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The Beggar Thy Neighbor Effects of Weak Japanese Yen: A GVAR Approach*

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This paper investigates whether a depreciated Japanese yen has the beggar thy neighbor effects on its neighboring countries. In order to assess it, we performed GVAR and GVC analyses using quarterly data from 1972 to 2013 of 19 countries. The results show that weak yen policy does have the beggar thy neighbor effects. According to our analyses, Japan was the main beneficiary from the weak yen policy, with the sharpest increase in its GDP. China and Australia were also identified as beneficiaries, and effects on the US and EU were neutral. The country that experienced most adverse output effects was identified to be Korea.

JEL Classification: E52, F31, F37, F41

Keywords: GVAR, global value chain, weak yen, spillover, Abenomics, quantitative easing, beggar thy neighbor

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1. INTRODUCTION

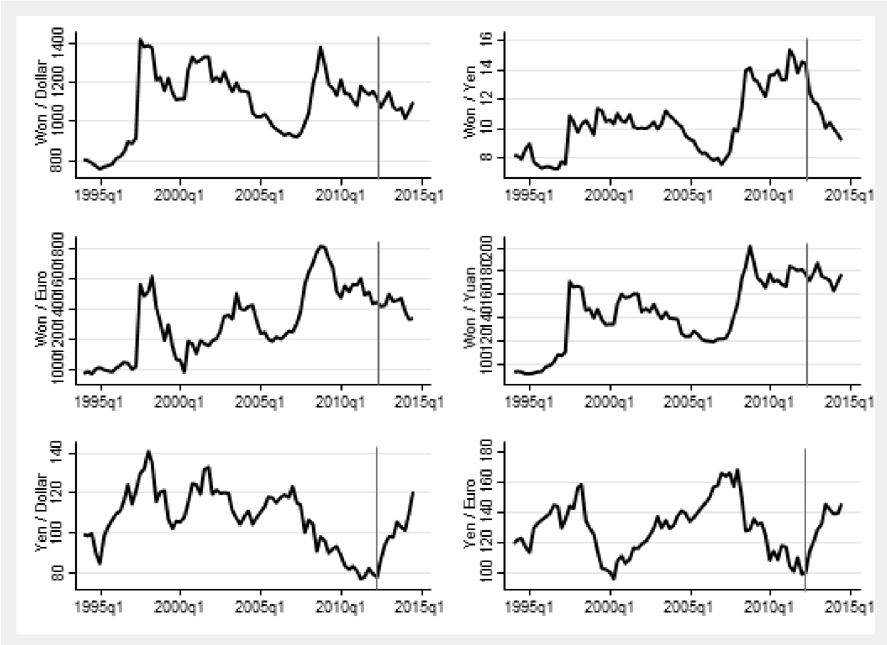
The increasing degree of economic integration within the world economy means that small open economies are often more vulnerable to external shocks. Since the 2008 global financial crisis, many major economies, including the US, Europe and Japan, have performed nonconventional monetary policy, called quantitative easing (hence forth ‘QE’). Japan has been at the forefront of such nonconventional monetary policy, having been conducting QE policy measures since 2001.

Despite these policy initiatives, Japanese economic recovery had failed to deliver a suitable level of economic performance. Therefore, Japanese government implemented more drastic quantitative and qualitative easing, known as QQE1, in 2013 and expanded QQE1 (known as QQE2) in 2014. These measures have been implemented since Prime Minister Abe took office in December 2012 as part of Abe’s Economic Policy Package Program (Abenomics).

The Abenomics consists of three main programs (so called “Three Arrows”); first program is a massive injection of new liquidity from the Bank of Japan (BOJ); second program is large new public works spending; third program is structural reforms that are intended to fix inefficiencies in Japanese economy. The first program of Abenomics aims to lower interest rates and the value of the yen. To enforce this program, in early 2016, the BOJ announced a lowering of its target interest rate to minus 0.1 %.

As is claimed by Fukuda (2015), to a certain degree, the first program of Abenomics seems to have attained its goal. It turns out that the increased liquidity made the yen weaker than other major currencies, which in turn boosted demand for Japanese exports and thereby revived Japan’s export driven economy. Figure 1 shows the trend of won/dollar, won/yen, won/euro, won/yuan, yen/dollar, yen/euro exchange rates. According to figure 1, the Japanese yen/dollar exchange rate shows a sharp depreciation since 2012. Before the Prime Minister Abe came to power in December 2012, the quarterly average yen/dollar exchange rate was 79.3 yen/dollar in the first quarter of

Figure 1 Exchange Rates of Neighboring Countries



Note: Vertical line denotes December 2012.
Source: IMF.

2012. However, it rose to 119.1 yen/dollar in the first quarter of 2015. Quarterly average of the Japanese stock price index (Nikkei 225) was 9,295 in the first quarter 2012, but it rose up to 18,226 in the first quarter 2015. Abenomics has succeeded in weakening the yen and raising stock prices.

In support of this, Otaki (2016) showed theoretically that Japanese QE policy has depreciated the Japanese real exchange rate and consequently supported an upturn in Japanese business via the multiplier effects.

As is widely perceived, the devaluation of a currency improves the trade balance of the country concerned at the cost of deteriorating those of its trading partners, which is called "Beggar Thy Neighbor" (hence forth 'BTN') effects. This weak yen policy, which aims to boost Japanese GDP by increasing exports, in many ways resembles BTN policies many countries adopted in the inter-war period between the world wars I and II in an attempt to drive export growth. The competitive devaluations had worsened the Great Depression of the 1930s.

This paper examines BTN effects from the Japanese weak yen policy on its trading partner countries. BTN issue emerged again since the 2008 global financial crisis. After the 2008 global financial crisis, the major economies (the US, EU, UK and Japan) have implemented QE policies and lowered their policy interest rates close to zero. Following these QEs, their currencies depreciated. As is mentioned earlier, Japanese QQE1 and QQE2 have led to a sharp depreciation of the yen and has given rise to serious concerns of its trading partners about its potential BTN effects.

In this study, we estimate the impact of a weak Japanese yen on GDPs of Japan and the rest of the world, with a special focus on Korea, China, and the US. The results will help us to ascertain whether BTN effects of weak yen exists in data. In order to empirically measure these effects, we have employed the Global Vector Autoregression (hence forth 'GVAR') methodology, based on the Global Value Chain (hence forth 'GVC') approach.

The main contribution of our paper is twofold. The first is that our paper is the first to use GVC approach in measuring the degrees of international linkages among the countries in GVAR analysis. The second is that this paper adds to the very sparse literature that employs GVAR analysis in measuring BTN effects of weak yen.

The rest of the paper is organized as follows. Chapter 2 reviews the relevant literature. Chapter 3 presents the underlying mechanics of the GVC and GVAR methodology. Chapter 4 describes the results from the generalized impulse response function analysis. Chapter 5 summarizes and concludes.

2. LITERATURE REVIEW

There has been growing number of studies on the effects of QEs of the US and the Eurozone on the rest of the world. A number of studies have claimed that they have a large spillover effects on emerging market economies (EME).

For example, Ahmed and Zlate (2012) and Bowman *et al*. (2015) explore the effects of the US QE on the capital flows to EMEs; Hausman and Wongswan(2011) explores the cross country variations by the US QE and tries to explain the reason of such variations; Bauer and Neely (2014) investigates the portfolio balance channels of international bond yield changes caused by the US QE; Menon and Ng (2013) examines the impact of Eurozone financial shocks on Southeast Asian economies; Taylor and Lee (2014) examines the propagation of the US financial crisis to Korea by using block recursive VAR; Gagnon *et al*. (2017) explores the spillover effects of the US QE on foreign financial markets; Chen *et al*. (2016) studies the impact of the US QE on both of EMEs and advanced economies, and Chen *et al*. (2017) compares the cross border effects of the US and Eurozone QEs by using a global vector error correction model (GVECM); Fratzscher *et al*. (2016) examines the impact of the US QE on both of portfolio flows of the US and 52 other countries; Xu and La (2017) assesses the spillover effects of the US QE through the bank lending channels; Kiendrebeogo (2016) finds that the US QE has been associated with net capital flows to developing countries, and to a lesser extent to advanced economics.

The phenomenon of weak yen is closely connected with the QE of Japan. Compared to the US and Eurozone QE, Japanese QE has received relatively little scholarly enquiry. Even though there has been a lot of contentious debate on the issue of weak yen, it is difficult to find rigorous empirical analysis on this subject. As the premise of the BTN effects refers to the export growth that comes from currency depreciation, most of the previous studies have sought to analyze the effects of the yen deprecation from the perspective of Japan's export and import.

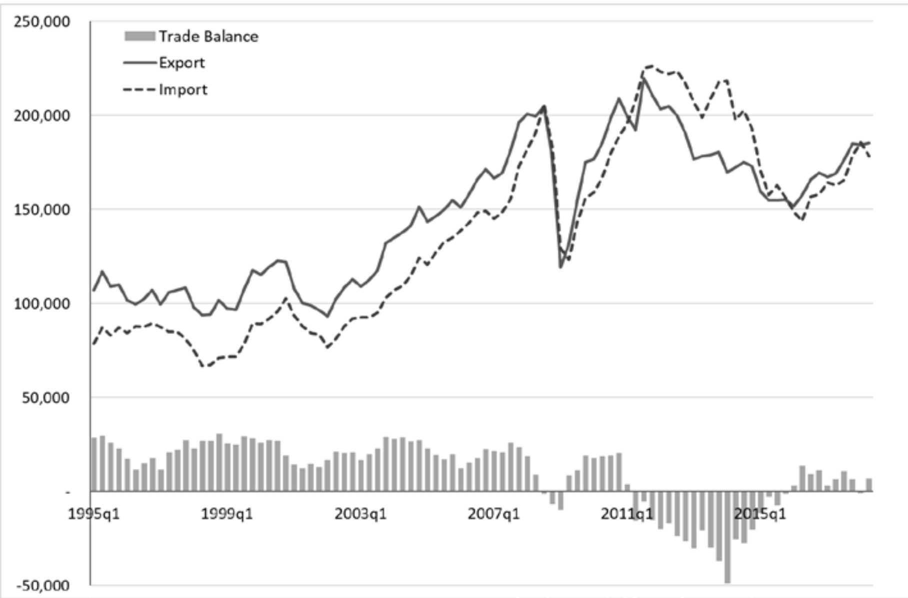
Maćkowiak (2006) estimates the effects of Japanese monetary policy shocks on East Asian economies by using Structural VAR models. Maćkowiak (2006) finds that Japanese monetary policy shocks only explain a modest fraction of the variances in real output, trade balances and exchange rates in East Asia, concluding that there is little evidence that Japanese monetary policy has any BTN effects on East Asian economies.

Chin (2013) examines the impact of a depreciated Japanese yen by estimating the elasticities of Japan's import and export demand functions. He concludes that a depreciation of the yen would result in an improvement in Japan's trade balance as the Marshall-Lerner condition held in Japan; a result that is compatible with the BTN effects of a weak yen.

Fukuda and Doita (2016) analyzes the effects of a depreciated yen on Japanese exports and concludes that despite the yen's sharp depreciation since Abenomics policy started, Japan's exports did not show any significant improvement as can be seen in figure 2. Their result indirectly denies the presence of any BTN effects that a weak yen may have on the rest of the world. They attribute this phenomenon to weak external demand for Japanese exports and increased overseas production by Japanese manufacturers.

Figure 2 Japanese Export, Import, and Trade Balance

(unit: million dollars)



Source: IMF.

Shimizu and Sato (2015), based on analyses using the ARDL model, claims that the actual effects of a depreciated yen have weakened during the Abenomics period, indirectly denying any BTN effects of the weak yen. They also attribute this finding to increases in Japanese overseas production. However, in terms of the relationship between Korea and Japan, they find that any depreciation in the value of the yen increases the competitiveness of Japanese products, partially acknowledging the BTN effects of Japanese monetary policy on Korea.

Kobayashi (2014) also finds that Japanese exports have not increased to previously forecast levels despite sharp depreciations in the value of the yen, which indicates a lack of any real spillover effects of Japanese monetary policy on other countries. Kobayashi (2014) attributes this phenomenon to Japanese companies' behavior that lowers prices of their exports to maintain market shares and to expanding overseas production capabilities.

Dekle and Hamada (2015), using VAR and GVAR methodologies, finds that yen depreciation that was brought about by Japanese expansionary monetary policies lowers GDP of the US and non-Japan Asian countries in the short-run. However, over the medium-to long-runs, they claim that the expansion of the GDP of Japan through the yen depreciation and rise in equity prices are likely to raise the GDPs of the US and the rest of Asia.

Kawai (2015) claims that even though the Japanese QE has resulted in a yen depreciation, there is not much evidence that the QE has had BTN effects on emerging Asian economies. In addition, he adds that the positive effects from Japanese fiscal stimulus offsets the negative effects of Japanese QE on other economies, especially those in Asia. Fukuda (2017), based on simple regressions of each individual countries' stock market indices on yen exchange rates, claims that Japan's QE has had much smaller BTN effects than were originally anticipated. Furthermore, he adds that the positive spillover effects of Japan's stock market recovery have been bigger than the negative effects of the regional BTN effects as Japan's QE progressed.

Ree *et al*. (2015), through examining the behavior of Japanese exporters, claims that persistent weak yen could raise the profits of Japanese exporters for a long time, and it would also fundamentally shift the relative competitiveness of Korean exporters vis-à-vis Japanese exporters. Ryou *et al*. (2019), by using time varying parameter VAR and Qualitative VAR models, claims that the effects of Japanese QE seem to have been successful in boosting the CPI of Japan, but have significant negative effects on Korea's GDP.

In estimating the BTN effects of a depreciated Japanese yen, two distinct features differentiate this study from the earlier studies reviewed above.

Firstly, we employ the GVC approach in measuring the degrees of linkages that exist between a particular country and its trading partners. The GVC refers to international fragmentation of production, in which production is vertically dispersed across countries. In the GVC, if a country produces intermediate goods, then other countries import them in order to assemble and export them. Under such fragmentation of production, exports and imports measured in gross terms containing intermediate inputs become misleading indicators of the degrees of linkages among the countries.

Most of the previous studies regarding trade utilize conventional gross trade statistics containing intermediate inputs in their analysis. Conventional gross trade statistics, based on the amount of exports and imports that pass through customs, are calculated without considering the trade of intermediate inputs for final exports. However, in the world of a vertically integrated global production system, conventional gross trade statistics can be misleading indicators of a country's domestic production and the degrees of trade interdependence among the countries.

For example, the conventional market value of a country's total exports includes intermediate goods, which are imported to be used in the production of final goods exports, are double counted. In this sense, they incorrectly measure the true amount of exports and imports that exist among the countries and give misleading indicators on the degrees of interdependence among the countries. To avoid this problem, we use the GVC approach that measures the degrees of interdependence based on value added basis of trade, instead of traditional gross amount of trade.

Secondly, we also utilize the GVAR; an econometric methodology which has been rarely used in the estimation of the BTN effects before. The GVAR model was first introduced by Pesaran, Schuermann, and Weiner (2004) (henceforth 'PSW') and further developed by Dées, di Mauro, Pesaran, and Smith (2007) (henceforth 'DdPS'). The GVAR is a global model linking individual country vector error-correcting models, in which the domestic variables are related to the country-specific foreign variables as an approximation of the common factor model. It allows for estimations of the long run and shot run relationships that exist among the countries in which complex interactions and interdependencies occur, avoiding the curse of dimensionality in a large system. Therefore, GVAR is a useful estimation methodology for complex international spillover problems, including the BTN effects.

3. EMPIRICAL MODEL

3.1. The GVC Model

In an attempt to measure the degrees of linkages that may exist among the countries included in our GVAR model, we have used trade weights in a way that are based on the value added basis of global value chains instead of conventional gross trade statistics.

Most empirical studies which measure the degrees of a country's engagement in global trade, have used conventional gross trade statistics which use the export and import amounts that are based on a customs clearance (henceforth 'CC') basis. However, as the CC basis trade statistics are measured in gross terms, instead of value added terms, they have critical defects in that they overestimate (by way of double counting) the trade volume that actually occurs among countries. For example, the trade volumes of the countries engaged in the trade of processed goods, on the CC basis, like Mexico and China, are generally overestimated due to the re-exporting of imported materials, capital goods and other intermediate product items.

As is emphasized by Choi and Park (2014), we may say that the measurement of trade by the CC basis is only valid at a time when trade flows comprise mostly finished goods. As the global value chains deepen, allowing goods to cross borders many times, more gross exports and imports include foreign intermediate inputs that do not create domestic value added. Therefore, CC basis trade statistics do not appropriately reflect the actual domestic production of a country, and they contain this double counting problem. They can be said to be inadequate in examining the degrees of interdependence among the countries in trading.[1)]

Thus, if one constructs the GVAR model by using CC basis trade statistics, it might misrepresent the real impacts of a particular shock. More specifically, the influence of the countries who are engaged in processed goods trade may be overestimated by double or triple counting the actual trade volume. Therefore, we tried to reduce the "biases" that exist by using the GVC basis trade statistics.

Firstly, let's examine the methodology associated with measuring how much value has been added to a particular country through the consumption of one of its exports abroad.[2)] Based on the equilibrium state of an input-output approach which is composed of C countries and G industries, the basic relationship is expressed as follows:

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} = \mathbf{Lf}, \tag{1}$$

where $\mathbf{x}$ denotes a CG×1 vector of gross output. $\mathbf{A}$ is the CG×CG matrix of

[1)] Let us consider this aspect using a simple example. Suppose country A exports $100 of goods, produced entirely within country A, to country B that further processes them before exporting them to country C where they are finally consumed. Country B adds value of only $10 to the goods, and exports $110 to C. In this situation, CC basis trade statistic shows total global exports and imports of $210 but only $110 of value added has been generated through their entire production. In addition, the trade linkages based on CC basis statistic misrepresent the reality; between country B and C, country C has a trade deficit of $110 with country B despite the fact that country B exports only $10 value added to country C; country A has no trade relations at all with country C (i.e., trade linkage between A and C is 0), while country A is the chief beneficiary of country C's consumption, exporting $100 value-added to country C. This example is from Ahmad (2013, p. 87).

[2)] For more details, see Stehrer (2012).

technical input-output coefficients, with each element denoting the input used in a particular industry in one country per unit of gross output, **f** denotes the CG×1 vector of final demand. The second part of right hand side, denotes the rearranged equation so that gross output is written as a function of the Leontief inverse matrix, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$, and the final demand vector **f**. Using the partitioned matrices for three countries, this equation is written in (2). To illustrate the concept of trade in value added products, we use a stylized three country model expressed in partitioned matrices without losing the characteristics of a generalized model.

$$\begin{pmatrix} X^r \\ X^s \\ X^t \end{pmatrix} = \begin{pmatrix} A^{rr}, A^{rs}, A^{rt} \\ A^{sr}, A^{ss}, A^{st} \\ A^{tr}, A^{ts}, A^{tt} \end{pmatrix} \begin{pmatrix} X^r \\ X^s \\ X^t \end{pmatrix} + \begin{pmatrix} f^r \\ f^s \\ f^t \end{pmatrix} = \begin{pmatrix} L^{rr}, L^{rs}, L^{rt} \\ L^{sr}, L^{ss}, L^{st} \\ L^{tr}, L^{ts}, L^{tt} \end{pmatrix} \begin{pmatrix} f^{rr} + f^{rs} + f^{rt} \\ f^{sr} + f^{ss} + f^{st} \\ f^{tr} + f^{ts} + f^{tt} \end{pmatrix}, \quad (2)$$

where $X^c\,(c = r, s, t)$ denotes the G×1 vector of gross output in Country *c*, L^{cd} the respective G×G submatrix of the Leontief inverse matrix and f^{cd} the G×1 vector for final demand of Country *d* in Country *c*.

Pre-multiplying this equation with a 1×CG vector of value added coefficients (value added per unit of gross output v), gives us the value added created from final demand and will be used in calculating the trade in value added (TVA).

$$TVA = \begin{pmatrix} v^{rr}, 0, 0 \\ 0, v^{ss}, 0 \\ 0, 0, v^{tt} \end{pmatrix} \begin{pmatrix} L^{rr}, L^{rs}, L^{rt} \\ L^{sr}, L^{ss}, L^{st} \\ L^{tr}, L^{ts}, L^{tt} \end{pmatrix} \begin{pmatrix} f^{rr} + f^{rs} + f^{rt} \\ f^{sr} + f^{ss} + f^{st} \\ f^{tr} + f^{ts} + f^{tt} \end{pmatrix}. \quad (3)$$

Export value added for country *r* to all other countries (TVA_X^r) includes the value added created in Country *r* in order to satisfy final demand in Countries *s* and *t*. Selecting the appropriate terms in the above equation provides the following expression.

$$TVA_X^r = \begin{pmatrix} v^{rr},0,0 \\ 0,0,0 \\ 0,0,0 \end{pmatrix} \begin{pmatrix} L^{rr},L^{rs},L^{rt} \\ L^{sr},L^{ss},L^{st} \\ L^{tr},L^{ts},L^{tt} \end{pmatrix} \begin{pmatrix} 0+f^{rs}+f^{rt} \\ 0+f^{ss}+f^{st} \\ 0+f^{ts}+f^{tt} \end{pmatrix}. \quad (4)$$

Import value added for country *r* from all other countries (TVA_M^r) should account for the value added created in Countries *s* and *t* in order to satisfy final demand of country *r*. So as to select the appropriate terms, the equation has to be written as:

$$TVA_M^r = \begin{pmatrix} 0,0,0 \\ 0,v^{ss},0 \\ 0,0,v^{tt} \end{pmatrix} \begin{pmatrix} L^{rr},L^{rs},L^{rt} \\ L^{sr},L^{ss},L^{st} \\ L^{tr},L^{ts},L^{tt} \end{pmatrix} \begin{pmatrix} f^{rr}+0+0 \\ f^{sr}+0+0 \\ f^{tr}+0+0 \end{pmatrix}. \quad (5)$$

Net trade in value added (TVA_N^r) can be calculated by the difference between exports and imports in value added.

$$TVA_N^r = TVA_X^r - TVA_M^r. \quad (6)$$

Exports, imports and net trade in value added for other countries, *s*, and *t* can be derived analogously.

Instead of the conventional gross export and import figures, we use the export in value added (TVA_X^r) and import in value added (TVA_M^r) in constructing the trade weight matrix in measuring the degrees of linkages that exist among countries (GVC matrix). As far as we know, no study has employed the GVC matrix in the GVAR model. By employing this GVC approach, we calculate the GVC matrix for 19 countries during the 2009-2011 period and use it within the construction of the GVAR model.

3.2. The GVAR Model

In this study, we use the GVAR model specification developed by PSW (2004) and DdPS (2007). The GVAR model can be briefly summarized as encompassing a two-step procedure. In the first step, the individual country-specific models are estimated in a way that is conditional on the rest of the world. These are VAR models augmented by the vector of star (*) variables, which represent country specific foreign variables. In the second step, the individual country VARX* models are stacked and solved simultaneously as one large global VAR model. The solution can be used for shock scenario analysis and forecasting as is usual with standard VAR models. By doing so, it allows us to systematically estimate the propagation of economic shock in a global setting.

The first step in the GVAR modelling process is to construct country specific foreign variables from a specific set of domestic variables. The country specific foreign variables are used as proxies for common unobserved factors and at the same time allow us to estimate the country specific endogenous variables, which help to deal with the problem of dimensionality.

To briefly describe the GVAR model presented by DdPS (2007) and PSW (2004), it is assumed that there are $N+1$ countries, indexed by $i=0,1,2,\ldots,N$. For each country, $k_i \times 1$ are the country specific macroeconomic variables $\mathbf{x}_{it}$, comprising of real GDP, inflation, real equity prices, real exchange rate, nominal short term interest rates, and nominal long term interest rates, $\mathbf{x}_{it}$ over time, by $t=0,1,2,\ldots,T$, and across $N+1$ countries.

DdPS (2007) and PSW (2004) construct the $k_i^* \times 1$ country specific foreign variables $\mathbf{x}_{it}^* = \sum_{j=0}^{N} w_{ij} x_{jt}$, where w_{ij}, $j=0,1,2,\ldots,N$, means the trade weight (the share of country j in the total trade of country i such that $w_{ii}=0$ and $\sum_{j=0}^{N} w_{ij} = 1$). The weights are predetermined, and are meant to capture the importance of country j for the i th economy.

Most studies have used trade weights obtained from the CC basis. However, in our study, we use the average trade weights calculated according to the GVC basis. This is an important distinction, and helps to define our unique contribution to the existing empirical literature.

For simplicity, if we confine our exposition here to a 2nd-order dynamic specification, then each country has a set of domestic and foreign-specific variables, the number of which can vary across countries. Specifically, for country i, the VARX* (2, 2) structure is given by:

$$\mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \mathbf{\Phi}_{i1}\mathbf{x}_{i,t-1} + \mathbf{\Phi}_{i2}\mathbf{x}_{i,t-2} + \mathbf{\Lambda}_{i0}\mathbf{x}_{it}^{*} + \mathbf{\Lambda}_{i1}\mathbf{x}_{i,t-1}^{*} + \mathbf{\Lambda}_{i2}\mathbf{x}_{i,t-2}^{*} + \mathbf{u}_{it}, \quad (7)$$

where $\mathbf{x}_{it}$ is a $k_i \times 1$ vector of the country specific domestic variables, $\mathbf{x}_{it}^{*}$ is a $k_i^{*} \times 1$ vector for the associated country specific foreign variables, and $\mathbf{u}_{it}$ is a serially uncorrelated and cross-sectionally weakly dependent processes. In constructing foreign specific variables $\mathbf{x}_{it}^{*}$, both of DdPS (2007) and PSW (2004) used CC basis trade weights. However, given our belief that the GVC trade weights better reflect international linkages among the nations than the CC basis trade weights, we use the GVC basis trade weights in constructing $\mathbf{x}_{it}^{*}$.

This country specific model can be separately estimated consistently under the condition of the weak exogeneity that exists among the country specific foreign variables $\mathbf{x}_{it}^{*}$ with respect to $\mathbf{x}_{it}$. This weak exogeneity condition of $\mathbf{x}_{it}^{*}$ with respect to $\mathbf{x}_{it}$ separates the individual country model from the whole system, allowing us to consistently estimate the individual country model separately without simultaneously estimating the whole system.[3)] By taking into account of the integration properties of the series $\mathbf{x}_{it}$ and $\mathbf{x}_{it}^{*}$, and treating $\mathbf{x}_{it}^{*}$ as weakly exogenous I(1) with respect to the parameters of this model, we can not only distinguish between the short and long run relationships but also interpret the long-run relationships from the point of co-integration.

To construct the GVAR model, we group both the domestic and foreign variables as being:

$$\mathbf{z}_{it} = \begin{pmatrix} \mathbf{x}_{it} \\ \mathbf{x}_{it}^{*} \end{pmatrix}. \quad (8)$$

3) For the proof, see the appendix of DdPS (2007).

Then we are able to obtain the corresponding error-correction form, VECMX* of (7), which is expressed as:

$$\Delta \mathbf{x}_{it} = \mathbf{c}_{i0} - \boldsymbol{\alpha}_i \boldsymbol{\beta}_i' \left[\mathbf{z}_{i,t-1} - \boldsymbol{\gamma}_i (t-1) \right] + \boldsymbol{\Lambda}_{i0} \Delta \mathbf{x}_{it}^* + \boldsymbol{\Gamma}_i \Delta \mathbf{z}_{i,t-1} + \mathbf{u}_{it}, \qquad (9)$$

where $\boldsymbol{\alpha}_i$ is a $k_i \times r_i$ matrix of rank r_i, and $\boldsymbol{\beta}_i$ is a $(k_i + k_i^*) \times r_i$ matrix of rank r_i. We can estimate (9) based on reduced rank regression, and obtain the estimates of the speed of adjustment coefficients, $\boldsymbol{\alpha}_i$, and the cointegrating vectors, $\boldsymbol{\beta}_i$, for each country model.

After the estimation is done on a country by country basis, we need to construct the GVAR model for the world as a whole (in terms of a $k \times 1$ global variable vector, $k = \sum_{i=0}^{N} k_i$), taking into account the fact that all of the variables are endogenous to the system as a whole.

Starting from the country-specific VARX(2,2) models in (7), where $\mathbf{z}_{it} = \left(\mathbf{x}_{it}', \ \mathbf{x}_{it}^{*\prime} \right)'$, we are able to write (7) for each economy as being:

$$\mathbf{A}_{i0} \mathbf{z}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1} t + \mathbf{A}_{i1} \mathbf{z}_{i,t-1} + \mathbf{A}_{i2} \mathbf{z}_{i,t-2} + \mathbf{u}_{it}, \qquad (10)$$

where $\mathbf{A}_{i0} = \left(\mathbf{I}_{k_i}, -\boldsymbol{\Lambda}_{i0} \right)$, $\mathbf{A}_{i1} = \left(\boldsymbol{\Phi}_{i1}, \boldsymbol{\Lambda}_{i1} \right)$, $\mathbf{A}_{i2} = \left(\boldsymbol{\Phi}_{i2}, \ \boldsymbol{\Lambda}_{i2} \right)$.

Then by collecting all of the domestic (endogenous) variables together, we can create the global vector $\mathbf{x}_t = \left(\mathbf{x}_{0t}', \ \mathbf{x}_{1t}', \ \ldots, \ \mathbf{x}_{Nt}' \right)'$ with the dimension $k \times 1$. We can then use the link matrices $\mathbf{W}_i$ defined by the country specific trade weights w_{ij} to obtain the identity

$$\mathbf{z}_{it} = \mathbf{W}_i \mathbf{x}_t, \qquad (11)$$

where $\mathbf{W}_i$ is a matrix with dimensions $(k_i + k_i^*) \times k$. This matrix $\mathbf{W}_i$ can be interpreted as a link matrix that allows each country model to be written in terms of the global variable vector $\mathbf{x}_t$. If we use the identity given by (11), then (10) can be written as

$$\mathbf{A}_{i0}\mathbf{W}_i\mathbf{x}_t = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \mathbf{A}_{i1}\mathbf{W}_i\mathbf{x}_{t-1} + \mathbf{A}_{i2}\mathbf{W}_i\mathbf{x}_{t-2} + \mathbf{u}_{it} \text{ for } i=0, 1, 2, \ldots, N. \quad (12)$$

Then by stacking each country specific models in (12), we can get (13),

$$\mathbf{G}_0\mathbf{x}_t = \mathbf{a}_0 + \mathbf{a}_1 t + \mathbf{G}_1\mathbf{x}_{t-1} + \mathbf{G}_2\mathbf{x}_{t-2} + \mathbf{u}_t, \quad (13)$$

where

$$\mathbf{G}_0 = \begin{pmatrix} \mathbf{A}_{00}\mathbf{W}_0 \\ \mathbf{A}_{10}\mathbf{W}_1 \\ \vdots \\ \mathbf{A}_{N0}\mathbf{W}_N \end{pmatrix}, \ \mathbf{G}_1 = \begin{pmatrix} \mathbf{A}_{01}\mathbf{W}_0 \\ \mathbf{A}_{11}\mathbf{W}_1 \\ \vdots \\ \mathbf{A}_{N1}\mathbf{W}_N \end{pmatrix}, \ \mathbf{G}_2 = \begin{pmatrix} \mathbf{A}_{02}\mathbf{W}_0 \\ \mathbf{A}_{12}\mathbf{W}_1 \\ \vdots \\ \mathbf{A}_{N2}\mathbf{W}_N \end{pmatrix},$$

$$\mathbf{a}_0 = \begin{pmatrix} \mathbf{a}_{00} \\ \mathbf{a}_{10} \\ \vdots \\ \mathbf{a}_{N0} \end{pmatrix}, \ \mathbf{a}_1 = \begin{pmatrix} \mathbf{a}_{01} \\ \mathbf{a}_{11} \\ \vdots \\ \mathbf{a}_{N1} \end{pmatrix}, \ \mathbf{u}_t = \begin{pmatrix} \mathbf{u}_{0t} \\ \mathbf{u}_{1t} \\ \vdots \\ \mathbf{u}_{Nt} \end{pmatrix}.$$

The $\mathbf{G}_0$ matrix has dimension $k \times k$ and is dependent on the trade weights and parameter estimates. If $\mathbf{G}_0$ is nonsingular, then by pre multiplying (13) by $\mathbf{G}_0^{-1}$, we can get the GVAR model in its more simplified form:

$$\mathbf{x}_t = \mathbf{b}_0 + \mathbf{b}_1 t + \mathbf{F}_1\mathbf{x}_{t-1} + \mathbf{F}_2\mathbf{x}_{t-2} + \boldsymbol{\varepsilon}_t, \quad (14)$$

where

$$\mathbf{F}_1 = \mathbf{G}_0^{-1}\mathbf{G}_1, \ \mathbf{F}_2 = \mathbf{G}_0^{-1}\mathbf{G}_2,$$

$$\mathbf{b}_0 = \mathbf{G}_0^{-1}\mathbf{a}_0, \ \mathbf{b}_1 = \mathbf{G}_0^{-1}\mathbf{a}_1, \ \boldsymbol{\varepsilon}_t = \mathbf{G}_0^{-1}\mathbf{u}_t.$$

(14) can be solved recursively and as such can be used for the purpose of conducting the generalized impulse response function analysis. For further details, see PSW (2004) and DdPS (2007).

3.3. The Data

In this paper, we use quarterly data for 19 countries from 1972 Q2 to 2013

Q1, which is the most recent available data set at the time of our empirical analysis.[4)]

Following the DdPS (2007), we specify the domestic, foreign and global variables included in the country-specific models as being:

$$y_{it} = \ln\left(GDP_{it} / CPI_{it}\right),$$

$$p_{it} = \ln\left(CPI_{it}\right),\ eq_{it} = \ln\left(EQ_{it} / CPI_{it}\right),$$

$$e_{it} = \ln\left(E_{it}\right),\ \ ep_{it} = \ln\left(E_{it}\right) - \ln\left(CPI_{it}\right),$$

$$\rho_{it}^{S} = 0.25 \times \ln\left(1 + R_{it}^{S} / 100\right),$$

$$\rho_{it}^{L} = 0.25 \times \ln\left(1 + R_{it}^{L} / 100\right),$$

and global variables

$$p_t^O = \ln\left(P_t^O\right),$$

$$p_t^m = \ln\left(P_t^m\right),$$

$$p_t^t = \ln\left(P_t^t\right),$$

where GDP_{it} = Nominal Gross Domestic Product of country i during period t, in domestic currency; CPI_{it} = Consumer Price Index in country i at time t; EQ_{it} = Nominal Equity Price Index; E_{it} = Exchange rate of country i at time t (units of foreign currency per US dollar); R_{it}^{S} = Nominal short-term rate of interest per annum, in percentage terms; R_{it}^{L} = Nominal long-term rate of interest per annum, in percentage terms; P_t^O = Price of oil (in USD); P_t^m = Price of agricultural raw materials (in USD); P_t^t = Price of metals (in USD).

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4) The data is available from https://sites.google.com/site/gvarmodelling/data.(accessed on August 25, 2015)

Table 1 Countries and Regions Included in the GVAR Model

Major	Euro	Rest of Western Europe	Latin	Asia	Rest of the World
USA	Germany	UK	Mexico	Korea	Turkey
China	France	Sweden		Indonesia	
Japan	Italy			India	
	Netherlands				
Other Developed	Belgium				
Canada	Austria				
Australia	Finland				
Number of countries	7	2	1	3	1

3.4. Country Specific Models

As is described earlier in the GVAR modeling, the country specific model is constructed using the country specific foreign variables $\mathbf{x}_{it}^{*}$. In this paper, the global observables variables p_t^o, p_t^m, p_t^t are combined with the foreign specific variables $\mathbf{x}_{it}^{*}$ and are jointly treated as being weakly exogenous. Most of the individual countries include y, Δp, ep, eq, ρ^S and ρ^L as domestic variables, and country specific foreign variables. DdPS (2007) constructed the country specific foreign variables $\mathbf{x}_{it}^{*}$ using CC basis trade statistic. In this paper, we calculated the GVC basis trade weights, that are based on the average trade flows computed over the three-year period from 2009-2011. In conjunction with this, we use GVC basis trade weights when constructing the foreign specific variables.

We tested the integration properties of the domestic variables $\mathbf{x}_{it}$ and the country specific foreign variables $\mathbf{x}_{it}^{*}$ by using the standard Dickey-Fuller tests and the Park and Fuller (1995) weighted symmetric ADF type tests, at the 5% significance level. The results show that the majority of the variables do not reject the null hypothesis of non-stationarity.

The lag orders of the individual VARX* models are determined according to the Akaike information criterion, with a maximum lag length of 2 for domestic variables and 1 for foreign variables. For the majority of the countries, a VARX*(2,1) specification is used. If we assume the existence of weak exogeneity of the country specific foreign variables $\mathbf{x}_{it}^{*}$, the corresponding error correction form of the country specific VARX* models in (2) is estimated separately for each country conditional on $\mathbf{x}_{it}^{*}$, allowing co-integration both within the domestic variables $\mathbf{x}_{it}$ and across $\mathbf{x}_{it}$ and $\mathbf{x}_{it}^{*}$ based on the use of reduce-rank regression.

After the estimates of $\boldsymbol{\beta}_i$ are obtained, we are able to obtain the consistent estimates of the remaining parameters of VECMX* by using OLS, then recover the corresponding VARX* form in (7). As a consequence of this, we can then combine these country specific VARX* models using the link matrix $\mathbf{W}_i$ as defined in (11).

3.5. Test for Weak Exogeneity of Country Specific Foreign Variables $\mathbf{x}_{it}^{*}$

The key assumption underlying the above estimation strategy is the weak exogeneity of country specific foreign variables $\mathbf{x}_{it}^{*}$ with respect to the long-run parameters of the conditional model. This assumption allows us to estimate each country individually and combine the findings of these estimations at a later stage.

The meaning of this assumption is that each individual country's economy is so small with respect to the rest of the world that each individual country receives long run feedback from the rest of the world, but it does not give long run feedback to the rest of the world, without ruling out the existence of any contemporaneous and lagged short run feedback between the countries.

As was described earlier, the country specific foreign variables are computed as weighted averages of the corresponding domestic variables of all countries, with the weights also being country specific.

A formal test for the existence of weak exogeneity for the country specific foreign variables was carried out by testing the joint significance of the estimated error-correction terms in the auxiliary equations for the country specific foreign variables, $\mathbf{x}_{it}^{*}$. In particular, for each h th element of $\mathbf{x}_{it}^{*}$, the following regression was conducted:

$$\Delta x^*_{it,h} = a_{ih} + \sum_{j=1}^{r_i} \delta_{ij,h} ECM_{ij,t-1} + \sum_{k=1}^{s_i} \phi_{ik,h} \Delta x_{i,t-k} + \sum_{m=1}^{n_i} \psi'_{im,h} \Delta x^*_{im} + \eta_{it,h}, \quad (15)$$

where $ECM_{ij,t-1}$, $j = 1, 2, ..., r_i$ are the estimated error-correction terms that correspond to the r_i co-integrating relations found for the term i th country model. The test for weak exogeneity is to ascertain whether any long run feedback exists from $\mathbf{x}_{it}$ to $\mathbf{x}^*_{it}$, while the foreign variables $\mathbf{x}^*_{it}$ have an influential impact on $\mathbf{x}_{it}$ over the long-run. Therefore, the test for weak exogeneity of $\mathbf{x}^*_{it}$ is an F-test of the joint hypothesis for the coefficients of ECM term $\delta_{ij,h} = 0,\ j = 1, 2, \ldots, r_i$, in (15). The test results for the focus countries are summarized in table 2.

The weak exogeneity test results show that at the 5% significance level, only 6 of the 102 regressions rejected the null hypothesis for the weak exogeneity assumption. These results validate our GVAR estimation.

Table 2 Weak Exogeneity Test Result

Country	F-test	Critical Value (5%)	y^*	Δp^*	eq^*	ep^*	ρ^{*S}	ρ^{*L}	p^{0*}	p^{m*}	p^{t*}
Australia	F(5,106)	2.30	0.99	0.91	1.00		0.23	0.62	0.74	3.49	0.69
Canada	F(3,115)	2.68	1.88	3.96	1.14		0.35	0.64	0.97	1.19	0.62
China	F(2,118)	3.07	0.40	0.17	0.08		0.84	1.11	0.56	0.20	1.17
Euro	F(2,116)	3.07	1.84	0.86	0.91		1.97	0.52	1.56	1.43	4.26
India	F(2,117)	3.07	0.79	2.11	2.04		1.38	1.57	1.37	1.00	0.12
Indonesia	F(3,107)	2.69	0.43	0.47	1.10		0.83	0.06	0.69	1.33	2.00
Japan	F(2,116)	3.07	0.85	1.17	1.35		0.04	0.92	1.09	0.96	2.39
Korea	F(4,114)	2.45	0.99	0.74	2.46		1.33	0.91	1.68	0.66	0.29
Mexico	F(3,117)	2.68	0.93	3.00	1.00		1.00	1.18	1.10	0.54	2.41
Sweden	F(2,116)	3.07	0.14	0.15	0.54		0.93	0.72	0.21	0.30	1.55
Turkey	F(1,119)	3.92	1.59	0.72	0.08		0.01	3.62	1.46	0.40	0.05
UK	F(3,115)	2.68	1.55	2.32	0.43		1.54	2.85	0.54	0.27	2.63
US	F(2,120)	3.07	0.54	6.97		0.08			0.56	3.21	2.43

4. GENERALIZED IMPULSE RESPONSE FUNCTION ANALYSIS

4.1. GVC Basis Trade Matrix

As part of our generalized impulse response function (GIRF) analysis, we calculate the GVC basis trade matrix and compare it with the CC basis trade matrix. A detailed description of these calculations is documented in table 1 and table 2 within the Appendix, however, a summary of the results for Korea, China, Japan and the US are displayed in table 3. By comparing the CC basis and GVC basis matrixes, we are able to deepen our understanding of the trade relationships that exist among the countries.

From the summarized results in table 3, a number of conclusions can be drawn. Firstly, the trade weights using the GVC basis for Korea, China and Japan are larger than the CC basis. For example, in case of Korea, the weight of China in Korea’s trade is 0.315 in terms of the CC basis. However, according to the GVC basis, it rises to 0.355. The same phenomenon also holds for China. Korea’s trade weight among China’s trade is only 0.052 according to CC basis, however, this weighting rises to 0.134 when using the GVC basis.

Table 3 Results Summary for the CC and GVC Basis Trade Matrixes

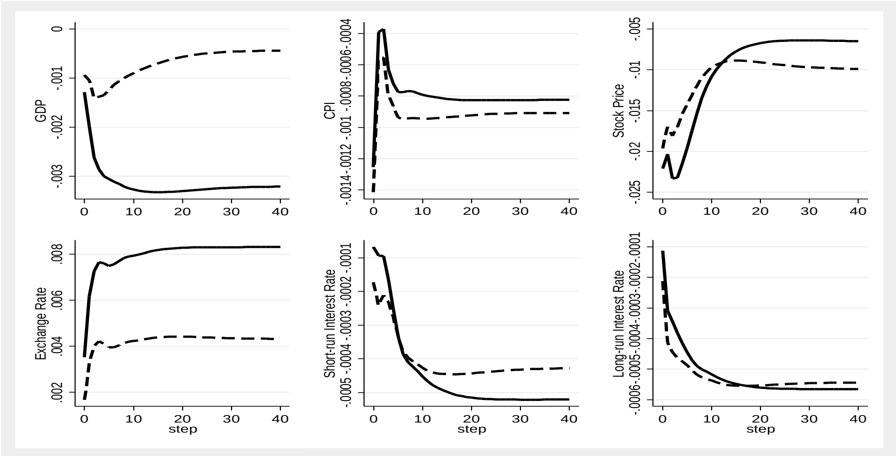
	Weight of Korea		Weight of China		Weight of Japan		Weight of the US	
	CC	GVC	CC	GVC	CC	GVC	CC	GVC
Korea			0.315	0.355	0.107	0.175	0.212	0.167
China	0.052	0.134			0.126	0.191	0.346	0.248
Japan	0.068	0.105	0.310	0.347			0.280	0.216
US	0.043	0.039	0.160	0.206	0.086	0.080		

Secondly, when we use GVC basis instead of CC basis, the trade weight of the US within Korea, China and Japan actually falls. For example, if we use the CC basis, the trade weight of the US among China's trade is 0.346, however it decreases to 0.248 if we use the GVC basis. From these results, we can conclude that if we consider the trade relationship among the East Asian countries (Korea, Japan and China) on the GVC basis, they are more interconnected with each other than we think based upon conventional CC basis trade statistics. In addition, their degrees of connection in trade with the US are less than traditionally been believed based on the CC basis.

To investigate the implications of three different external shocks, we make use of the GIRF, proposed in Koop, Pesaran and Potter (1996). The GIRF was originally developed for non-linear models, however, Pesaran and Shin (1998) extended its application to multivariate time series models. The GIRF is an alternative to the Orthogonalized Impulse Responses (OIR) of Sims (1980). The major advantage of using the GIRF over the OIR, is that the GIRF is invariant to the ordering of the variables and the countries in the GVAR model, which is clearly an important merit when compared to that of the OIR. Given our desire to analyze the time profile of the effects that a depreciated Japanese yen has on the world economy, we will focus on the GIRF when constructing the GVAR.

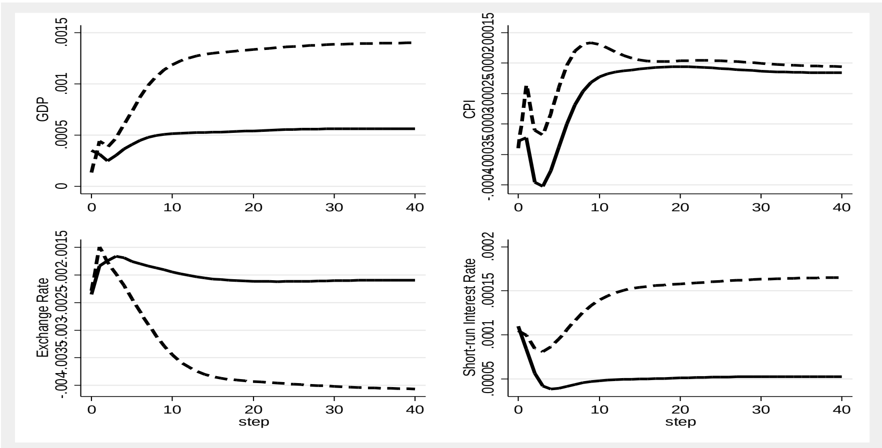
If we compare the differences in the GIRFs obtained using the CC and GVC basis trade matrixes, from figure 3 to figure 6, we are able to gain a clearer understanding of the effects of a weak Japanese yen. For example, by looking at figure 3, Korea's GIRF of GDP, obtained by the CC and GVC basis trade matrixes, show significantly different levels of movement and as such supports our use of the GVC basis trade statistics.

Figure 3 The GIRFs of the Yen Shock Obtained by Comparing the CC and GVC Basis for Korea



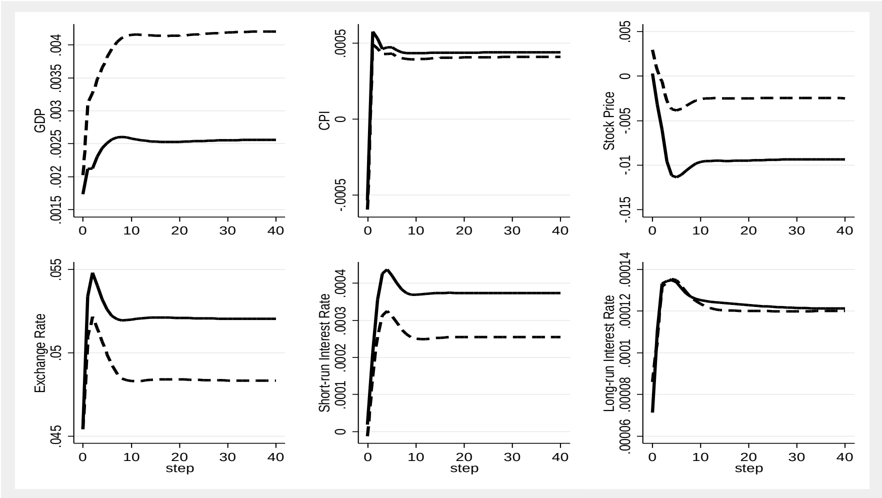
Note: - - - - denotes CC basis, —— denotes GVC basis.

Figure 4 The GIRFs of the Yen Shock Obtained by Comparing the CC and GVC Basis for China



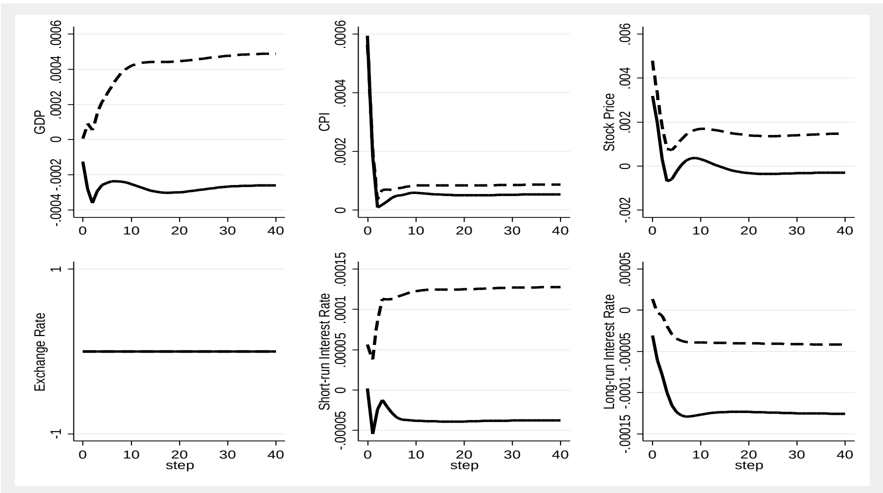
Note: - - - - denotes CC basis, —— denotes GVC basis.

Figure 5 The GIRFs of the Yen Shock Obtained by Comparing the CC and GVC Basis for Japan



Note: - - - - denotes CC basis, —— denotes GVC basis.

Figure 6 The GIRFs of the Yen Shock Obtained by Comparing the CC and GVC Basis for the US



Note: - - - - denotes CC basis, —— denotes GVC basis.

4.2. Effects of Japan's Real Exchange Rate Shock on GDP

If we consider Japan's role in the world economy from the global value chain perspective, we can simplify it as having three main functions: an exporter of consumer goods, an exporter of capital goods and intermediate goods, and an importer of raw materials and intermediate goods. Within these roles, a relevant framework is now suggested.

Firstly, Japan exports consumer goods to the world, which are expected to be price elastic and are likely to compete with the other consumer goods being exported by neighboring countries. In this regard, a weaker yen will lower the price of Japan's products and as a consequence help to erode its neighbors' global market share. Such an impact will eventually lead to a decrease in the income of its neighboring countries, and therefore exhibiting a typical type of BTN effects. In this instance, we call the effects that Japan's neighboring countries have to suffer as a result of weak yen, as the '*price effects*'.

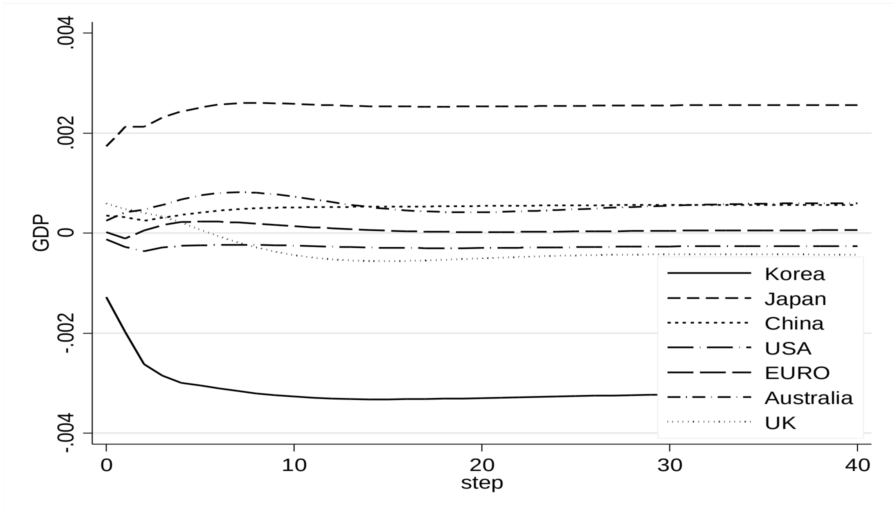
Secondly, Japan exports high quality machineries and equipment and key intermediate goods to its neighboring countries. In this respect, a lower valued yen can lower its neighbors' investment and production costs, which can therefore increase the investment and production capabilities of the neighboring countries that import Japanese capital and intermediate goods. In this instance, we call the effects that the neighboring countries enjoy as a result of the weaker yen, as the '*investment effects*'.

Thirdly, Japan is a heavy importer of raw materials and intermediate goods. As the imports of raw materials and intermediate goods reflects induced demand, neighboring countries are dependent on Japanese income and export levels. If Japanese income or export levels increase, then the imports of raw materials and intermediate goods will also rise, leading to an increase in the income of the countries that export raw materials and intermediate goods to Japan. In this instance, we call this secondary effects, created by a weaker yen, and enjoyed by the countries that export raw materials and intermediate goods, as the '*income effects*'.

The price, investment and income effects of a weaker yen have varying degrees of impact on the income levels of the neighboring countries. For example, the price effects have negative impacts, however, the investment and income effects have positive effects on the neighbor countries' income levels.

The dynamics of a weak yen shock to the world economy is shown from figure 7 to figure 9. The shock given is in the form of a one standard deviation devaluation of the yen/dollar real exchange rate. An examination of figure 7 shows, Korea appears to have been the most seriously affected by the shock. In contrast, China and Australia have been beneficiaries of the move, whereas the US receives a negligible but negative impact, while the EU countries are relatively unaffected. This result highlights the highly competitive relationships that exist between Korea and Japan in the world final product market. That is, the weaker yen makes Japanese products more affordable in the world market, which leads to an erosion in Korea's export market share.[5)]

Figure 7 The Shock of Japan's Real Exchange Rate Change on GDP



5) Korea has ESI (Export Similarity Index) around 0.5 with Japan. This figure means that in the world market, almost 50% of Korea's exports have the same 6-digit HS code, thereby competing with Japanese exports.

According to our results, the negative price effects of the weaker yen seem to outweigh any positive investment and income effects that Korea may enjoy. However, if we look at the cases of both Australia and China, a weaker yen has a positive impact on their respective GDP performances with a slight increase being recorded in both countries. The slight increase in China's GDP seems to reflect the country's position in global supply chain for final goods production.

When compared with Korea, China has a less competitive relationship with Japan in the final goods market. Therefore, on the price effects side, we can expect that China will have smaller negative price effects than Korea. China imports from Japan capital goods and key intermediate products in the processing trade such as components and semi-manufactured goods. Therefore, on the investment effects side, a depreciated yen allows China to import cheaper Japanese investment goods and key inputs in the processing trade. On the income effects side, China also receives higher revenue from its export of raw materials and intermediate products, which may help to increase the China's income levels. According to our analysis, the positive investment effects that China receives as a result of a devalued yen seem to outweigh any negative price effects it may experience.

In case of Australia, its slight increase in GDP reflects the increase in revenue it would enjoy by exporting raw materials more to Japan; an impact that highlights the 'income effects' defined earlier. A weaker yen means that Japanese products are more competitive than those of their rival countries, which increases exports and income of Japan, which would lead to an increase in imports of raw materials. This would in turn lead to an increase in income for countries such as Australia that export raw materials. Our analysis concludes, that the positive income effects that Australia enjoys outweighs any negative price effects it may experience.

The results for the US and the EU demonstrate that the negative price effects and positive investment and income effects of a weaker yen are basically neutral. However, as the impulse responses of these countries are centered around zero, these results needs to be checked by bootstrapping, which will be discussed in a later subsection.

Our results so far are relevant to important international macroeconomic theory of the exchange rate depreciation. Under sticky price assumption, Obstfeld and Rogoff (1995, 1996) show that currency depreciation stemming from monetary expansion is equally beneficial to all countries. The implication of their model is sharply different from the standard BTN inference from the Mundell-Fleming-Dornbusch model.

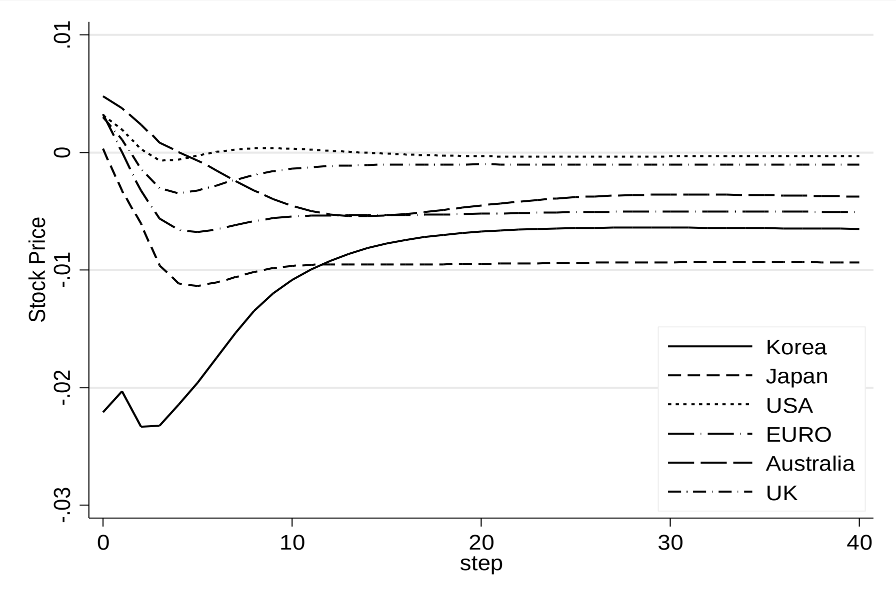
The results suggest a new angle for an extension of Obstfeld and Rogoff (1995, 1996). According to the result of our paper, with the depreciation of yen, the price effects on neighboring countries are negative, depending on the degrees of substitution of each country's export products with those of Japan in the world market. At the same time, the investment and income effects of other countries are positive. Effects of a depreciation of yen depends on the sum of these effects of a particular country. If a country has a negative price effects that dominate the positive investment and income effects, then the country will experience 'beggar' thy neighbor effects from the Japanese deprecation. However, if a country has positive investment and income effects that dominate relatively small negative price effects, due to low degrees of substitution, then it will enjoy 'prosper' thy neighbor effects instead.

4.3. Effects of Japan's Real Exchange Rate Shock on Stock Markets

Next we turn to effects of a yen depreciation on stock markets. As figure 8 shows, in the short run, a weaker yen has negative effects on most of the stock markets around the world, lowering the stock prices of most of the world's countries including those of Japan.

The effects of the weak yen shock on other equity markets is rather quick and significant. For Japan, real equity prices appear to fall for nearly 4 consecutive quarters before a slight rebound occurs. In Europe, their equity markets show a similar pattern to those of the Japanese stock market. In this instance, it falls for almost 4 quarters, but to a slightly lesser degree to that of the Japanese stock market, before making a slight rebound. In contrast, the

Figure 8 The Shock of Japan's Real Exchange Rate Change on Real Equity Prices



US stock market seems to have been almost completely unaffected, while the Australian stock market actually increased as a result of the weak yen shock. This was then followed by a steady decrease over 12 quarters, before finally bouncing back a little.

However, for Korea, its impact on equity markets was felt deeply with a significant fall. Despite such a fall, its stock bounced back at a rate that was much quicker than any other countries measured. In other worlds, the weak yen had both a significant negative effects on Korea's stock market but also an accompanying period of rapid recovery.

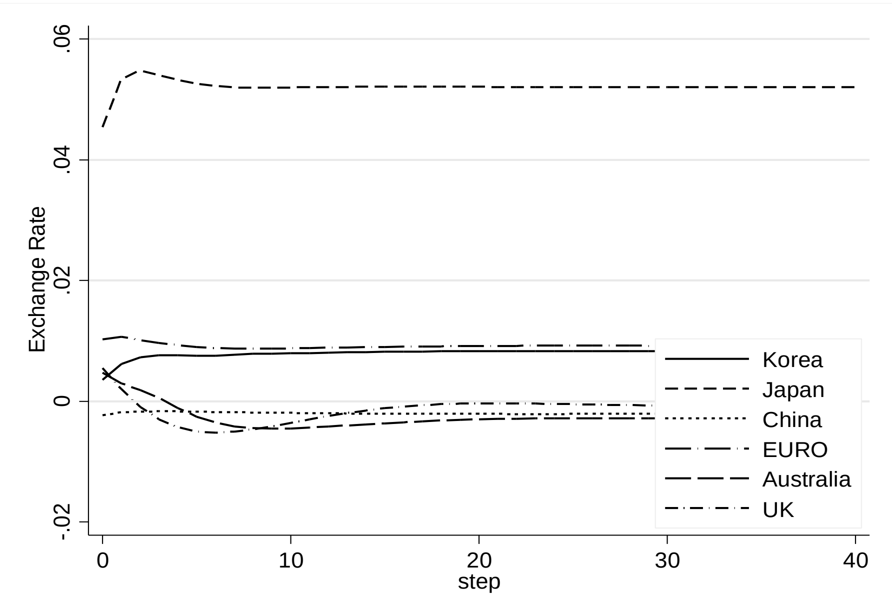
This result demonstrates the desire of global investors to avoid risk. For many, the Korean stock market has been regarded as a place to park assets in way that allows them to withdraw their investments whenever they want to readjust their emerging market portfolio.

4.4. Effects of Japan's Real Exchange Rate Shock on Real Exchange Rates of Other Countries

A weaker yen also affects the real exchange rates of other countries. As figure 9 demonstrates, a weaker yen also led to a depreciation in the values of both the Korean won and Euro. However, the real exchange rate of the Chinese yuan did not seem to be affected by the depreciation of the yen. Such a result supports the conclusions drawn in the previous section. That is, the negative effects of the weaker yen on China's trade, in terms of export reductions, are basically offset by the gains made from cheaper imports from Japan.

It is interesting to note that the Australian dollar appreciates as a result of a depreciation of yen. This finding is indicative of the 'income effects' defined earlier that a weaker yen increases demand for Japanese exports which in turn

Figure 9 The Shock of Japan's Real Exchange Rate Change on Real Exchange Rates



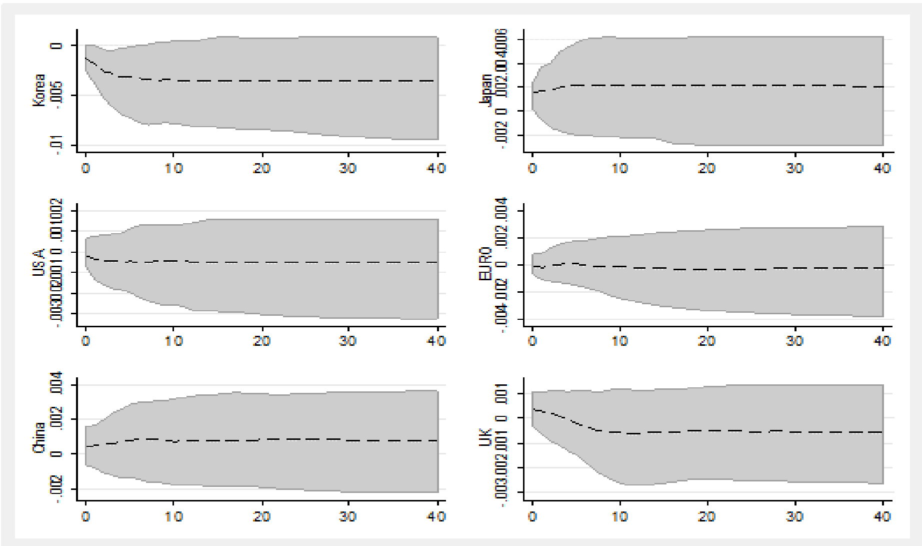
leads to increased demand for raw materials by Japanese companies. These changes in demand directly correlate with an increase in the export of raw materials from Australia, which increases Australian foreign reserves, thereby leading to an appreciation of the Australian dollar.[6)]

Finally, in terms of inflation and short-term interest rates, the GIRF shows that a weaker yen had no significant effects on the Korean economy.

4.5. Bootstrap Estimates of the GIRFs on GDP

According to the GVAR impulse response analysis, a depreciated yen has large effects on the GDP performance of the countries included in the study, especially in the case of Korea. In this sense, a weaker yen may have BTN effects on other countries. In order to confirm this conjecture, we conduct a bootstrap estimation of the GIRF analysis.

Figure 10 Bootstrapping Estimates of the GIRFs on GDP



6) Similar results are also found in the case of Indonesia.

Figure 10 shows the bootstrapping results of the GIRFs on GDP. According to the bootstrapping result, at 95% confidence interval area, zero was included in the results of other countries. However, unlike other countries, only Korea's GIRF did not include zero at 95% confidence interval. This result reconfirms that at 95% confidence level, a depreciation in the value of the yen has a negative impact on Korea's GDP. In addition, like that of China, the GIRFs of the US and Japan included zero within 95% confidence interval, although the validity of the results may be limited.

These results seem to confirm again our supposition on the degrees of competition and complement of final products among these countries in world markets; Korea has high degrees of competition in final product export market with Japan; China has lower degrees of competition with Japan in the final product export market. Supporting these results, in a comparative analysis of the industry-specific exchange rates between Japan and Korea, Shimizu and Sato (2015) finds that a recent depreciation in the value of the yen has improved the export price competitiveness of the Japanese manufacturing sectors.

5. CONCLUSION

Our study sought to ascertain whether Japan's weakening currency as a result of QE had the BTN effects on 19 of world's major economies. To investigate this issue, we construct a GVAR model using the GVC weighted matrix and quarterly data from 1972 to 2013 sample period. We estimated generalized impulse responses to one standard error shock of real exchange rate depreciation of Japanese yen using the estimated GVAR.

Key findings are as follows. The country that benefited the most in terms of changes in income was Japan, while Korea was the most negatively affected. However, BTN effects of yen depreciation is not uniform, but different from country to country. China and Australia were seen as being clear beneficiaries of the weaker yen, with both seeing their GDP performances slightly improve. In contrast, the effects on the US were negative but negligible, while the EU was basically unaffected.

We interpreted these in terms of the degrees of competition and complement among the participating countries in the global supply chain processes. We conceptualized the effects that result from a weaker yen on neighboring countries into three categories; the price effects, which increase price competitiveness of Japanese products and reduce neighboring countries' exports competing with Japan in world's final product markets; the investment effects, which reflect the benefits that are enjoyed by the countries that import key capital and intermediate goods from Japan; the income effects, which reflect the benefits enjoyed by the countries that export raw materials to Japan, that is induced by increased export of Japan.

'Beggar' thy neighbor or 'Prosper' thy neighbor from the depreciation of yen would depend on the sum of these three effects for a particular country. If a country has negative price effects that dominates the positive investment and income effects, then the country will experience negative BTN effects from a Japanese yen deprecation. However, if a country has positive investment and income effects that dominate negative price effects, due to low degrees of substitution, then it will enjoy prosper thy neighbor effects by a Japanese yen deprecation.

Of the countries included in the study, Korea was the most significantly and adversely affected. The key reason seems to be the high level of competition that exists between Korea and Japan in the world's final product markets, where a weaker yen provides a critical competitive edge for Japanese products which undermines Korea's export competitiveness. Under our framework, the negative price effects of the weaker Japanese yen dominate the investment effects for Korea.

For China, a slight increase in GDP in response to a weak yen reflects not only its lower level of competition in final product market but also the higher degrees to which it complements Japan in both the raw materials and intermediate products markets. In our frame work, it can be interpreted as being the investment effects that result from a weaker yen outweigh the negative price effects for China. For Australia, a slight increase in GDP in response to a weak yen, can also be interpreted that positive income and investment effects outweighing negative price effects.

Finally, the results for the US are negative but negligible, while the EU has been largely unaffected by the shock of a weaker yen, can be interpreted as that the negative price effects have been cancelled out by the positive investment and income effects for these regions.

The limitation of our study lies in that this study employed a static methodology with fixed data. The degrees of competition among the countries change and structural change may take place in Japan since Abenomics. Thus, it would be meaningful to find a time varying relationship between weak yen policy of Japan and the effects on its neighboring countries. This will be left for future research.

In summary, this research has made two major contributions. First, this paper utilizes the GVC approach for the first time while constructing the GVAR model. This way of modelling provides a more accurate measure of the linkages for GVAR model than conventional trade statistics. Secondly, it adds to the very sparse literature that uses GVAR as a means of investigating the presence of the BTN effects of Japanese yen depreciation. Finally, we hope that this study could help policy makers around the world to establish future exchange rate policies.

APPENDIX

Table A1 Customs Clearance (CC) Basis Trade Matrix

Country	Australia	Canada	China	Euro	India	Indonesia	Japan	Korea	Mexico	Sweden	Turkey	UK	US
Australia	0	0.033	0.341	0.092	0.04	0.029	0.196	0.07	0.009	0.005	0.006	0.044	0.136
Canada	0.012	0	0.076	0.092	0.016	0.005	0.043	0.012	0.027	0.006	0.004	0.043	0.664
China	0.047	0.047	0	0.207	0.051	0.023	0.126	0.052	0.022	0.008	0.022	0.049	0.346
Euro	0.033	0.042	0.206	0	0.032	0.014	0.059	0.032	0.023	0.043	0.043	0.185	0.287
India	0.032	0.042	0.099	0.244	0	0.023	0.05	0.015	0.011	0.015	0.026	0.086	0.356
Indonesia	0.056	0.019	0.201	0.164	0.052	0	0.213	0.07	0.01	0.004	0.018	0.035	0.156
Japan	0.037	0.035	0.31	0.142	0.02	0.031	0	0.068	0.023	0.006	0.014	0.035	0.28
Korea	0.028	0.029	0.315	0.17	0.022	0.027	0.107	0	0.025	0.008	0.025	0.032	0.212
Mexico	0.01	0.069	0.043	0.095	0.008	0.003	0.021	0.007	0	0.003	0.004	0.015	0.722
Sweden	0.03	0.03	0.134	0.387	0.02	0.013	0.037	0.024	0.012	0	0.017	0.095	0.201
Turkey	0.015	0.022	0.068	0.561	0.02	0.01	0.024	0.013	0.008	0.018	0	0.114	0.126
UK	0.03	0.05	0.08	0.447	0.021	0.006	0.034	0.017	0.011	0.023	0.023	0	0.257
US	0.035	0.192	0.16	0.224	0.034	0.012	0.086	0.043	0.103	0.013	0.01	0.089	0

Table A2 Global Value Chain (GVC) Basis Trade Matrix

Country	Australia	Canada	China	Euro	India	Indonesia	Japan	Korea	Mexico	Sweden	Turkey	UK	US
Australia	0	0.01	0.321	0.111	0.056	0.033	0.201	0.087	0.008	0.009	0.003	0.047	0.113
Canada	0.005	0	0.085	0.062	0.006	0.004	0.032	0.015	0.039	0.004	0.003	0.037	0.71
China	0.058	0.025	0	0.211	0.039	0.029	0.191	0.134	0.016	0.008	0.01	0.033	0.248
Euro	0.019	0.022	0.216	0	0.039	0.012	0.062	0.033	0.019	0.076	0.056	0.241	0.205
India	0.056	0.015	0.234	0.253	0	0.062	0.054	0.058	0.009	0.009	0.014	0.052	0.183
Indonesia	0.05	0.012	0.215	0.111	0.079	0	0.242	0.122	0.005	0.005	0.009	0.015	0.134
Japan	0.072	0.023	0.347	0.123	0.017	0.05	0	0.105	0.015	0.005	0.003	0.024	0.216
Korea	0.053	0.017	0.355	0.107	0.032	0.044	0.175	0	0.02	0.004	0.009	0.016	0.167
Mexico	0.003	0.036	0.097	0.058	0.006	0.002	0.033	0.027	0	0.002	0.001	0.007	0.727
Sweden	0.013	0.01	0.066	0.648	0.014	0.004	0.021	0.013	0.005	0	0.017	0.111	0.078
Turkey	0.007	0.011	0.133	0.527	0.031	0.012	0.026	0.035	0.004	0.021	0	0.081	0.112
UK	0.019	0.034	0.096	0.581	0.022	0.004	0.029	0.011	0.006	0.032	0.02	0	0.145
US	0.014	0.234	0.206	0.161	0.022	0.011	0.08	0.039	0.174	0.007	0.007	0.045	0

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