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Major exchange rates and value-added exports

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Abstract:

This study's primary concern is that exporting or multinational firms tend to be more reliant on intermediate imports with major currencies. We investigate the effects of exchange rates on value-added exports in the linkage with the exports-FDI feedback for sustainable free trade development in OECD countries. Our bilateral findings are that the exchange rate effects are greater for gross than value-added exports except for Germany and greater for intermediate goods than final goods exports except for Italy. But there are no significant differences in the effects of exchange rate changes on exports regardless of US dollar and other currencies. Meanwhile, foreign income has a positive effect on all exports, and the exports-FDI feedback has a weak positive effect on exports to China due to increased FDI into China while the value-added exports-FDI nexus has a weak positive effect on all FDIs

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Our primary concern is that exporting or multinational firms tend to be more reliant on intermediate imports and foreign affiliation. In today's situation of the great intermediary trade and foreign direct investments (FDI), this study investigates the effects of major exchange rates on value-added exports focusing on the export-FDI feedback dynamic, which would be new with respect to the existing literature.

Koopman et al. (2014), Johnson and Noguera (2012), and Hummels et al. (2001) provide the vertical specialization to track the value-added trade flows. Gunnella et al. (2017) analyze the global market using value-added exports instead of gross exports due to the closer relation between industries through intermediate trade. Choi et al. (2019) find that currency depreciation has a negative effect on gross exports because of intermediary imports but a positive effect on value-added exports as depreciation improves the trade balance for small open countries; this can sometimes hold for large countries.

Multinational enterprises invest more complex FDI and sourcing strategies to increase specialization in global value chains (Beugelsdijk et al., 2009; Buelens and Tirpák, 2017). Bergstrand and Egger (2007) analyze the sales of foreign affiliates, Harach and Rodrigues-Crespo (2014) find that FDI increases exports differently across sections, and Carril-Caccia and Pavlova (2018) find that exports in final goods favor FDI but exports in intermediate goods do not. Additionally, the selection effect according to which more productive firms self-select into

oversea markets and the treatment effect of learning by exporting and multinational production may be simultaneously significant. Consequently, export-FDI feedback in addition to export-led FDI and FDI-led exports, is explored (Tsaurai, 2013; Aizenman and Noy, 2006). It is important because this feedback dynamic is less known. So, the value-added gain from participating in the export-FDI feedback can be significant.

In international trade, global transmission of exchange rate change relies on the invoicing currency (Tille and Goldberg, 2009). Melvin and Sultan (1990) indicate that a necessary condition for an exporter's domestic currency invoicing is a negative correlation between the exchange rate and the production cost, and Takatoshi et al. (2015) demonstrate that the invoicing choice of inter-firm trade is determined by the destination of the subsidiary's exports and exchange rate volatility. The invoicing currency plays a central role in global shock transmission and optimal monetary policy (Corsetti and Pesenti, 2005).[1] Still, the US dollar is a representative settlement currency. The dollar invoicing has a great influence on the domestic exports and imports as well as the world trade flows (Goldberg and Tille, 2008). Recently, Bruno and Shin (2019) found that the depreciation of US dollar invoicing increases global trade activity through a financial channel such as dollar-funded bank credit supply, but the opposite is also true because exporters reliant on banks with higher dollar funding suffer.

From the perspective of the decision to serve global value-chained foreign markets through both exports and FDI with invoicing currencies, this study is (1) a consideration of the role of value-added exports in the linkage with FDI, (2) an examination of the direct effects of exchange rates on value-added exports, and (3) an investigation of the indirect effect of exchange rates on the exports-FDI nexus. In empirical tests, we estimate value-added trade and FDI data for OECD countries as destination countries. Our findings will make a specific contribution to the literature on international economic frameworks as well as provide an updated implication on trade policies to improve real exports and economic performance.

This study is organized as follows. In section 1, we review standard trade models and explain more clearly what is important in this study. In section 2, we explain the empirical analysis and provide the testing results. In section 3, we summarize findings and conclude the study.

1. Trade models review

This section uses traditionally standard bilateral trade models to explain the relations between value-added exports, exchange rates with invoicing currency, and the export-FDI feedback. Initially, in the situation where exports are increasingly composed of intermediate input imports and foreign affiliation, we recognize the bilateral effects of exchange rate, $q = 1/q^*$, income, and export-FDI linkage where q is the domestic real exchange rate and q^* is the foreign real exchange rate:

[1] When exporters set prices in their own currencies, producer currency pricing changes the relative prices of domestic and imported goods based on the exchange rate, which leaves monetary policy free to focus on domestic shocks. When exporters set their prices in their customers' currencies, this local currency pricing leaves the relative prices of domestic and imported goods unchanged as a result of the exchange rate, which leaves monetary policy to concentrate on domestic and foreign shocks.

$X = f_1(q, Y^*, d)$, $\frac{\partial X}{\partial q} > 0, \frac{\partial X}{\partial Y^*} > 0$, $\frac{\partial X}{\partial d} < 0$, or $\frac{\partial X}{\partial d} > 0$

$X^* = f_2(q^*, Y, d)$, $\frac{\partial X^*}{\partial q^*} > 0, \frac{\partial X^*}{\partial Y} > 0$, $\frac{\partial X^*}{\partial d} < 0$, or $\frac{\partial X^*}{\partial d} > 0$

where X is the value-added exports, the gross exports minus the foreign content of exports due to intermediate trades; X^* is the foreign value-added exports, the foreign gross exports minus the domestic content of foreign exports; Y is the domestic income or market size; Y^* is the foreign income or market size; d is the exports-FDI feedback nexus.[2]

Now, we introduce a settlement currency choice into international transactions. Suppose that agents can invoice in the currency of the larger country, whether foreign or domestic, with the major currency or the vehicle currency, while agents rarely invoice in the currency of the smaller country with the non-major currency, as follows:

$\sum_{k=1}^{3} C^k = 1$ for all, $k \in \{MC, VC, NC\}$

where C represents a certain currency k, MC is the major currencies (e.g., euro, pound), VC is the vehicle currency (e.g., US dollar), and NC is the non-major currencies (e.g., Korean won).

In other words, if agents invoice in one of the major, vehicle, and non-major currencies, then the value of exports can be displayed as follows:

$VX = X(q, Y^*, d, VF) \cdot P^* \cdot S$

$VX^* = X^*(q^*, Y, d, VF^*) \cdot P^*$, or $VX^* = X^*(q_1^*, Y, d, VF^*) \cdot P_1^* \cdot S_1$

where VX is the value of value-added exports in the domestic currency, VX^* is the value of foreign value-added exports in the foreign currency, P^* is the foreign price, P_1^* is the foreign price in foreign country 1, S is the nominal exchange rate, q_1 is the real exchange rate against foreign country 1, and S_1 is the nominal exchange rate against foreign country 1.[3]

If the exchange rate changes in value, then the changes of the value-added exports, ceteris paribus, are:[4]

$\frac{\Delta VX}{\Delta S} = [\frac{\Delta X}{\Delta S} \cdot P^* \cdot S + X \cdot P^*]$

$\frac{\Delta VX^*}{\Delta S} = [\frac{\Delta X^*}{\Delta S} \cdot P^*]$, or

$\frac{\Delta VX^*}{\Delta S1} = [\frac{\Delta X^*}{\Delta S1} \cdot P_1^* \cdot S_1]$

It is obvious that the feedback nexus between exports and FDI is complex, that exports and FDI interact to comprise firms' international operations. Then, the exchange rate change affects both exports and FDI via the channels of the feedback between exports and FDI. If the exchange rate changes in value, then the changes of the value-added exports-FDI feedback are as follows:

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[2] In addition, we apply the same explanatory variables used as trade models to the dependent variable of FDI as follows: $F = f_3(q, Y^*, d)$, $\frac{\partial F}{\partial q} < 0, \frac{\partial F}{\partial Y^*} > 0$, $\frac{\partial F}{\partial d} > 0$ and $F^* = f_4(q^*, Y, d)$, $\frac{\partial F^*}{\partial q^*} < 0, \frac{\partial F^*}{\partial Y} > 0$, $\frac{\partial F^*}{\partial d} > 0$ where F is the overseas FDI, the horizontal FDI plus the vertical FDI plus the exports platform FDI or the vertical FDI plus the exports platform FDI or the vertical FDI only, and F^* is the foreign FDI.

[3] Similarly, if agents invoice in the major, vehicle, and non-major currencies each, then the value of FDI can be represented as follows: $VF = F(q, Y^*, d, VX) \cdot R^* \cdot S$, and $VF^* = F^*(q^*, Y, d, VX^*) \cdot R^*$, or $VF^* = F^*(q_1^*, Y, d, VX^*) \cdot R_1^* \cdot S_1$, where VF is the value of outflowed FDI in term of domestic currency, VF^* is the value of foreign outflowed FDI in terms of foreign own currency, R^* is the foreign capital price, and R_1^* is the foreign capital price in foreign country 1.

[4] Similarly, if the exchange rate changes in value, then the changes of FDI, ceteris paribus, are as follows: $\frac{\Delta VF}{\Delta S} = [\frac{\Delta F}{\Delta S} \cdot R^* \cdot S + F \cdot R^*]$ and $\frac{\Delta VF^*}{\Delta S} = [\frac{\Delta F^*}{\Delta S} \cdot R^*]$, or $\frac{\Delta VF^*}{\Delta S1} = [\frac{\Delta F^*}{\Delta S1} \cdot R_1^* \cdot S_1 + F^* \cdot R_1^*]$.

$$\frac{\Delta(VX \cdot VF)}{\Delta S} = [\frac{\Delta X}{\Delta S} \cdot P^* \cdot S + X \cdot P^*] \cdot [F \cdot R^* \cdot S] + [X \cdot P^* \cdot S] \cdot [\frac{\Delta F}{\Delta S} \cdot R^* \cdot S + F \cdot R^*]$$

$$\frac{\Delta(VX^* \cdot VF^*)}{\Delta S} = [\frac{\Delta X^*}{\Delta S} \cdot P^*] \cdot [F^* \cdot R^*] + [X^* \cdot P^*] \cdot [\frac{\Delta F^*}{\Delta S} \cdot R^*], \text{ or}$$

$$\frac{\Delta(VX^* \cdot VF^*)}{\Delta S1} = [\frac{\Delta X^*}{\Delta S1} \cdot P_1^* \cdot S_1 + X^* \cdot P_1^*] \cdot [F^* \cdot R_1^* \cdot S_1] + [X^* \cdot P_1^* \cdot S_1] \cdot [\frac{\Delta F^*}{\Delta S1} \cdot R_1^* \cdot S_1 + F^* \cdot R_1^*]$$

These equations imply that each change in the feedback nexus between value-added exports and FDI may have different volume effects with diverse adjusting lags due to the different value effects by one's way of currency contracts. We consider the currency contract just after currency devaluation for the value effect, and we consider the quantity adjustment in a long period after currency depreciation for the volume effect.

2. Empirical model and testing results

This section reports econometric procedures and testing results. We estimate an extended gravity equation[5] on global value chains where firms can access foreign markets or resources and produce products in foreign countries through vertical linkages (Krugman and Venables, 1996; Hummels et al., 2001; etc.). However, our regressions are not a gravity model because we ignore bilateral links in a single regression using distance as a regressor. Rather, our estimates provide a set of bilateral relations separately.

We estimate the effects of major exchange rates on value-added exports by employing the following equations:

$$VX_{ij,t} = \text{constant} + b_1 \cdot S_{ij,t} + b_2 \cdot Y^*_{ij,t} + b_3 \cdot \text{control} + b_4 \cdot \text{dummy}$$

where $VX_{ij,t}$ is bilateral value-added exports between exporting country i and its imported countries j with major and non-major invoicing currencies at time t, $S_{ij,t}$ is the exchange rate between home country i and j at t, $Y^*_{ij,t}$ is home country i related foreign country j' income at t, and the dummy variable represents the free trade area. In particular, the control variable represents the exports-FDI feedback and VF for VX or VX for VF where the distance separating countries suggests trade impediments to trade such as distance, barriers, and borders.[6] The parameters, constant and b are estimated from the regression.

Above all, exports now fulfill both foreign consumer demand for which income is the demand shifter and intermediate demand for which total production costs shift the demand. Baldwin and Taglioni (2011) point out that using GDP in the gravity equation is inappropriate for bilateral trade flows where intermediate goods are important because using GDP as the economic mass proxy is worse for the underlying demand due to vertical specialization trade. This implies that GDP will have lower explanatory power for nations where intermediate goods trade. Also, we include the exports-FDI feedback as an endogenous variable of linear interaction to assess the respective determinants of exports and FDI.

To check our conjectures, we estimate the above model for different sets of OECD countries and major sectors for time series that span the years 1995 to 2015, and we run the above linear equation in the form of a bilateral relationship. Plainly, we use this approach to

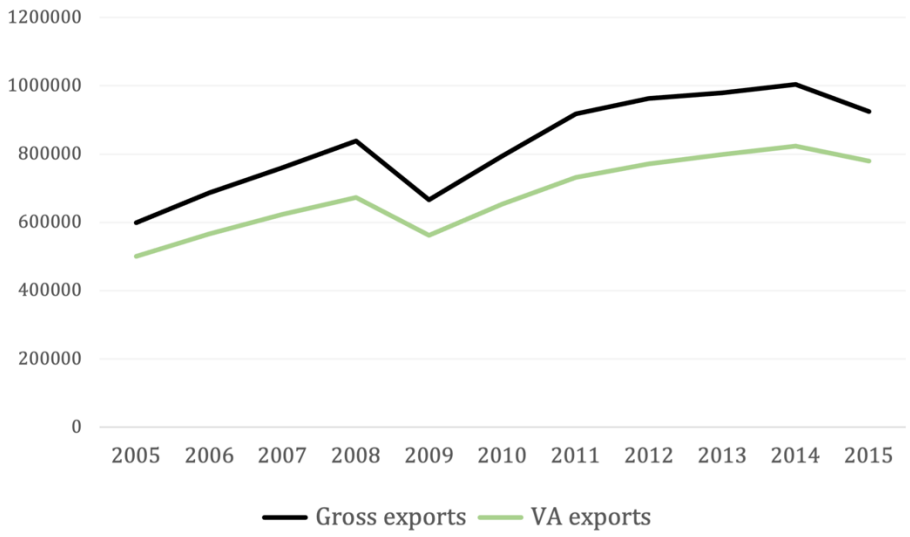
[5] The gravity model has become a common method for estimating bilateral trade flows. Anderson and van Wincoop (2004) provide a theoretical foundation for the gravity model.

[6] Similarly, $VF_{ij,t}$ = constant + $b_1 \cdot S_{ij,t}$ + $b_2 \cdot Y^*_{ij,t}$ + $b_3 \cdot$ control + $b_4 \cdot$ dummy, where $VF_{ij,t}$ is bilateral FDI between investing country i and its host countries j with various invoicing currencies at t.

investigate the impacts of crucial factors when trade in parts and components is important. To explore this more systematically, we consider a more continuous relationship between the importance of intermediates trade and the point-estimate on the variables on the full sample. Additionally, we suppose that vehicle currency is USD, major currency includes GBP, EUR, JPY, AUD, CAD, and non-major currency is like KRW, based upon the foreign exchange turnover in the foreign exchange markets.[7]

Our interest is in exploring the value-added responses of the exports and FDI to main factors including major exchange rates. We obtained yearly data from OECD-WTO for the value-added trade statistics and Federal Reserve Economic Data for other economic statistics. To estimate the effect of major factors on value-added trade flows, we specify the set of dependent variables and explanatory variables for the period between 1995 and 2015 by using all the value-added data available from OECD-WTO.

Figure 1. *Dynamics of gross and value-added exports in the US manufacturing industry*



Notes: Gross and value-added exports are measured by industry-level unit.
Source: OECD, *TiVA database*.

In the preliminary-testing stage, we carry out graphical representation to give a general sense of main testing results. Figure 1 indicates dynamic relationships between gross exports and value-added exports in the US manufacturing industry. This shows that value-added exports are less than gross exports because minus imports of intermediary goods have

[7] According to the BIS, daily averages in April, 2016 and 2019 are USD = 87,6% and 88.3%, GBP = 12.8% and 12.8%, EUR = 31.4% and 32.3%, JPY = 21.6% and 16.8%, AUD = 6.9% and 6.8%, CAD = 5.1% and 5.0%, KRW = 1.7% and 2.0% respectively. Also, selected currency pairs in April, 2016 and 2019 which are used in our study, are USD/CAD = 4.3% and 4.4%, USD/CNY = 3.8% and 4.1%, USD/MXN = 1.8% and 1.6%, USD/EUR = 23.1% and 24%, USD/JPY = 17.8% and 13.2%, USD/AUD = 5.2% and 5.4%, USD/CAD = 4.3% and 4.4%, USD/KRW = 1.5% and 1.9%, EUR/GBP = 2% and 2%, EUR/CNY =0% and 0.1%, AUD/JPY = 0.6% and 0.5%, and others.

increased during the sample period, except during the financial crisis. Also, it seems that the gap between gross and value-added exports has been greater from the 2000s.

In the empirical testing procedures, we test the core single variables in each of three major exporting countries for the chosen sample for unit roots to examine the long-run equilibrium in the stationarity testing stage. The results, using the Dickey-Fuller test (1979), are presented in table 1 in appendix 2. This indicates that all level variables except for several FDIs are non-stationary and first-difference stationary during the sample period except for several exchange rates.

Second, we use the time series integrated in order one in the long-term equilibrium testing stage. The results are confirmed by using the cointegration procedure of Engle and Granger (1987). Table 2 in appendix 2 presents that all the null hypotheses of no cointegration for all models except some are not rejected at the 5% level. Therefore, in the sense that all models need to be estimated with stationary data to avoid any spurious regression problem, we use the first-difference stationary data to estimate the models that are not cointegrated while we use the level stationary data to estimate some models that are cointegrated.

Finally, the statistically significant testing results for bilateral models to investigate the effects of major factors on both value-added exports and FDI are presented in tables 1 to 9.

For US bilateral exports, which use vehicle currency (table 1), we find that USD appreciation to the currencies of major counter-partners has a positive effect on value-added exports, gross exports and exports of final goods in Canada, China, and Mexico but on exports of intermediates in Canada only. Foreign income also has a significantly positive effect on value-added exports, gross exports, exports of final goods and exports of intermediates in Canada, China and Mexico. Particularly, exports-FDI nexus has a weak positive feedback effect on China only, and the US has no structural changes for free trade with Canada, China, or Mexico for the sample period.

In the case of value-added exports, USD appreciation to CAD, CNY, and MEX has a strong positive effect on value-added exports. Foreign income also has a significantly positive effect on value-added exports, as we expected. The United States has no structural changes for free trade with Canada, China, and Mexico, but the exports-FDI feedback has a weak positive feedback effect on value-added exports to China.

In the case of gross exports, USD appreciation to CAD, CNY, and MEX has a strong positive effect on gross exports, and foreign income has a significantly positive effect. The United States has no structural changes for free trade, but the exports-FDI feedback has a weak positive feedback effect on gross exports to China.

In the case of exports of final goods, USD appreciation to CAD, CNY, and MEX has a strong positive effect on exports of final goods. Foreign income has a significantly positive effect. The United States has no structural changes for free trade. However, the exports-FDI feedback has a weak positive feedback effect on exports of final goods to China.

In the case of exports of intermediate goods, USD appreciation to CAD has a strong positive effect on exports of intermediate goods in Canada only, and foreign income has a significantly positive effect on exports of intermediate goods. The United States has no structural changes for free trade, but the exports-FDI nexus has a weak positive feedback effect on exports of intermediate goods to China.

Table 1 – *Value-added exports and FDI: United States*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
USA-Canada	925.8 (0.19)	0.146 (0.0)*	-0.0 (0.90)	0.0 (0.0)*
USA-China	178.6 (0.47)	0.018 (0.0)*	0.00001 (0.0)*	0.0 (0.0)*
USA-Mexico	186.5 (0.66)	0.119 (0.0)*	-0.0 (0.79)	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
USA-Canada	-291,073 (0.0)*	0.251 (0.0)*	-0.0 (0.26)	0.0 (0.0)*
USA-China	-1,270,593 (0.0)*	0.024 (0.0)*	0.00001 (0.0)*	0.0 (0.0)*
USA-Mexico	-464,494 (0.09)^	0.14 (0.0)*	-0.0 (0.79)	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
USA-Canada	1191.8 (0.19)	0.19 (0.0)*	0.0 (0.85)	0.0 (0.0)*
USA-China	42.57 (0.88)	0.02 (0.0)*	0.00001 (0.0)*	0.0 (0.0)*
USA-Mexico	-12.55 (0.98)	0.158 (0.0)*	-0.0 (0.89)	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
USA-Canada	-383,715 (0.0)*	0.329 (0.0)*	-0.0 (0.40)	0.0 (0.0)*
USA-China	-1,288,349 (0.0)*	0.027 (0.0)*	0.00001 (0.0)*	0.0 (0.0)*
USA-Mexico	-601,135 (0.08)^	0.192 (0.0)*	-0.0 (0.80)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
USA-Canada	823.65 (0.06)^	0.12 (0.0)*	-0.0 (0.47)	0.0 (0.0)*
USA-China	199.8 (0.23)	0.01 (0.0)*	0.000003 (0.0)*	0.0 (0.0)*
USA-Mexico	22.4 (0.92)	0.067 (0.0)*	0.0 (0.95)	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
USA-Canada	-121,571 (0.0)*	0.151 (0.0)*	-0.0 (0.19)	0.0 (0.0)*
USA-China	-801,747 (0.0)*	0.012 (0.0)*	0.00001 (0.0)*	0.0 (0.0)*
USA-Mexico	-262,442 (0.07)^	0.08 (0.0)*	-0.0 (0.90)	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
USA-Canada	416.2 (0.52)	0.069 (0.01)*	0.0 (0.34)	0.0 (0.0)*
USA-China	-146.6 (0.52)	0.01 (0.0)*	0.000004 (0.04)*	0.0 (0.0)*
USA-Mexico	-40.7 (0.90)	0.09 (0.0)*	-0.0 (0.88)	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
USA-Canada	-255,736 (0.0)*	0.173 (0.0)*	0.0 (0.66)	0.0 (0.0)*
USA-China	-486,318 (0.16)	0.014 (0.0)*	0.00001 (0.01)*	0.0 (0.0)*
USA-Mexico	-338,207 (0.13)	0.11 (0.0)*	-0.0 (0.82)	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
USA-Canada	-874,4 (0.26)	-0.03 (0.28)	0.000002 (0.01)*	0.0 (0.0)*
USA-China	119.8 (0.55)	0.002 (0.34)	0.00001 (0.0)*	0.0 (0.0)*
USA-Mexico	12.3 (0.93)	-0.0 (0.63)	0.000004 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
USA-Canada	44,352 (0.17)	-0.033 (0.04)*	0.00001 (0.0)*	0.0 (0.0)*
USA-China	77,457 (0.75)	-0.0 (0.60)	0.00001 (0.0)*	0.0 (0.0)*
USA-Mexico	30,312 (0.51)	-0.006 (0.13)	0.00001 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *VF* and *D*, which are level stationary.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

Table 2 – *Value-added exports and FDI: United Kingdom*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
UK-USA	177.0 (0.24)	0.01 (0.05)*	0.0 (0.80)	0.0 (0.0)*
UK-Germany	114.8 (0.44)	0.012 (0.03)*	0.0 (0.82)	0.0 (0.0)*
UK-China	66.8 (0.16)	0.0003 (0.0)*	0.00005 (0.11)	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
UK-USA	-105,864 (0.0)*	0.007 (0.03)*	-0.000001 (0.11)	0.0 (0.0)*
UK-Germany	-13,689 (0.87)	0.016 (0.04)*	0.0 (0.71)	0.0 (0.0)*
UK-China	-180,062 (0.0)*	0.003 (0.0)*	0.0003 (0.25)	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
UK-USA	198.3 (0.27)	0.013 (0.03)*	0.0 (0.89)	0.0 (0.0)*
UK-Germany	-244.6 (0.05)*	0.015 (0.0)*	0.0 (0.85)	0.0 (0.0)*
UK-China	79.2 (0.17)	0.004 (0.0)*	0.00005 (0.05)*	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
UK-USA	-124,674 (0.0)*	0.009 (0.01)*	-0.000001 (0.08)*	0.0 (0.0)*
UK-Germany	-68,893 (0.01)*	0.021 (0.0)*	0.0 (0.78)	0.0 (0.0)*
UK-China	-212,023 (0.01)*	0.005 (0.0)*	0.0 (0.12)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
UK-USA	46.7 (0.51)	0.01 (0.0)*	-0.0 (0.66)	0.0 (0.0)*
UK-Germany	43.4 (0.46)	0.005 (0.03)*	0.0 (0.73)	0.0 (0.0)*
UK-China	31.1 (0.24)	0.002 (0.0)*	0.0001 (0.0)*	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
UK-USA	-31,530 (0.05)*	0.009 (0.0)*	-0.0 (0.17)	0.0 (0.0)*
UK-Germany	-3440 (0.81)	0.007 (0.03)*	0.0 (0.59)	0.0 (0.0)*
UK-China	-78,094 (0.05)*	0.002 (0.0)*	0.00007 (0.0)*	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
UK-USA	146.5 (0.38)	0.003 (0.55)	0.0 (0.64)	0.0 (0.0)*
UK-Germany	94.6 (0.45)	0.011 (0.02)*	0.0 (0.76)	0.0 (0.0)*
UK-China	49.6 (0.16)	0.002 (0.01)*	0.0 (0.32)	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
UK-USA	-89,178 (0.01)*	0.001 (0.87)	-0.0 (0.45)	0.0 (0.0)*
UK-Germany	-15,363 (0.62)	0.013 (0.04)*	0.0 (0.69)	0.0 (0.0)*
UK-China	-136,957 (0.0)*	0.002 (0.0)*	0.0 (0.72)	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
UK-USA	-119.1 (0.73)	-0.008 (0.43)	0.00001 (0.0)*	0.0 (0.0)*
UK-Germany	45.02 (0.36)	-0.002 (0.34)	0.00003 (0.0)*	0.0 (0.0)*
UK-China	4.11 (0.79)	-0.0002 (0.43)	0.00005 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
UK-USA	49587 (0.50)	-0.008 (0.45)	0.00002 (0.0)*	0.0 (0.0)*
UK-Germany	-8666 (0.49)	-0.002 (0.52)	0.00003 (0.0)*	0.0 (0.0)*
UK-China	-8448 (0.72)	-0.0002 (0.49)	0.00005 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D*.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, we find that the largest US exports to Canada are GX, VX, GXI, and GXF. For US exports to China, the largest are GX, VX, and GXF. For US exports to Mexico, the largest are GX, VX, and GXF.

Finally, in the case of FDI, neither exchange rate nor foreign income has effects on FDI outflows; exceptionally, foreign income has a negative effect on FDI in Canada. The United States has no structural changes for free trade. In particular, the value-added exports-FDI feedback has a statistically significant but weak positive feedback effect on FDI to Canada, China, and Mexico.

For the bilateral UK exports in table 2, we find that GBP appreciation to USD and CNY has a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods in the US and China, but GBP appreciation in REER and GBP appreciation to the euro has a positive effect on gross exports only in Germany. Foreign income also has positive effects on these exports except for exports of intermediate goods to the US. In particular, the exports-FDI feedback has little feedback effect on these exports. The exports-FDI nexus has a weak positive effect on gross exports to China and on exports of final goods to China, while the exports-FDI feedback has a weak negative effect on gross exports to the United States. Moreover, the United Kingdom has no structural changes for free trade with the United States, Germany, or China for the sample period.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, we find that the largest UK exports to the United States are GX, VX, GXI, and GXF. For UK exports to China, the largest are GX, VX, GXI, and GXF.

In the case of FDI, neither exchange rate nor foreign income has effects on FDI outflows to the United States, Germany, and China, but in particular, the value-added exports-FDI feedback has a statistically significant but weak positive feedback effect on FDI to these countries.

For the bilateral German exports in table 3, we find that the German currency depreciation rate has a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods to France only, and EUR depreciation has a positive effect on gross exports to France. Foreign income also has a positive effect on all of these except for the value-added exports to France. In particular, the exports-FDI feedback has little feedback effect on these exports in China only. Furthermore, Germany has no structural changes for free trade with the United States, China, or France for the sample period.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, we find that the largest Germany exports to France are VX, GX, GXI, and GXF.

In the case of FDI, neither exchange rate nor foreign income has effects on FDI outflows, but exceptionally, foreign GDP has a negative effect on FDI to France. In particular, the value-added exports-FDI feedback has a statistically significant but weak positive feedback effect on FDI to these countries.

Table 3 – *Value-added exports and FDI: Germany*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
Germany-USA	83.64 (0.79)	0.017 (0.0)*	-0.0 (0.37)	0.0 (0.0)*
Germany-China	387.6 (0.24)	0.006 (0.02)*	0.00002 (0.0)*	0.0 (0.0)*
Germany-France	-1853.2 (0.0)*	0.02 (0.29)	-0.0 (0.26)	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
Germany-USA	-15,314 (0.37)	0.018 (0.0)*	-0.0 (0.46)	0.0 (0.0)*
Germany-China	-253,950 (0.12)	0.008 (0.04)*	0.00001 (0.09)^	0.0 (0.0)*
Germany-France	796.8 (0.34)	-0.0 (0.70)	-0.0 (0.26)	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
Germany-USA	-0.564 (0.99)	0.025 (0.0)*	-0.0 (0.41)	0.0 (0.0)*
Germany-China	445.1 (0.33)	0.008 (0.03)*	0.00002 (0.0)*	0.0 (0.0)*
Germany-France	-613.0 (0.0)*	0.04 (0.0)*	0.0 (0.66)	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
Germany-USA	-19,902 (0.43)	0.026 (0.0)*	-0.0 (0.53)	0.0 (0.0)*
Germany-China	-326,657 (0.15)	0.011 (0.05)*	0.00001 (0.09)^	0.0 (0.0)*
Germany-France	-653.2 (0.0)*	0.045 (0.0)*	0.0 (0.63)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
Germany-USA	-135 (0.54)	0.012 (0.0)*	0.0 (0.79)	0.0 (0.0)*
Germany-China	253.3 (0.34)	0.0038 (0.09)^	0.00003 (0.0)*	0.0 (0.0)*
Germany-France	-231.0 (0.0)*	0.019 (0.0)*	-0.0 (0.72)	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
Germany-USA	2,118 (0.86)	0.011 (0.0)*	0.0 (0.88)	0.0 (0.0)*
Germany-China	-126,799 (0.35)	0.005 (0.15)	0.00002 (0.02)*	0.0 (0.0)*
Germany-France	-215.7 (0.0)*	0.021 (0.0)*	-0.0 (0.63)	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
Germany-USA	143.4 (0.65)	0.014 (0.0)*	-0.0 (0.22)	0.0 (0.0)*
Germany-China	190.4 (0.47)	0.005 (0.04)*	0.00001 (0.10)^	0.0 (0.0)*
Germany-France	-381.7 (0.0)*	0.021 (0.0)*	0.0 (0.40)	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
Germany-USA	-22,867 (0.16)	0.015 (0.0)*	-0.0 (0.32)	0.0 (0.0)*
Germany-China	-185,503 (0.15)	0.006 (0.05)*	0.0 (0.54)	0.0 (0.0)*
Germany-France	-438.6 (0.0)*	0.024 (0.0)*	0.0 (0.33)	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
Germany-USA	143.1 (0.67)	0.0 (0.88)	0.00001 (0.0)*	0.0 (0.0)*
Germany-China	-35.2 (0.53)	-0.0007 (0.16)	0.00001 (0.0)*	0.0 (0.0)*
Germany-France	-35.1 (0.33)	-0.002 (0.0)*	0.00001 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
Germany-USA	-6456.1 (0.63)	0.001 (0.69)	0.00001 (0.0)*	0.0 (0.0)*
Germany-China	19,181 (0.48)	-0.001 (0.11)	0.00001 (0.0)*	0.0 (0.0)*
Germany-France	-20.6 (0.55)	-0.001 (0.0)*	0.00001 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D* and for level stationary *FDI*. In the case of France, however, all the variables are level stationary variables because they are cointegrated.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

Table 4 – *Value-added exports and FDI: France*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
France-Germany	-35.3 (0.92)	0.02 (0.0)*	-0.0 (0.67)	0.0 (0.0)*
France-USA	134.5 (0.44)	0.006 (0.02)*	0.0 (0.21)	0.0 (0.0)*
France-China	168.3 (0.24)	0.003 (0.01)*	0.0 (0.31)	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
France-Germany	-616.5 (0.0)*	0.028 (0.0)*	0.0 (0.07)^	0.0 (0.0)*
France-USA	-12,683 (0.09)^	0.007 (0.10)^	0.0 (0.43)	0.0 (0.0)*
France-China	-78,632 (0.15)	0.003 (0.01)*	0.0 (0.84)	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
France-Germany	-154.7 (0.79)	0.028 (0.0)*	-0.0 (0.64)	0.0 (0.0)*
France-USA	127.9 (0.60)	0.010 (0.0)*	0.0 (0.16)	0.0 (0.0)*
France-China	225.5 (0.28)	0.004 (0.0)*	0.0 (0.25)	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
France-Germany	-1,068,5 (0,0)*	0.041 (0.0)*	0.0 (0.14)	0.0 (0.0)*
France-USA	-14,722 (0.16)	0.011 (0.0)*	0.0 (0.31)	0.0 (0.0)*
France-China	-107,166 (0.17)	0.005 (0.02)*	0.0 (0.72)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
France-Germany	142.7 (0.59)	0.012 (0.0)*	-0.0 (0.62)	0.0 (0.0)*
France-USA	-39.3 (0.82)	0.006 (0.02)*	0.0 (0.27)	0.0 (0.0)*
France-China	122.5 (0.26)	0.002 (0.02)*	0.0 (0.61)	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
France-Germany	-301.1 (0.06)^	0.016 (0.0)*	0.0 (0.22)	0.0 (0.0)*
France-USA	-2,880 (0.72)	0.006 (0.03)*	0.0 (0.36)	0.0 (0.0)*
France-China	-59,566 (0.15)	0.002 (0.02)*	-0.0 (0.79)	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
France-Germany	-302.9 (0.43)	0.017 (0.0)*	-0.0 (0.71)	0.0 (0.0)*
France-USA	167.7 (0.33)	0.004 (0.10)^	0.0 (0.36)	0.0 (0.0)*
France-China	104.6 (0.39)	0.002 (0.01)*	0.00001 (0.11)	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
France-Germany	-768.8 (0.0)*	0.025 (0.0)*	0.0 (0.15)	0.0 (0.0)*
France-USA	-11,764 (0.12)	0.005 (0.08)*	0.0 (0.65)	0.0 (0.0)*
France-China	-44,428 (0.32)	0.003 (0.03)*	0.0 (0.37)	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
France-Germany	12.3 (0.98)	0.0 (0.91)	0.00001 (0.01)*	0.0 (0.0)*
France-USA	-896.7 (0.24)	-0.003 (0.74)	0.00001 (0.02)*	0.0 (0.0)*
France-China	-112.4 (0.11)	0.003 (0,0)*	0.00002 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
France-Germany	156.2 (0.67)	0.0 (0.96)	0.0 (0.54)	0.0 (0.0)*
France-USA	20,824 (0.55)	-0.005 (0.66)	0.00001 (0.03)*	0.0 (0.0)*
France-China	16,397 (0,56)	0.003 (0.0)*	0.00002 (0,0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D* and for level stationary *FDI*.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

Table 5 – *Value-added exports and FDI: Italy*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
Italy-Germany	4.372 (0.97)	0.015 (0.0)*	-0.000004 (0.06)*	0.0 (0.0)*
Italy-France	-7.587 (0.95)	0.018 (0.0)*	0.000001 (0.07)*	0.0 (0.0)*
Italy-China	51.1 (0.61)	0.002 (0.01)*	-0.00003 (0.09)^	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
Italy-Germany	-217.6 (0.07)*	0.018 (0.0)*	-0.000004 (0.04)*	0.0 (0.0)*
Italy-France	-154 (0.25)	0.021 (0.0)*	0.0 (0.23)	0.0 (0.0)*
Italy-China	-72,255.5 (0.06)*	0.002 (0.01)*	-0.0 (0.24)	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
Italy-Germany	-93.8 (0.70)	0.021 (0.0)*	-0.000004 (0.13)	0.0 (0.0)*
Italy-France	-97.5 (0.68)	0.024 (0.0)*	0.000001 (0.05)*	0.0 (0.0)*
Italy-China	60.8 (0.67)	0.003 (0.01)*	-0.0 (0.17)	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
Italy-Germany	-518.8 (0.0)*	0.028 (0.0)*	-0.00005 (0.03)*	0.0 (0.0)*
Italy-France	-419.3 (0.05)*	0.032 (0.0)*	0.0 (0.28)	0.0 (0.0)*
Italy-China	-102,681.3 (0.07)*	0.003 (0.02)*	-0.0 (0.38)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
Italy-Germany	56.6 (0.55)	0.009 (0.0)*	-0.000006 (0.02)*	0.0 (0.0)*
Italy-France	-50.6 (0.64)	0.012 (0.0)*	0.000001 (0.14)	0.0 (0.0)*
Italy-China	41.9 (0.62)	0.001 (0.03)*	-0.000004 (0.10)^	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
Italy-Germany	-36.2 (0.66)	0.01 (0.0)*	-0.000006 (0.02)*	0.0 (0.0)*
Italy-France	-140.5 (0.16)	0.015 (0.0)*	0.0 (0.40)	0.0 (0.0)*
Italy-China	-53,930 (0.10)^	0.002 (0.04)*	-0.0 (0.25)	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
Italy-Germany	-149 (0.43)	0.012 (0.0)*	-0.0 (0.50)	0.0 (0.0)*
Italy-France	-46.9 (0.75)	0.012 (0.0)*	0.000002 (0.05)*	0.0 (0.0)*
Italy-China	19.9 (0.80)	0.001 (0.02)*	-0.0 (0.47)	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
Italy-Germany	-481.8 (0.0)*	0.018 (0.0)*	-0.0 (0.14)	0.0 (0.0)*
Italy-France	-278.5 (0.04)*	0.018 (0.0)*	0.0 (0.25)	0.0 (0.0)*
Italy-China	-49,549 (0.10)^	0.002 (0.04)*	-0.0 (0.81)	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
Italy-Germany	-190.4 (0.43)	0.001 (0.80)	0.00001 (0.0)*	0.0 (0.0)*
Italy-France	100.3 (0.89)	-0.003 (0.78)	0.00001 (0.0)*	0.0 (0.0)*
Italy-China	20.2 (0.67)	0.001 (0.0)*	0.00003 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
Italy-Germany	-33.1 (0.88)	-0.0 (0.97)	0.00001 (0.0)*	0.0 (0.0)*
Italy-France	824.9 (0.24)	-0.02 (0.27)	0.00001 (0.0)*	0.0 (0.0)*
Italy-China	7346 (0.71)	0.0014 (0.01)*	0.00003 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D* and for level stationary *FDI*.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

For France's bilateral exports in table 4, we find that EUR depreciation has a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods to Germany while EUR depreciation has a positive effect on value-added exports only to the United States. Foreign income also has a positive effect on these exports, but in particular, the exports-FDI feedback has little feedback effect on them. The exports-FDI feedback has a weak positive effect on value-added exports to Germany, and France has no structural changes for free trade with the United States, Germany, or China for the sample period.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, French exports to Germany are GX, GXI, VX, and GXF.

In the case of FDI, neither exchange rate nor foreign income has effects on FDI outflows to the United States, Germany, and China while foreign income has a positive effect on FDI to China only. Particularly, the value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI to these countries.

For Italy's bilateral exports in table 5, we find that EUR depreciation has a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods to China. EUR depreciation has a positive effect on value-added exports, gross exports and exports of intermediate goods to Germany, and on both gross exports and exports of intermediates to France. Foreign income also has a positive effect on these exports. Particularly, the exports-FDI feedback has a slight feedback effect on them. The exports-FDI feedback has a weak positive effect on value-added exports, gross exports, final goods exports, and intermediate goods exports to France. The exports-FDI feedback has a weak negative effect on value-added exports, gross exports, and final goods exports to Germany. The exports-FDI feedback has a weak negative effect on value-added exports and final goods exports to China. Also, Italy has no structural changes for free trade with Germany, France, or China for the sample period.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, we find that the largest Italian exports to Germany are GX, GXI, and VX. For Italian exports to China, the largest are GX, VX, GXF, and GXI.

In the case of FDI, neither exchange rate nor foreign income has effects on FDI outflows to these countries except for a positive effect of foreign income in China. In particular, the value-added exports-FDI feedback has a statistically significant but weak positive feedback effect on FDI to these countries.

For the bilateral exports for Japan in table 6, we find that JPY appreciation to USD and KRW has a positive effect on value-added exports, gross exports and exports of intermediate goods to both the United States and Korea while JPY depreciation has a positive effect on gross exports, exports of final goods and exports of intermediate goods to China. Foreign income also has a positive effect on all the exports in the United States and Korea except for exports to China. In particular, the exports-FDI feedback has a slight feedback effect on these exports to China and Korea but not to the United States. The exports-FDI feedback has a weak positive effect on all the exports to China and Korea. Japan has no structural changes for free trade with the United States, China, or Korea for the sample period.

Table 6 – *Value-added exports and FDI: Japan*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
Japan-China	-389.2 (0.14)	-16.1 (0.38)	0.00003 (0.0)*	0.0 (0.0)*
Japan-USA	299.1 (0.30)	0.037 (0.01)*	0.0 (0.52)	0.0 (0.0)*
Japan-Korea	151.8 (0.22)	0.049 (0.0)*	0.00005 (0.05)*	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
Japan-China	-691.1 (0.77)	-21.0 (0.29)	0.00002 (0.02)*	0.0 (0.0)*
Japan-USA	-533.05 (0.04)*	0.043 (0.0)*	-0.0 (0.89)	0.0 (0.0)*
Japan-Korea	-400005 (0.0)*	0.092 (0.0)	0.0 (0.43)	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
Japan-China	-572.1 (0.07)*	-19.2 (0.38)	0.00003 (0.0)*	0.0 (0.0)*
Japan-USA	249.0 (0.44)	0.044 (0.01)*	0.0 (0.45)	0.0 (0.0)*
Japan-Korea	115.6 (0.42)	0.05 (0.0)*	0.00007 (0.01)*	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
Japan-China	177.7 (0.95)	-28.9 (0.24)	0.00003 (0.01)*	0.0 (0.0)*
Japan-USA	-572.1 (0.05)*	0.051 (0.0)*	0.0 (0.95)	0.0 (0.0)*
Japan-Korea	-453,078 (0.0)*	0.107 (0.0)*	0.0 (0.15)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
Japan-China	-224.7 (0.10)^	-5.68 (0.55)	0.00004 (0.0)*	0.0 (0.0)*
Japan-USA	87.3 (0.60)	0.02 (0.01)*	0.0 (0.68)	0.0 (0.0)*
Japan-Korea	10.09 (0.84)	0.018 (0.0)*	0.00008 (0.04)*	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
Japan-China	-60.1 (0.96)	-9.08 (0.39)	0.00004 (0.0)*	0.0 (0.0)*
Japan-USA	-142.4 (0.35)	0.025 (0.0)*	0.0 (0.89)	0.0 (0.0)*
Japan-Korea	-89,016 (0.17)	0.029 (0.0)*	0.0 (0.23)	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
Japan-China	-358.2 (0.08)*	-12.7 (0.36)	0.00003 (0.0)*	0.0 (0.0)*
Japan-USA	169.8 (0.38)*	0.019 (0.05)*	0.0 (0.20)	0.0 (0.0)*
Japan-Korea	103.1 (0.31)	0.037 (0.0)*	0.00006 (0.0)*	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
Japan-China	519.9 (0.77)	-19.7 (0.21)	0.00003 (0.01)*	0.0 (0.0)*
Japan-USA	-408.3 (0.02)*	0.025 (0.0)*	0.0 (0.72)	0.0 (0.0)*
Japan-Korea	-347,879 (0.0)*	0.075 (0.0)*	0.00003 (0.09)*	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
Japan-China	41.9 (0.02)*	-1.28 (0.28)	0.00005 (0.0)*	0.0 (0.0)*
Japan-USA	-60.3 (0.12)	-0.004 (0.04)*	0.00001 (0.0)*	0.0 (0.0)*
Japan-Korea	-1.35 (0.82)	0.0 (0.91)	0.00002 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
Japan-China	-195.7 (0.24)	-0.16 (0.90)	0.000005 (0.0)*	0.0 (0.0)*
Japan-USA	77.7 (0.03)*	-0.004 (0.01)*	0.00001 (0.0)*	0.0 (0.0)*
Japan-Korea	7240.1 (0.34)	-0.0 (0.48)	0.00002 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D*.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

Table 7 – *Value-added exports and FDI: Australia*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
Australia-China	461.6 (0.01)*	0.010 (0.0)*	-0.0 (0.32)	-22,167.1 (0.0)*
Australia-USA	38.6 (0.15)	0.002 (0.11)	0.0 (0.15)	-285 .8 (0.51)
Australia-Japan	433.1 (0.0)*	0.0 (0.30)	-0.0003 (0.11)	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
Australia-China	-82,461 (0.31)	0.011 (0.0)*	0.0 (0.59)	-18,468.1 (0.01)*
Australia-USA	-3,106.5 (0.03)*	0.002 (0.03)*	0.000002 (0.09)^	-353.1 (0.37)
Australia-Japan	-1,926,982 (0.04)*	0.007 (0.02)*	-0.0 (0.28)	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
Australia-China	492.1 (0.02)*	0.012 (0.0)*	-0.0 (0.33)	-24,149 (0.0)*
Australia-USA	43.08 (0.18)	0.002 (0.08)*	0.0 (0.13)	-312 (0.54)
Australia-Japan	478.9 (0.0)*	0.002 (0.26)	-0.0003 (0.10)^	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
Australia-China	-90,772 (0.29)	0.012 (0.0)*	0.0 (0.57)	-20,159 (0.0)*
Australia-USA	-3,415.9 (0.05)*	0.002 (0.02)*	0.000003 (0.09)^	-387 (0.42)
Australia-Japan	-2,071,281 (0.05)*	0.008 (0.02)*	-0.0 (0.27)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
Australia-China	8.25 (0.69)	0.001 (0.0)*	0.0 (0.87)	-872 (0.21)
Australia-USA	13.5 (0.31)	0.0 (0.20)	0.0 (0.43)	-232.4 (0.29)
Australia-Japan	48.3 (0.02)*	0.0 (0.17)	0.0 (0.48)	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
Australia-China	-5,556 (0.53)	0.001 (0.0)*	0.0 (0.77)	-712.9 (0.32)
Australia-USA	1,262.3 (0.08)^	0.0007 (0.08)^	0.0 (0.36)	-256.6 (0.22)
Australia-Japan	-336,264 (0.02)*	0.001 (0.0)*	0.0 (0.56)	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
Australia-China	477.5 (0.02)*	0.010 (0.0)*	-0.0 (0.36)	-23.208 (0.0)*
Australia-USA	28.7 (0.17)	0.001 (0.07)*	0.00001 (0.06)*	-76.6 (0.82)
Australia-Japan	434.2 (0.0)*	0.0 (0.41)	-0.00035 (0.07)*	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
Australia-China	-83,008 (0.33)	0.010 (0.01)*	0.0 (0.54)	-19,360 (0.01)*
Australia-USA	-2,129.2 (0.06)*	0.002 (0.02)*	0.00001 (0.03)*	-125.9 (0.69)
Australia-Japan	-1,724,421 (0.09)^	0.0068 (0.05)*	-0.0 (0.23)	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
Australia-China	-23.34 (0.03)*	0.0003 (0.05)*	0.00002 (0.0)	660.8 (0.04)*
Australia-USA	153.1 (0.29)	-0.014 (0.01)*	0.00005 (0.0)*	-546.7 (0.81)
Australia-Japan	-1.56 (0.64)	0.0 (0.43)	0.00002 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
Australia-China	4,408 (0.31)	0.0003 (0.07)*	0.00001 (0.0)*	467.7 (0.18)
Australia-USA	-8,239.4 (0.31)	-0.012 (0.01)*	0.00005 (0.0)*	-798.9 (0.73)
Australia-Japan	17,211 (0.44)	0.0 (0.75)	0.00002 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D* and for level stationary *FDI*.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, we find that the largest Japanese exports to the United States and Korea are GX, VX, and GXI. For Japanese exports to China, the largest are GX, GXI, and GXF.

In the case of FDI, neither exchange rate nor foreign income has effects on FDI outflows to Korea, but JPY appreciation has a positive effect on FDI to China, and JPY depreciation to USD has a positive effect on FDI to the United States. Foreign GDP has a negative effect on FDI to the United States, and the value-added exports-FDI feedback has a statistically significant but weak positive feedback effect on FDI to these countries.

For Australia's bilateral exports in table 7, we find that AUD appreciation to USD has a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods to the United States. Similarly, AUD appreciation and AUD appreciation to JPY have a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods to Japan while currency depreciation has a negative effect on value-added exports, gross exports, and exports of intermediate goods to China. Meanwhile, foreign income has a positive effect on all of these exports. In particular, the exports-FDI feedback has little feedback effect on them. The exports-FDI feedback has a weak positive effect on value-added exports, gross exports and intermediates exports to the United States but the exports-FDI nexus has a weak negative effect on value-added exports, gross exports and intermediates exports to Japan. Australia also has a negative structural change for free trade with China for the sample period but no structural change for free trade with Japan.

In addition, as we measure the sizes of exchange rate effects on increases in exports by using elasticity, the Australian exports to the US and Japan have GX, VX, GXI and GXF in that order, while the Australian exports to China have GX, GXI and VX.

In the case of FDI, the exchange rate has no effect on FDI outflows to the United States and Japan but AUD depreciation has a positive effect on FDI to China. Foreign income has a positive effect on FDI to China but a negative effect on FDI to the United States and no effect on FDI to Japan. The value-added exports-FDI feedback has a statistically significant but weak positive feedback effect on FDI to these countries.

For Canada's bilateral exports in table 8, we find that CAD appreciation and CAD appreciation to USD have a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods in the United States. However, there is no statistically significant effect of foreign income. Particularly, the exports-FDI feedback has a weak positive effect. Canada has no structural changes for free trade with the United States for the sample period.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, the largest Canadian exports to the United States are GX, VX, GXI, and GXF.

In the case of FDI, CAD depreciation and CAD depreciation to USD have a positive effect on FDI outflow to the United States. Foreign income has a negative effect on FDI to the United States. The value-added exports-FDI feedback has a statistically significant but weak positive feedback effect on FDI to the United States.

Table 8 – *Value-added exports and FDI: Canada*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
Canada-USA	1911.3 (0.01)*	0.02 (0.19)	0.0 (0.33)	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
Canada-USA	-173,546 (0.0)*	0.02 (0.16)	0.000003 (0.01)*	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
Canada-USA	2,358.1 (0.01)*	0.02 (0.34)	0.0 (0.16)	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
Canada-USA	-208,166 (0.0)*	0.018 (0.36)	0.000004 (0.0)*	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
Canada-USA	494.33 (0.12)	0.0 (0.99)	0.000003 (0.03)*	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
Canada-USA	-37,663 (0.09)^	-0.0 (0.94)	0.000004 (0.0)*	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
Canada-USA	1.782.4 (0.01)*	0.02 (0.30)	0.0 (0.25)	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
Canada-USA	-170,958 (0.0)*	0.01 (0.24)	0.000003 (0.0)*	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
Canada-USA	-202.7 (0.05)*	-0.0007 (0.05)*	0.000004 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
Canada-USA	14,799 (0.0)*	-0.0 (0.31)	0.000004 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX-VF* nexus for *VX* and *VF*, and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D* and for level stationary *FDI*.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

For Korea's bilateral exports in table 9, we find that KRW appreciation to CNY has a positive effect on value-added exports and intermediates exports to China while KRW appreciation and KRW appreciation to JPY have a positive effect on value-added exports, gross exports, and intermediates exports to Japan.

In addition, measuring the sizes of exchange rate effects on increases in exports using elasticity, the largest Korean exports to China are VX and GXI. For Korean exports to Japan, the largest are GX, GXI, VX, and GXF.

Furthermore, foreign income has a positive effect on these exports. In particular, the exports-FDI feedback has little effect; this nexus has a weak positive effect on gross exports and intermediates exports to the United States, on value-added exports and gross exports to China, and on value-added exports to Japan. Meanwhile, Korea has a negative structural change for free trade with China but no structural change for free trade with Japan.

In the case of FDI, neither exchange rate nor foreign income has effects on FDI outflows to the United States, China or Japan. Particularly, the value-added exports-FDI feedback has a statistically significant but weak positive effect on FDI to these countries.

Table 9 – *Value-added exports and FDI: Korea*

	Bilateral regression equations			
For VX	***S***	***Y****	***N***	***D***
Korea-China	134.5 (0.08)^	0.01 (0.0)*	0.0 (0.15)	-10,683 (0.05)*
Korea-USA	22.4 (0.61)	0.01 (0.02)*	0.0 (0.23)	862 (0.62)
Korea-Japan	76.47 (0.02)*	0.004 (0.01)*	-0.0 (0.21)	0.0 (0.0)*
For VX	***E***	***Y****	***N***	***D***
Korea-China	-175.1 (0.0)*	0.01 (0.0)*	0.00001 (0.08)^	-9,117 (0.01)*
Korea-USA	-7.73 (0.11)	0.008 (0.01)*	0.0 (0.43)	697.8 (0.66)
Korea-Japan	-1,276 (0.0)*	0.006 (0.0)*	-0.0001 (0.05)*	0.0 (0.0)*
For GX	***S***	***Y****	***N***	***D***
Korea-China	210.7 (0.11)	0.018 (0.0)*	0.0 (0.16)	-29,765 (0.0)*
Korea-USA	27.3 (0.65)	0.016 (0.0)*	0.00003 (0.06)^	-1,659 (0.51)
Korea-Japan	120.6 (0.09)^	0.008 (0.01)*	-0.0 (0.23)	0.0 (0.0)*
For GX	***E***	***Y****	***N***	***D***
Korea-China	-224.8 (0.04)*	0.08 (0.0)*	0.00001 (0.10)^	-27,352 (0.01)*
Korea-USA	-9.67 (0.16)	0.015 (0.0)*	0.0 (0.09)^	-1,916.7 (0.41)
Korea-Japan	-1,859 (0.04)*	0.010 (0.0)*	-0.0 (0.16)	0.0 (0.0)*
For GXF	***S***	***Y****	***N***	***D***
Korea-China	46.4 (0.29)	0.005 (0.01)*	0.0 (0.16)	-12,741 (0.0)*
Korea-USA	21.0 (0.58)	0.007 (0.03)*	-0.0 (0.88)	-273.9 (0.86)
Korea-Japan	30.6 (0.17)	0.003 (0.0)*	-0.0 (0.31)	0.0 (0.0)*
For GXF	***E***	***Y****	***N***	***D***
Korea-China	-53.1 (0.16)	0.005 (0.01)*	0.0 (0.12)	-12,189 (0.0)*
Korea-USA	-5.01 (0.25)	0.007 (0.02)*	-0.0 (0.87)	-382.6 (0.79)
Korea-Japan	-518.4 (0.07)^	0.004 (0.0)*	-0.0 (0.21)	0.0 (0.0)*
For GXI	***S***	***Y****	***N***	***D***
Korea-China	162.8 (0.15)	0.013 (0.0)*	0.0 (0.24)	-16,833 (0.04)*
Korea-USA	-39.65 (0.30)	0.009 (0.0)*	0.0 (0.0)*	-1,092 (0.46)
Korea-Japan	89.6 (0.09)^	0.005 (0.03)*	-0.0 (0.24)	0.0 (0.0)*
For GXI	***E***	***Y****	***N***	***D***
Korea-China	-176.6 (0.08)^	0.013 (0.01)*	0.0 (0.17)	-14,981 (0.06)^
Korea-USA	-4.22 (0.30)	0.007 (0.01)*	0.0 (0.01)*	-1,057 (0.47)
Korea-Japan	-1,335 (0.05)^	0.007 (0.0)*	-0.0 (0.18)	0.0 (0.0)*
For VF	***S***	***Y****	***N***	***D***
Korea-China	-0.33 (0.95)	-0.0 (0.26)	0.00001 (0.0)*	306.6 (0.51)
Korea-USA	3.30 (0.54)	-0.0 (0.53)	0.00002 (0.0)*	-191.0 (0.40)
Korea-Japan	0.59 (0.51)	-0.0 (0.98)	0.00005 (0.0)*	0.0 (0.0)*
For VF	***E***	***Y****	***N***	***D***
Korea-China	-2.45 (0.67)	-0.0 (0.23)	0.00001 (0.0)*	307.9 (0.51)
Korea-USA	-0.38 (0.54)	-0.0 (0.56)	0.00002 (0.0)*	-201.0 (0.38)
Korea-Japan	11.5 (0.33)	-0.0 (0.66)	0.00005 (0.0)*	0.0 (0.0)*

Notes: *VX* = value-added exports, *GX* = gross exports, *GXF* = gross exports of final goods, *GXI* = gross exports of intermediates, *VF* = foreign direct investment, *Y**= bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *E* = spot exchange rate, *N* = *VX*-*VF* nexus for *VX* and *VF,* and *D* = dummy variable for free trade. Parentheses indicate *p*-values for the explanatory variables. * : statistically significant at 5%, and ^ at 10% in the model with intercept. All variables used are the first-difference stationary variables, except for *D*.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

4. Conclusion

With our findings when firms are reliant to value-added trade with major currencies and FDI, we address the role of value-added exports in the linkage with FDI, the direct effects of exchange rates on value-added exports, and the indirect effect of exchange rates on the exports-FDI feedback. Our bilateral findings are summarized as three key results.

First, the positive effects of exchange rates are greater for gross than value-added exports except for Germany. And the exchange rate effects are greater for intermediate goods than final goods exports except for Italy. The bilateral findings are different from Choi et al. (2019), that the exchange rate has a negative effect on gross exports due to intermediate imports but a positive effect on value-added exports.

Second, there are no significant differences in the bilateral effects of exchange rate changes on exports between the United States with vehicle currency, other major countries with major currencies such as the pound or euro, and other countries with non-major currencies such as the Korean won. This implies that the exchange rate effects on value-added exports and intermediate goods exports are more important regardless of dollar and major currencies, although the depreciation of US dollar increases global trade via a financial channel (Bruno and Shin, 2019).

Third, the exports-FDI feedback explored by Tsaurai (2013) and Aizenman and Noy (2006) has a weak positive effect on exports to China due to increased FDI into China. And all the value-added exports-FDI feedback has a weak effect on FDI. Meanwhile, foreign income has a positive effect on all exports as we expected.

The topic of this study is highly relevant given the constructive roles that have resorted to the bilateral effects of major exchange rates on value-added trade linked with foreign affiliation. However, we acknowledge that the value-added samples available are limited and that future research would benefit from a larger and more recent data set.

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Appendix 1. Testing results

1. US bilateral trade

In detailed findings, we find that vehicle currency (USD) appreciation to CAD, CNY, and MEX has a strong positive effect on value-added exports, gross exports, and final goods exports in Canada, China, and Mexico, but on intermediate goods exports in Canada only. Measuring the sizes of exchange rate effects on increases in exports using elasticity, we find that the largest US exports to Canada are gross exports, value-added exports, intermediate goods exports, and final goods exports. For US exports to China, the largest are gross exports, value-added exports, and final goods exports; to Mexico, the primary US exports are gross, value-added, and final goods exports. Briefly, these findings demonstrate that overall, the United States experiences no currency devaluation effect on exports to countries with CAD and other non-major currencies such as CNY and MEX, that the exchange rate effects on these exports are greater for gross than value-added exports as well as greater for intermediate goods than final goods exports, and that we find no significant difference in the effects of exchange rate changes on US exports to Canada, China, and Mexico.

Foreign income has a significantly positive effect on all exports, which implies that they all increase with the increasing sizes of the importing countries' economies. The United States also has no structural changes for free trade with Canada, China, or Mexico for the sample period because of the NAFTA pact formed with Canada and Mexico in 1992, and the lack of a free trade agreement with China. We find in particular that the exports-FDI nexus has a significant but weak positive feedback effect on value-added, gross, final goods, and intermediate goods exports in China. This implies that the United States has had vertical, horizontal, and export platform FDI in China.

In contrast, neither exchange rate nor foreign income has effects on FDI, which indicates that neither is significant for FDI. However, the value-added exports-FDI nexus has a very significant but weak positive feedback effect on US FDI in Canada, China, and Mexico.

2. UK bilateral trade

For the United Kingdom, we find that major currency (GBP) appreciation to USD and CNY has a positive effect on value-added exports, gross exports, final goods exports, and intermediate goods exports to the United States and China. GBP appreciation in real effective exchange rate and GBP appreciation to the euro have a positive effect on gross exports only in Germany. Again measuring exchange rate effect sizes on increases in exports using elasticity, we find that the highest-ranking UK exports to the United States and to China are gross, value-added, intermediate goods, and final goods exports. This implies that overall, there is no currency devaluation effect for the United Kingdom on exports to countries with vehicle currency (USD), major currency (EUR), or non-major currency (CNY), that the exchange rate effect size is greater for gross than for value-added exports as well as greater for intermediate goods than for final goods exports, and that we find no significant difference in the effects of exchange rate changes on UK exports to the United States, Germany, and China.

Meanwhile, UK foreign income has a positive effect on all exports except for those of intermediate goods to the United States, implying that exports increase with the increasing sizes of importing countries' economies. Separately, the United Kingdom has no structural changes for free trade with the United States, Germany, or China for the sample period because of its membership in the European Economic Community, of which Germany is a member as well, and because the European Union has no free trade agreement with the United States or China. The exports-FDI nexus also has little feedback effect on the exports to these countries, with a weak positive effect on gross and final goods exports to China and a weak negative effect on gross exports to the United States; these findings imply that the United Kingdom has had vertical, horizontal, and export platform FDI in China. In contrast, neither exchange rate nor foreign income has effects on FDI outflows to the United States, Germany, or China. Here, the value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI to these countries.

3. Germany bilateral trade

For Germany, we find that currency depreciation in real effective exchange rate has a positive effect on value-added, gross, final goods, and intermediate goods exports to France only, and EUR depreciation has a positive effect on gross exports to France. Measuring the

exchange rate effect sizes on increases in exports using elasticity, the largest German exports to France are value-added, gross, intermediate goods, and final goods exports. This implies that Germany has a currency devaluation effect on exports to France even though they use the same euro and that the size of the devaluation effect is greater for value-added than for gross exports as opposed to the other countries.

Meanwhile, foreign income has a positive effect on all exports except for the value-added exports to France, implying that exports increase with the increasing size of importing countries' economies. Separately, Germany has no structural changes for free trade with the United States, China, and France because of its membership in the Eurozone with France, and because the European Union has no free trade agreement with the United States or China. The exports-FDI nexus has little feedback effect on the exports in China, implying that Germany has had vertical, horizontal, and export platform FDI in China. In contrast, exchange rate and foreign income have no effects on FDI outflows, but exceptionally, foreign GDP has a negative effect on FDI to France. Here, the value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI to these countries.

4. France bilateral trade

For France, we find that EUR depreciation has a positive effect on value-added, gross, final goods, and intermediate goods exports to Germany, and EUR depreciation has a positive effect on only value-added exports to the United States. Measuring the sizes of exchange rate effects on increases in exports using elasticity, we find that the highest-ranking French exports to Germany are gross, intermediate goods, value-added, and final goods exports. This implies that France has a currency devaluation effect on exports to Germany even though they use the same euro, and the size of the devaluation effect is greater for gross than for value-added exports.

Meanwhile, foreign income has a positive effect on all exports, implying that exports increase with the increasing sizes of importing countries. France has no structural changes for free trade with the United States, Germany, and China because of its membership in the Eurozone with Germany, and because the European Union has no free trade agreement with the United States and China. The exports-FDI nexus has little feedback effect on the exports of these countries. The exports-FDI nexus has a weak positive effect on value-added exports to its neighbor Germany. In contrast, neither exchange rate nor foreign income has effects on FDI outflows to the United States, Germany and China while foreign income has a positive effect on FDI to China only. Here, the value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI to these countries.

5. Italy bilateral trade

For Italy, we find that EUR depreciation has a positive effect on value-added, gross, final goods, and intermediate goods exports to China, on value-added, gross, and intermediate goods exports to Germany, and on gross and intermediate goods exports to France. Measuring the sizes of exchange rate effects on increases in exports using elasticity, the largest Italian exports to Germany are gross, intermediate goods, and value-added exports whereas the largest Italian exports to China are gross, value-added, final goods, and intermediate goods exports. This

implies that Italy has a currency devaluation effect on exports to Germany and France even though they use the same euro as well as on exports to China and that the size of the devaluation effect is greater for gross than for value-added exports.

Meanwhile, foreign income has a positive effect on all exports, implying that exports increase with the increasing sizes of importing countries. Italy has no structural changes for free trade with Germany, France, or China because of its membership in the Eurozone with Germany and France, and because the European Union has no free trade agreement with China. The exports-FDI nexus has little feedback effect on the exports of these countries. The exports-FDI nexus has a weak positive effect on value-added, gross, final goods, and intermediate goods exports to France, a weak negative effect on value-added, gross, and final goods exports to Germany, and a weak negative effect on value-added and final goods exports to China. In contrast, neither exchange rate nor foreign income has effects on FDI outflows in these countries except for a positive effect of foreign income in China. Here, the value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI in these countries.

6. Japan bilateral trade

For Japan, we find that JPY appreciation to USD and KRW has a positive effect on value-added, gross, and intermediate goods exports to the United States and Korea while JPY depreciation has a positive effect on gross, final goods, and intermediate goods exports to China. Measuring the sizes of exchange rate effects on increases in exports using elasticity, the largest Japanese exports to the United States and Korea are gross, value-added, and intermediate goods exports while the largest Japanese exports to China are gross, intermediates, and final goods exports. This implies that Japan has a currency devaluation effect on exports to China, but Japanese currency depreciation has a negative effect on exports to the United States and Korea, and that the size of the devaluation effect is greater for gross than for value-added or intermediate goods exports.

Meanwhile, foreign income has a positive effect on all the exports in the United States and Korea except for China, implying that exports increase with the increasing economic sizes of counterparts the United States and Korea. Japan has no structural changes for free trade with the United States, China and Korea because Japan has no free trade agreement with them. Here, the exports-FDI nexus has a little feedback effect in China and Korea except for the United States. The exports-FDI nexus has a weak positive effect on all the exports to China and Korea, implying that Japan has had vertical, horizontal, and export platform FDI in China and Korea. In contrast, neither exchange rate nor foreign income has effects on FDI outflows to Korea. But JPY appreciation has a positive effect on FDI in China, and JPY depreciation to USD has a positive effect on FDI in the United States. Foreign GDP has a negative effect on FDI to the US. The value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI in these countries.

7. Australia bilateral trade

For Australia, we find that AUD appreciation to USD has a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods to the US.

Similarly, currency appreciation in real effective exchange rate and AUD appreciation to JPY have a positive effect on value-added exports, gross exports, exports of final goods, and exports of intermediate goods to Japan while currency appreciation has a positive effect on value-added exports, gross exports, and exports of intermediate goods to China. Measuring the sizes of exchange rate effects on increases in exports using elasticity, the largest Australia exports to the United States and Japan are gross exports, value-added exports, exports of intermediates, and exports of final goods while the largest Australia exports to China are gross exports, exports of intermediates, and value-added exports. This implies that overall, Australia has no currency depreciation effect on exports to China, the United States and Japan, and that the size of the exchange rate effect is greater for gross than for value-added exports.

Meanwhile, foreign income has a positive effect on all of them, implying that exports increase with increasing economic sizes of counterpart countries. Australia has a negative structural change for free trade with China, but no structural change for free trade with Japan because Australia enacted a free trade agreement with China and Japan in 2015. In particular, th exports-FDI nexus has little feedback effect on them. The exports-FDI nexus has a weak positive effect on value-added exports, gross exports and exports of intermediates to the United States and a weak negative effect on value-added exports, gross exports and exports of intermediates to Japan. In contrast, the exchange rate has no effects on FDI outflows in the United States and Japan while AUD depreciation has a positive effect on FDI in China. Foreign income has a positive effect on FDI in China but a negative effect on FDI in the United States, and no effect on FDI in Japan. Here, the value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI to these countries.

8. Korea bilateral trade

For Korea, we find that as a non-major currency, KRW' appreciation to CNY has a positive effect on value-added and intermediate goods exports to China, while KRW' appreciation in real effective exchange rate and KRW' appreciation to JPY have a positive effect on value-added, gross, and intermediates exports to Japan. Measuring the exchange rate effect sizes on export increases using elasticity, we find that Korea's highest-ranking exports to China are value-added and intermediate goods exports whereas the highest ranking to Japan are gross, intermediates, and value-added exports. These findings demonstrate that overall, there may be no currency depreciation effect on Korea's exports to either China or Japan, that the exchange rate effect size is greater for gross than for value-added exports, and that we find no significant difference in the effects of exchange rate changes on Korea exports to China and Japan.

Meanwhile, foreign income has a positive effect on all exports, again implying that exports increase with the increasing sizes of counterpart countries' economies. Korea has a negative structural change for free trade with China but no change for free trade with Japan; this is because Korea and China might have had a free trade agreement since 2015 and no agreement with Japan. In particular, the exports-FDI nexus has little feedback effect on these exports. The exports-FDI nexus has a weak positive effect on gross and intermediate goods exports to the United States, on value-added and gross exports to China and on value-added exports to Japan. These findings suggest vertical, horizontal and export platform FDI from Korea to the United States, China, and Japan. In contrast, neither exchange rate nor foreign income has effects on

FDI outflows to the United States, China, or Japan. In particular, the value-added exports-FDI nexus has a statistically significant but weak positive feedback effect on FDI to these countries.

Appendix 2. Unit root tests and other diagnostic statistics

Table A1 – *Unit root tests for stationarity*

	Level variables, first difference variables			
	Exports	**FDI**	**Foreign GDP**	**Exchange rate**
USA-Canada	-0.891, -4.530*	-3.460*, -6.179*	-0.927, -2.547	-1.430, -2.385
USA-China	4.058, -2.464	-4.874*, -8.213*	4.510, -1.494	-1.430, -2.385
USA-Mexico	-1.342, -4.338*	-4.353*, -7.105*	-1.521, -4.159*	-1.430, -2.385
UK-USA	-1.452, -2.854^	-2.544, -4.304*	0.454, -2.748^	-1.523, -4.171*
UK-Germany	-1.477, -4.775*	-4.165*, -6.788*	-0.782, -3.264*	-1.523, -4.171*
UK-China	1.099, -3.903*	-2.533, -4.934*	4.510, -1.171*	-1.523, -4.171*
Germany-US	-0.509, -4.476*	-3.151*, -5.948*	0.454, -2.748^	-1.634, -3.672*
Germany-China	0.252, -4.228*	-1.460, -5.835*	4.510, -1.494	-1.634, -3.672*
Germany-France	-0.949, -4,385*	-4.449, -8.569*	-0.920, -2.828^	-1.634, -3.672*
France-Germany	-1.173, -4.567*	-3.576*, -7.719*	-0.782, -3.264*	-1.228, -3.768*
France-US	-1.678, -3.751*	-3.080*, -4.717*	0.454, -2.748^	-1.228, -3.768*
France-China	0.859, -5.044*	-2.976^, -6.802*	4.510, -1.494	-1.228, -3.768*
Italy-Germany	-2.089, -4.351*	-4.307*, -7.357*	-0.782, -3.264*	-2.631, -4.125*
Italy-France	-1.595, -3.929*	-4.063*, -6.675*	-0.920, -2.828^	-2.631, -4.125*
Italy-China	0.376, -4.836*	-3.053*, -5.892*	4.510, -1.494	-2.631, -4.125*
Japan-China	-0.843, -5.018*	-0.811, -4.274*	-3.065*, -4.143*	-1.464, -3.861*
Japan-US	-2.579, -5.274*	-1.435, -5.137*	0.454, -2.748^	-1.464, -3.861*
Japan-Korea	-1.266, -3.603*	-1.794, -3.819*	0.071, -3.717*	-1.464, -3.861*
Australia-China	-0.180, -2.796^	-3.773*, -6.444*	4.510, -1.495	-1.551, -5.112*
Australia-US	-1.595, -5.717*	-5.129*, -7.841*	0.454, -2.748^	-1.551, -5.112*
Australia-Japan	-1.273, -4.606*	-3.837*, -5.027*	-1.742, -3.029*	-1.551, -5.112*
Canada-US	-1.636, -4.477*	-3.219*, -6.151*	0.454, -2.748^	-1.597, -5.428*
Korea-China	1.275, -2.740^	-1.598, -5.179*	4.510, -1.494	-3.114*, -5.239*
Korea-US	0.640, -3.577*	-0.963, -4.090*	0.403, -2.675^	-3.114*, -5.239*
Korea-Japan	-1.772, -4.076*	-0.955, -5.552*	-1.742, -3.029*	-3.114*, -5.239*

Notes: Exports = value-added bilateral exports, FDI = bilateral foreign direct investment, Foreign GDP = bilateral foreign GDP, and Exchange Rate = real (broad) effective exchange rate of home country. *: statistically significant at the 5% level (critical value = -3.011) and ^ at the 10% level (critical value = -2.645) in the model with intercept.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

Table A1 indicates that all level variables except for several FDIs are non-stationary and first-difference stationary during the sample period except for several exchange rates. In the case of the United States, all exports and foreign GDPs are first-difference stationary and FDIs are level stationary; in the case of the UK, all variables are first-difference stationary. For Germany, all variables are first-difference stationary except for Germany-US FDI and Germany-China foreign GDP; for France, all variables are first-difference stationary except France-China

foreign GDP. All FDIs for France are level stationary. In the case of Italy, all variables are first-difference stationary except for Italy-China foreign GDP, while all FDIs are level stationary; in the case of Japan, all variables are first-difference stationary except for Japan-China foreign GDP. For Australia, all variables are first-difference stationary except for Australia-China foreign GDP, while all FDIs are level stationary; for Canada, all variables are first-difference stationary while FDI is level stationary. In the case of Korea, all variables are first-difference stationary except for Korea-China foreign GDP, while exchange rate is level stationary. In brief, these results indicate that we can use either first-difference stationary variables or cointegrated level variables.

Table A2 – *Cointegration tests for long-run equilibrium*

	Cointegration equations	
	VX = f (*S*, *Y, *N*, *D*)**	**VF = f (*S*, *Y**, *N*, *D*)**
USA-Canada	-1.341	-3.541
USA-China	-2.242	-4.470^
USA-Mexico	-1.684	-3.692
UK-USA	-1.667	-2.217
UK-Germany	-3.508	-4.349
UK-China	-3.357	-4.109
Germany-US	-2.386	-3.852
Germany-China	-2.543	-2.224
Germany-France	-4.916^	-5.195*
France-Germany	-5.473*	-3.894
France-US	-2.101	-3.379
France-China	-2.830	-2.394
Italy-Germany	-3.916	-4.085
Italy-France	-2.728	-3.449
Italy-China	-3.554	-5.331*
Japan-China	-2.357	-3.795
Japan-US	-2.899	-3.451
Japan-Korea	-1.431	-2.664
Australia-China	-3.417	-3.007
Australia-US	-4.523	-5.996*
Australia-Japan	-3.282	-5.199*
Canada-US	-2.181	-4.799^
Korea-China	-1.720	-1.984
Korea-US	-1.524	-1.576
Korea-Japan	-2.934	-3.223

Notes: *VX* = value-added bilateral exports, *VF* = bilateral foreign direct investment, *Y** = bilateral foreign GDP, *S* = real (broad) effective exchange rate of home country, *N* = *VX-VF* nexus, *D* = dummy variable for free trade. * statistically significant at the 5% level (critical value = -5.116), and ^ at the 10% level (critical value = -4.651) in the model with intercept.
Source: OECD, *TiVA database*, and Federal Reserve Bank of St. Louis, *FRED database*.

Table A2 presents that all the null hypotheses of no cointegration for all models except some are not rejected at the 5% level. For the US, no models are cointegrated except for the US-China

VF model; for the United Kingdom, no models are cointegrated. For Germany, no models are cointegrated except for the Germany-France VX and VF models. For France, no models are cointegrated except for the France-Germany VX model; for Italy, none are cointegrated except for the Italy-China VF model. In the case of Japan, no models are cointegrated; for Australia, none are cointegrated except for the Australia-US and Australia-Japan VF models. For Canada, the VX model is not cointegrated but the VF model is; for Korea, no models are cointegrated. Therefore, we use the first-difference stationary data to estimate the models that are not cointegrated while we use the level stationary data to estimate some models that are cointegrated.

Also, statistically significant testing results for bilateral models to investigate the effects of major factors on both value-added exports and FDI are presented in tables 1 to 9; we confirm that the estimations reflect the fitness of the model with reasonable coefficients of determination and feasibility of linear regression with residual diagnostics such