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**An Empirical Analysis of East  
Asian Computer Exports**

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Willem Thorbecke

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Willem Thorbecke is a senior fellow at the Asian Development Bank Institute, Tokyo.

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Asian Development Bank Institute  
Kasumigaseki Building 8F  
3-2-5 Kasumigaseki, Chiyoda-ku  
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500  
Fax: +81-3-3593-5571  
URL: [www.adbi.org](http://www.adbi.org)  
E-mail: [info@adbi.org](mailto:info@adbi.org)

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**Abstract**

For the last 15 years, computers have been the leading export category from East Asia to the rest of the world. They are produced within regional production and distribution networks. Japan; Republic of Korea; and Taipei,China construct sophisticated technology-intensive parts and components and ship them to the People's Republic of China (PRC) and Association of Southeast Asian Nations (ASEAN) for processing by lower-skilled workers and re-export. This paper presents evidence that exchange rate appreciations in countries supplying parts and components to East Asian assembly economies would curtail computer exports, while exchange rate appreciations in assembly economies would not. The evidence also indicates that decreases in income in importing countries would significantly reduce computer exports. These findings imply that if growth remains slow in the rest of the world, computer exports will no longer be able to play the same role as an engine of growth. This evidence thus provides impetus to create initiatives to promote the demand for final goods in the region.

**JEL Classification: F32, F41**

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## 1. INTRODUCTION

Since 1994, the leading export category from East Asia to the rest of the world has been computers and office equipment. These goods are produced within regional production and distribution networks. Japan; the Republic of Korea (hereafter Korea); and Taipei,China construct sophisticated technology-intensive parts and components and ship them to the People's Republic of China (PRC) and the Association of Southeast Asian Nations (ASEAN) countries for processing by lower-skilled workers. The assembled computers are then exported throughout the world.

This slicing up of the value-added chain involves complicated combinations of intra-firm trade, arms-length transactions, and outsourcing (Kimura and Ando 2005). The resulting production networks allow firms to divide production processes into fragmented blocks that can be allocated across countries based on differences in factor endowments (Fukao, Ishido, and Yoshiike 2003).

Within these networks, Japan; Korea; and Taipei,China primarily produce high-tech parts and components and the PRC, Malaysia, the Philippines, and Thailand primarily perform lower-skilled assembly operations. Rasiah (2009) reported that skill and research and development intensity levels in the electronics industry are often much higher in Korea and Taipei,China than in ASEAN member countries. Austria (2008) found that the PRC and ASEAN countries focus on the labor-intensive assembly of electronics goods, and that original equipment manufacturing and original brand manufacturing activities take place in other, more advanced Asian economies.

Because factories in the PRC and ASEAN country perform primarily low-skilled assembly operations, little of the value-added in the electronics industry comes from these countries. Koopman, Wang, and Wei (2008) reported that the PRC's value-added in the computer industry is small. Using mathematical programming techniques and detailed data from trade statistics and input-output tables they found that PRC value-added in electronic computers is less than 5%. Agarwalla (2005) reported that the Philippines' value-added in the electronics industry is also small. In a comprehensive study, he finds that the local value-added is less than 15%. Austria (2008) similarly concluded based on a detailed analysis of import and export data that ASEAN's electronics exports are highly import-dependent and that domestic value-added is minimal.

Koopman, Wang, and Wei (2008) noted that in cases like this where the share of domestic content in exports is small, the effect of exchange rate changes in assembly countries on trade volumes will also be small. Yoshitomi (2007) similarly argued that a unilateral appreciation in East Asian assembly countries would not affect processed exports much. Because most of the value-added of processed goods comes from other countries in the region, he states that a joint appreciation throughout East Asia would cause a much larger decrease in sophisticated high-tech exports from assembly countries.

This paper investigates how computer exports from East Asia are affected by exchange rate changes in assembly countries and in countries supplying the technologically-sophisticated intermediate inputs used to assemble computers. To do this, the paper employs both the bilateral exchange rate between assembly countries and importing countries and a trade-weighted exchange rate between countries supplying parts and components to assembly countries and countries importing final computers from assembly countries.

The results indicate that exchange rate appreciations in East Asian supplier countries would cause a large decrease in computer exports from the region but that exchange rate appreciations in assembly countries would not. The results also indicate that a recession in the rest of the world would curtail computer exports.

These findings provide guidance for East Asian policymakers seeking to promote recovery from the 2008–2009 economic crisis. If the slowdown in the rest of the world is protracted, then computer exports will no longer be able to play the same role as an engine of growth. In addition, if the United States (US) dollar depreciates against Asian currencies in the medium run, computer exports will decline further.<sup>1</sup>

This evidence thus provides impetus to attempts in East Asia to promote domestic and regional demand. For instance, improving health care, education, and pension systems may stimulate spending in East Asia by reducing precautionary saving. In addition, improving infrastructure and reducing intra-regional impediments to trade can promote growth and development. If income and spending in East Asia increase, the region will be better able to weather a decrease in exports to the rest of the world.

The next section presents the data and methodology. The third section contains the results of the study. The fourth section concludes.

## 2. DATA AND METHODOLOGY

### 2.1 The Computer Industry in East Asia

East Asia is characterized by intricate production and distribution relationships, constituting part of a global triangular trading network. Japan; Korea; Taipei,China; and multinational companies located in ASEAN countries produce sophisticated, technology-intensive intermediate goods and ship them to the PRC and ASEAN countries for assembly by lower-skilled workers. The finished products are then exported throughout the world.

Foreign direct investment (FDI) flows and multinational companies play an important role in these triangular trading patterns. As Gaulier, Lemoine, and Unal-Kesenci (2005) discussed, FDI flows and multinational company activities reduce costs in host countries, transfer technological and managerial know-how, increase local procurement, multiply trade in intermediate goods, and strengthen distribution networks.

Triangular trading patterns are clearly evident in the computer industry. Table 1 disaggregates total exports from East Asia to the PRC and ASEAN countries by product category in 2007. ASEAN is defined to include Malaysia, the Philippines, and Thailand.<sup>2</sup> The product category 'electronic components' is easily the leading export category in Table 1.<sup>3</sup> Twenty-three percent of the exports from East Asian countries to the processor economies are electronic components.

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<sup>1</sup> Bénassy-Quéré, Béreau, and Mignon (2009) argue that global rebalancing will be accompanied by a depreciation of the dollar over time.

<sup>2</sup> Indonesia is excluded because it plays only a small role in the computer industry. Singapore is excluded because its role in entrepôt trade may complicate attempts to estimate exchange rate elasticities.

<sup>3</sup> Electronic components correspond to the ISIC classification number 321. Data on electronic components comes from the CEPII-CHELEM database.

**Table 1: Exports from East Asia to the PRC and ASEAN Countries by Product Category, 2007**

<b>Product Category</b>	<b>Percent of Total Imports</b>
Electronic Components	22.93
Basic Chemicals	10.44
Computers and Office Equipment	7.47
Special Purpose Machinery	5.22
Manufacturing Basic Iron and Steel	5.20
Optical Instruments and Photographic Equipment	4.87
Refined Petroleum Products	4.14
Manufacturing Basic Non-ferrous Metal	3.81
General Purpose Machinery	3.10
TV and Radio Transmitters	3.01
TV and Radio Receivers	2.81
Other Chemical Products	2.68
Parts for Motor Vehicles	2.34
Electricity Distribution Apparatus	1.75
Plastics Products	1.54
Motor Vehicles	1.51
Other Electrical Equipment	1.38

Notes: East Asia includes People's Republic of China; Japan; Malaysia; Philippines; Singapore; Korea; Taipei, China; and Thailand. ASEAN includes Malaysia, the Philippines, and Thailand.

Source: CEPII-CHELEM Database DVD (accessed 15 July 2009).

This percentage is similar for the PRC and ASEAN (as a group) taken separately. For the PRC, 24% of goods coming from the rest of East Asia are electronic components; for ASEAN, the figure is 21%. In both cases, this is the largest import category.

Table 2 disaggregates total exports from ASEAN countries and the PRC to the world in 2007. The product category "computers and office equipment" is easily the most exported product category. Almost 13% of exports from the processor economies are in this category.

**Table 2: Exports from the PRC and ASEAN Countries to the World by Product Category, 2007**

<b>Product Category</b>	<b>Percent of Total Exports</b>
Computers and Office Equipment	12.80
Electronic Components	6.96
TV and Radio Transmitters	6.60
Wearing Apparel	5.84
TV and Radio Receivers	5.45
Manufacturing Basic Iron and Steel	3.33
General Purpose Machinery	3.30
Basic Chemicals	3.08
Other Fabricated Metal Products	2.50
Footwear	2.25
Prepared Meat, Fruit, Oils	2.20
Furniture	2.13
Special Purpose Machinery	2.04
Other Chemical Products	1.90
Domestic Appliances	1.88
Knitted Fabrics and Articles	1.76
Electric Motors and Generators	1.75

Note: ASEAN includes Malaysia, the Philippines, and Thailand.

Source: CEPII-CHELEM Database DVD (accessed 15 July 2009).

This percentage again does not change much if one looks at the PRC or ASEAN (as a group) separately. For the PRC 12% of total goods exports are in this category and for ASEAN 15% are.

Tables 3 and 4 show the countries providing electronic components to the PRC and ASEAN countries, and the countries purchasing final assembled computers and office equipment from the PRC and ASEAN countries. More than 80% of the electronic components to the processor economies come from other East Asian countries. More than 70% of the final goods assembled in the PRC and ASEAN go outside the region. Thus, East Asia as a whole tends to produce computers by splitting up the value chain within the region and exporting the finished products throughout the world.

**Table 3: Countries Exporting Electronic Components to the PRC and ASEAN Countries, 2007**

Country	Percent of Total Exports Of Electronic Components to the PRC and ASEAN Countries
Taipei, China	20.52
Japan	16.32
Singapore	11.45
Korea	11.17
United States	10.29
Malaysia	8.43
Philippines	8.18
Germany	2.99
Thailand	2.63
People's Republic of China	2.48
Ireland	1.60
France	0.71
Mexico	0.38
United Kingdom	0.38
Indonesia	0.35
Netherlands	0.32
Hong Kong, China	0.31

Note: ASEAN includes Malaysia, the Philippines, and Thailand.

Source: CEPII-CHELEM Database DVD (accessed 15 July 2009).

**Table 4: Countries and Regions Importing Computers and Office Equipment from the PRC and ASEAN Countries, 2007**

Country or Region	Percent of Total Computer Exports from the PRC and ASEAN Countries
United States	30.28
Eurozone	21.37
Japan	7.56
People's Republic of China	4.41
Singapore	3.83
Hong Kong, China	3.46
Canada	2.62
Malaysia	2.38
Korea	2.25
Mexico	2.24
Australia	1.94
Thailand	1.73
Taipei, China	1.56
Czech Republic	1.50
India	0.99
Russian Federation	0.96

Note: ASEAN includes Malaysia, the Philippines, and Thailand.

Source: CEPII-CHELEM Database DVD (accessed 15 July 2009).

## 2.2 Identifying Trade Elasticities

This paper investigates how exchange rate changes in both East Asian assembly countries (PRC, Malaysia, Philippines, and Thailand) and in supply chain countries affect exports of processed goods. To do this it uses data on final computer and office equipment exports from the 4 assembly countries to 28 importing countries and data on electronics components exports from the 10 leading supply chain countries to the 4 assembly economies. There has been substantial variation both cross-sectionally and over time in exchange rates between the 4 assembly and 10 supply chain countries and the 28 countries importing the finished computers. This approach should thus help to identify in an econometric sense how exchange rate changes affect computer exports.

The imperfect substitutes model of Goldstein and Khan (1985) implies that the quantity of exports *demanded* by other countries depends on income in the other countries and the price of exports relative to the price of domestically produced goods in those countries. The quantity of exports *supplied* depends on the export price relative to the domestic price level in the exporting country. By equating demand and supply one can derive an export function:

$$ex_t = \alpha_{10} + \alpha_{11} rer_t + \alpha_{12} rgdp_t + \varepsilon_t \quad (1)$$

where  $ex_t$  represents the log of real exports,  $rer_t$  represents the log of the real exchange rate, and  $rgdp$  represents the log of foreign real income.

Real exchange rates and real income are often taken as given when estimating export equations. This approach may be subject to simultaneous-equation and omitted-variable bias. If the elasticity of supply is infinite, however, it is possible to identify the parameters in equation (1).

In this case there is reason to believe that the perfect supply elasticity assumption may be reasonable. The International Monetary Fund (2005) argues that the supply of imports for processing into Asian assembly countries tends to vary one for one with the demand from the rest of the world for processed exports. Thus, sophisticated intermediate goods tend to flow elastically into Asian processor economies to accommodate increases in demand in the rest of the world.

## 2.3 Weighted Exchange Rates

Because the lion's share of the value-added of final computers comes from the technology-intensive parts and components rather than from assembly operations, this paper includes a weighted exchange rate among the countries supplying electronic components to the PRC and ASEAN countries. To calculate the weighted exchange rate, data on electronic components imports into the assembly nations was used. As Table 3 shows, more than 90% of electronics components imports in 2007 came from 10 countries. These are the East Asian economies (PRC; Malaysia; Japan; Philippines; Singapore; Korea; Taipei,China; and Thailand) plus Germany and the US. This same pattern holds for every year going back to 1990. These countries are thus assumed to be the major exporters of electronic components to the PRC and ASEAN.

For every year between 1990 and 2006 weights are calculated based on the percentage of electronic components going from the 10 major exporters to the 4 processor economies. Weights are calculated separately for each of the 4 processor economies and for each year. For instance, if 10% of Thailand's electronic components imports from the major electronic components exporters came from Japan in 2001, then  $w_{Thailand,Japan,2001}$  would equal 0.10. In order to explain Thailand's exports of computers to an individual country such as the United Kingdom (UK),  $w_{Thailand,Japan,2001}$  would be multiplied by the exchange rate

between Japan and the UK in 2001 ( $rer_{UK,Japan,2001}$ ). In similar ways weights can be calculated for Thailand's imports of electronic components from the other 9 major electronic components exporters. The products of these weights and the bilateral exchange rates between the major electronic components exporters and the UK could be calculated. The sum would then give a weighted exchange rate for computer exports from Thailand to the UK.

$$(wrer_{Thailand,UK,2001} = \sum_{k=1}^{10} w_{Thailand,k,2001} * rer_{UK,k,2001}).$$

More generally, the weighted exchange rate between East Asian assembly country  $i$  and country  $j$ , purchasing computers from country  $i$  would be given by:

$$wrer_{i,j,t} = \sum_{k=1}^{10} w_{i,k,t} * rer_{j,k,t} \quad (2)$$

where  $wrer_{i,j,t}$  is the weighted exchange rate,  $w_{i,k,t}$  is the proportion of electronic components coming into processor country  $i$  from electronic components exporter  $j$ , and  $rer_{j,k,t}$  is the bilateral exchange rate between country  $j$  that purchases the final good and country  $k$  that produces electronic components.

To calculate  $wrer$  in this way it is necessary to measure exchange rates using a common numeraire. This can be done by employing the real exchange rate variables constructed by the Centre D'Etudes Prospectives et D'Information Internationales (CEPII). The CEPII real exchange rate between countries  $i$  and  $j$  is calculated by first dividing gross domestic product (GDP) in dollars for country  $i$  by GDP in purchasing power parity for country  $i$  and doing the same for country  $j$ . The resulting ratio for country  $i$  is then divided by the ratio for country  $j$ . This variable measures the units of consumer goods in country  $i$  needed to buy a unit of consumer goods in country  $j$ . It can be compared across countries as well as across time. Because it is comparable across countries, it can be used in equation (2) to calculate  $wrer$ . Higher values of  $wrer$  correspond to stronger exchange rates among the countries supplying parts and components.

## 2.4 Data and Econometric Methodology

The dependent variable is the log of computer and office equipment exports.<sup>4</sup> These data are measured in US dollars and are obtained from the CEPII-CHELEM database. They are deflated using the US Bureau of Labor Statistics price deflator for imports of computers and office equipment.

The panel data set includes final exports from 4 East Asian processor economies (PRC, Malaysia, Philippines, and Thailand) to 28 countries over the 1990–2006 period.<sup>5</sup>

<sup>4</sup> Computers and office equipment correspond to the ISIC classification number 300.

<sup>5</sup> The importing countries are: Argentina; Australia; Austria; Belgium; Bangladesh; Brazil; Canada; Chile; Denmark; Finland; France; Germany; Greece; Italy; Japan; Netherlands; New Zealand; Norway; Poland; Saudi Arabia; Korea; Spain; Sweden; Switzerland; Taipei,China; Turkey; the UK; and the US.

The independent variables include real income in the importing country ( $rgdp$ ), the weighted real exchange rate between the supplier countries and the country purchasing the final good ( $wrer$ ), and the bilateral real exchange rate between the assembly countries and the country purchasing the final good ( $rer$ ). Real income is measured in constant US dollars (base year 2000). As discussed above,  $wrer$  is constructed using real exchange rate data obtained from the CEPII-CHELEM database.

In addition, the stock of FDI in the assembly country and a World Trade Organization (WTO) dummy variable for the PRC's exports are also included as independent variables. As discussed above, FDI plays an important role in processing trade. An increase in the stock of FDI may therefore lead to an increase in computer exports. Several authors (e.g., Garcia-Herrero and Koivu 2007) have also found that accounting for the PRC's WTO accession helps to explain its exports. Data on the stock of FDI are obtained from the United Nations Conference on Trade and Development (UNCTAD) website.<sup>6</sup> The data are measured in US dollars and deflated using the US consumer price index. The WTO variable for the PRC's exports is a dummy variable that takes on a value of 1 after the PRC joined the WTO and 0 before.<sup>7</sup>

The model is estimated using dynamic ordinary least squares (DOLS). DOLS involves regressing the left-hand side variable on a constant, the right-hand side variables, and lags and leads of the first differences of the right hand side variables. The individual export equations have the form:

$$\begin{aligned}
 ex_{i,j,t} = & \beta_0 + \beta_1 rgdp_{j,t} + \beta_2 wrer_{i,j,t} + \beta_3 rer_{i,j,t} + \beta_4 FDI_{i,t} + \beta_5 WTO_t \\
 & + \sum_{k=-p}^p \alpha_{1,k} \Delta rgdp_{j,t-k} + \sum_{k=-p}^p \alpha_{2,k} \Delta wrer_{i,j,t-k} + \sum_{k=-p}^p \alpha_{3,k} \Delta rer_{i,j,t-k} \\
 & + \sum_{k=-p}^p \alpha_{4,k} \Delta FDI_{i,t-k} + \partial_i + \mu_j + \gamma_t + u_{i,j,t}, \quad (3) \\
 & t = 1, \dots, T; \quad i = 1, \dots, N.
 \end{aligned}$$

Here  $ex_{i,j,t}$  represents real exports from assembly economy  $i$  to country  $j$ ;  $rgdp_{j,t}$  equals real income in importing country  $j$ ;  $wrer_{i,j,t}$  represents the weighted exchange rate between the countries providing parts and components to country  $i$  and the importing country  $j$ ;  $rer_{i,j,t}$  represents the bilateral exchange rate between assembly country  $i$  and importing country  $j$ ;  $FDI_{i,t}$  represents the stock of FDI in assembly country  $i$ ;  $WTO$  is the WTO dummy variable for the PRC; and  $\partial_i$ ,  $\mu_j$ , and  $\gamma_t$  are country  $i$ , country  $j$ , and time fixed effects. All the variables are measured in natural logs.

<sup>6</sup> <http://stats.unctad.org/FDI/TableView/tableView.aspx?ReportId=1254> (accessed 26 August 2009).

<sup>7</sup> Garcia-Herrero and Koivu (2007) posit that the PRC's WTO accession began affecting its trade after it became certain that the PRC would join the WTO in the beginning of 2000. The WTO dummy variable is thus set equal to one beginning in 2000.

### 3. RESULTS

Table 5 presents the results from estimating equation (3) using a DOLS(1,1) specification.<sup>8</sup> Columns (1) and (2) report the findings including country-pair fixed effects and columns (3) and (4) report the findings including exporter and importer fixed effects.

**Table 5: Panel DOLS estimates of computer exports from the PRC and ASEAN Countries to 28 Countries, 1990–2006**

	Country-Pair Fixed Effects	Country-Pair Fixed Effects	Exporter and Imported Fixed Effects	Exporter and Imported Fixed Effects
	(1)	(2)	(3)	(4)
Real GDP	2.69*** (0.28)	2.96*** (0.33)	2.42*** (0.32)	2.69*** (0.35)
Supplier's RER	-1.72*** (0.57)	-1.54*** (0.35)	-1.69*** (0.51)	-1.54*** (0.34)
Bilateral RER	0.73 (0.47)	1.15*** (0.31)	0.66 (0.44)	1.10*** (0.30)
FDI Stock	0.09 (0.15)	0.76*** (0.18)	0.11 (0.14)	0.77*** (0.18)
WTO Dummy	0.63** (0.30)	0.14 (0.15)	0.64** (0.28)	0.15 (0.14)
Time		0.10*** (0.01)		0.10*** (0.01)
Adjusted R-Squared	0.93	0.92	0.91	0.90
Number of Observations	1537	1537	1537	1537

ASEAN = Association of Southeast Asian Nations, DOLS = dynamic ordinary least squares, FDI = foreign direct investment, GDP = gross domestic product, RER = real exchange rate, WTO = World Trade Organization.

Notes: DOLS(1,1) estimates. Heteroskedasticity-consistent standard errors are in parentheses. The data extend from 1990 to 2006. Because the DOLS estimation uses leads and lags of the first difference of the right-hand side variables, the actual sample period is from 1992–2005. Period fixed effects are also included except when a time trend is employed.

\*\*\* (\*\*) denotes significance at the 1% (5%) level.

Source: CEPII-CHELEM Database DVD (accessed 15 July 2009), UNCTAD database (<http://stats.unctad.org/FDI/TableViewer/tableView.aspx?ReportId=1254>, accessed 26 August 2009).

The first row presents the coefficients on income. They are statistically significant in every case and vary from 2.41 to 3.08. These results indicate that a 1% increase in income abroad would raise computer exports by about 3%. The high values for the income elasticity reflect the fact that consumers are more likely to purchase high-tech goods such as computers as their incomes increase.

<sup>8</sup> Results using other DOLS specifications are similar and are available on request.

The second row reports the coefficients on the weighted exchange rate in supply chain countries. These coefficients are also statistically significant in every case and of the expected negative sign, indicating that an appreciation of *wrer* reduces processed exports. The values vary from -1.54 to -1.72, implying that a 10% appreciation among supply chain countries would reduce computer exports by about 16%.

The third row reports the coefficients on the exchange rate in assembly countries. These coefficients are not of the expected negative sign but are positive. In two cases they are also statistically significant. These results are sensitive to whether a time trend is included.

The fourth and fifth rows report values for the FDI stock and the WTO dummy variable. The coefficients are of the expected positive sign. As in the case of the bilateral exchange rate, however, the results are sensitive to whether a time trend is included.

Table 6 reports the results of estimating equation (3) excluding the exchange rate in supply chain countries. This is the traditional way of estimating export equations. The coefficients on income are again positive and statistically significant in every specification, and their values are again close to 3. The coefficients on the bilateral exchange rate are again sensitive to whether a trend term is included. The coefficients are of the expected (negative) sign and statistically significant when the time trend is excluded, but close to zero when the trend term is included.

**Table 6: Panel DOLS estimates of computer exports from the PRC and ASEAN Countries to 28 Countries, 1990–2006**

	Country-Pair Fixed Effects	Country-Pair Fixed Effects	Exporter and Imported Fixed Effects	Exporter and Imported Fixed Effects
	(1)	(2)	(3)	(4)
Real GDP	2.75*** (0.30)	3.19*** (0.38)	2.47*** (0.34)	2.92*** (0.41)
Bilateral RER	-0.68** (0.28)	0.06 (0.26)	-0.72*** (0.28)	0.02 (0.25)
FDI Stock	0.01 (0.11)	0.80*** (0.20)	0.06 (0.11)	0.80*** (0.20)
WTO Dummy	1.25*** (0.21)	0.57*** (0.20)	1.26*** (0.20)	0.59*** (0.19)
Time		0.09*** (0.02)		0.10*** (0.02)
Adjusted R-Squared	0.93	0.92	0.91	0.90
Number of Observations	1537	1537	1537	1537

ASEAN = Association of Southeast Asian Nations, DOLS = dynamic ordinary least squares, FDI = foreign direct investment, GDP = gross domestic product, RER = real exchange rate, WTO = World Trade Organization.

Notes: DOLS(1,1) estimates. Heteroskedasticity-consistent standard errors are in parentheses. The data extend from 1990 to 2006. Because the DOLS estimation uses leads and lags of the first difference of the right-hand side variables the actual sample period is from 1992–2005. Period fixed effects are also included except when a time trend is employed.

\*\*\* (\*\*) denotes significance at the 1% (5%) level.

Source: CEPII-CHELEM Database DVD (accessed 15 July 2009), UNCTAD database (<http://stats.unctad.org/FDI/TableView/tableView.aspx?ReportId=1254>, accessed 26 August 2009).

Table 7 reports the results of estimating equation (3) excluding the exchange rate in assembly countries. In every specification, the coefficients on income remain positive and statistically significant and the coefficients on the exchange rate in supply chain countries remains negative and statistically significant.

**Table 7: Panel DOLS estimates of computer exports from the PRC and ASEAN Countries to 28 Countries, 1990–2006**

	Country-Pair Fixed Effects	Country-Pair Fixed Effects	Exporter and Imported Fixed Effects	Exporter and Imported Fixed Effects
	(1)	(2)	(3)	(4)
Real GDP	2.68*** (0.28)	3.08*** (0.36)	2.41*** (0.32)	2.81*** (0.39)
Supplier's RER	-1.00** (0.32)	-0.58** (0.25)	-1.04*** (0.31)	-0.61*** (0.23)
FDI Stock	-0.01 (0.03)	0.72*** (0.20)	0.00 (0.12)	0.72*** (0.19)
WTO Dummy	0.95*** (0.15)	0.57*** (0.16)	0.94*** (0.15)	0.56*** (0.19)
Time		0.09*** (0.02)		0.10*** (0.02)
Adjusted R-Squared	0.93	0.92	0.91	0.90
Number of Observations	1537	1537	1537	1537

ASEAN = Association of Southeast Asian Nations, DOLS = dynamic ordinary least squares, FDI = foreign direct investment, GDP = gross domestic product, RER = real exchange rate, WTO = World Trade Organization.

Notes: DOLS(1,1) estimates. Heteroskedasticity-consistent standard errors are in parentheses. The data extend from 1990 to 2006. Because the DOLS estimation uses leads and lags of the first difference of the right-hand side variables the actual sample period is from 1992–2005. Period fixed effects are also included except when a time trend is employed.

\*\*\* (\*\*) denotes significance at the 1% (5%) level.

Source: CEPII-CHELEM Database DVD (accessed 15 July 2009), UNCTAD database (<http://stats.unctad.org/FDI/TableView/tableView.aspx?ReportId=1254>, accessed 26 August 2009).

The findings in Table 5 are robust to changing the number of leads and lags in the DOLS specification. In every case, the coefficient on income remains positive and statistically significant and the coefficient on the supplier's exchange rate remains negative and statistically significant.

The important implication of these results is that an appreciation in East Asian supply chain countries would produce a large drop in computer exports. This makes sense as the lion's share of the value-added of the final computers comes from supply chain countries.

On the other hand, there is no robust evidence that an appreciation in East Asian assembly countries would decrease computer exports. This also makes sense. If the value-added in an assembly country is 10%, then even under complete exchange rate pass-through, a 10% appreciation in an assembly economy would only raise the foreign currency price of computers by 1%. If exporters or distributors in the importing country absorb part of the exchange rate appreciation, the change in the prices paid by consumers in the importing country would be even less.

A second implication of the results presented here is that a decrease in income in the importing countries would cause a large drop in computer exports. This finding combined with the evidence in Table 4 that more than 70% of computer goods exports go outside of the region indicate that the 2008–2009 slowdown in the rest of the world is contributing to a large decrease in East Asian computer exports. The reduction in exports from the PRC and ASEAN countries in turn reduces the production of electronic components in East Asian supply chain countries, curtailing output and employment throughout the region. Because the US purchased one-third of the computers and office equipment exported from the PRC and ASEAN countries before the 2008–2009 crisis, the slowdown in the US economy is contributing significantly to the drop in computer exports from East Asia.

## 4. CONCLUSION

“Computers and office equipment” has been the leading export category from East Asia to the rest of the world for the last 15 years. Firms in the region have produced these goods within regional production and distribution networks. They have broken up long production processes and allocated production blocks across developing, emerging, and developed economies in the region based on differences in factor endowments.

This study examined the factors affecting the exports of computers produced within East Asian production networks. The results indicate that exchange rate appreciations in countries supplying parts and components would reduce computer exports from East Asian processor economies. In addition, the findings indicate that a decrease in income in importing countries would cause a large drop in computer exports. On the other hand, there is no robust evidence that exchange rate changes in assembly countries would affect exports.

This evidence has several implications for researchers and policymakers. One follows from the work of Cline and Williamson (2009). They argue that US current account deficits and Asian current account surpluses will expand in the future, and conclude that this combination poses a systemic threat to the global economy. To resolve these imbalances, they argue that real exchange rates in the PRC and Malaysia need to appreciate by 20% in effective terms and by 40% against the US dollar. They also conclude that real exchange rates in Japan and Korea need to *depreciate*. However, the results in this paper call into question whether appreciations in the PRC and Malaysia combined with depreciations in Japan and Korea would reduce East Asia’s surpluses. Fifty percent of the PRC’s and Malaysia’s exports are processed exports produced using parts and components coming from East Asia. Appreciations in the PRC combined with depreciations in developed Asia are unlikely to significantly reduce processed exports. Appreciations throughout the region would be needed to rebalance trade between Asia and the US.

A second implication for researchers concerns how to model the effects of the global crisis on Asia. Kawai and Zhai (2009) used a multi-country dynamic general equilibrium model to analyze how the global financial crisis is affecting East Asia. They find that a slowdown in the US or a depreciation of the US dollar would reduce exports and GDP more in emerging East Asia than in developed East Asia. However, the authors did not incorporate the flow of parts and components from developed East Asia to emerging East Asia in their model. Because much of the value-added of emerging East Asia’s exports comes from developed East Asia, the estimated effects of a US slowdown on output in emerging East Asia would be smaller and the estimated effect on output in developed East Asia larger when these linkages are taken into account.

A third implication concerns how the 2008–2009 economic crisis is affecting computer exports. Because the majority of computer exports before the crisis went to developed economies and because the income elasticity of demand is high, recessions in the US, Europe, and Japan are causing large decreases in the demand for computers produced in

the region. If the developed world recovers from the current crisis quickly, then demand for computers should pick up as well. If not, demand will remain constrained. Demand will fall even more if the dollar depreciates against Asian currencies in the medium-run, as Bénassy-Quéré, Béreau, and Mignon (2009) and others predict. Computer exports may thus not play the same role as an engine of growth that they played before the crisis. East Asian policymakers should therefore strengthen social safety nets, improve infrastructure, reduce intra-regional impediments to trade, and undertake other initiatives to promote the demand for final goods within the region.

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