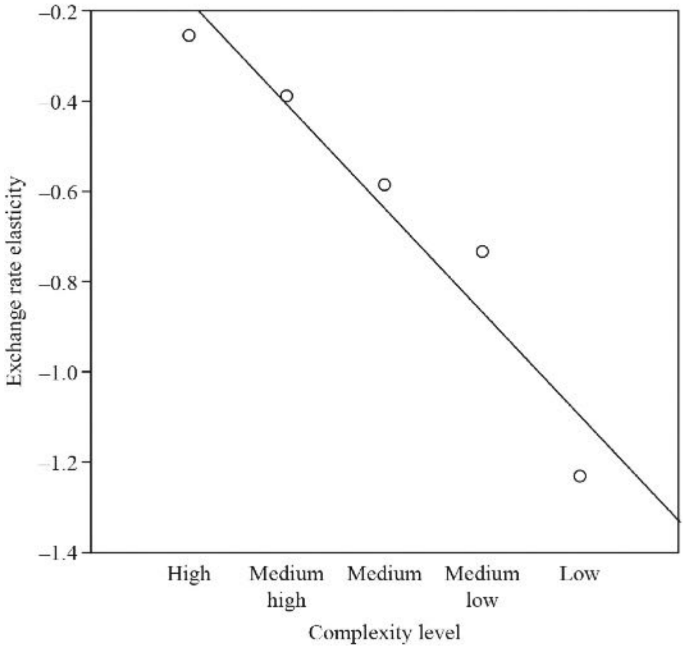


Notes: Complexity levels are determined by product rankings based on the Massachusetts Institute of Technology (MIT) Observatory of Economic Complexity (OEC) data. The figure presents real exchange rate elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five sophistication levels based on their average ranking among 960 goods according to data from the MIT OEC. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 economies 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-economy gross domestic product and time and importer-product fixed effects.
Source: Authors' calculations.

error of regression = 0.519. Durbin–Watson statistic = 2. Dummy variables included for each HS 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

Figure 4. **The Relationship between Product Complexity and Real Exchange Rate Elasticities for the People's Republic of China's Exports**



Notes: Complexity levels are determined by product values based on the Massachusetts Institute of Technology (MIT) Observatory of Economic Complexity (OEC) data. The figure presents real exchange rate elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five sophistication levels based on their average values among 960 goods according to data from the MIT OEC. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 economies 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-economy gross domestic product and time and importer-product fixed effects.
Source: Authors' calculations.

so that we can interpret the coefficient as an elasticity.[7] The results are as follows:

$$\log(\beta_{\mathrm{BRER},\,i}) = \underset{(0.189)}{0.775^{***}} + \underset{(0.120)}{0.269^{**}} \log(\mathrm{PCI}_{\mathrm{Value},\,i}). \tag{11}$$

Number of observations = 960. Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** (**) = significant at 1% (5%) level. Adjusted

[7]To avoid taking logarithms of negative values, we added 4.01 to the elasticity values and 5 to the Hidalgo–Hausmann and MIT OEC PCI values.

R-squared = 0.133. Standard error of regression = 0.244. Durbin–Watson statistic = 2.12. Dummy variables included for each HS 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% increase in PCI values is associated with a 2.69% increase in the exchange rate elasticity.

Table 3. **Gross Domestic Product Elasticities for the People's Republic of China's Manufacturing Exports Sorted into Five Sophistication Categories**

Variable (1)	Products Sorted by Hidalgo and Hausmann Product Complexity Rankings (2)	Products Sorted by Hidalgo and Hausmann Product Complexity Values (3)	Products Sorted by MIT Product Complexity Rankings (4)	Products Sorted by MIT Product Complexity Values (5)
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)

Continued.

Table 3. *Continued.*

Variable (1)	Products Sorted by Hidalgo and Hausmann Product Complexity Rankings (2)	Products Sorted by Hidalgo and Hausmann Product Complexity Values (3)	Products Sorted by MIT Product Complexity Rankings (4)	Products Sorted by MIT Product Complexity Values (5)
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

GDP = gross domestic product, MIT = Massachusetts Institute of Technology.
Notes: The table presents GDP elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five 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]), and 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 economies 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 the importing-economy level.
Source: Authors' calculations.

As a sensitivity check, we run a regression analogous to equation (11) using the PCI values obtained from the MIT OEC:

$$\log(\beta_{\mathrm{BRER},\,i}) = \underset{(0.085)}{0.997^{***}} + \underset{(0.051)}{0.127^{**}} \log(\mathrm{PCI}_{\mathrm{Value},\,i}). \tag{12}$$

Number 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 = 1.9. Dummy variables included for each HS 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% increase in PCI values is associated with a 1.27% increase in the exchange rate elasticity.

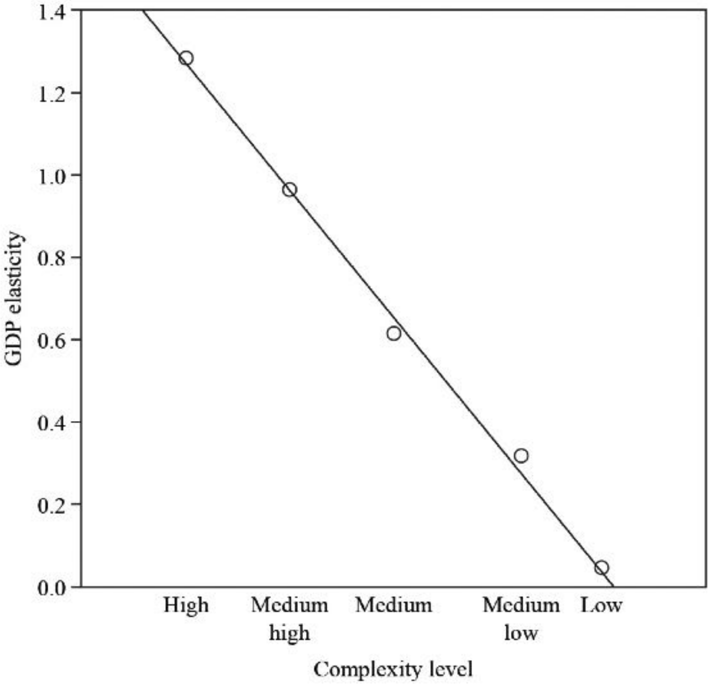
Table 3 presents the results from using interaction terms to allow GDP elasticities to vary across the five complexity categories. Column (2) sorts exports based on average rankings of the Hidalgo–Hausmann PCI, column (3) based on values of the Hidalgo–Hausmann PCI, column (4) based on average rankings of the MIT OEC PCI, and column (5) based on values of the MIT OEC PCI. 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 1% level, implying that the GDP elasticities differ across complexity levels.

In column (2) with exports sorted based on Hidalgo–Hausmann rankings, the GDP elasticity is 1.287 for the most sophisticated exports, 0.967 for medium-high sophisticated exports, 0.617 for medium sophisticated exports, 0.355 for 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 1.273 for the most sophisticated exports, 1.208 for medium-high sophisticated exports, 0.726 for medium sophisticated exports, 0.448 for 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 1.335 for the most sophisticated exports, 1.117 for medium-high sophisticated exports, 0.803 for medium sophisticated exports, 0.47 for 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 1.296 for the most sophisticated exports, 1.315 for medium-high sophisticated exports, 0.915 for medium sophisticated exports, 0.635 for medium-low sophisticated exports, and −0.097 for the least sophisticated exports.

Figures 5–8 plot 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 nonprice competitiveness should have higher income elasticities.[8]

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

Figure 5. **The Relationship between Product Complexity and Real Gross Domestic Product Elasticities for the People's Republic of China's Exports**

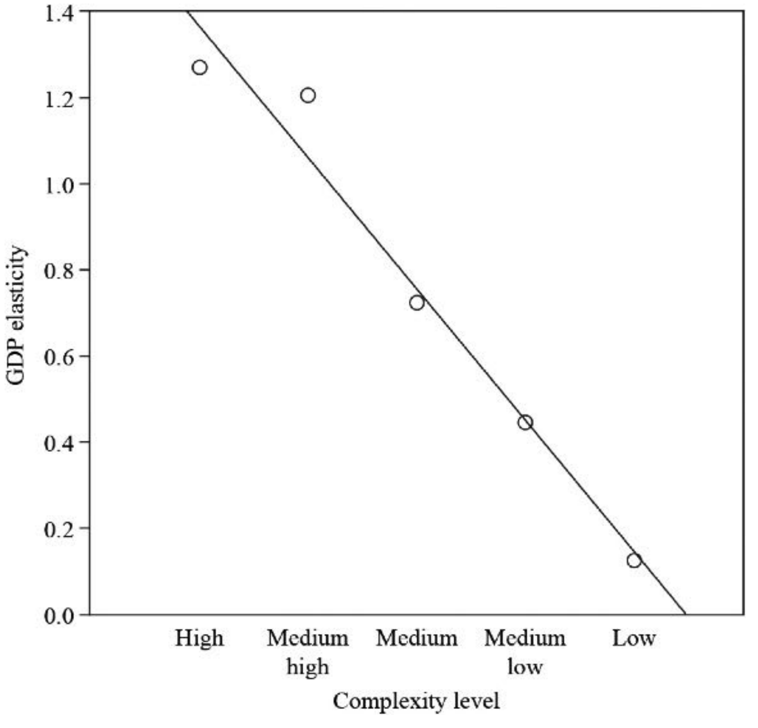


Notes: Complexity levels are determined by product rankings based on Hidalgo and Hausmann's Product Complexity Index. The figure presents real gross domestic product (GDP) elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five 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 economies 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.
Source: Authors' calculations.

The GDP elasticities in Table 2 equal 0.775. This indicates that the PRC'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

Figure 6. **The Relationship between Product Complexity and Real Gross Domestic Product Elasticities for the People's Republic of China's Exports**

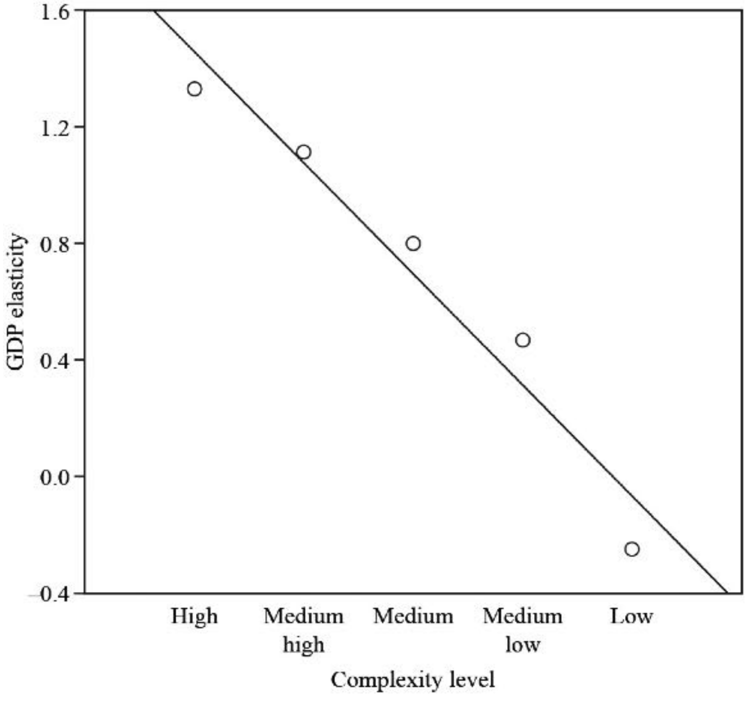


Notes: Complexity levels are determined by product values based on Hidalgo and Hausmann's Product Complexity Index. The figure presents real gross domestic product (GDP) elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five 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 economies 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.
Source: Authors' calculations.

upgrading can help to maintain stability in the volume of the PRC's exports in the face of exchange rate fluctuations.

The PRC's complexity rating based on the approach of Hidalgo and Hausmann (2009) rose from 46th in 1995 to 18th in 2018. As the PRC'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)–(5) of Table 2 indicates that

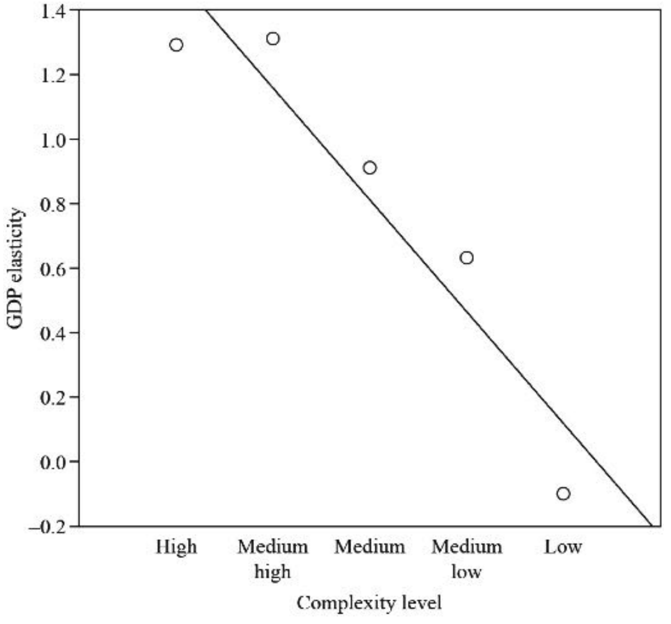
Figure 7. **The Relationship between Product Complexity and Real Gross Domestic Product Elasticities for the People's Republic of China's Exports**



Notes: Complexity levels are determined by product rankings based on the Massachusetts Institute of Technology (MIT) Observatory of Economic Complexity (OEC) data. The figure presents real gross domestic product (GDP) elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five sophistication levels based on their average ranking among 960 goods according to data from the MIT OEC. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 economies 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.
Source: Authors' calculations.

elasticities for the 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 condition will only just hold or not hold at all for the PRC in the future. Thus, depreciations in the RER will have very limited impact in improving the PRC's trade balance going forward.

Figure 8. **The Relationship between Product Complexity and Real Gross Domestic Product Elasticities for the People's Republic of China's Exports**



Notes: Complexity levels are determined by product values based on the Massachusetts Institute of Technology (MIT) Observatory of Economic Complexity (OEC) data. The figure presents real gross domestic product (GDP) elasticities for manufacturing exports from the People's Republic of China (PRC). Harmonized System (HS) 4-digit level exports from the PRC are divided into five sophistication levels based on their average values among 960 goods according to data from the MIT OEC. The regression includes the PRC's manufacturing exports (960 goods) disaggregated at the HS 4-digit level to 190 economies 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.
Source: Authors' calculations.

IV. Conclusion

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

Arbatli 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 at the HS 4-digit level to 190 partner economies. We find that a 10% appreciation of the renminbi 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 Government of the PRC has employed trade and industrial policies to upgrade its industries (Huang, Salike, and Zhong 2017). These policies helped improve the PRC's economic complexity ranking, as measured using the method of Hidalgo and Hausmann (2009), 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 toward the technology frontier.

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