CURRENCY AND INTERNATIONAL TRADE IN THE AGE OF GLOBALISED PRODUCTION: A QUANTITATIVE ANALYSIS

MA Thesis

JULY 5, 2018

WORD COUNT: 12872
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Title: Currency and International Trade in the Age of Globalised Production: A Quantitative Analysis

Abstract:

This research analyses the relationship between real effective exchange rates and trade balance changes in the presence of differing levels of global value chain complexity and fragmentation in a large sample of economies using a variety of quantitative analysis techniques (ordinary least square regression, two-stage least squares regression, fixed effects regression, and panel vector autoregression). The research expects economies which are more integrated into global value chains, with larger greater global value chain complexity, to have a weaker relationship between real effective exchange rates and trade balances changes. The results of the quantitative analysis find a weaker relationship between the two variables and suggests some potential effects that this will have on debates within global political economy.

1. Introduction

This research will begin by setting out the research question to be examined. The academic motivation to explore the research question will then be set out. A thorough literature review will follow, examining the theoretical underpinnings at the heart of the relationship that the research question seeks to examine as well as the theoretical framework for how a potential change in the relationship between the dependent and independent variable can be understood. The data to be used and its sources are then set out. The model and methodology of the research are then discussed in depth, followed by the results of the empirical analysis. A brief outline of some of the potential implications for global political economy are set out before a brief conclusion to summarise the research.

This research will examine the research question: *Did the increase in fragmentation of global value chains lead to a change in the connection between changes in the real effective exchange rate and trade balance changes?*

The rise of globalisation, particularly of the economic variety, has led to a rise in the international interconnectedness of production, and global value chain (GVC) complexity has increased at a firm level. This research will examine whether these increasingly complex GVCs have weakened the link between real effective exchange rate (REER) changes, and trade balance adjustments. It will be necessary to examine the connection between our dependent and independent variables across two sets of data. The first set being when GVCs were less complex and the second set being instances of significant GVC fragmentation and complexity.

This research question is relevant to the recent public discourse surrounding Britain's exit from the European Union. Notably, the weakening of the British pound following the

Brexit referendum did not bring the expected reduction in Britain's trade deficit (McGeever, 2016; Elliot, 2017). This research will test quantitatively whether the relationship between currency strength fluctuations and trade balance adjustments has weakened over time. This will be tested at a macro level for all states for whom the relevant data is available. Thus, the results will allow generalisable conclusions to be drawn. It is will also allow for the examination of the potential explanations for any discrepancy between the accepted theory and either the unique case of Brexit or, should the results of the quantitative research suggest it, the new relationship between currency fluctuations and trade balance adjustments.

This research should prove relevant because of the rise in global interconnectedness and complexity of GVCs in recent decades. The effects that the post-Brexit weaker pound has had, or rather failed to have had, suggests that the accepted economic theory regarding currency fluctuations and trade balance adjustments is either no longer valid or it is incomplete. By testing the relationship between the two variables, this research will shed light on why this economic theory is not valid in the case of post-Brexit Britain, or it may suggest a more generalised change has occurred with regard to the dynamics of international trade. Should the results of this research show that the presence of increasingly complex GVCs affects the strength of the relationship between currency fluctuations and trade balance adjustments, it will have important implications for international economic relations and the global economy. Conversely, should these results prove that there has been no change in the relationship then this research will have disproven a theory of why post-Brexit Britain has failed to close its trade deficit despite the weaker pound, and may lead to offer an alternate hypothesis which could have important implications for Britain's domestic political economy and international political economy.

2. Literature Review: Theoretical Framework

The research question that will be examined in this research is: *Did the increase in fragmentation of global value chains lead to a change in the connection between changes in the real effective exchange rate and trade balance changes?* With this in mind it will be necessary for the literature review to establish some key points. Firstly, has this research question already been examined and is further examination is required? Secondly, how would established theory approach the research question? Thirdly, is the research question supported by theory? Finally, what are some alternative explanations for the relationship described in the research question?

This literature review begins by investigating whether this research question has already been examined. Ghosh (2013: 283-284) sets out a theoretical framework to explain how GVCs might interact with the connection between currency strength changes and changes in a countries trade balance. He examines this empirically with regard to Mexican Maquiladora industries on the US-Mexico border, which are integrated into a cross-border value chain with the United States, to see whether they are less responsive to currency strength changes than other industries (Ghosh, 2013: 283). Ghosh (2013: 292) finds that "[t]he REER-elasticity of Mexico's non-Maquiladora trade balance is positive (0.172) and significant, while that of Maquiladora-only is negative and statistically insignificant". While this research is similar in some ways to the research that this paper undertakes, it does not prevent this paper from adding to the academic knowledge on the subject. Firstly, Ghosh (2013: 283) assumes a North-South relationship between countries in the GVC, this research seeks to examine the topic from a more general point of view, without assuming a North-South relationship between trading partners. Secondly, Ghosh's (2013: 285) research uses import and export data for Mexico which includes or excludes the Maquiladora industries, while this research computes a measure of GVC complexity using UN Comtrade intermediate goods trade which will allow more empirical accuracy in its examination of the effects of GVC fragmentation. Springford and Tilford (2016: 1) examine the case of Britain post-Brexit and assess why the decline in the pound has not led to a boost in exports. They suggest several reasons for the change, including different levels of growth in the world economy, change in the structure of the British economy, and British integration into EU supply chains (Springford and Tilford, 2016: 2-4). While Springford and Tilford's report raises interesting explanations for Britain's failure to increase its exports in the presence of a devalued pound, their research focuses only on Britain in the wake of Brexit, which may be a special case. Furthermore, their research does not aim to explain the role of GVCs in the REER- trade balance relationship.

The theoretical causal mechanism that connects changes in the REER and trade balance changes must be examined before moving on to the novel effects theorized in the research question. The Mundell-Fleming model, which is one of the simplest and widespread models to explain trade balances, determines that the trade balance is influenced by "the level of output at home in relation to output abroad and by the exchange rate" (Argy, 1994: 53). According to theories of international trade a devaluation of a state's currency should make its exports cheaper and its imports more expensive which should in turn lead to an "improvement in the trade balance" (a move towards surplus) of the state (Arize, Malindretos, and Igwe, 2017: 313,

321). This will occur as a result of a change in the respective demands for a state's exports and the demand by the state for imports from abroad (Karagöz, 2016: 451). In the event of a currency appreciation, international trade theory would expect the reverse to occur, exports would become more expensive and imports would become cheaper. This would lead the trade balance to a move towards deficit. Arize, Malindretos, and Igwe (2017: 325) find this relationship to be borne out empirically. However, according to Fratzscher, Juvenal and Sarno (2010: 644) the magnitude of this relationship is contested, as some studies show currency depreciations reducing trade deficits by a large amount and others being less clear or showing a weaker relationship. Arize, Malindretos, and Igwe (2017: 314) acknowledge this, suggesting that recent empirical studies on this relationship have been mixed, with some finding a positive relationship between REER and trade balance, while others fail to find any relationship between the two variables. Thus, it would appear that this topic requires further study.

According to the Dornbush model, exchange rates will change instantly, and even overshoot their correct value, with regard to a monetary shock, but price levels will adjust more slowly and only reach equilibrium in the long run (Argy, 1994: 203-204, Dornbusch, 1976: 1166). Thus, for this research it is clear that any change in the REER that we observe will have a lagged effect on the trade balance. Indeed, this is consistent with the empirical results that Fratzscher, Juvenal and Sarno (2010: 644) observe.

This relationship is usually assumed to be symmetrical, with the effect of a currency devaluation on the trade balance being the same magnitude as the effect of a currency appreciation but in the opposite direction, but some research has suggested that the relationship may be asymmetrical (Arize, Malindretos, and Igwe, 2017: 315-316). Arize, Malindretos, and Igwe's (2017: 324-325) own analysis finds the relationship to be asymmetrical, with "the evidence indicat[ing] that in the long run, the trade balance reacts more strongly to depreciations than to appreciations". However, their analysis only looked at eight countries of with similar characteristics and thus the results may not be generalisable.

It is worth noting that the effect of currency strength changes on trade balance does not explain the entire change in trade balance at a given time (Huchet-Bourdon and Korinek, 2011: 4). There is much evidence to suggest that levels of foreign income (or world income) will affect the trade balance of states. This makes theoretical sense since an increase in foreign income would lead to an increase in foreign demand, increasing exports (Sharma, 2003: 442). Conversely, it is expected that an increase in domestic income would lead to an increase in

domestic demand for imports and domestic goods, decreasing exports and increasing imports (Karagöz, 2016: 452; Sharma, 2003: 442). Equally, domestic income may affect trade balances. Rose (2000: 16) finds empirically that higher gross domestic product (GDP) increases trade. Karagöz (2016: 451) draws on the work of Aysan & Hacıhasanoğlu who find that a rise in nominal wages affected exports negatively. The European Commission (1995: 2) argue that foreign income and domestic income cause an income effect where net exports are affected by the relative foreign and domestic incomes, with a relative increase in domestic income "leading to a deterioration of net exports". Thus, changes in both foreign and domestic income would be expected to factor into trade balance changes.

It is now necessary to examine the theoretical basis for the new causal relationship outlined in the research question. Ghosh (2013: 282) explains the effect that increased fragmentation will have on the connection between currency fluctuations and trade balance changes. Ghosh (2013: 282) explains that in the case of "standard" trade, "imports are destined for use in the importing country and exports are largely produced within the country". He suggests that with the increasing fragmentation of GVCs that both final goods and intermediate goods cross borders multiple times in their production process (Ghosh, 2013: 282). Springford and Tilford (2016: 3), in trying to explain the case of Brexit Britain, corroborate this, finding that "[f]oreign demand for intermediate goods and services is slower to respond to price changes than is demand for finished goods". This then leads to change in the connection between trade balance changes and currency strength changes since "with production sharing, imported parts and components are destined for inclusion in the country's exports" leading to situation where a currency depreciation raises a country's exports, while at the same time raising the price of its imported components "which partly offsets the expansionary effect of the depreciation on exports" (Ghosh, 2013: 282). Similarly, the opposite will occur in the event of a currency appreciation. Thus, increasingly complex GVCs "[lower] the sensitivity of a nation's trade balance to changes in exchange rates" (Ghosh, 2013: 282). In their study, Arize, Malindretos, and Igwe (2017: 315) note that "[t]here is a possibility that these economies may be interconnected since some factors may affect imports and exports of these countries in a similar fashion, and, if this true, the estimation must take into account the potential correlation of the error terms across each country's error term". The increasing prevalence of GVCs would appear to be one such factor and this research may thus increase the understanding of international trade theory.

Finally, it is necessary to examine what other variables could cause the trade balance of a state to change. Fratzscher, Juvenal and Sarno (2010: 644) argue that asset price changes may have an effect on the trade balance. Fratzscher, Juvenal and Sarno (2010: 644) argue that this works theoretically "through wealth effects. The underlying logic is that a rise in asset prices […] increases expected income of households and thus consumption, while also making it easier for firms to finance investment opportunities, inducing a deterioration in a country's trade balance". Furthermore, Fratzscher, Juvenal and Sarno's (2010: 657) empirical analysis finds that, in the case of the US, asset price shocks account for a greater percentage of the change in the trade balance than REER shocks. Relatedly Karagöz (2016: 452) suggests that the level of export prices relative to domestic prices will have an effect on levels of exports as lower prices will lead to an "[i]ncrease in domestic demand diverts exports supply towards domestic consumption, leading to a fall in exports volume". However, the real exchange rate "is a function of domestic and foreign prices" (European Commission, 1995: 2). Thus, a measure of domestic prices need not be controlled for as to do so may lead to a specification error in the model caused by double counting the price effect.

The European Commission (1995: 29) argues that the effect of a relative strengthening of a country's currency could be offset by gains in productivity in that country. This is confirmed by Karagöz (2016: 451) who cites the work of Aysan & Hacıhasanoğlu who find that the main factor effecting Turkish export growth since 2000 has been productivity.

Domestic policies are also found to have an effect on trade balances. Karagöz (2016: 447-448) notes that entering into a customs union agreement with the EU in 1996 led to a lagged increase in exports, while Import-Substitution policies in the 1970s led to increases in Turkey's trade deficit. It is worth noting that these domestic policies are in many ways intangible and therefore are difficult to quantify. In the scope of this research they could not be integrated into the quantitative analysis, but they are worth noting.

Karagöz (2016: 452) claims that level of inward foreign direct investment (FDI) may have an effect on the trade balance. He suggests that evidence on the effect of FDI on the trade balance is ambiguous and dependant on the motives behind the FDI (Karagöz, 2016: 452; Sharma, 2003: 436, 442). FDI aimed at securing access to a state's domestic market will not increase that state's export, but FDI aimed at "taking advantage of the country's comparative advantage" to compete internationally will increase a state's exports (Karagöz, 2016: 452; Sharma, 2003: 436, 442). Karragöz's (2016: 455) own analysis of Turkey finds that inward

foreign direct investment has a positive effect on exports. Sharma's (2003: 443) analysis of India finds no statistically significant connection between inward FDI and India's exports. While measures of inward FDI are easy to obtain, it is not possible to differentiate FDI aimed at international markets and FDI aimed to circumvent tariff barriers, so this research will not use a measure of inward FDI in its model of trade balances.

Exchange rate risk or volatility is expected to have a negative effect on levels of international trade (Klaassen, 2000: 5, 155-156; Clark et al., 2004: 3; European Commission, 1995: 1-2) and thus affect the trade balance. "The standard argument is that less exchange risk decreases the riskiness of trade profits, leading risk averse traders to increase trade" (Klaassen, 2000: 3). If a firm exports goods and is paid in a foreign currency then the firm must make decisions related to production "in advance of any subsequent exchange rate movements" (Clark et al. 2004: 3). This theory assumes that "there are no hedging possibilities" which is particularly unrealistic for developed economies with developed forward markets (Clark et al., 2004: 3) However, Klaassen (2000: 174-176) finds "no clear effect of [exchange rate] risk on exports". Furthermore, Clark et al. (2004: 2, 20, 24) also find "no evidence of a negative effect of exchange rates on world trade". Huchet-Bourdon and Korinek (2011: 5) find that currency volatility affects trade without following a specific pattern, they find that there is no consensus in the literature on the effect of currency volatility on trade (Huchet-Bourdon and Korinek, 2011: 6, 8). As such, it will not be necessary to include a measure of currency volatility as a control variable in this research.

Related to exchange rate volatility is membership of the eurozone. The choice of countries to join the single currency limited the monetary policy autonomy in Europe while also fixing European exchange rates (Klein and Shambaugh, 2010: 148). Rose (2000: 10) claims that an "increase in trade stemming from a common currency is one of the few undisputed gains from European Economic and Monetary Union". The common currency would be expected to eliminate currency volatility between eurozone members while also reducing transaction cost for trade (Clark et al., 2004: 2). The common currency is found to increase trade flows with other countries who are also members with a large positive effect (Clark et al., 2004: 20, 25-26; Klein and Shambaugh, 2010: 149). Rose (2004: 103) finds similar results suggesting that the "currency union effect has an economically and statistically significant effect". Furthermore, Klein and Shambaugh (2010: 152) note that "there is a fundamental difference between the effect of this type of fixed exchange rate on trade, and the

effect of low exchange rate volatility on trade". Furthermore, they note that empirical research on the effect of the eurozone on intra-eurozone trade and other currency unions finds that the eurozone effect is not generalisable (Klein and Shambaugh, 2010: 153). As such, while this research does not see it as necessary to control for currency volatility, it will be necessary to control for eurozone membership.

Other factors which may affect trade include distance between countries, "cultural similarity, geographical position, historical links, and preferential trading arrangements" which will affect transactions costs (Clark et al., 2004: 21; Rose, 2004: 99). Sharma (2003: 442) suggests that levels of infrastructure may affect exports, and in turn the trade balance, by "reducing costs, ensuring timely supply of exports and thereby improving export performance". Additionally, different sectors of the economy may have different relations between exchange rates and trade balance due to "the degree of competition among producers and […] the existence of trade barriers" which may lead to imperfect competition or monopoly power, which could dull the effect of the exchange rate-trade balance mechanisms (European Commission, 1995: 3). However, these factors are either intangible or too difficult to integrate into a macro-level analysis like this research paper and as such will not be included in the analysis.

It is necessary to discuss how international trade has changed and how that might influence this research. Thus, we must examine how international trade and GVCs have evolved. Although international production is not a new phenomenon, the current magnitude of international trade as well as the degree of fragmentation of GVCs is new (Thun, 2014: 285; Arndt and Kierkowski, 2001: 2). Indeed, Arndt and Kierzkowski (2001: 5) state that trade in components has risen significantly in recent years with "many final products [becoming] truly global pulling together parts and components from many nations". Central to this is the Multinational Corporation which Thun (2014: 284) defines as "firms that have operations in two or more countries" and as "accounting for one-third of total world exports of goods and services" in 2008. But as Ravenhill (2017: 17) points out, the structure of international trade has changed with an increasing proportion of it being trade in components rather than final products, which are shipped between several countries before being assembled and exported to their final market.

Firms can now break up their value chains and choose the location of each part according to competitive advantage rather than geography (Thun, 2014: 285). The modern

processes which allow for this fragmentation allow for a "more complex division of labour" and allow different parts of the production process to be "spatially separated and undertaken at locations where the costs are lowest" (Arndt and Kierkowski, 2001: 2). Central to this is the time-space compression that has occurred as a result of technological change associated with economic globalisation. Equally, technological advancement in communication technology, which allow better coordination of value chains, have helped increase the size and complexity of GVCs (Ali-Yrkkö et al., 2011: 265). Levison (2016: 11, 18) goes as far as to claim that transport costs have become effectively zero allowing trade to flourish and lowering the barrier of geography. Thun (2014: 288) further argues that the "digital revolution and the shift to modularity" were also integral to fragmentation and expansion of GVCs.

Arndt and Kierkowski (2001: 8) point out that "published trade data do[es] not make it easy to assess and evaluate the role of cross-border production". As such, it may be necessary to use a proxy variable in place of GVC complexity as the nature of the data may make it impossible to obtain satisfactorily. Thun (2014: 285) suggests that increased FDI may prove a straightforward indicator for increased global production. Thun (2014: 286) however argues that though FDI is an important element of the global production process, it "neglects the outsourcing of production" which "need not necessarily be accompanied by any trans-border flows of capital". For this reason, it will likely underestimate the magnitude of global interconnectedness.

Thun (2014: 286) suggests that a potential proxy measure of GVC fragmentation might be "the growth of trade in trade in intermediate goods" under the assumption that an increase in GVC fragmentation lead to more trade in intermediate goods and services. Sturgeon and Memedovic (2011: 5), in trying to quantify GVCs, focus only on trade in goods because "rich international trade statistics are only available for goods". Sturgeon and Memedovic (2011: 7) begin to construct an indicator of the extent of GVCs by using UN Comtrade data. This research will similarly use UN Comtrade data on trade in intermediate goods as a proxy for GVC complexity.

3. Methodology

3.1 Model and Specification

The model will use the natural log of the continuous variables described above except in the case of the trade balance as a percentage of GDP, as some data points are negative

numbers, to be able to compare how a percentage change in one variable affects the dependent variable as opposed to interpreting the data in absolute terms (Kahane, 2008: 84). The general model is given as:

$$TB_t = \beta_1 + \beta_2 \log REER_t + \beta_3 \log GDP_t + \beta_4 \log WorldGDP_t + \beta_5 EUR_t + \beta_6 \log REER_{t-1} + \beta_7 Year_t + u_1$$

$$REER_t = \beta_8 + \beta_9 TB_{t-1} + \beta_{10} \log GDP_t + \beta_{11} \log WorldGDP_t + \beta_{12} EUR_t + \beta_{13} Inflation_t + \beta_{14} Year_t + u_2$$

where β is the coefficient for each variable and u is the error term for each equation. Inflation is included in the REER equation as an instrumental variable for the two-stage least squares regression as it is noted that inflation influences the REER (Dornbusch, 1976: 1162, 1171). This data is obtained from the World Bank (World Bank, 2018d). Another possible instrumental variable was real interest rate which is also noted to influence the REER (Frisch, 2003: 27; Dornbusch, 1976: 1162). However, available data on real interest rates available from the World Bank is missing for several years (World Bank, 2018e) and as such it was not included in the model as it would have greatly diminished the number of usable data points.

According to the Dornbusch Overshooting Model, price equilibrium is only achieved in the long-run (Dornbusch, 1976: 1166), so we would expect to see a lag between the fluctuation in exchange rate and the related change to the trade balance. Since the real effective exchange rates will have a lagged effect on the trade balance of a country we will use $REER_{t-1}$ as a variable, where t is the time period of the dependent variable and 1 is a lag of one period. Furthermore, since REER is time series and REER is thought to be affected by the trade balance data, it would be expected that the $REER_t$ would be affected by the trade balance at time t-1. Thus, the trade balance at t-1, written as TB_{-1}, is also included in the model of $REER_t$.

This quantitative analysis will begin by performing ordinary least squares regression to establish the connection between REER and trade balances in the presence of different levels of GVC fragmentation and complexity. The two levels of GVC complexity will be given by taking the bottom 80 percentiles of the variable of GVC complexity and denoting it as low-complexity. The upper 20 percentiles will thus be denoted as high-complexity.

The ordinary least square regression will likely prove inaccurate given that the explanatory variable is endogenous to the dependent variable and the error terms will be correlated (Gujarati, 2004: 764). Thus, trade balance changes and REER are expected to be

colinear and have co-varying error terms. This is visible in the model for the relationship between the variables:

$$TB_t = \beta_1 + \beta_2 \log REER_t + \beta_3 \log GDP_t + \beta_4 \log WorldGDP_t + \beta_5 EUR_t + \beta_6 \log REER_{t-1} + \beta_7 Year_t + u_1$$

$$REER_t = \beta_8 + \beta_9 TB_{t-1} + \beta_{10} \log GDP_t + \beta_{11} \log WorldGDP_t + \beta_{12} EUR_t + \beta_{13} Inflation_t + \beta_{14} Year_t + u_2$$

REER is an independent variable for Trade Balance while Trade Balance is an independent variable for REER. As such, it will be necessary to perform a two-stage least squares regression.

This raises the question of why should one perform the ordinary least squares regression if it is inaccurate. Gujarati (2004: 766) claims that "although OLS is generally inapplicable to simultaneous-equation models, one can use it, if only as a standard or norm of comparison" as long as one then uses a more suited regression as well, "and the results of the two methods compared, at least qualitatively". Gujarati (2004: 766) notes that "the results of the inappropriately applied OLS may not differ very much from those obtained by more sophisticated methods" and that "this approach might give us some idea about how badly OLS does in situations when it is applied inappropriately". The two-stage least squares regression is designed to remove the effect of the interrelated error term from the dependent variable (Gujarati, 2004: 772), TB_t so that the true effect of the independent variable on it can be examined. The two-stage least square regression is performed by regressing the independent variable, $REER_t$, in terms of an instrument variable, "[i]n the second stage, the analyst uses the predicted values from the first-stage equation, [$\widehat{REER_t}$], to predict the outcome conditional on the same exogenous covariates" (Best and Wolf, 2014: 292; Greene, 1997: 741). Best and Wolf (2014: 294-295) note that instrumental variable regressions such as two-stage least squares have "substantially more expected sampling variance than other estimators" and as such instrumental variables which "only weakly predict the causal variable of interest should be avoided entirely".

Multi-level regressions assume "that there is neither unit-specific nor group-specific unobserved heterogeneity" (Best and Wolf, 2014: 327). Thus, it is also necessary to perform a fixed effects regression model. "A fixed-effects regression is specified on the level of the units and includes group-specific constants (the so-called 'fixed effects')" (Best and Wolf, 2014:

327). Thus, the fixed effects regression will allow the examination the effect that fixed effects, at a country level, will have on the relationship between our dependent and independent variables. As such, the fixed effect regression will control for the effects of each country by introducing a dummy variable for country, taking into account the "individuality" of each country and letting their intercepts vary (Gujarati, 2004: 642). This will be particularly useful as it will allow the examination of cultural, historical, and geographical factors (Clark et al., 2004: 21; Rose, 2004: 99) which would otherwise be impossible to measure and control for in this research. However, there are drawbacks to this type of regression. Firstly, introducing too many dummy variables may lead to a degrees of freedom problem (Gujarati, 2004: 646), and this will be particularly pronounced if we continue to control for the time effect of each year, as in the ordinary least squares regression. Secondly, it may not be possible to "identify the impact of [other] time-invariant variables" (Gujarati, 2004: 646).

However, given that our model includes "the appearance of the lagged value of the dependent variable on the right-hand side" a vector autoregression (VAR) may be the most appropriate method to examine the research question. The VAR approach examines "several endogenous variables together. But each endogenous variable is explained by its lagged, or past, values and the lagged values of all other endogenous variables in the model; usually, there are no exogenous variables in the model" (Gujarati, 2004: 837). Before performing a VAR it is necessary to decide on the maximum lag length (Gujarati, 2004: 849). This is important since "[i]ncluding too many lagged terms will consume degrees of freedom, not to mention introducing the possibility of multicollinearity [while i]ncluding too few lags will lead to specification errors" (Gujarati, 2004: 849). The optimal number of lags will be judged using Akaike's information criterion (AIC) (Greene, 1997: 787).

The VAR model will be written differently from the above models. It is written as follows:

$$TB_t = \beta_1 + \sum_{j=1}^{k} \beta_2 \log REER_{t-j} + \beta_3 \log GDP_t + \beta_4 \log WorldGDP_t + \beta_5 EUR_t + u_{1t}$$

$$REER_t = \beta_6 + \sum_{j=1}^{k} \beta_7 TB_{t-j} + \beta_8 \log GDP_t + \beta_9 \log WorldGDP_t + \beta_{10} EUR_t + u_{2t}$$

where k is the maximum lag of the VAR model and u represents impulses or shocks.

One benefit of using a VAR model is that it "obviates a decision as to what contemporaneous variables are exogenous" (Greene, 1997: 815). The assumption of $\widehat{REER}_t$ as the instrumental variable, in the two-stage least squares regression, could be challenged on the basis of its potential endogeneity within the system, as modelled previously.

Given that this research is dealing with time series data for several countries it is necessary to treat the data as panel data (Markus, 1979: 7). The approach of using a panel VAR, as opposed to VAR on individual countries, will allow the research to continue to control for fixed effects of countries while still assuming that all variables in the system are endogenic (Góes, 2016: 86; Lin and Zhu, 2017: 782). The results of the panel VAR will be "average responses of endogenous variables to an exogenous shock in any variable after controlling for time-invariant characteristics of individual member" (Góes, 2016: 87-88). Góes (2016: 88) notes that "one of the setbacks of the GMM/IV approach is that it imposes homogeneous dynamics across individuals" thus the split in the data set between low-complexity and high-complexity GVCs will control for this and allowing for the results to be interpreted to note any differences in dynamics. Lin and Zhu (2017: 783) note that "when $T \geq L + 3$, the PVAR model can be estimated. When $T \geq 2L + 2$, the PVAR model can be estimated under steady state".

Ordinary least squares regressions were performed on the data set as a whole, the low-complexity data, and the high-complexity data. Ordinary least squares regressions were run first on the independent and dependent variables alone. The control variables for domestic GDP and world GDP were then added. A third regression was done, controlling for membership of the eurozone in addition to the previous control variables. Another regression was run adding a dummy variable for the year, to control for any time specific effects. Finally, a regression was run that added the lagged REER at time t-1. The results are presented and examined in the results selection below.

Two-stage least squares regressions were performed on the same sets of data as the above ordinary least squares regressions (the data set as a whole, the low-complexity data, and the high-complexity data). The instrumental variable for this regression will be $Inflation_t$. The same control variables will be examined as in the ordinary least squares regression above. Only the variables $REER_t$ and $REER_{t-1}$ are deemed to be endogenous. Thus GDP, world GDP and membership of the eurozone are deemed to be exogenous and are included as instruments for

themselves, so as to not bias the regression. The two-stage least square regression will be run twice, omitting the dummy variable for the year in one case, to simplify the regression. This will allow the results to be compared. The results are presented and examined in the results selection below.

The fixed effects regression was performed on the same sets of data as the Ordinary least squares and two-stage least squares regressions. The dummy variable, to control for country fixed effects, was included for a regression of the independent and dependent variables. This was included in addition to the control variables included in the ordinary least squares regression. The dummy control variable for year was included as above, however due to the likely difficulty in interpreting any meaningful result arising from so many degrees of freedom, an additional regression was included which removed the year dummy. Results of this are presented in the results section.

A panel vector autoregression was performed on the same sets of data outlined in the above regressions. Following Lin and Zhu's (2017: 783) method of choosing lag, outlined above, the maximum lag length should be set to 2 or 3, since the length of the time series is relatively short for some countries in the low and high complexity sub-data sets "in order to avoid the deviation of the parameter estimation caused by the reduction of freedom". The lags of 2 and 3 were tested according to AIC for each of the data sets with a lag of 2 producing the lowest AIC for all data sets, and as such was chosen as the maximum lag of the panel VAR. The variables for GDP, world GDP and membership of the eurozone are set as exogenous variables in the panel VAR function to simplify the results, as this research is only interested in the connection between REER and trade balance. Generalized impulse response functions are then simulated on the panel VAR models. Results of this are presented in the results section.

3.2 Data

Taking a cue from Thun (2014) and Sturgeon and Memedovic (2011) the proxy that is used for GVC complexity is a measure of trade in intermediate goods as a percentage of a country's GDP. The value of intermediate goods trade was obtained from the UN Comtrade database (United Nations Comtrade, 2018). In order to obtain just trade in intermediate goods, the relevant BEC codes were used, as specified by United Nations Trade Statistics (2018)[1]. Once obtained, the total trade, import and exports, in intermediate goods in all the relevant BEC categories were added together for each country in each year. This absolute value was then divided by the GDP of that country in that year obtained from the World Bank (2018b), giving the proxy for GVC complexity. This was done to control for the size of a country's economy so that countries with large economies, and thus larger volumes of trade, would not bias the variable and in turn bias the research.

The dependent variable will be a measure of the trade balance of a country as a percentage of the country's GDP at a given time, and this will be written as TB_t. This research avoids using the absolute value of the trade balance as it would be skewed heavily by the increasing volume of trade year on year, as well as differences between countries in the size of economies. Data on trade balances is obtained from the World Bank data set of net trade in goods and services at current US dollar prices (World Bank, 2018a). This data is reported on an annual basis.

The independent variable will be a measure of REER in a given period. The REER at a given time will be define as as $REER_t$. This data is obtained from the Bank of International Settlements and covers 61 economies (Bank of International Settlements, 2018). This data is reported on a monthly basis and as such must be aggregated to match the dependent variable.

[1] The appropriate BEC codes for intermediate goods trade are:
"111* Food and beverages, primary, mainly for industry
121* Food and beverages, processed, mainly for industry
21* Industrial supplies not elsewhere specified, primary
22* Industrial supplies not elsewhere specified, processed
31* Fuels and lubricants, primary
322* Fuels and lubricants, processed (other than motor spirit)
42* Parts and accessories of capital goods (except transport equipment)
53* Parts and accessories of transport equipment" (United Nations Trade Statistics, 2018)

Thus, the data used will be a simple average of the 12-month period starting and ending in line with the calendar year (December to January).

While it is necessary to include control variables to ensure that the model is properly constructed and avoids specification bias, at the same time increasing the number of variables may make the model less dynamic and make it harder to infer an academically relevant result (Lütkepohl, 2004: 86). Thus, the research will endeavour to include all relevant control variables without adding unnecessary variables.

The country's GDP will be included as a control variable. This is necessary since the strength of a currency is linked to the strength of a country's economy and because a change in GDP will affect the trade balance as a percentage of GDP and could also affect the absolute amount of trade a country engages in. Huchet-Bourdon and Korinek (2011: 5) find that an increase in a country's "income is a strong driver of trade", since it leads to "an increase in the value of domestic imports through the increased purchasing power of domestic consumers". This data can be obtained from the World Bank (2018b). This variable will be written as GDP_t.

The model will also control for world GDP since the strength of the world economy will likely affect trade volumes, and thus trade balance for the countries that we will be examining. Huchet-Bourdon and Korinek (2011: 5) find that an increase in foreign income "plays a significant role in determining domestic exports". This data can be obtained from the World Bank (2018c). This variable will be written as $WorldGDP_t$.

It is necessary to include a control variable for membership of the Eurozone. This is necessary given that a large percentage of eurozone trade is with other Eurozone members, which may skew any correlation between our dependent and independent variable since a weakening of the Euro for a eurozone country will not affect the price of goods in that country vis-à-vis their main trading partners, other eurozone countries. This variable will be written as EUR_t in the model. This variable will be dichotomous and will be coded "0" when the country is not a eurozone member and "1" when it is a member.

Given that the data set involves time series data, it is necessary to include a dummy variable for the year, to control for any time specific factors that any year might have which could bias our model, such as "world business cycle, global shocks, etc." (Clark, 2004: 22). This will be written $year_t$.

In order to control for the outliers in the data set, the data points in the top and bottom percentile for REER and trade balance as a percentage of GDP were removed from the regression analysis. Furthermore, some data points were missing one or more of the variables required for the model. Since the gaps do not seem to be "systematically related to the phenomenon being modelled" they can be safely removed from the data set (Greene, 1997 :428).

4. Results

4.1 Descriptive Statistics

In order to get a rough idea of the relationship between the key variables, and to see if the variables adhere to conventional economic theory, or if the increased complexity of GVCs affects the relationship between the dependent and independent variables, the trade balance as a percentage of GDP is graphed against the log of REER. This is done for the data set as a whole, the instances of low GVC complexity, and the instances of high GVC complexity as defined in the methodology section below. Based on economic theory, it is expected that relationship between trade balance and REER would be negative with the graph sloping down. It would further be expected that if more complex GVCs had weakened the relationship, as the research question seeks to examine, then the slopes of the low and high complexity graphs would differ, with high complexity graphs slope being less negative.

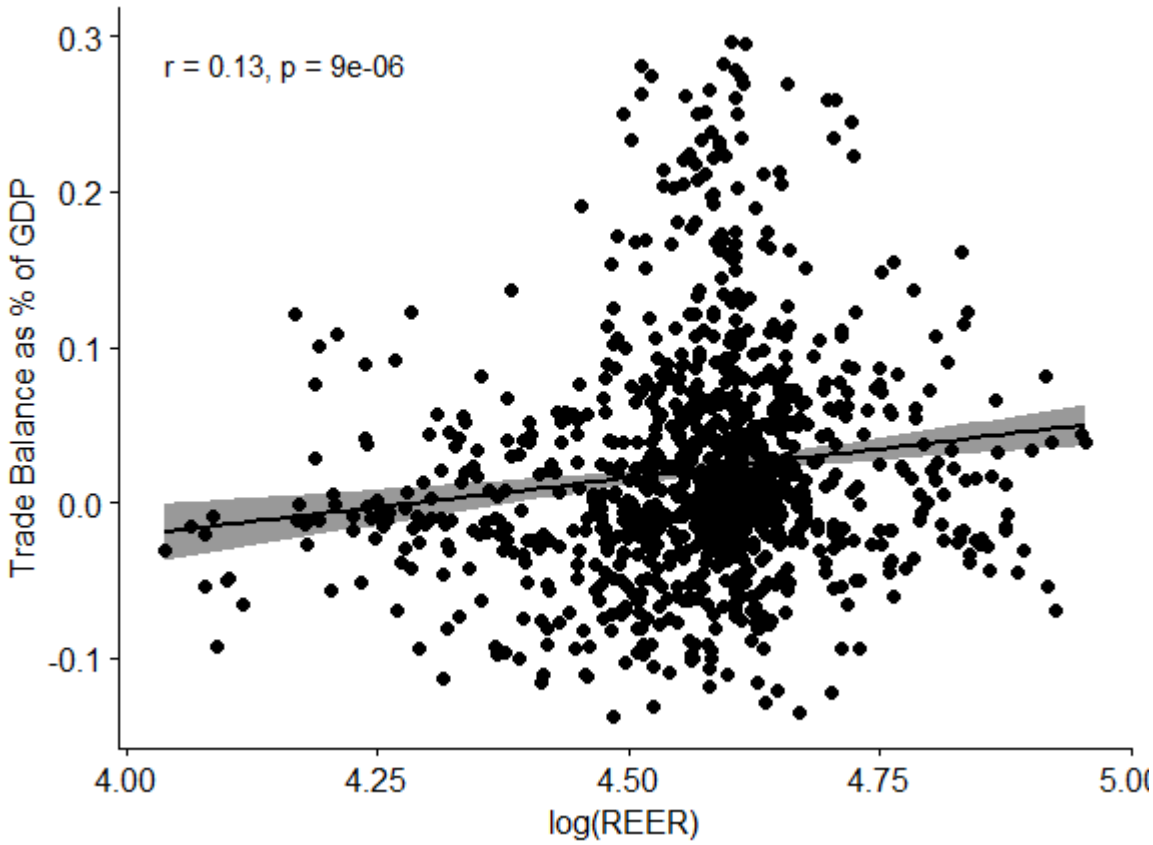

Fig.1 All Data – Trade Balance as a percentage of GDP against log of REER

Figure 1 shows the relationship between the trade balance as a percentage of GDP and the log of REER for the data set as a whole. Rather than the expected negative correlation between the variables, the slope of the graph is slightly positive, suggesting that any increase in REER, the currency strength of a country, would in fact lead to a great trade surplus. This is not in keeping with economic theories.

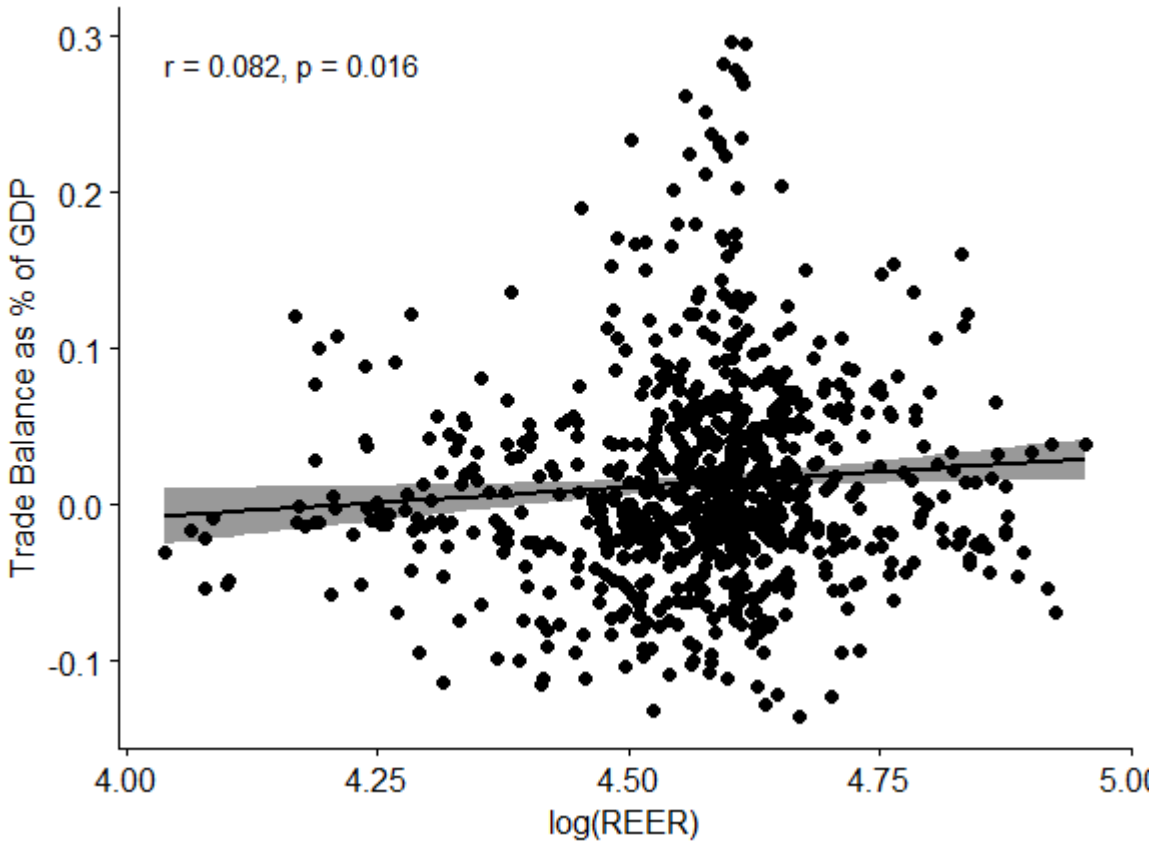

Fig.2 Bottom 80 percentiles of GVC Complexity – Trade Balance as a percentage of GDP against log of REER

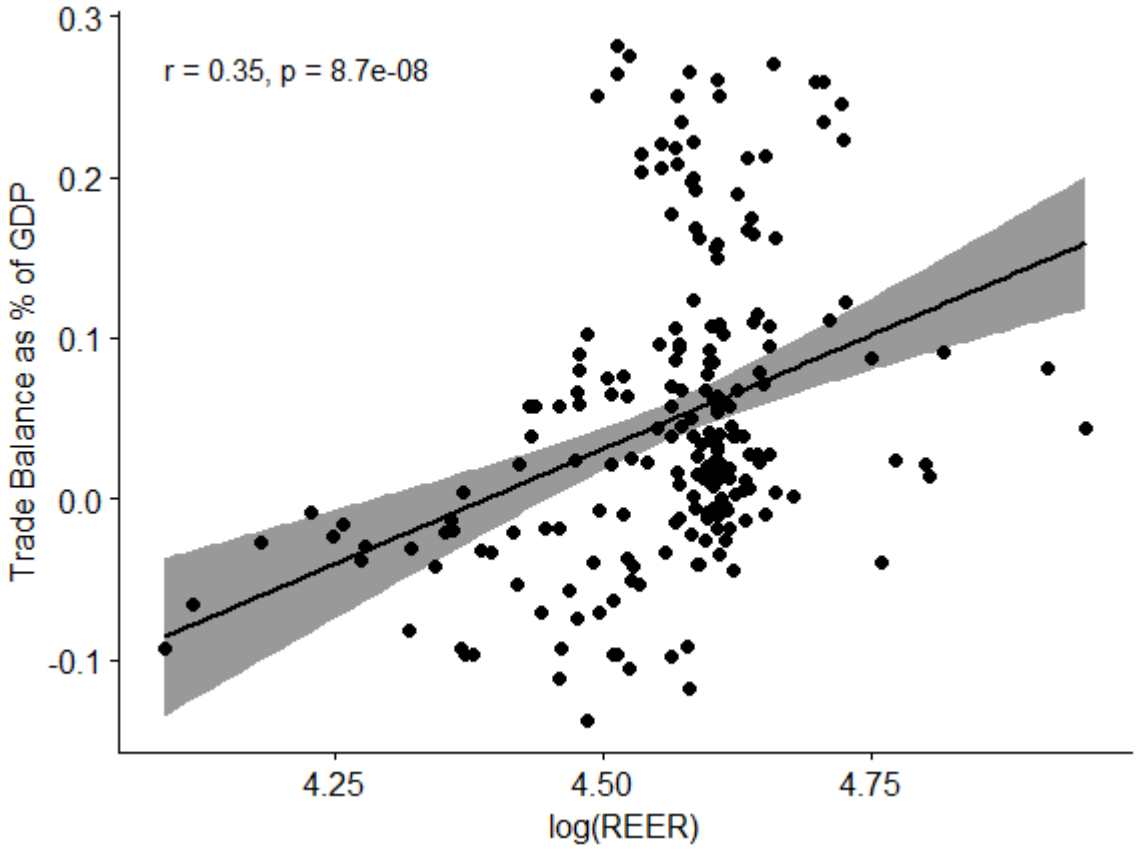

Fig.3 Top 20 percentiles of GVC Complexity – Trade Balance as a percentage of GDP against log of REER

Figure 2 shows the same relationship but for the low-complexity data. Again, the relationship does not conform to the expected relationship. In this instance, the variables are less positively correlated. Meanwhile, figure 3, which plots the relationship for the high-complexity data, shows a much larger positive correlation.

It is possible that the positive slope of the three graphs is caused by another variable, such as the ones described in the data section above. If this is the case then the regressions should show a negative relationship between the two variables once the appropriate controls are introduced. However, the marked difference in the slopes of the low and high complexity data suggests that more complex GVCs may have altered the relationship between trade balance and real effective exchange rate, suggesting that the research question: *Did the increase in fragmentation of global value chains lead to a change in the connection between changes in the real effective exchange rate and trade balance changes?* may be answered in the affirmative.

3.2 Econometric Results

Ordinary Least Squares Regression

The results of the ordinary least squares regression are presented as follows:

Table 1. Ordinary Least Squares Regression for full data set

Full Data Set OLS Results

	Dependent variable:				
	TB_GDP				
	(1)	(2)	(3)	(4)	(5)
log(REER)	0.075***	0.063***	0.061***	0.065***	-0.009
	(0.017)	(0.017)	(0.017)	(0.018)	(0.036)
log(GDP)		0.001	0.001	0.001	0.001
		(0.001)	(0.001)	(0.001)	(0.001)
log(World_GDP)		0.020***	0.019***	0.035**	0.033**
		(0.007)	(0.007)	(0.017)	(0.017)
EUR			0.005	0.004	0.004
			(0.005)	(0.005)	(0.005)
log(REER_t.1)					0.077**
					(0.033)
Year Effects	No	No	No	Yes	Yes
Constant	-0.322***	-0.911***	-0.870***	-1.403***	-1.355**
	(0.077)	(0.206)	(0.210)	(0.527)	(0.526)
Observations	1,086	1,086	1,086	1,086	1,086
R2	0.018	0.028	0.028	0.039	0.044
Adjusted R2	0.017	0.025	0.025	0.017	0.021
Residual Std. Error	0.073 (df = 1084)	0.072 (df = 1082)	0.072 (df = 1081)	0.073 (df = 1061)	0.073 (df = 1060)
F Statistic	19.894*** (df = 1; 1084)	10.203*** (df = 3; 1082)	7.896*** (df = 4; 1081)	1.789** (df = 24; 1061)	1.948*** (df = 25; 1060)
Note:					*p<0.1; **p<0.05; ***p<0.01

The ordinary least squares regression on the full data set shows a statistically significant relationship between trade balance as a percentage of GDP and REER for all sets of control variables, except the regression which contains the control variable $REER_{t-1}$. In that regression, the variable $REER_{t-1}$ was found to be statistically significant, and $REER_t$ was not. For the first four regressions, $REER_t$ was found to be statistically significant at $p<0.01$. For the fifth regression, $REER_{t-1}$ is statistically significant at $p<0.05$. That $REER_{t-1}$ is statistically significant while $REER_t$ is not is not surprising and is in keeping with the suggestion in the theory of a lagged effect of currency strength on trade balances.

More surprising is the direction of the relationship. An increase of 1% in the value of $REER_t$ (or in the case of the fifth regression, $REER_{t-1}$) will lead to between a 0.061 and 0.077 increase in trade balance as a percentage of GDP depending on the control variables used. In simpler terms, an appreciation currency strength will lead to an increase in a country's trade balance surplus (or decrease in a country's trade balance deficit). This is unexpected and not in keeping with economic theory.

The regression finds domestic GDP to not have a statistically significant effect on the trade balance while World GDP has a statistically significant positive relationship with trade balance. This makes sense, as an increase in world income should lead to an increase exports, all else being equal. Membership of the eurozone is not found to have a statistically significant relationship with trade balance as a percentage of GDP.

Table 2. Ordinary Least Squares Regression for low GVC complexity

Bottom 80 Percentiles OLS Results

	Dependent variable:				
	TB_GDP				
	(1)	(2)	(3)	(4)	(5)
log(REER)	0.040**	0.035**	0.030*	0.033*	-0.016
	(0.016)	(0.017)	(0.017)	(0.017)	(0.034)
log(GDP)		0.0001	0.0001	-0.0001	-0.0002
		(0.001)	(0.001)	(0.001)	(0.001)
log(World_GDP)		0.012*	0.009	0.019	0.018
		(0.007)	(0.007)	(0.016)	(0.016)
EUR			0.017***	0.015***	0.015***
			(0.005)	(0.005)	(0.005)
log(REER_t.1)					0.051*
					(0.031)
Year Effects	No	No	No	Yes	Yes
Constant	-0.168**	-0.525**	-0.413**	-0.742	-0.720
	(0.075)	(0.208)	(0.210)	(0.512)	(0.512)
Observations	869	869	869	869	869
R2	0.007	0.011	0.022	0.043	0.046
Adjusted R2	0.006	0.007	0.017	0.016	0.018
Residual Std. Error	0.065 (df = 867)	0.065 (df = 865)	0.065 (df = 864)	0.065 (df = 844)	0.065 (df = 843)
F Statistic	5.817** (df = 1; 867)	3.108** (df = 3; 865)	4.858*** (df = 4; 864)	1.571** (df = 24; 844)	1.622** (df = 25; 843)
Note:					*p<0.1; **p<0.05; ***p<0.01

The ordinary least squares regression on the low-complexity GVC data set shows similar statically significant relationships between trade balance as a percentage of GDP and REER for all sets of control variables, except the regression which contains the control variable

$REER_{t-1}$. For the first two regressions, $REER_t$ was found to be statistically significant at $p<0.05$. For the third and fourth regressions, the relationship was statistically significant at $p<0.1$. For the fifth regression, $REER_{t-1}$ is statistically significant at $p<0.1$.

The relationship between the variables was less strongly positively correlated than in the full data set, while still proving the opposite of what economic theory would predict. An increase of 1% in the value of $REER_t$ (or in the case of the fifth regression, $REER_{t-1}$) will lead to between a 0.030 and 0.051 increase in trade balance as a percentage of GDP depending on the control variables used.

Domestic GDP is again not statistically significant while world GDP is only statistically significant in the second regression at $p<0.1$ Once membership of the eurozone is introduced as a control variable, world GDP ceases to have a statistically significant effect. Membership of the eurozone is found to be statistically significant at $p<0.01$, and has a positive relationship with trade balance as a percentage of GDP, suggesting that membership of the single currency moves trade balances towards surplus.

Table 3. Ordinary Least Squares Regression for high GVC complexity

Top 20 Percentiles OLS Results

	Dependent variable:				
	TB_GDP				
	(1)	(2)	(3)	(4)	(5)
log(REER)	0.286***	0.196***	0.206***	0.206***	0.0004
	(0.052)	(0.053)	(0.052)	(0.054)	(0.156)
log(GDP)		0.032***	0.031***	0.032***	0.031***
		(0.005)	(0.005)	(0.005)	(0.005)
log(World_GDP)		-0.029	-0.012	0.034	0.025
		(0.019)	(0.020)	(0.054)	(0.054)
EUR			-0.041***	-0.045***	-0.045***
			(0.014)	(0.015)	(0.015)
log(REER_t.1)					0.185
					(0.132)
Year Effects	No	No	No	Yes	Yes
Constant	-1.255***	-0.750	-1.308**	-2.746	-2.371
	(0.235)	(0.542)	(0.565)	(1.684)	(1.700)
Observations	217	217	217	217	217
R2	0.125	0.277	0.305	0.330	0.336
Adjusted R2	0.121	0.267	0.292	0.250	0.253
Residual Std. Error	0.088 (df = 215)	0.080 (df = 213)	0.079 (df = 212)	0.081 (df = 193)	0.081 (df = 192)
F Statistic	30.717*** (df = 1; 215)	27.190*** (df = 3; 213)	23.301*** (df = 4; 212)	4.125*** (df = 23; 193)	4.055*** (df = 24; 192)
Note:					*p<0.1; **p<0.05; ***p<0.01

The ordinary least squares regression on the high-complexity GVC data set shows similar relationships to the previous data sets with statically significant relationships observed between trade balance as a percentage of GDP and REER for all sets of control variables except the regression which contains that control variable $REER_{t-1}$. For the first four regressions $REER_t$ was found to be statistically significant at $p<0.01$. However, in the fifth regression no statistically significant relationship was observed between $REER_t$ or $REER_{t-1}$ and trade balance as a percentage of GDP.

The relationship between the variables was much more strongly positively correlated than in the low-complexity data set. An increase of 1% in the value of $REER_t$ in the first four regressions will lead to between a 0.196 and 0.286 increase in trade balance as a percentage of GDP, depending on the control variables used. While this continues to be the opposite of what economic theory predicts, it is in keeping with the suggestion of this paper, that increased complexity of GVCs has changed the connection between changes in the REER and trade balance changes.

Domestic GDP is found to be statistically significant at $p<0.01$, and positively correlated, while world GDP is not found to be statistically significant. Membership of the eurozone is found to be negatively correlated and statistically significant at $p<0.01$. It is curious that membership of the eurozone would have the opposite relationship to trade balances as in the low-complexity of GVC data set. This suggests that for economies which are more integrated into GVCs, membership of the eurozone will have a negative effect on trade balances, tending more towards deficit.

When the results of the OLS regression on the high-complexity and low-complexity data are compared we see while the direction of the relationship is positive in both cases, which is not consistent with established economic theory, the magnitudes are different. The high complexity data finds that the magnitude of the positive correlation is greater than in the low-complexity data. Thus, there appears to be a difference in how the two sets of economies react to REER appreciation and depreciation.

Two-Stage Least Squares Regression

The results of both two-stage least squares regressions are given below.

Table 4. Two-Stage Least Squares Regression

Two-Stage Least Squares Regression Results

	Dependent variable:					
	TB_GDP					
	All Data		Low Complexity		High Complexity	
	(1)	(2)	(3)	(4)	(5)	(6)
log(REER)	20.351*	0.602***	11.830**	0.325***	78.014	0.610***
	(11.994)	(0.080)	(5.477)	(0.068)	(222.378)	(0.111)
log(GDP)	0.001	-0.004**	-0.003	-0.002	0.110	0.028***
	(0.027)	(0.002)	(0.019)	(0.002)	(0.300)	(0.006)
log(World_GDP)	0.131	0.024	0.088	0.012	1.302	0.085
	(0.305)	(0.024)	(0.206)	(0.019)	(4.101)	(0.068)
EUR	-0.032	-0.012	-0.002	0.007	-0.222	-0.050***
	(0.101)	(0.008)	(0.070)	(0.007)	(0.729)	(0.017)
log(REER_t1)	-17.695*		-10.470**		-60.765	
	(10.708)		(4.942)		(174.555)	
Year-effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-16.292	-3.360***	-8.884	-1.778***	-123.649	-6.148***
	(12.844)	(0.804)	(7.738)	(0.663)	(344.878)	(2.245)
Observations	1,076	1,076	859	859	217	217
R2	-283.472	-0.772	-141.241	-0.288	-817.634	0.172
Adjusted R2	-290.245	-0.813	-145.510	-0.325	-919.964	0.074
Residual Std. Error	1.264 (df = 1050)	0.100 (df = 1051)	0.796 (df = 833)	0.076 (df = 834)	2.918 (df = 192)	0.093 (df = 193)

Note: *p<0.1; **p<0.05; ***p<0.01

In the regression of the data set as a whole, $REER_t$ is found to be statistically significant at $p<0.1$, with a one percent increase in $REER_t$ causing trade balance as a percentage of GDP to increase by a much larger amount than in the ordinary least squares regression. However, $REER_{t-1}$ is also found to be statistically significant at $p<0.1$. $REER_{t-1}$ is found to be negatively

correlated with the trade balance as a percentage of GDP, with a large magnitude. The net effect of $REER_t$ and $REER_{t-1}$ is positive (assuming the values of each are not too different) at a lower magnitude than either individual magnitudes. No other variable is found to be statistically significant in either regression. The result of the two-stage least squares regression on the data set as a whole suggest that the REER has an immediate, or close to immediate, positive effect on the trade balance with the value of the with the value of REER at time t-1 having a smaller negative effect on the trade balance. The net effect appears to suggest that REER is positively correlated with trade balance with a larger magnitude once endogeneity is controlled for.

Similar results are obtained for the low-complexity data set. With both $REER_t$ and $REER_{t-1}$ being statistically significant at $p<0.05$. The coefficients of the correlations have the same sign as in the data set as a whole, but the magnitudes are decreased, suggesting that the net effect of REER is less positive in low-complexity of global value chain situations. The high-complexity data set show no statistically significant correlations between any of the variables and the trade balance as a percentage of GDP.

Recognising that the values of $REER_t$ and $REER_{t-1}$ appear to be cancelling each other out, and recognising that the two-stage least squares regression is less appropriate than the VAR regression for estimating lagged effects, the regression is re-run excluding the variable $REER_{t-1}$. The results are included in the table presented above.

The results of the two-stage least squares regression now show REER to be statistically significant at the level $p<0.01$ and to be positively correlated across all three data-sets. The high-complexity data showing nearly double the effect of a one percent increase in REER on trade balance as a percentage of GDP when compared to the low-complexity data. Furthermore, while the removal of $REER_{t-1}$ has decreased the magnitude of the correlation between the dependent and independent variables in all three data sets, the magnitude remains greater than in the ordinary least squares regressions suggesting that endogeneity masked the magnitude of the effect of REER on trade balance.

Domestic GDP is found to be statistically significant in the whole data set and the high complexity data but not the low-complexity data. Membership of the euro was found to be statistically significant and negatively correlated with the trade balance in the high-complexity data set.

Like the ordinary least squares regression, the two-stage least squares regression results do not conform to established economic theory since the correlation between the dependent and independent variables is positive, however the difference in the magnitude of the correlation persists, suggesting a difference in the relationship between REER and trade balance in the presence of more complex GVCs.

Fixed Effects

The results of the fixed effects regressions are presented below.

Table 5. Fixed Effects Regression

Fixed Effects Results

	Dependent variable:					
	TB_GDP					
	All Data		Low Complexity		High Complexity	
	(1)	(2)	(3)	(4)	(5)	(6)
log(REER)	-0.017	-0.004	-0.013	-0.005	-0.085	0.091
	(0.022)	(0.022)	(0.021)	(0.021)	(0.083)	(0.087)
log(GDP)	-0.042***	-0.047***	-0.044***	-0.049***	-0.077***	-0.144***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.025)	(0.027)
log(World_GDP)	0.070***	0.090***	0.063***	0.081***	0.129***	0.312***
	(0.010)	(0.013)	(0.010)	(0.012)	(0.031)	(0.042)
EUR	0.016**	0.014**	-0.008	-0.016**	0.021	0.025*
	(0.006)	(0.006)	(0.007)	(0.008)	(0.014)	(0.013)
log(REER_t.1)	0.036**	0.032*	0.009	0.007	0.177***	0.077
	(0.018)	(0.018)	(0.017)	(0.017)	(0.062)	(0.065)
Year-effects	No	Yes	No	Yes	No	Yes
Country-effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-1.118***	-1.657***	-0.750***	-1.240***	-2.338***	-6.778***
	(0.175)	(0.309)	(0.181)	(0.309)	(0.520)	(0.955)
Observations	1,086	1,086	869	869	217	217
R2	0.746	0.756	0.744	0.759	0.838	0.874
Adjusted R2	0.731	0.736	0.725	0.735	0.819	0.843
Residual Std. Error	0.038 (df = 1023)	0.038 (df = 1003)	0.034 (df = 810)	0.034 (df = 790)	0.040 (df = 193)	0.037 (df = 174)
F Statistic	48.545*** (df = 62; 1023)	37.963*** (df = 82; 1003)	40.516*** (df = 58; 810)	31.879*** (df = 78; 790)	43.469*** (df = 23; 193)	28.717*** (df = 42; 174)
Note:						*p<0.1; **p<0.05; ***p<0.01

Broadly similar results, in terms of the correlation of the control variables on the trade balance, are seen in the two regressions. Domestic GDP is seen to have a statistically significant negative correlation with trade balance at $p<0.01$. Conversely, world GDP is seen to have a statistically significant positive correlation with trade balance at $p<0.01$. This is in keeping with predicted theory. It suggests that greater domestic income increases the appetite for imports

while greater world income increases the appetite for exports. It makes sense that this result only appears once country specific factors have been controlled for, as one country's exports are another country's imports, and thus the balance of exports worldwide would need to be zero. With regard to the magnitude of the effects of domestic and world GDP, the magnitudes were high in the cases of high-complexity of GVC data which suggests that countries which are more integrated into GVCs are more sensitive to changes in domestic and world GDP. This is not unexpected and makes intuitive sense. Membership of the euro was found to be statistically significant but only when year and country effects were controlled for. In this case, the membership of the euro was positively correlated at $p<0.1$ for the high-complexity data and negatively correlated at $p<0.05$ for the low-complexity data. This suggests that, all else being equal, membership of the euro led more globally integrated economies to tend towards surplus while less globally integrated economies tended towards deficit. This is an interesting finding but is beyond the scope of this research and requires further research to examine.

$REER_t$ was not found to be statistically significant in any of the fixed effects regressions. Without the year dummy variable, $REER_{t-1}$ was found to be statistically significant at $p<0.05$ for the data set as a whole, at $p<0.01$ for the high-complexity data, and was not statistically significant for the low-complexity data. In all cases the correlation was positive. In the high-complexity data set, $REER_{t-1}$ was correlated with a greater magnitude than either the data set as a whole or the low-complexity data. When the dummy variable for year is included, $REER_{t-1}$ is found to be positively correlated to the trade balance as a percent of GDP at similar relative strengths but it is only statistically significant in the regression of the data set as a whole at $p<0.1$. These results, like the OLS and 2sls results, fail to conform to established economic theory. However, the magnitude of the correlations is further reduced, suggesting that fixed effects play a role in the model and that their presence allows the model to be better specified. Furthermore, the differences in the magnitude of the correlations remains, suggesting that an economy's greater integration into GVCs changes the relationship between REER and trade balance.

Panel Vector Autoregression

Before running the panel VAR, the stability of the model is tested for each of the data sets. The results of the stability test are given in the Appendix. The model satisfies the stability condition for the high and low complexity data sets. The data set as a whole fails to satisfy the stability test (See Appendix). However, since this research is aimed at comparing the

relationship of REER and trade balance for different levels of GVC complexity, the data set as a whole is of lesser importance. The results of the panel VAR on the complete data set are presented below for completeness but will not be expanded upon.

The results of the panel VAR on the entire data set, the low-complexity data set and high-complexity data set are as follows:

Table 6. Panel VAR for all data, low-complexity data and high-complexity GVC data

```
------------------------------------------------------------------------------------------
Dynamic Panel VAR estimation, twostep GMM
------------------------------------------------------------------------------------------
Transformation: First-differences
Group variable: Country
Time variable: Year
                          All Data              Low-Complexity Data       High-Complexity Data
                 Number of observations = 1    Number of observations = 8    Number of observations = 2
                 086                           69                            17
                 Number of groups = 58         Number of groups = 54         Number of groups = 19
                 Obs per group:                Obs per group:                Obs per group:
                     min = 10                      min = 1                       min = 1
                     avg = 18.72414                avg = 16.09259                avg = 11.42105
                     max = 22                      max = 22                      max = 21

==========================================================================================
                  fd_TB_GDP   fd_logREER   fd_TB_GDP   fd_logREER   fd_TB_GDP   fd_logREER
------------------------------------------------------------------------------------------
fd_lag1_TB_GDP    0.4442 ***   0.0297      -0.0467 *    -0.0113       0.0112      0.0103
                 (0.0441)     (0.0352)     (0.0226)     (0.0241)     (0.0435)    (0.0934)
fd_lag1_logREER   0.0576 *     0.9438 ***  -0.0787 *     0.9637 ***  -0.0117      0.0103
                 (0.0277)     (0.0379)     (0.0361)     (0.0622)     (0.0303)    (0.0706)
fd_lag2_TB_GDP    0.3796 ***  -0.0951 ***  -0.0112      -0.0787 ***  -0.0024      0.0016
                 (0.0344)     (0.0154)     (0.0286)     (0.0085)     (0.0429)    (0.0419)
fd_lag2_logREER  -0.0204       0.0028       0.1167 **   -0.0486      -0.0007      0.0018
                 (0.0554)     (0.0339)     (0.0440)     (0.0759)     (0.0330)    (0.1171)
fd_lag3_TB_GDP    0.3538 ***  -0.2604 ***   0.0849 ***  -0.2489 ***  -0.0184      -0.0098
                 (0.0248)     (0.0269)     (0.0220)     (0.0755)     (0.1420)    (0.0392)
fd_lag3_logREER  -0.0156      -0.2183 ***  -0.0592      -0.1888 ***   0.0166      0.0307
                 (0.0436)     (0.0306)     (0.0460)     (0.0554)     (0.1105)    (0.1066)
fd_logGDP        -0.0019 ***   0.0042 ***  -0.0016 ***   0.0026 *     0.0253 *    0.0053
                 (0.0005)     (0.0011)     (0.0004)     (0.0012)     (0.0112)    (0.0223)
fd_logWGDP       -0.0022       0.0322 ***   0.0057       0.0325 **   -0.0197      0.1335 ***
                 (0.0043)     (0.0083)     (0.0051)     (0.0119)     (0.0222)    (0.0189)
fd_EUR            0.0081 ***   0.0045       0.0120 ***   0.0068 *     0.0487      0.0291
                 (0.0022)     (0.0041)     (0.0029)     (0.0031)     (0.0614)    (0.0755)
const             0.0147       0.1148 ***  -0.0281       0.1581 ***  -0.0007      0.0014
                 (0.0144)     (0.0056)     (0.0179)     (0.0179)     (0.0183)    (0.0176)
==========================================================================================
*** p < 0.001, ** p < 0.01, * p < 0.05
                 Hansen test of overid.       Hansen test of overid.       Hansen test of overid.
                 restrictions:                restrictions:                restrictions:
                 chi2(72) = 165.3 Prob > chi2 = 0  chi2(72) = 100.76 Prob >  chi2(68) = 13.23 Prob > chi2 =
                 (Robust, but weakened by many     chi2 = 0.014               1
                 instruments.)                (Robust, but weakened by     (Robust, but weakened by many
                                              Many instruments.)           instruments.)
```

The results of the panel VAR on the low-complexity data set show that REER has a statistically significant negative effect on trade balance at $p<0.05$ at a lag of one period. The effect of REER lagged to two periods is statistically significant at $p<0.01$ in a positive direction and with a magnitude greater than at the lag of one. At a lag of three the correlation is negative but not at a statistically significant level. Trade Balance has a statistically significant negative

effect on itself at lag one at $p<0.05$ and a statistically significant positive effect on itself at lag three. Trade balance is found to have a negative correlation with REER at lags two and three at $p<0.001$. REER is positively correlated with itself at lag one at $p<0.001$ and negatively correlated at lag three at $p<0.001$ but with a smaller magnitude. Together this suggests that the variables are endogenously connected, with REER having a lagged effect on the trade balance at lags one and two. Finally, the control variables for domestic GDP and membership of the eurozone are found to be statistically significant to trade balance and REER while world GDP is only statistically significant to REER.

The results of the panel VAR on the high-complexity data are different to the low-complexity data. The panel VAR of the high-complexity data shows no statistically significant relationship between trade balance as a percentage of GDP and REER. Thus, these results suggest a fundamental change in the relationship between REER and trade balance changes has occurred as a result of the change in the complexity of GVCs. The results of the panel VAR show that the connection between the variables has been weakened, and in the presence of high fragmentation of GVCs it is no longer statistically significant. This suggests that the research question of this paper can be answered positively, that the change in the fragmentation and complexity of GVCs has altered the relationship between the variables.

While it is interesting that the low-complexity data does not show a clear cut negative correlation between REER and trade balance, as would be expected by basic economic theory, the results of the panel VAR do show that the variables are correlated and have an endogenous relationship with one another. The high-complexity data shows no statistically significant correlation between the variables at any of the examined lags. Thus, the results strongly suggest a fundamental weakening of the relationship between REER and trade balance in the manner outlined in the theoretical framework section of this paper.

Graphs of the impulse response functions are shown below. As in the case of the panel VAR results, due to the stability test the generalised impulse response function for the data as a whole is presented for completeness but not elaborated upon.

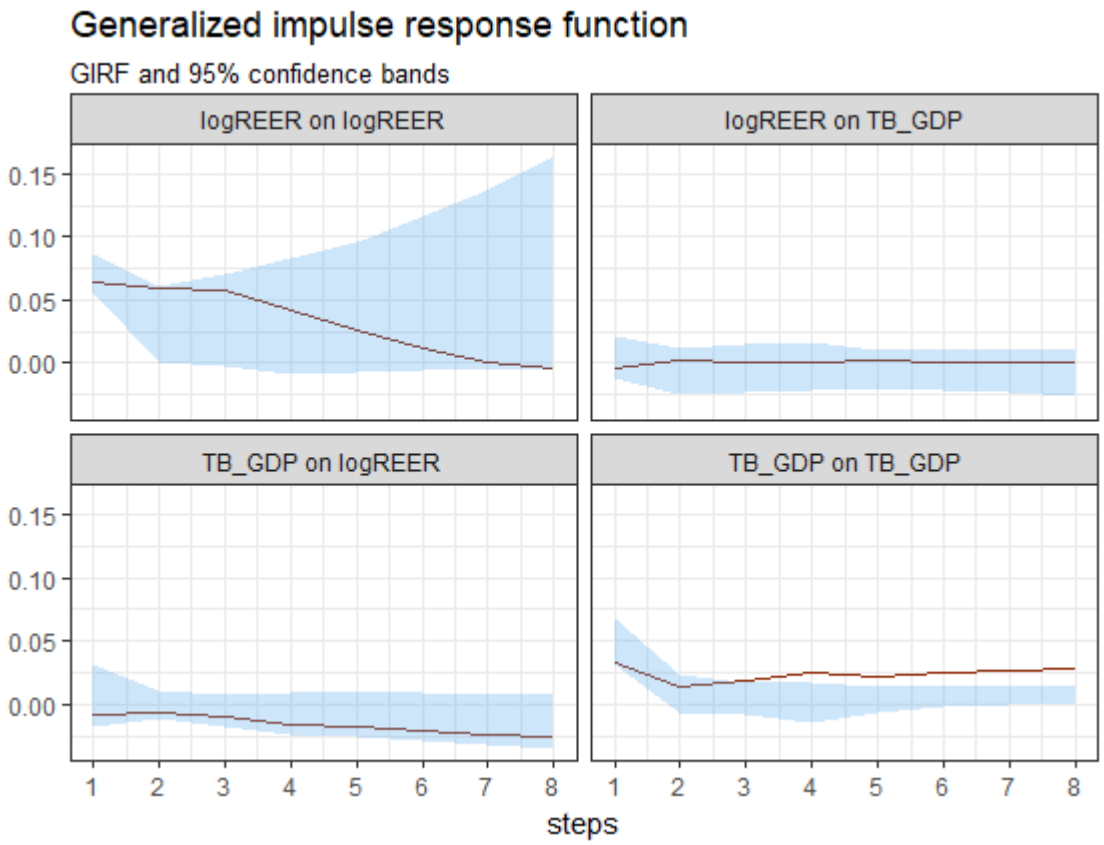

Fig 4. Generalised Impulse Response Function for full data set

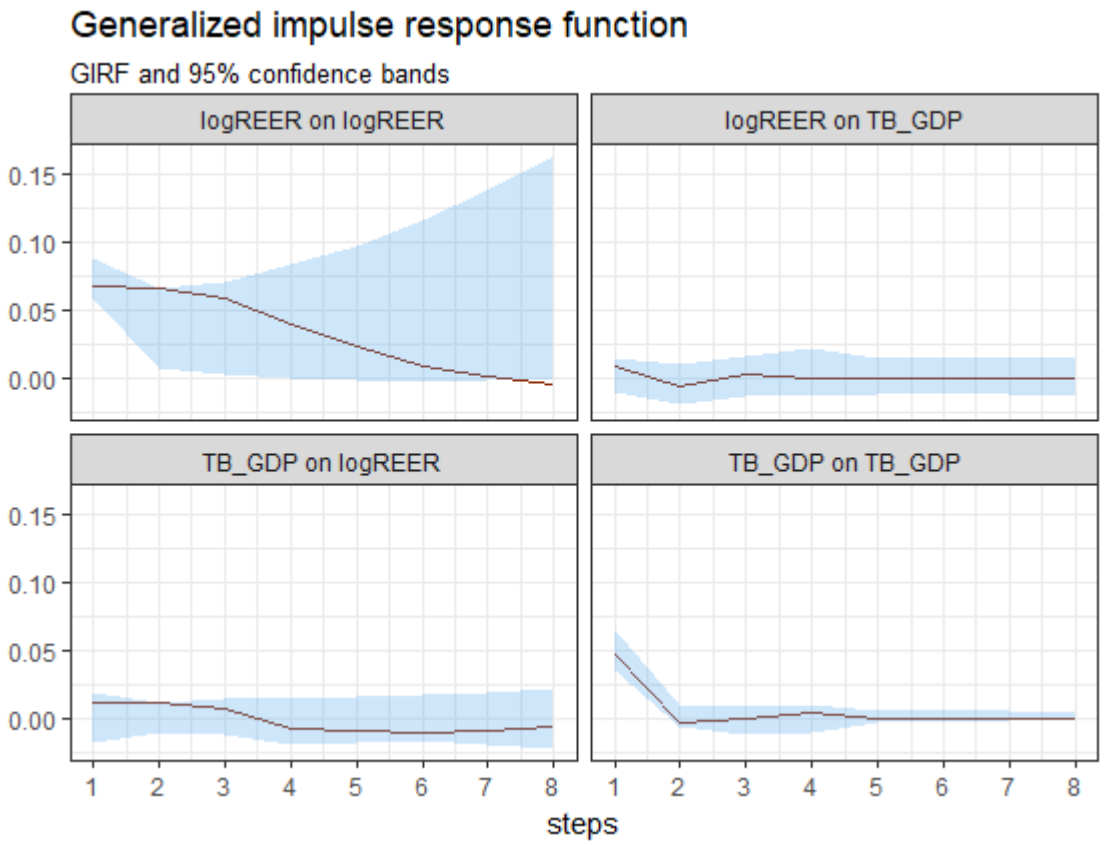

Fig 5. Generalised Impulse Response Function for low-complexity GVC data

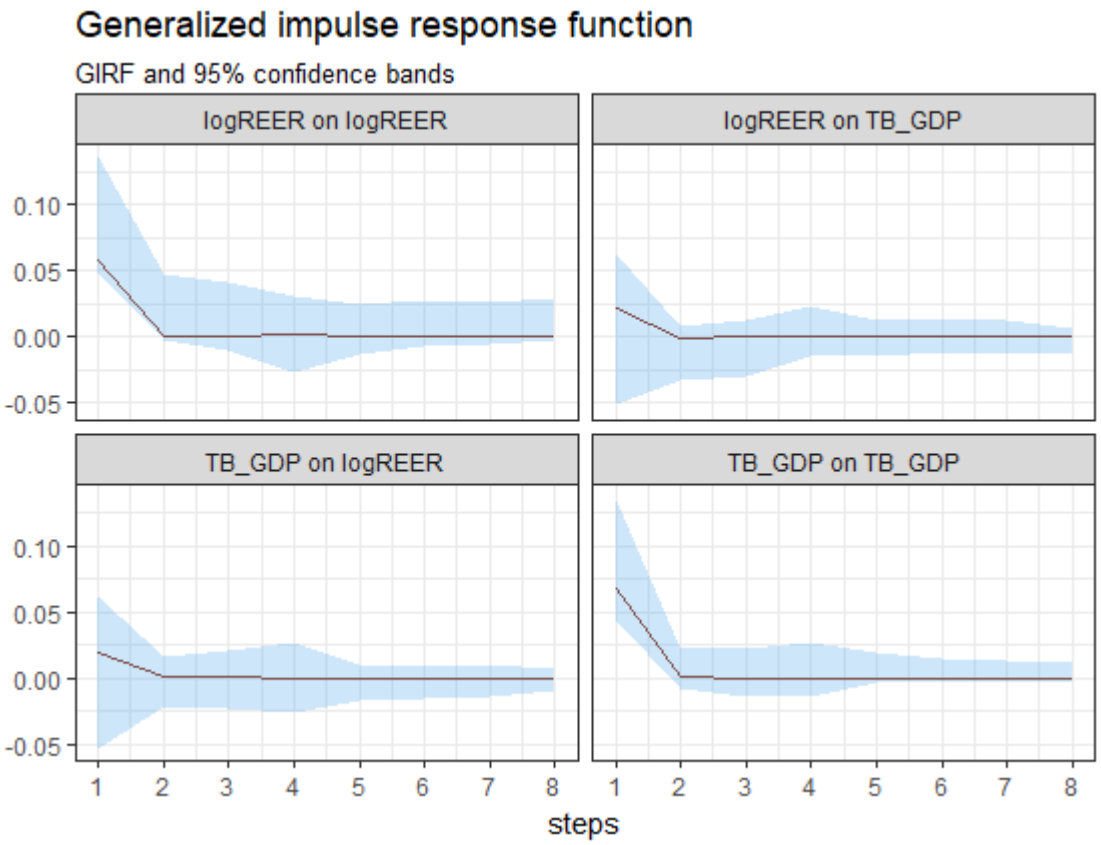

Fig 6. Generalised Impulse Response Function for high-complexity GVC data

The impulse response functions show the response of REER and trade balance as a percentage of GDP (on each row respectively) to a one standard deviation shock to the other variable.

In the low-complexity data, a shock to the REER leads to an increase in REER for three periods before dissipating. It also leads to an increase trade balance as a percentage of GDP for the first three periods before dissipating and reversing. A shock to the trade balance causes an increase of REER in period one which reverses in period two before settling at 0. The shock to the trade balance also leads to an increase in trade balance in period one which has a small negative effect and small positive effect in periods two to four before dissipating.

In the high-complexity data, a shock to REER leads a two-period increase in REER and a two-period increase in trade balance before dissipating entirely. A shock to trade balance has a similar two period positive effect on REER and on trade balance before ceasing to have an effect. However, due to the wide confidence interval bands relative to the effect of the shock, the impulse response function suggests no statistically significant relationship between REER

and trade balance in the high-complexity data set. This corroborates the results of the panel VAR and further suggests that the relationship between REER and trade balance changes has weakened.

The impulses response functions for the two data sets show a marked difference in the lagged relationship between REER and trade balance suggesting that the two variables have a different relationship with one another in the presence of different levels of GVC complexity. In the case of the low-complexity data a relationship exists between the two variables. Conversely, there is no statistically significant relationship between the variables in the high-complexity data set, suggesting that at higher levels of GVC fragmentation and complexity the relationship between REER and trade balance as a percentage of GDP has been weakened.

Overall Interpretation

The results of this research suggest that the research question *Did the increase in fragmentation of global value chains lead to a change in the connection between changes in the real effective exchange rate and trade balance changes?* can be answered in the affirmative. It would appear that the increased fragmentation and complexity of GVCs has changed the relationship between the REER and the trade balance. The results of each of the regressions run showed a change in the magnitudes or statistically significance of the relationship between the two variables.

While the ordinary least squares and two-stage least squares regressions consistently show that REER and trade balance as a percentage of GDP are positively correlated, which is not in keeping with the expected outcome, the results of these regressions are less plausible due to the problems laid out in the methodology section. The ordinary least squares regression is overly simplified, does not deal with the endogeneity that exists between the variables, and fails to effectively deal with time series nature of the data. While the two-stage least squares regression does a better job with regard to controlling for endogeneity, the other problems persist. Furthermore, these regressions fail to account for country effects and as such may lead to biased results stemming from country specific factors. This is not to say that these regressions are without value as they provide a point of comparison for the other more complex and better specified regressions. The differences between the two-stage least squares regression and ordinary least squares regression, suggest that the variables are endogenous. Furthermore,

their results do show a difference in the relationship between REER and trade balance, albeit only in terms of magnitude between the low-complexity and high-complexity data sets.

Thus, the results of the fixed effects regression and panel VAR provide more robust results. The fixed effects regression controls for country specific factors and shows a significant difference in the results compared to the ordinary least squares and two-stage least squares regressions, suggesting that country specific factors are an important control variable in the analysis of the relationship between our variables. The panel VAR, in assuming endogeneity and examining the lagged effect of the variables on one another, is likely to provide the most accurate results for the examination of the relationship between REER and trade balance changes. The panel VAR and impulse response functions show a statistically significant relationship between REER and trade balance as a percentage of GDP for low-complexity GVC data, and no statistically significant relationship for high-complexity GVC data. Thus, the results of the panel VAR and impulse response functions, which show a clear change in the relationship between REER and trade balance in the presence of differing levels of GVC complexity, provide the clearest evidence that the research question can be answered positively, that the connection between changes in the REER and trade balance changes is changed, and weakened, by higher levels of GVC fragmentation.

3.3. Global Political Economy Ramifications

The results of the quantitative analysis will have an effect of future international political economy and global trade interactions. In the past, states have tried to devalue their currencies to stimulate exports and thus their economy. During the Asian Financial Crisis, Thailand pursued this strategy (Klaassen, 2000: 3). However, this devaluation "lowered the competitiveness of its trading partners" leading them to also devalue and causing price inflation, disruption to the real economy and social unrest (Klaassen, 2000: 3). Thus, the change in the relationship between exchange rate strength and trade balance should lead to a change in the decision-making process of states seeking to stimulate their exports, as well as a change in the behaviour of states who, in game theory terms, were forced to also follow this strategy.

Furthermore, if increased fragmentation and complexity of GVCs have weakened the connection between trade balance and REER, as this research suggests, other strategies will need to be considered by states who wish to boost their export competitiveness. This reopens the debate around internal devaluation, focusing on "on structural reforms to boost potential

growth, create jobs, and improve competitiveness" (Kersan-Škabić, 2016: 30), as a policy prescription for countries who seek to gain competitiveness. Internal devaluation was seen as a solution to the economic crisis in the eurozone because "EU member states [had] surrendered their ability to use national monetary and exchange rate policies" (Kersan-Škabić, 2016: 31). While the increase in the fragmentation of GVCs does not mean that states have surrendered their ability to devalue their currencies, the results of this research suggest that such policies will have a diminished effect. Thus, much like the situation in the eurozone, it could be argued that internal devaluation is the only route for economies that are highly integrated into GVCs to regain competitiveness and improve their trade balances. However, internal devaluation when compared to currency devaluation carries with it greater political and social costs as well as taking longer to implement (Kersan-Škabić, 2016: 31). Furthermore, in the case of the eurozone it has been argued that internal devaluation does not make economic sense since it "will exacerbate the situation in terms of a negative shock in aggregate demand" (Alexiou and Nellis, 2013: 816). Brazys and Regan (2017: 421) meanwhile argue that the internal devaluation model which assumes that a reduction in labour costs will "correlate with an expansion of net exports" is flawed since richer countries will not be able to increase labour cost competitiveness to the point of competing with non-OECD countries. They argue that other factors, such as the active role of the state and access to the EU labour market proved more important to post-crisis recovery than labour cost competitiveness in richer countries (Brayzs and Regan, 2017: 421-422). Thus, it is debateable whether internal devaluation can act as a direct substitute for currency devaluation but it is clear that this debate is important in light of the results of this research.

The European Commission (1995: 1) argues that "currency misalignments may, by changing the relative prices of domestic and foreign products, affect trade performance." This is interesting because this new relationship between currency and trade balance due to GVC is not yet understood and therefore may be affecting currency valuations. "[T]here is a consensus in the empirical literature on the negative impact of misalignment on trade. At the world level, misalignment effects contributed significantly to the decline of trade growth after 1973 although this effect was lower than the trade policy and income effects" (European Commission, 1995: 2). Thus, although the magnitude of the misalignment effect may be small, nonetheless a misunderstanding of how to value currency in a more globalised world could affect global trade and thus global income. Therefore, it is important that currencies and their effect on trade balances be correctly valued so as to minimize this effect.

Thus, the results of this research raises interesting questions and add to existing debates in the global political economy literature. These issues warrant further examination however it is beyond the scope of this research to do so.

4. Conclusion

In conclusion, this research has examined the research question *Did the increase in fragmentation of global value chains lead to a change in the connection between changes in the real effective exchange rate and trade balance changes?* and found that the relationship between REER and trade balance has changed. This was shown through quantitative analysis of the two variables using ordinary least squares regression, two-stage least squares regression, fixed effects regression, and vector autoregression. The results of these regression techniques showed a difference in the magnitude of the correlation between the variables, and differences in the statistical significance of the variables. In the panel VAR analysis, the most sophisticated specification, the results showed a statistically significant relationship between REER and the trade balance in the low-complexity GVC data set, and no statistically significant relationship in the high-complexity GVC data set. Finally, the research has noted the relevance of this change in the relationship for the field of international political economy.

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Appendix

Table 7. Stability test on panel VAR model of data set as a whole

```
Eigenvalue stability condition:

             Eigenvalue   Modulus
1  1.0782517+0.0000000i 1.0782517
2  0.6865177+0.3000365i 0.7492186
3  0.6865177-0.3000365i 0.7492186
4 -0.3303526+0.4738745i 0.5776590
5 -0.3303526-0.4738745i 0.5776590
6 -0.4025707+0.0000000i 0.4025707
Not all the eigenvalues lie inside the unit circle.
PVAR does not satisfies stability condition.
```

Table 8. Stability test on panel VAR model of low-complexity data

```
Eigenvalue stability condition:

             Eigenvalue   Modulus
1  0.6504609+0.3016750i 0.7170127
2  0.6504609-0.3016750i 0.7170127
3  0.5049788+0.0000000i 0.5049788
4 -0.2087985+0.4557693i 0.5013207
5 -0.2087985-0.4557693i 0.5013207
6 -0.4713444+0.0000000i 0.4713444

All the eigenvalues lie inside the unit circle.
PVAR satisfies stability condition.
```

Table 9. Stability test on panel VAR model of high-complexity data

```
Eigenvalue stability condition:

             Eigenvalue   Modulus
1  0.3093315+0.0000000i 0.3093315
2 -0.1461959+0.2572543i 0.2958936
3 -0.1461959-0.2572543i 0.2958936
4  0.1218206+0.2168327i 0.2487100
5  0.1218206-0.2168327i 0.2487100
6 -0.2390504+0.0000000i 0.2390504

All the eigenvalues lie inside the unit circle.
PVAR satisfies stability condition.
```