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FIRST DRAFT FOR COMMENT

THE IMPACT OF FREE TRADE AGREEMENTS ON VERTICAL SPECIALISATION

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Fist Draft

Abstract

The concurrent international fragmentation of production structures and propagation, in recent decades, of FTAs suggests the presence of a link between these processes. In this paper, the impact of an FTA on this type of trade is investigated through a theoretically augmented gravity model of input trade. Controlling for the endogenous formation of trade agreements, through a set of country-year fixed effects, the empirical results suggest that an FTA increases the value of intermediate imports by 25%. However, when a more targeted measure of bilateral value chain activity is considered, capturing the value of intermediate imports used to service exports to the same country of origin, the FTA effect more than doubles to 65%. The results also suggest the presence of magnification effects which see value chain activity being more sensitive to changes in trade costs than traditional trade flows. They highlight that trade policy may play an active role in the propagation of such modes of production.

1. INTRODUCTION

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This paper aims to provide an empirical analysis of the impact of Free Trade Agreements (FTA) on vertically specialised trade[2]. The concurrent rise in the number of FTAs with the unprecedented growth in this type of trade (see Hummels et al., 2001; Yeats, 2001; Yi, 2003; and OECD, 2010 inter alia), strongly suggests that these processes could be linked as does the evidence presented in Lopez-Gonzalez and Holmes (2011). However, to capture the impact of an FTA on vertically specialised trade one has to isolate the trade policy element from other factors, such as proximity or income, which are also likely to determine the degree of bilateral vertical specialisation.

To this end, a theoretically motivated gravity model of input trade, similar to Baldwin and Taglione (2007 and 2011), is developed. The model draws on Ethier's (1982) concept of 'international economies of scale' where the division of labour is addressed through a Constant Elasticity of Substitution (CES) function on the production side. This functional form transposes the concept of 'love of variety' (Dixit and Stiglitz, 1977) to production in an attempt to capture the output gains that are described in Adam Smith's (1776) *pin factory* (see also Chakraborty, 2003). In the same way that consumers gain utility from consuming more varieties of products, firms may be seen to increase output through a greater spread in the use of intermediate input varieties (see Ethier, 1982 and Bas and Strauss-Kahn, 2011). This provides a representation of the gains that can be achieved from the fragmentation of production.

The impact of an FTA on this type of trade is then investigated through the estimation of the resulting gravity model of input trade. The empirical strategy draws on the endogenous trade policy literature to eliminate the biases that arise from the endogenous formation of trade agreements (Baier and Bergstrand, 2007). Unobserved heterogeneity is the likely source of bias and is caused by the presence of unobserved characteristics that simultaneously determine bilateral trade flows and the incentives to form trade agreements. It is suggested herein that a country-year Fixed Effects approach provides an adequate tool for capturing unbiased estimates of the FTA effect. The results then show that, on average and ceteris paribus, overall imports of intermediate products are 25% higher between preferential partners. But the impact of an FTA is found to be 5 percentage points higher on intermediate imports used to produce world exports, or, in other words, when these are part of an *international* value chain. The FTA impact is larger still (65%) on intermediate imports which are part of a *bilateral* value chain (i.e. where both the origin of the intermediate and the destination of the consequent export is the same country[3]).

These results suggest that imports belonging to a bilateral sequence of production are more responsive to changes in trade costs and income than traditional trade flows. This may be indicative of the presence of 'magnification' effects (Yi, 2003) which arise in vertically specialised sequences of production which are characterised by a back and forth movement of products across borders[4]. Because the removal of border barriers to trade can lead to sizeable reductions in the trade costs of such production sequences, FTAs can play an active role in promoting bilateral value chain activity.

[2] FTAs as defined in art. XXIV of the GATT/WTO.

[3] An example of this type of trade can be found in the patterns of specialisation witnessed in the NAFTA region where Mexico exports intermediate products to the US who subsequently imports the finished processed good i.e. *maquiladoras* trade.

[4] Yi (2003) argues that the presence of these magnification effects help explain why world trade has increased at a faster rate than world GDP.

The methodological contributions of this paper are two-fold. First, it suggests that country-year fixed effects may be used to resolve issues of unobserved heterogeneity. These are less restrictive than the pair-wise fixed effects that are proposed by the literature (Baier and Bergstrand, 2007). These findings are particularly relevant for studies that use short panels where the variance of the FTA variable may be limited in time[5]. Second, this paper shows that a more widespread measure of intermediate goods trade, which relies on the identification of intermediate products through the BEC (Broad Economic Classification) nomenclature, performs as well as a measure that captures similar flows but is informed from Input Output tables. However, these measures do not serve as proxies for value chain activity as well as the more targeted measures of bilateral vertical specialisation (as argued in Lopez-Gonzalez and Holmes, 2011). It is found that the use that is given to imported intermediates is important in determining the impact that an FTA has on this type of production. In particular, trade policy has a greater impact on value chain activity than it does on the import of intermediate products that are used to satisfy total output (domestic or exported).

The remainder of this paper is organised as follows. The second section provides a conceptual note on the role that trade agreements can play in shaping vertical specialisation. The third section then gives an overview of the challenges that are faced in capturing bilateral measures of vertical specialisation. It also discusses the empirical approaches used in the literature to analyse the impact of trade agreements on trade flows. Section four provides an appraisal of the theoretical literature focusing on how it can be applied to the case of vertically specialised trade. The fifth section presents a derivation of an empirically testable model of input trade. Section 6 discusses the empirical strategy, the data and the results obtained. Conclusions and a discussion of the main findings and shortcomings are given in the final section.

2. A Conceptual Note on the Impact of FTAs on Vertical Specialisation

There are two main channels through which FTAs may impact vertical specialisation. The first is through the shallow integration effects that arise from the removal of tariff barriers to trade. The second is through the removal of 'behind the border' measures which is commonly associated with elements of deep integration.

2.1. Magnification and Shallow Integration effects

The removal of tariff barriers to trade between preferential countries could have a two-fold impact on vertically specialised trade. This is because VS involves both an import and an export process. Because FTAs are reciprocal, this form of liberalisation may stimulate both a wider use of intermediate products from a preferential partner and also increase the market access for the associated exported product. This would occur when the reduction in trading costs leads to a reduction in the landed prices of both the intermediate good used and the final good produced. It then follows that the impact of an FTA on the amount of trade between two countries, in the presence of vertically specialised modes of production, should be positive (leaving issues of the extent to which this may be trade creating or trade diverting aside for now).

[5] This is likely to become problematic as trade agreements proliferate.

When production structures are shared between two countries and intermediate goods go back and forth numerous times between these, *magnification effects* may arise (Yi, 2003). Goods that cross borders multiple times incur import taxes at each border crossing. Hence the removal of tariffs could affect trade flows by a multiple of the amount of times that the product crosses a border. A simple mathematical example can help illustrate this point. Consider the value (v) of a product in any given country (A or B) to be represented by the simple equation $v = p\tau^n Q$ where p is the price of the product and is equal to one, τ is 1 plus the ad-valorem tariff barrier and represents iceberg trading costs, n is the amount of times that this product crosses a border and Q represents the quantity of this product which is also assumed to be unity[6]. Now consider this product moving across borders but not receiving any value added at any border crossing (this means that all values are held constant except the number of times the product crosses a border). Upon its first border crossing, i.e. when it is exported from country A to country B, n takes the value of one and the landed price in nation B is $p\tau Q$. But if this product is then re-exported to country A, the value of the product in market A becomes $p\tau^2 Q$. It can then be shown that the change to the value of the product is an increasing function of n; the amount of times the good crosses a border (holding all other things constant).

This crude example of tariff magnification effects suggests that removing a tariff barrier between two countries which are already heavily vertically specialised can have an important cost reducing effect tied to the degree of fragmentation, or border-crossings, between these countries[7]. Yi (2003) formalises this idea in a Ricardian framework. He argues that vertical specialisation can help explain the growth of world trade better than 'standard models'. These have to assume "counterfactually large elasticities of substitution between goods" (Yi, 2003:p.1) to reconcile the slow reductions in tariff with the large growth in trade flows in recent decades.

Hummels et al. (1999 p.25) hint that "as vertical specialization [sic] tends to magnify the effects of barriers, it may also magnify the welfare consequences, malignant or benign, of preferential barriers"[8]. Hence if there is indeed a higher responsiveness of trade flows to tariff cuts under more internationally fragmented production structures, then the Vinerian effects of FTAs, in the presence of vertical specialisation, could become more pronounced (i.e. magnified). And this will add to the fact that fragmentation may increase the base of tradables so that there will not only be more border crossings per product but also more products crossing borders. There might also be qualitative changes to how trade creation and trade diversion arises rendering their grasp even more complex. Because of the nature of vertical specialisation, there is room for trade creation and diversion occurring at both ends of the VS chain (import and/or export). If trade creation on the import side results in the reduction of input prices, it may then make the export industry more competitive and hence induce further trade creation on the export side. This introduces the possibility of complex feedback mechanisms. Additionally, there can be a simultaneous trade creating element on the export side and a trade diverting effect on the import side (or the reverse).

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[6] Assuming positive values and no drawback provisions.

[7] Although one can argue that drawback provisions will stop this magnification effect the idea still holds if you add a sequence of production involving three countries.

[8] This was in the working paper that led to Hummels et al (2001). It seems that this statement did not make the cut for the final revision! However in light of the evidence presented in Yi (2003) this quote may remain relevant.

This increased dimensionality in transactions considerably complicates the traditional welfare analysis of trade creation and diversion (WTO 2011). Moreover, the new literature on offshoring and FTAs in the presence of incomplete contracts indentifies further channels of influence (Ornelas and Turner, 2008 and Antras and Staiger, 2011). Ornelas and Turner (2008) argue that the interaction between specific assets and incomplete contracts leads to a 'hold-up' problem that results in an inefficient amount of trade taking place. This hold-up problem arises because investment on production is carried out before payments are realised. The "ex-post haggling over prices leads suppliers to capture only a fraction of the return to their investment" (Antras and Staiger 2011:p10). This results in conventional trade models underestimating the responsiveness of trade flows to trade liberalisation.

2.2. What about the role of Deep Integration?

Where linkages between countries go beyond simple arms-length dealings and processes of international production demand common regulatory frameworks that ensure appropriate governance structures for value chain activity, deep bilateral trade agreements may prove even more beneficial. The creation of *common economic spaces* where institutional integration, market contestability, and regulatory cooperation are feasible may result in the formation of positive externalities that facilitate the propagation of regional value chains. Although hard to define, deep integration generally involves some form of international cooperation in removing behind the border measures that restrict bilateral trade. These non-tariff measures (NTMs) generally arise from cross-country differences in regulatory frameworks.

It is hard to quantify the impact that deeper integration may have on value chain activity. This is because the positive externalities which arise from deep integration may have wide-ranging effects. Conceptually, the creation of a common economic space can set in motion mechanisms that enhance collaboration between firms. By reducing uncertainty in the realisation of contractual obligations, or through the creation of a favourable environment that bolsters investment, deep integration may not only reduce transaction costs but also provide sufficient conditions for greater and more efficient economic interactions[9]. This may then lead to a wider propagation of technologies within an integrated area and may set in motion *learning by doing* mechanisms which can result in productivity gains and hence economic growth. Deep integration may also lead to larger trade flows between countries arising through the promotion of finer specialisation; a greater exploitation of economies of scale; or from the introduction of competition at finer levels of production.

An interesting feature of deep integration is that it need not necessarily involve deep institutional cooperation. The aforementioned gains can be achieved by private enterprises through self-imposed governance mechanisms (or standards). There are two interesting and contrasting examples of how the integration path and vertical specialisation can meet. The EU's deep integration initiatives that resulted in the creation of the Single Market may have played a pivotal role in the propagation of regional value chains. This is corroborated by the

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[9] One example of deep 'institutional' integration is the EU's single market. It functions under a set of common regulations where the European Commission and the European Court of Justice (ECJ), supra-national institutions, defend the principles of the single market. If these are violated, the ECJ has the power of overturning a country or a firms' actions so that the regulations are adhered to. Similarly, the European Commission retains supra-national powers in issues related to competition policy. A common rule of law across an integrated area should result in a reduction in uncertainty and hence can promote area wide investment or cooperation between firms located in different MS.

high degrees of vertical specialisation between EU members as seen in Lopez-Gonzalez and Holmes (2011). However the fast-paced integration initiatives in South East Asia seem to have come as a result of the widespread fragmentation taking place in the region. Regionalism in South East Asia seems to be playing catch-up to the rising demand for institutional harmonisation that has arisen from the regional spread of production networks (WTO, 2011). This then suggests that the process of vertical specialisation may come either as a result of, or lead to, further and indeed deeper institutional integration. This, in turn, raises issues relating to the endogeneity of these processes where vertical specialisation can lead to a greater demand for deeper trade agreements or alternatively deeper trade agreement can further promote vertically specialised trade[10].

3. Capturing the Effects of an FTA on Vertical Specialisation: Preliminaries

The near absence of research into the impact of trade agreements on vertical specialisation is partly due to the elusive nature of what actually qualifies as an intermediate good – the *identification problem*. And also from the valuation of trade flows in national trade statistics – the *valuation problem*.

The identification of intermediate products is not straightforward. Despite the Broad Economic Classification (BEC) giving some guidance, complications in identifying intermediate products remain owing mainly to the non-exclusive use of these products. When products can be used as either intermediates or final consumption goods, these classifications can lead to an over or an under identification of the actual amount of trade in intermediates taking place. This suggests that different identification methods should be pursued in an empirical analysis.

The valuation problem then adds to this through a possible 'inflation' of the value of trade that is taking place between countries. Trade statistics are computed in such a manner that the entire value of a product, and not the value added, is captured at each border crossing. Resulting from this is a possible 'double-counting' of trade (see Daudin et al., 2008; and Johnson and Noguera, 2011). As there is little knowledge on the decomposition of value added between countries, it is hard to identify the severity of this problem. However the net/gross distinction in the way trade statistics are computed may have implications in the estimation of gravity models (this is discussed at greater lengths in the Appendix). But this only becomes an issue if the theoretical models suggest that net trade flows rather than gross trade flows need to be considered. The expenditure functions that are typically used to derive gravity point to the use of neither in particular and arguments for using net or gross flows can be equally defended. On the one hand, the realisation of an import involves paying the gross value of the product, however on the other, if this imported product contains domestic value added then one can argue that part of the product is already 'accounted for'. Much of the research in the field of the net/gross distinction has been concerned with obtaining net valuations of trade flows (Johnson and Noguera, 2011; Koopman et al 2008; and Daudin et al, 2008), but the implications of using one over the other in gravity estimations has received little attention to date.

[10] This issue is treated in a recent paper by Orefice and Rocha (2011)

But even if intermediate goods can be appropriately identified and valued, it is also possible that FTAs have an impact on these flows that is contingent on the use that is given to these products. Intermediate inputs can be used to supply the domestic market or alternatively export markets, and this distinction may be important. In the heterogeneous firm literature (Melitz, 2003), firms engaged in export markets possess a productivity advantage over firms that satisfy domestic markets. The work of Bas and Strauss-Kahn (2011) hints at the existence of similar differences between firms engaged in production for domestic markets and those participating in value chain activity. Because FTAs are likely to promote the activity of such firms to a greater extent than those solely engaged in domestic sales (see previous discussion on magnification), then it might be expected that the impact of an FTA is different across the use that is given to intermediate products. The use of indicators of bilateral vertical specialisation, as developed in Lopez-Gonzalez and Holmes (2011), may mitigate some of these problems and allow one to capture different facets of international production.

3.1. The Bilateral Vertical Specialisation Indicator

The indicator favoured in this paper tracks *bilateral* vertical specialisation. Up until now, the main hurdle in looking at the role of trade agreements on vertically specialised trade has been that current measures of this phenomenon have only been able to capture *total* degrees of VS with respect to the world rather than with respect to bilateral partners. The extension of the VS indicator made in Lopez-Gonzalez and Holmes (2011) presents the opportunity of capturing the degree of vertical specialisation across country pairs. This then paves the way for an estimation of the role of trade agreements in this process. In its raw form, the indicator is based on Hummels et al. (2001) but it is extended so that the bilateral element of value chain activity can be identified. It is computed using input-output tables merged with trade data from the following equation:

$$VSI_{ij} = \frac{VS}{X_j} = \frac{\mu A^{Mij}\left[I - A^{Dij}\right]^{-1} X^k_{ij}}{\sum_j X^k_{ij}} \tag{1}$$

Where μ is an *1 x n* vector of 1's, A^{Mij} is the imported technical coefficient *n x n* matrix from partner country j, $[I-A^D]^{-1}$ is the *n x n* Leontief inverse, X^k_{ij} is an *n x 1* vector of exports from country i to country j in sector k, and $\sum_1 X^k_{ij}$ is a scalar of total exports of country i to country j. The bilateral component of this measure is captured through the construction of bilateral imported intermediate matrices, A^{Mij}, which delimit the use of inputs from a given country of origin. These intermediates are then combined with domestic intermediates to produce output destined to foreign markets.

The measure then captures the amount of imported intermediates, from a given origin, that are used in the production of exports to a chosen destination (the backward linkage). The indicator can also be adapted to capture the amount of intermediates that are exported to other destinations and then combined by these to produce exports (the forward linkage). A full measure of vertical specialisation is then the sum of these two linkages net of the reciprocal content of these[11]. An intuitive explanation of what the indicator captures is helpful. The indicator identifies the value of intermediate imports (the numerator of the second term of equation 1), in a particular sector, that are needed to satisfy an export demand vector. This is then presented as a simple share of exports to a chosen destination. In its aggregate form it is a trade weighted average of the sectoral degrees of bilateral vertical specialisation.

By embodying a production sequence where intermediate products are sourced from abroad, combined with domestic value added and subsequently exported, the measure captures the conveyor-belt nature that appears to typify international value chain activity. It is different from other measures that have been used in the empirical literature because it tracks the *use* given to intermediate products rather than the overall value of these flows (see Feenstra (1998) and Yeats (2001) which rely on the BEC nomenclature). The use is identified according to the destination of the resulting output flow. This can be either towards satisfying total demand (domestic and international), or towards satisfying international demand only. Where imports of intermediates used for the latter purpose may better represent the presence of international value chain activity.

For this purpose, it will be convenient, in the empirical section, to differentiate across three uses, or indeed types, of intermediate products. The first will capture the value of intermediates that are used by the economy, irrespective of the final use that is given to these. Such flows will be indexed with the suffix '_tot' throughout. The second captures the intermediate products that belong to a process of vertical specialisation, and are thus used to produce exports to *any* international destination. The suffix that identifies this instance will be '_bvs'. The final use that can be given to intermediate imports also involves an exporting activity, but this export is towards the country where the imported intermediates originated from. This will be identified through a '_bvsbil' suffix. This captures a fully bilateral element of value chain interactions where countries use each other's output in a series of sequenced production steps. A real world example of such production sequences arises in *maquiladora* trade where Mexico imports intermediate products from the US and subsequently exports finished products back to the US.

Although input-output measures of vertical specialisation are very useful, they also have their limitations. The country coverage of IO tables is restricted and so is the coverage in time so that these indicators can only be calculated for a selection of relatively developed countries during a rather short time span. The fairly aggregate sectoral aggregation of these tables also hides important sub-industry level linkages that cannot be captured[12]. In addition, the measures of vertical specialisation are computed, or inferred, rather than observed and can hence be driven by some of the restrictive assumptions that are needed for their calculation (see Lopez-Gonzalez and Holmes, 2011). Nevertheless, these measures allow one to disentangle the use of intermediate products and hence are more in tune with 'actual' production linkages than trade based measures. These might then provide a more accurate depiction of value chain activity which motivates the use of this indicator in looking at the impact of FTAs on vertical specialisation[13].

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[11] The forward linkage of country A with country B is likely to have country B intermediates and the total measure of vertical specialisation nets this out. See previous Lopez-Gonzalez and Holmes (2011).

[12] Leontieff 'technologies' are aggregated across a very narrow set of sectors.

[13] See Lopez-Gonzalez and Holmes (2011) for a wider discussion on the extension of this indicator to capture bilateral interactions and also a survey of the extent of vertical specialisation across countries and regional partners.

3.2. EMPIRICAL METHODS: THE GRAVITY MODEL

Looking at the impact of FTAs on trade has generally been approached through a gravity model. It draws on Newton's law of gravity which sees the force between objects as a function of a gravitational constant times the product of the combined mass and the squared distance. Economists have taken the objects of this equation to be countries and used GDP measures to capture their mass in an effort to explain bilateral trade flows. The strong empirical explanatory power of this set-up has led to its widespread use despite a lack of initial theoretical grounding[14]. It was Anderson (1979) who was first to provide a theoretical backbone to Tinbergen's (1962) novel empirical application. The empirical success of the gravity model is now partly attributed to the fact that its derivation can be achieved on the basis of many different theoretical models (see Evenett and Keller (2002); Helpman et al. (2008); and Anderson (2010)). Over 30 years after his original contribution, Anderson (2010:p1) states that the model is no longer an "intellectual orphan".

The gravity model can be derived from an expenditure system where the amount of exports a country sells to another is a function of how much the partner country spends on tradable goods (from all destinations) times the share the partner country spends on a typical good variety in the origin country. This share then depends on the real price of the goods which then varies with the costs of transactions. As way of example, a first approximation to the derivation of a gravity model with complete specialisation and homogeneous consumer preferences in a frictionless world can be shown (following Anderson, 1979)[15]. Consider a world composed of two countries where trade is costless. Exports of country A to country B are determined by country B's marginal propensity to consume country A's products (s_A) so that $X_{AB}=s_AY_B$. Country A's total income (Y_A) is the sum of domestic sales and exports to country B. Where preferences are homogeneous ($s_A=s_B=s$) the following condition will hold $Y_A= s(Y_A+Y_B)$. Solving for s and substituting back into the export equation the simple frictionless gravity model is obtained[16]:

$$X_{AB} = \frac{Y_A Y_B}{Y_W} \tag{2}$$

Adding trade frictions (τ) to this model is relatively simple and yields a gravity specification much like equation (2) but where a τ parameter, capturing trade costs, is introduced in the denominator. Extending this to include a set of countries, and maintaining the complete specialisation and homogeneous preference assumptions, enables the estimation of the log-linearised gravity equation which has the following form:

$$LnX_{ij}=\beta_0 + \beta_1 lnY_{i,j} + \beta_2 lnY_{i,j} - \beta_3 \tau_{i,j} + u_{i,j} \tag{3}$$

[14] Some of the most influential theoretical justifications can be found in Anderson (1979), Deardorff (1985), Bergstrand (1985, 1989), Anderson and Van Wincoop (2003).

[15] See Evenett and Keller (2002) for a discussion of the derivation of the gravity model under different assumptions such as imperfect specialisation.

[16] Where Y_w is equal to $Y_A + Y_B$

where β_0=-ln(Y_w) and $u_{i,j}$ is i.i.d. Trade frictions (τ) between countries are generally captured through geographical indicators (great circle distances; contiguity) and institutional dummies (FTAs for example). Anderson and Van Wincoop's (2003) contribution was to augment this equation by incorporating 'multilateral resistance'. They found that trade flows between two countries were not only affected by their proximity, but also by how remote these were from the rest of the world. They rationalised McCallum's (1995) puzzling findings that saw the border effects between Canadian provinces and US states reduce trade by over 2000% by adding relative price indices. They found that the inflated border effect fell to 60% when multilateral resistance is accounted for[17].

The gravity model of trade has since been extended and used in many ways. Rose (2003) sought to capture the impact of monetary unions on trade flows, and the use of these models to capture the effects of FTAs on trade flows is widespread; Soloaga and Winters, 2001; Carrere, 2006; Baier and Bergstrand, 2007; and Magee, 2008, are but a few notable examples. Through Helpman et al. (2008), the gravity model can now be derived in a world of 'heterogeneous firms' (Melitz, 2003) so that export market selection can be modelled (which deals with the presence of zeroes in the trade matrix). Chaney (2008) then uses a similar set-up to include the intensive and extensive margins of trade.

Extending the gravity specification to a world with intermediate goods trade has received little attention. One notable exception is found in Baldwin and Taglione's (2011) working paper. Although they are primarily concerned with the role of the 'mass' variables in a world with increased trade in parts and components, their approach sets an important precedent for the use of gravity models in looking at trade in intermediates. Baldwin and Taglione (2011) use the shorthand assumption, common in the economic geography literature, that trade in final goods is isomorphic to trade in intermediate goods, hence they derive their gravity model of intermediate goods trade from a consumer expenditure function that follows Baldwin and Taglione (2007). They argue that the mass variable in the estimation should be gross output rather than the value added measures of GDP that are commonly used. In a world that is interconnected and where demand comes from varying locations net measures of output are less representative of the interactions that take place and hence gross measures would be preferable. If indeed trade is measured gross, then so too should income owing to the general equilibrium conditions of the model where total imports, from all origins, including the domestic economy, are equated to total income.

Although only implicitly derived, Baldwin and Taglione's (2011) paper appears to suggest that trade in intermediates is motivated by similar factors that encourage trade in final goods. Hence if the derivation of gravity can be achieved through a production function, in lieu of the expenditure function approach used by Anderson (1979), then it should show similar attributes to its total trade cousin. However, such a derivation will demand greater emphasis on production functions. In particular one may need to consider that if the output of a given country can be used in the production sequence of another, then one is moving away from a world of competing trade to one where trade becomes complementary.

[17] McCallum's inflated results were also being driven by the size of the different regions.
Although AvW's model requires information on relative prices, which is often not available, and it assumes that trade costs are symmetric across partners, Feenstra (2002) shows that a similar specification can be obtained without the restrictive symmetric trade costs assumption. Additionally, Feenstra (2004) argues that multilateral resistance does not require data on relative price differences because multilateral resistance can be controlled for, in an econometric specifications, using reporter and partner country dummy variables.

4. A REVIEW OF THE RELATED THEORETICAL LITERATURE.

Vertical specialisation, but more generally trade in intermediate goods, has been approached using an array of theoretical models. These have been grounded in the confines of traditional and 'new' trade theory and serve to explain different facets of what is a similar phenomenon. They range from; standard Ricardian models (Sanyal and Jones, 1982; Feenstra and Hanson, 1996; Deardorff, 2001; and Yi, 2003); H-O frameworks (Jones and Kierzkowski, 2001; Deardorff, 2001; Arndt, 2002; Baldwin and Robert-Nicoud, 2010); new trade theory approaches (Ethier, 1982; Burda and Dluhosch, 2002; Lüthje, 2001 and 2003); to New Economic Geography settings (Venables, 1996; Krugman and Venables, 1996; Fujita et al., 1999; Baldwin and Taglioni, 2011)[18]. Many of these approaches are theoretical in nature and not readily testable but they provide the foundations of the model that will be presented in the next section.

A new theory explaining the causes and consequences of vertical specialisation is probably not needed. This is a new phenomenon, but it may still be driven by similar comparative advantages and economies of scale forces. They may have just become more apparent since they occur at finer levels and involve different units of analysis[19]. McKinnon (1966) was first to argue that trade in intermediate products "led a rather shadowy existence in the formal pure theory of international trade", this despite accounting for 60 - 70% of world trade. Ethier's (1979 and 1982) theoretical underpinnings then provided a first attempt at incorporating intermediate products into mainstream 'new' trade theory. In parallel, Sanyal and Jones (1982) also produced a model of trade in 'middle products' where, as in Ethier's (1982) derivation, all trade took place in intermediate goods[20]. Ethier justifies this approach by arguing that traded products tend to receive some form of domestic value added before they reach final consumer. What these papers suggest is that tackling vertical specialisation may best be approached from a producer's perspective. Indeed Ethier (1982:p391) argued that "producer' goods are in fact much more prominent in trade than are consumers' goods". And it seems that this observation is possibly more relevant today than when it was written[21].

4.1. *TRADITIONAL TRADE THEORY APPROACHES*

Owing to growing empirical evidence on the prevalence of this type of trade, intermediate products and indeed vertical specialisation have received mounting attention. Yi (2003) was first in underlining the importance of vertical specialisation in explaining the growth of trade. Using a dynamic Ricardian model a la Dornbusch, Fischer and Samuelson (1977), he showed how tariff dismantlement could motivate vertically specialised sequences of production arising through the increased exploitation of technological differences across countries. In

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[18] More recently, a theory of offshoring based on *trade in tasks* (Grossman and Rossi-Hansberg 2008) rather than goods gained prominence. It supports Blinder's (2006) call for a new paradigm suited to the *new unbundling* (Baldwin 2006 and 2010) phenomenon under which vertical specialisation falls. But Baldwin and Robert-Nicoud (2010) suggest that there might not be need for such a *new paradigm*. They argue that offshoring can be incorporated into the mainstream of trade theory through induced productivity gains arising via technological change.

[19] see Blinder's (2006) new dichotomy arising from offshoreable and non-offshoreable tasks

[20] Sanyal and Jones' (1982) model assumed a very specific form of production occurring in input and output tiers. The former saw the combination of resources (local) to produce output that would subsequently enter the world market. The latter would see domestic use of intermediate products combined with local value added to produce final consumption goods.

[21] see Feenstra 1998; Yeats 1998, 2001 and Hummels et al 2001 amongst others for accounts of the rise in intermediate goods trade and vertical specialisation

contrast, the H-O approach to vertical specialisation (Deardorff, 1998) sees countries specialising in the segments of production which use their relatively abundant factor of production. Fragmentation introduces scope for further specialisation across segments requiring different factor inputs and hence this type of production yields the classical gains from trade but in greater magnitudes given that specialisation occurs over a larger array of products. Arndt (2002) linked this set-up to regional integration and argued that entering into an agreement with a country with different factor intensities could result in a more efficient allocation of tasks (resources) across countries.

Most of the new approaches to vertical specialisation rely on such cross-country differences as drivers of fragmentation. Grossman and Rossi-Hansberg's (2006 and 2008) theory of offshoring introduces the concept of *trade in tasks* supporting Blinder's (2006) call for a new paradigm suited to the *second unbundling* (Baldwin 2006 and 2010) phenomenon under which vertical specialisation falls. The basic idea is that fragmentation leads to gains that are akin to factor augmenting technological change. Fragmentation is beneficial because it exploits cross country differences in factor intensities. In this line, Baldwin and Robert-Nicoud (2010) argue that there might not be a need for a *new paradigm* as offshoring is much like a productivity gain that arises through technological change.

However, evidence suggests that much vertically specialised trade takes place amongst similarly endowed economies and hence that models that incorporate product differentiation may be important too.

4.2. 'New' Trade Theory and Applications – the love of input variety

The 'new' trade theory models of Krugman (1979 and 1981), and Helpman and Krugman, (1985) are set in a monopolistically competitive world where product differentiation satisfies consumers' 'love of variety' (Dixit Stiglitz 1977). This set-up proved to be more in line with the patterns of trade of modern economies where the simultaneous import and export of similar final products was commonplace. In such models, consumers demand different varieties of products and gain 'utility' from consuming more varieties. However, recent evidence suggests that intra-industry trade is nowadays increasingly taking place in intermediate rather than final products (Yeats, 2001).

In the same way that traditional 'love of variety' models cater for consumers attaining a higher utility through the consumption of extra varieties, similar setups can also model how firms may attain lower costs of production through the use of more intermediate inputs. This may reflect the gains that can be derived from vertical specialisation. If the entry of a new product variety identifies an increase in the degree of fragmentation, then, it can be shown that, like in the case of the utility of a consumer, firms should be able to increase the output they produce holding everything else constant[22].

The 'love of variety' that drives models of product differentiation is intuitively easy to grasp, however transposing this modelling framework into a firm's demand for inputs requires a little more thought. One would need to identifying how, and if, firms gain from having access to a greater landscape of intermediate products. A priori, a greater availability and demand for intermediate products presents firms with new opportunities to more narrowly specialise along finer defined comparative advantages. The fragmentation of production structures may

[22] They can operate at a lower iso-cost line

also liberate resources occupied in the inefficient production of in-house intermediates. A rise in the landscape of intermediates may also act as an insurance mechanism against an over-reliance from a particular supplier. It may also increase the diffusion of technology or indeed afford producers the option of buying a particular input that they would not have been able to produce themselves[23]. This points to the possible existence of a 'love of input variety'. And this has desirable modelling properties. It implies that the production function can be modelled using a CES aggregate of inputs in the classical Dixit-Stiglitz setting as in Ethier (1982)[24]. The division of labour can then be captured by the degree of fragmentation or the use of input varieties in production and can benefit from 'international economies of scale' (Ethier, 1982).

However, under such frameworks, the introduction of a new intermediate variety leads to a proportional marginal reduction in the use of all other inputs. This is a consequence of the monopolistic competition assumptions which require there to be a common price for all inputs used. Given the common elasticity of substitution and the fixed budget constraint which typifies these models; as the number of varieties tends to infinity, the quantity of each variety used tends to zero. This restriction implies that the technological requirements needed to produce a unit of output are uniform in the use of all available intermediate varieties. This stands at odds with what we learn from how firms operate or indeed what we see in Input-Output tables where technical coefficients vary and industries use inputs in different proportions. This suggests that these models may need to be altered in an effort to capture a heterogeneous use of input varieties. Indeed Krugman's original model (1979, 1981) included a preference parameter that served a related purpose. Using a similar set-up, where the preference parameter becomes a technological requirement, can bring these models closer to the realities of modern production.

In keeping with trying to reconcile these models with the realities of production, another addition may also be warranted. The traditional Dixit-Stiglitz approach to love of variety is unbounded. This implies that consumers derive the same amount of extra utility from the consumption of any extra variety, irrespective of how many varieties are already on offer. Transposing this concept to the case of a CES production function that aggregates intermediate inputs implies the existence of an unlimited 'love of input variety'. Such an outcome is much less desirable, and indeed defendable, in the presence of cost rather than utility functions. But it is possible to follow Ardelean (2006) in creating a bounded love of variety. The introduction of a parameter that identifies the number of varieties on offer and which is dependent on the elasticity of substitution can be used for such a purpose. This is akin to saying that when inputs are highly substitutable, then the addition of an extra product is less beneficial to the production of output (the reverse also holds where the output gains from an extra variety are higher if products are not close substitutes). This reflects the fact that

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[23] See Goldberg et al (2009) for empirical evidence on the links between an increase in input varieties contributing to the expansion of product scope (as discussed by Bas and Strauss-Khan(2010) who also provide evidence of such links for a sample of French firms).

[24] Luthje's (2001 and 2003) adaptation of Lancaster's (1979) concept of 'ideal varieties' may also be important. This approach is borne from the assumption that for every final good, there exists an ideal intermediate good/input that fits the production sequence perfectly. If this ideal variety is not available, then firms will have to devote resources to the transformation of an input so that it matches the required ideal specifications. Contrary to the love of variety approach, the ideal variety approach posits that an increased use of intermediate goods does not translate directly into greater production possibilities. Although a greater availability of intermediate varieties increases the probability of the ideal good variety being produced and hence gains may be achieved through this channel too.

less specialised products, which might be more similar, are less valuable to the production process. Or similarly; that more specific inputs may be better adapted to production than more generic ones.

A monopolistic competition approach to intermediate goods trade implies the existence of an extensive margin of inputs as is implicit in the models based on Ethier's (1982) conjectures. More intermediate varieties used in production imply a finer division of labour which then suggests that the scope for vertical specialisation may be tied to the amount of intermediate varieties that partner countries produce. Countries that produce more varieties may then trade more with each other. This idea is similar to the 'vertical linkages' (Venables, 1996) that arise in the economic geography literature where firms' location is, in part, determined by how easily accessible downstream markets are.

4.3. NEW ECONOMIC GEOGRAPHY INSIGHTS

New Economic Geography (NEG) models may also be well suited to the analysis of vertical specialisation. Venables' (1996) model identified the linkages between upstream and downstream firms within an economic space. Krugman and Venables (1995; henceforth KV) captured the same relationship but they allowed a representative firm to take on the role of both upstream and downstream activities. The difference between economic geography and new trade theory models is that firms in the former are allowed to relocate across regions. Hence this literature is concerned with the forces that determine this location rather than with the origins of the flows of products. Nevertheless, its modelling insights are important as these incorporate sequences of productions where intermediate inputs are processed to produce output.

The KV model predicts that an increase in the number of firms within a spatial location brings about three important effects (Krugman and Venables 1995;p.864). The first is a reduction in the price of manufactured products, which, by construction, can serve as both intermediate and final products. The introduction of a new firm, or variety, reduces market power and hence sees a shift in the demand curve, implying a loss in firm profitability, for all producers. However, if manufacturing firms use manufactured inputs as intermediates, the reduction in price also reduces the total and marginal costs of firms. This may then reverse the loss in profitability. KV term this the forward linkage effect. Additionally, there is also a corresponding increase in the demand for products and this gives rise to increases in the total expenditure on manufactures. This is the backward linkage effect[25].

This approach to production may be relevant in the analysis of vertical specialisation for two reasons. Firstly, because the emphasis on the linkages between firms and the role of transport costs resembles the link between vertically specialised trade and regional integration. This is to the extent that trade agreements play a role in reducing transaction and/or trading costs. The second reason relates to the 'conveyor belt' approach which closely reflects value chain activity. More traditional delimitations of production generally assume that intermediate inputs always serve the purpose of producing final output, but if one is part of a sequenced production chain, then the output of one firm becomes the intermediate input for the next segment of production. If this is the case, then the efficiency of production of suppliers matters for your own efficiency of production (see Samuelson, 2001 for a simple implication of this in a Ricardian setting).

[25] Note that these linkages are different from those defined in Lopez-Gonzalez and Holmes (2011).

The NEG framework is useful in modelling vertical specialisation because this process involves the geographical dispersion of production. However, incorporating multiple locations to this type of set-up can be particularly tricky because of unstable or multiple equilibriums. Hence instead of augmenting the NEG models, one can draw on their characteristics to inform a theoretical approach to vertical specialisation as in Baldwin and Taglione (2011). This involves taking the separation of production as given rather than trying to explain how it arises. This is convenient because this investigation is not interested in how firms locate in different markets, but rather in the role of trade policy in promoting the process of fragmentation or indeed the origins of intermediate inputs.

4.4. Other Approaches

Whilst the models discussed above tend to be based on the traditional Krugman assumption of firm homogeneity, recent findings, from the heterogeneous firm literature, pioneered by Melitz (2003), suggest that this may be an unreasonable assumption. It is now well established that firms operate under different costing structures and that not all firms in an economy engage in export markets. This strand of literature incorporates this empirical regularity into a theoretical framework. It posits that firms within a country draw their productivity from a distribution. Those whose draw is above a certain threshold are able to engage in export markets because they can face a fixed cost that is required to enter these. A productivity draw below this threshold confines a firm to producing either for the domestic market or not at all[26].

One direct empirical implication of this literature, which might be relevant to the case of vertically specialised trade, is that the amount of traded varieties is a subset of total world varieties. This is consistent with the observation that countries which have larger domestic markets tend to exhibit lower degrees of vertical specialisation (Nordas 2004)[27]. A wider array of readily available intermediate products at home implies less dependence on world markets for inputs and hence the introduction of heterogeneities in the degrees of vertical specialisation across countries. The theoretical backbone of Helpman et al.'s (2008) model is of particular relevance here. They derive a gravity model using insights from the heterogeneous firm literature. In this model heterogeneity arises from the presence of a marginal cost with two components. The first is firm specific and its inverse identifies a firm's productivity in the production process. The second is country specific and identifies the productivity of the factors of production of a country. These marginal costs then determine how a firm can face the fixed costs associated to entering export markets. If income per capita can reflect the productivity of the factors of production in a country then richer countries should be able to sustain more exporting firms. This would imply that they would export more intermediate varieties.

Another possibility is that countries that use more imported components, or whose firms engage in wider international vertical specialisation, derive a productivity boost from this activity and hence are more prepared to engage in export markets. These productivity effects could be achieved through various channels. First through Ethier-type international economies of scale, and perhaps secondly through the backward and forward linkages

[26] This is in line with the accepted notion that it is only the most productive firms that engage in export markets. However issues of causality remain unresolved. Are firms productive because they export or do they export because they are productive?

[27] Although some firms may also be able to fragment more

reflected in the NEG models. The lower marginal costs that may be achieved through a better utilisation of inputs could then provide increased resources to face the fixed costs to exporting. This mechanism is not directly discussed in the heterogeneous firm literature which remains relatively silent on the origin of these productivity differences. A very recent paper by Bas and Strauss-Kahn (2011) suggests the presence of such a link between participation in value chain activity and productivity gains. Furthermore, the correlation between productivity growth and vertical specialisation observed in Lopez-Gonzalez and Holmes (2011) also lends some supporting evidence to this idea.

The above discussed theoretical approaches can help pin down the determinants of vertical specialisation. However, there is a parallel strand of literature that deals with the organisational aspects that arise from such modes of production which is also likely to be important. Supply side models such as that of Burda and Dluhosch (2002) are good half way steps between these. Here cost competition drives Smithian specialisation and fragmentation is modelled through an index, z, which denotes specialisation across stages of value added within a value chain. Although fragmentation reduces production costs, it incurs a coordination cost arising from the larger complexities of the shared production sequences. The interplay between these costs then determines the desirability of engaging in vertically specialised trade.

This concept of a cost to the coordination of value chain activities comes from the literature pioneered by Ronald Jones and Henryk Kierzkowski[28]. They motivate a narrative on fragmentation based on producer service costs which fits in the broader context of the analysis of the organisational choices of firms and Multinational Enterprises (MNEs). It is concerned with the organisation of transactions and/or the governance of value chains in the presence of international fragmentation. Here a distinction is made between various forms of transactions that occur either between or within firms (or MNEs) situated in different countries. These can take forms such as arms-length dealings or parent-affiliate trade. The organisational choices of firms may play a role in shaping vertical specialisation through, for example, the diffusion of technology across affiliate firms. In this line Markusen's (1989) Knowledge-Capital model involving investment flows is of particular relevance. More recently Antras and Staiger (2011) also identify other sets of costs that arise from the customisation of inputs and the lock-in effects arising from incomplete contracts between importing and exporting firms in the presence of offshoring.

One of the main challenges with approaching the analysis of the role of trade agreements on vertical specialisation through these organisational models is that the empirical analysis generally requires detailed data on firm activity and ownership which is not readily available or indeed comparable across countries[29].

Looking back at the different approaches that one can draw upon to model value chain activity suggests that there is no lack of tools to deal with this type of trade. However, tackling the determinants of vertical specialisation from one approach rather than from another will result in locking the model to the approach's dominant assumption. It is important to underline that the traditional frictions between the older trade theories of comparative advantages and those of product differentiation are likely to remain. The one favoured in this paper is the latter both for its convenience and its characterisation of value

[28] See Jones and Kierzkowski (1990, 1997 and 1999) Also see Arndt and Kierzkowski (2001)

[29] Another notable contribution on the organisation of firms and production across national borders can be found in Grossman and Helpman (2004).

chain activity. Although this does not mean that traditional trade theory forces, in the form of comparative advantages, derived from either technological or factor endowment differences, are not going to play a role.

It is also worth mentioning that the organisational choices of firms, and to a broader extent the interactions between these, are also going to be important. The institutional arrangements governing transactions and the environment in which these operate will be chief. This is where trade policy, and particularly international institutional cooperation, or regulatory harmonisation, is likely to play a role. Firstly through the elimination of tariff barriers to trade or the shallow integration effects, but perhaps more importantly through the role that deeper integration can play in bolstering value chain activity. The creation of stable trading environments need not only facilitate the search for appropriate partners, but should also provide a legal basis for economic interactions and disputes. A coherent rules-based system would then be conducive to the creation of 'thicker' markets which may play an active role in reducing transaction costs (see Antras and Staiger 2011).

5. A GRAVITY MODEL OF INPUT TRADE

The impact of FTAs on trade flows has traditionally been captured through the introduction of various dummy variables, delimiting the presence (or absence) of an FTA between two partners, to a gravity equation[30]. The goodness of fit of these models leads Anderson (2010:p.1) to argue that the gravity model is "one of the most successful empirical models in economics". However, these models are usually derived from consumer theory through an expenditure system (see Anderson (1979) and Anderson and Van Wincoop (2003)). This is an inappropriate setting for a model of input trade which should be approached from the production side. Baldwin and Taglione (2011) bypass this step by assuming that the demand for intermediate goods trade is isomorphic to final demand which is derived from consumer theory. This is a convenient and not unreasonable assumption, but some important insights may be lost in the process[31].

The aim of this section is to provide a model of input trade from the perspective of the producer. This is accomplished by relating input demand to typical gravity variables. It does not seek to provide an exhaustive theoretical framework of supply conditions across different countries in the presence of vertically specialised trade but rather to justify the use of a gravity model in subsequent estimations. In the process, the model draws on elements from Ethier (1982); Fujita et al (1999); Anderson and Van Wincoop (2003); Ardelean (2006); and mainly Baldwin and Taglione (2007, 2011).

A gravity model of input trade can be approached from the supply side, as in Helpman et al (2008) and Channey (2008), or alternatively from an input demand function. The former approach is chosen for its similarity with the traditional derivations of gravity (i.e. Anderson,

[30] There are many examples of papers that have used gravity models to look at the impact of trade agreements on trade flows but perhaps the most salient are Soloaga and Winters (2001) Carrere (2006) and Baier and Bergstrand (2007).

[31] It is also a very common assumption of the NEG literature

1979, Anderson and Van Wincoop. 2003 and Baldwin and Taglione 2007 and 2011) and also for its simplicity[32].

5.1. THE MODEL

A representative producer in country *i* produces output (X_i) by combining differentiated intermediate inputs (*x*). These are sourced from an array of origins M (M= j=1, 2, ...), who produce a heterogeneous number *n* of differentiated varieties. The substitution between inputs is captured by the parameter σ so that the production function is additively separable and exhibits a constant elasticity of substitution (CES). This is assumed to be above unity so as to reflect the *international economies of scale* of Ethier's (1982) model. The efficiency with which inputs are combined is captured by a country specific term A_i leading to the following representative production function:

$$X_i = A_i \left[\sum_M \sum_n x_{i,j}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{4}$$

The CES aggregator captures the gains that can be achieved from the fragmentation of productions structures. A particular case of this production function serves illustrate this point. If there are no technological constraints in the use of varieties; and all countries produce a homogenous amount of inputs because firms are symmetric across countries (i.e. identical cost structures in the production of intermediates), then it can be show that the above expression collapses to[33]:

$$X_i = Mn^{\frac{\sigma}{\sigma-1}} x_{i,j} \tag{5}$$

This implies that holding everything else constant, output (X_i) is an increasing function of the number of intermediate products *n* that are used (assuming that the substitution parameter is above unity). If the number of intermediates used goes hand in hand with the degree of fragmentation of a production sequence, then this set-up mimics the gains originally depicted in Adam Smith's Pin Factory. This is because each 'task' leading to the creation of a pin can be seen to yield a 'new' intermediate product. So that the sharpening of the iron produces an intermediate good that is a 'sharpened iron piece'; and the process of adding the head of the pin then produces another intermediate product which is a 'sharpened pin with a head'. Then each step of the production of a pin can then be associated with the use of a new intermediate product.

The use of such a CES production function follows Ethier (1982) and is also similar to Romer (1987) and Chakraborty (2003). However, this type of production function is limited. On the one hand, it does not incorporate factor endowments and assumes that products are costlessly assembled. On the other, Ethier (1982:p391) noted that this type of function, in a

[32] A supply side approach to the derivation of gravity with vertical specialisation, although highly desirable, is beyond the scope of this study. The demand side approach requires less limiting assumptions and serves capture the most important facets of intermediate goods trade.

[33] The identical cost hypothesis implies that the A_i term in this instance is the same across all countries and can be thought of being equal to 1. This simplification is for expositional purposes.

monopolistically competitive setting, leads to an optimal production sequence where an "infinitesimal amount of each intermediate product is used over an infinite number of processes". This occurs because the assumed symmetries in the cost structures of firms across countries lead to a common price for any input variety and hence to a common use of the value of inputs from all origins[34]. The resulting counterfactually large (infinite) 'love of input variety' does not reflect the realities of production.

For the model to more accurately reflect these realities, the use of inputs in the production sequence is restricted through the introduction of two new parameters. The first is a technological parameter (φ) which reflects different uses of inputs across countries in the production sequence[35]. The second is a parameter (n) that captures heterogeneities in the quantity of intermediate varieties produced across countries[36]. Both these terms will enter the production function and will be decreasing in the degree of substitutability. Hence as σ increases (higher substitutability) the value associated to an extra variety n will fall[37]. Similarly the influence of the φ parameter will also fall as substitutability between inputs increases reflecting that producers will be able to substitute across varieties the more similar these are perceived to be (hence attributing less value to a particular input). Incorporating these variables yields the following production function[38]:

$$X_i = A_i \left[\sum_M n_j^{\frac{1}{\sigma}} \varphi_j^{\frac{1}{\sigma}} x_{i,j}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{6}$$

A representative firm in country i produces output by combining inputs from different origins (these origins include the domestic economy). It uses more inputs from the origins that produce a greater number of varieties, n, and also from countries that produce the varieties that are most in line with the production technologies available. Although not derived, it is

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[34] This coupled with a budget constrains will imply that as more varieties are added to the system the value of each variety used will tend towards zero (i.e. spread across more varieties). So that as n tends to infinity then x tends to zero. Hence Ethier's statement of an infinite number of processes and an infinitesimal amount of input value.

[35] This parameter ranges from zero to infinity and identifies the production technologies in a particular country. It is similar to Krugman's original preference parameter for varieties. Furthermore, because producers aim to satisfy demand and consumers can be seen to prefer some varieties over others, this term can also capture the taste for a particular variety from a representative consumer.

[36] Because the interest of this model is in the demand for intermediate products, a supply model is not explicitly presented, however the presence of different efficiency variables, homogeneous within countries but different across countries, can lead to a structure where some countries can sustain more firms than others when there is a fixed cost to producing or indeed exporting (as in the Melitz (2003) heterogeneous firm literature.

[37] Intuitively this implies that the love of variety exhibits diminishing returns as substitutability increases. This set-up is similar to that of Ardelean (2006) although an additional parameter that captures the love of variety has not been introduced here as there is little interest in tracking the love of input variety. Rather the aim is to reduce this so that it reflects a more realistic production sequence.

[38] The CES structure implies that the production function is additively separable and homogeneous

assumed that the supply conditions and the efficiency parameter generate the production of a heterogeneous amount of inputs by country[39]. Similarly it is assumed that all produced output is either consumed or enters into a production process as an input. One can then obtain the input demand function by minimising costs subject to the above production function[40]. These costs are the sum of the purchases of inputs from all destinations.

$$C_i = \sum_M n_j \varphi_j p_{i,j}(x) x_{i,j} \tag{7}$$

It can then be shown that the associated input demand function for products originating from country j is[41]:

$$x_{i,j} = \frac{n_j^{1-\sigma} \varphi_j^{1-\sigma} p_{i,j}(x)^{-\sigma}}{\left[\Sigma_M \left(n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma}\right)\right]} C_i \tag{8}$$

The demand for products from country j is then a function of the relative cost of inputs from a particular country and C which captures the amount spent on inputs in country i (If all trade were to occur in intermediate products, C would need to capture gross output X_i[42]). The price term can be defined as follows:

$$p_{i,j}(x) = p_j a_j \tau_{i,j} \tag{9}$$

Where p_j is the producer price, a_j is the common mark-up in monopolistically competitive models (above unity and dependent on the elasticity of substitution term); and $\tau_{i,j}$ captures the bilateral iceberg trade cost which is above unity and represents the trade and transport barrier mark-up between countries. Much of what follows draws heavily on Baldwin and Taglione's (2007) derivation of gravity. Substituting the price equation (9) into the demand equation (8) and multiplying by the price term on the left hand side so as to capture the total value of inputs ($V_{i,j}$) yields;

$$V_{i,j} = \frac{n_j^{2-\sigma} \varphi_j^{2-\sigma} \left(a_j p_j \tau_{i,j}\right)^{1-\sigma}}{\left[\Sigma_M n_j^{2-\sigma} \varphi_j^{2-\sigma} \left(\left[a_j p_j \tau_{i,j}\right)\right]^{1-\sigma}\right]} C_i \tag{10}$$

[39] The presence of efficiency variables adjusts so that more efficient countries supply greater varieties of products. This is similar to the NEG models.
[40] Under monopolistic competition, total costs will be equal to total revenue due to free entry and exit of firms driving down profits to zero in each country. This means that it is also possible to approach the minimisation problem through the revenue function that is the sum of all sales in all destination markets
[41] See Appendix A2.2 for a step by step derivation.
[42] This would reflect the concerns of Baldwin and Taglione (2011) which suggests that, where intermediate goods trade is concerned, measures of GDP in value added terms may be inappropriate.

Where $V_{i,j}= n_j\ \varphi_j\ p_j\ a_j\ \tau_j\ x_{i,j}$ is the value of the input flow from country j. Assuming symmetry across firms so that there is a common producer price, and noting that the sum of all imported and domestic intermediate varieties must equate to the value of total costs so that $C_j = \sum_M V_{ij}$, the above function can be expressed as follows

$$\sum_M V_{ij} = C_j = p_j^{\ 1-\sigma} \sum_M \frac{n_j^{2-\sigma} \varphi_j^{2-\sigma} \left(a_j \left[\tau_{i,j}\right) \right]^{1-\sigma}}{\left[\sum_M n_j^{\ 2-\sigma}\ \varphi_j^{\ 2-\sigma} \left(\left[a_j p_j \tau_{i,j} \right) \right]^{1-\sigma} \right]} C_i \tag{11}$$

Solving for the price term yields[43]:

$$p_j^{\ 1-\sigma} = \frac{C_j}{\Omega_1}, where\ \Omega_1 = \sum_M \frac{n_j^{2-\sigma} \varphi_j^{2-\sigma} \left(a_j \left[\tau_{i,j}\right) \right]^{1-\sigma}}{\left[\sum_M n_j^{\ 2-\sigma}\ \varphi_j^{\ 2-\sigma} \left(\left[a_j p_j \tau_{i,j} \right) \right]^{1-\sigma} \right]} C_i \tag{12}$$

Substituting this expression into the demand equation (10) to eliminate the producer price and rearranging then gives a gravity type equation of the following form[44]:

$$V_{i,j} = \left(n_j \varphi_j\right)^{2-\sigma} \left(a_j \tau_{i,j}\right)^{1-\sigma} \frac{C_i C_j}{\Omega_1 P_j} \tag{13}$$

The above equation is similar, in form, to most derivations of gravity (namely Anderson and Van Wincoop 2003, Feenstra 2004, Baldwin and Taglione 2007, 2011 and Helpman et al. 2008) except that it incorporates the number of varieties that each country produces and a

[43] The term Ω_i is often referred to as market openness (AvW 2003)
[44] Here the price term is defined by:

$$P_j = \left[\sum_M n_j^{\ 2-\sigma}\ \varphi_j^{\ 2-\sigma} \left(\left[a_j p_j \tau_{i,j} \right) \right]^{1-\sigma} \right]$$

technological parameter[45]. These enter the gravity specification in a similar fashion as Anderson and Van Wincoop's (2003) 'multilateral resistance' term. It is actually an augmented multilateral resistance term that reflects a world where countries produce a heterogeneous amount of varieties and are constrained by production technologies. Another difference with respect to the traditional gravity literature is that the general equilibrium condition only occupies the value that countries spend on inputs rather than the more common income term[46].

The model presented has its caveats which are worth noting. Firstly, it does not take into consideration the possible impact of the emergence of new varieties on the price index. Feenstra (1994) suggests that not accounting for this in aggregate import price indices can be problematic. He proposes the use of 'exact' price indices that account for entry and exit of varieties between years. Broda and Weinstein (2006) then provide an empirical implementation of these new price indices showing how gains from new imported varieties arise. The trouble with these approaches is that they require an in depth knowledge of trading structures and are complicated to aggregate to reduced-form scenarios. Feenstra (1994), Broda and Weinstein (2006) and Goldberg et al (2009) exploit the trade aggregation systems to identify new varieties arising in a single country, extending this to many countries in a generalised gravity structure raises a series of theoretical and empirical complications.

Secondly, the model has avoided an exact definition of the cost functions and in particular how these interact with market conditions so that different countries can sustain a different number of varieties. Although this would be highly desirable, it is beyond the scope of this paper. It is worth noting that the heterogeneous firm literature (Melitz, 2003), and in particular the cost structures of firms as determinants of participation in export markets as in Helpman et al.'s (2008) gravity model would be a good place to start with such a model[47]. If the productivity parameter could be associated to the degree of vertical specialisation then there would be a case for countries which are more vertically specialised being able to sustain higher productivity firms which engage in export markets. However such a structure would imply the presence of different price mark-ups across countries thus complicating the derivation of gravity.

Despite these shortcomings, the model presented provides a justification for using a gravity model to estimate input trade. It suggests that particular care need be placed on what is regularly termed as 'the mass variables'; where these should reflect gross purchases of inputs rather than the typically used total income (i.e. GDP) variable (as noted by Baldwin and Taglione 2011).

5.2. *VERTICAL SPECIALISATION*

To relate the indicator of vertical specialisation to the above derived input demand equation it is useful to recall the different components of the indicator. As defined in equation (1), vertical specialisation captures the imported input content of exports. More specifically it is the value of imported inputs from a chosen partner as a share of total exports to that same

[45] A similar specification can be derived in the case where there are no technological constraints as shown in the appendix A2.2.
[46] Because the value spent on inputs is likely to be lower than total income, one would expect that, upon estimation using GDP variables, the coefficients on this measure will be below unity.
[47] Chaney (2008) also provides a gravity model for heterogeneous firms but focuses more closely on intensive and extensive margins.

partner[48]. Hence the numerator of this expression is an input demand that is similar to that derived in equation (13). The denominator of this indicator is then a total demand for exports equation. Assuming that total import demand from a partner country is isomorphic to the input demand equation (as in Baldwin and Taglione, 2011), it can be shown that equation (13) can be modified to generate an export demand equation with the following specification:

$$V_{j,i}^{T} = \frac{Y_i Y_j n_j^{2-\sigma} \varphi_{i,j}^{2-\sigma} \left(a_j \left[\tau_{i,j} \right) \right]^{1-\sigma}}{\Omega_i \left[\sum_n n_j{}^{2-\sigma} \varphi_j{}^{2-\sigma} \left(\left[a_j p_j \tau_{i,j} \right) \right]^{1-\sigma} \right]}$$

(14)

Here the subscripts are reversed from specification (13) to reflect that country i's exports to country j are country j's imports from country i ($V_{j,i}^{T}$). This function has similar determinants to those of the input demand equation. However a few changes arise. The technology constraints (φ) now represent taste parameters for consumers but exhibit similar properties in terms of substitution i.e. the degree of substitution between goods used for final consumption and those used for input demand is assumed constant and the same. The number of varieties that each country produces also enters the specification in the same way. The main difference between (13) and (14) is found in the income terms that appear in the latter equation but not in the former. This is because income is assumed to be fully exhausted in the purchase of final and intermediate products whereas in equation (13) the assumption was that only a share of this would be exhausted by intermediate demand (C_i that is derived from (7)).

Deriving an expression that captures vertical specialisation in its share format can then be done by dividing (13) by (14) so that:

$$VS_{i,j} = \frac{V_{i,j}^{I}}{V_{j,i}^{T}} = \left(\frac{n_j \varphi_j}{n_i \varphi_i} \right)^{2-\sigma} \left(\frac{\tau_{i,j}}{\tau_{j,i}} \right)^{1-\sigma} \frac{C_j C_i}{Y_j Y_i}$$

(15)

This equation suggests that the degree of vertical specialisation between two partners will depend on the relative amount of varieties that each produce; the relative preferences for these varieties; the share of output that is spent on intermediates; and the relative mark-ups and trade costs between partners[49]. What is particularly convenient about this set-up is that it lends itself to the elimination of unobservable factors that may bias estimated coefficients in a typical gravity setting. This is because some of the time invariant bilateral characteristic between partners will cancel out. Effectively, the multilateral resistance (P) and Openness

[48] In its fully bilateral form although it can also be presented as a share of total exports rather than exports to the same country where the inputs originated.

[49] For simplicity it is assumed that mark-ups are the same across countries and hence are not presented in equation 15.

(Ω's) terms have been eliminated[50]. These expressions can then be used to inform the empirical strategy.

6. ECONOMETRIC ANALYSIS

Estimating the impact of a trade agreement on vertically specialised trade has to be approached with care. Traditionally, FTA impact effects have been captured through dummy variables introduced into a gravity model. However, Baier and Bergstrand (2002, 2004, and 2007) warn us that such an approach will need to account for the endogenous formation of FTAs. Countries select into agreements, and possibly for reasons that also drive their current level of trade. If two countries sign a trade agreement as a result of factors that are unobservable, to the econometrician, and which are correlated with current trade flows, then standard cross-sectional OLS estimations will be biased and the effects of a trade agreement may not be appropriately captured by the FTA coefficient.

Baier and Bergstrand (2004) argue that preferential partners tend to share similar characteristics that should theoretically enhance the gains from a concluded FTA. This implies that they have chosen their partners 'well' and also that there is a strong case for rejecting the hypothesis that the FTA variable is exogenous. Magee's (2003) work supports this idea. He finds that high levels of bilateral trade increase the probability of an FTA being concluded[51]. Using a cross sectional gravity model for the year 1980, Magee finds a positive FTA coefficient for agreements that were only present in the period 1985-2001. Hence countries engaging in preferential trade deals were already heavily engaged in 'above average' trade. In a similar vein, Holmes (2005) uses the minimum export share between two partners to predict the probability of these forming a trade enhancing FTA. Compelling evidence of endogeneity is also found in Baier and Bergstrand (2007) who show a strong instability both in the magnitude of the FTA coefficient and in its sign when running a series of cross sectional gravity estimations at varying time intervals. They argue that unobserved heterogeneity is likely to be the main cause for this.

To grasp the problem, it is useful to consider a 'true model' of intermediate goods trade taking the following form[52]:

$$V_{ij} = X_{ij}\beta + v_{ij}$$
$$v_{ij} = c_i + u_{ij} \tag{16}$$

The value of intermediate goods trade between two countries (V_{ij}) is determined by a set of observable covariates X_{ij} and an error structure v_{ij}. The latter is formed of an unobservable component that is individual country specific, c_i, and a random error component exhibiting the usual properties ($E(x_{ij}| u_{ij}) = 0$). If the unobservable term c_i is uncorrelated with the covariates then one can estimate equation (16) using traditional OLS. This is because the composite error term comes to exhibit normal properties (i.e. is a random disturbance). However if $Cov(x_{ij},c_i) \neq 0$ then OLS will yield biased estimates of the β coefficients. In the case of vertical specialisation, as in the case for normal trade flows, this unobserved

[50] The specification where the world becomes the destination of exports changes the above expression somewhat in the sense that the denominator is expressed with respect to the world rather than with respect to country j.

[51] This is sometimes known as the 'natural trading partner' hypothesis. It sees countries engaging in above normal trade as more prone in concluding trade agreements.

[52] Time subscripts are dropped for presentational purposes

heterogeneity is likely to arise through the correlation between the unobservable variable, c_i, and the FTA dummy introduced in the covariates. Baier and Bergstrand (2007) argue that this arises from country specific characteristics which drive both selection into trade agreements and also the value of current trade flows[53].

An example can serve illustrate how unobserved heterogeneity arises. Consider the case where Country A has a larger than normal import flow from Country B because it has an 'affinity' for the set of products that this country produces. Symmetrically, Country B also exhibits similar affinities for Country A products so that these countries are close trading partners in terms of volumes of trade. Because these affinities cannot be observed by econometricians and affect both the degree of trade between countries and possibly the selection forces to form an FTA (i.e. its desirability), then not accounting for these, when estimating the impact of an FTA on trade flows, will yield biased estimates on the FTA coefficient[54]. Unobserved heterogeneity can also arise from differences in regulatory frameworks across countries. Again, if two countries have different standards for the production of automobiles, but share the complementary characteristics needed for value chain interactions, then they may wish to engage in bilateral regulatory harmonisation through an FTA. This difference in regulatory frameworks will be both a reason to engage in a preferential trade deal and also a factor that affects current, and indeed past, trade flows.

Consider the outcome variable VS with subscript 1 to be the observed degree of bilateral vertical specialisation between two countries that share an FTA and VS with subscript 0 to occur where there is no FTA. Ideally, if one could observe both VS levels with and without an FTA for a given dyad of countries for a particular year, then the Average Treatment Effect (ATE) of belonging to an FTA could be calculated as the difference in the means of the observed outcomes conditional on a set of covariates x[55]:

$$ATE = E(VS_1 - VS_0 \mid x) \tag{17}$$

Such an approach would yield consistent estimates under the assumptions that; i) the outcomes variables are independent so that the degree of VS between two countries does not affect that between others; ii) observations are drawn from a random sample; and iii) the treatment indicator (FTA) is mean independent of both VS_1 and VS_0 (ignorability of treatment). For the first assumption to hold, general equilibrium effects, which are likely to be important where vertical specialisation is concerned, would need to be ruled out[56]. The second

[53] Baier and Bergstrand (2007) suggest that biases in the estimation of FTA effects are likely driven by unobserved heterogeneity rather than omitted variables or errors in measurement.

[54] In this example, the bias is likely to be positive. This is because the FTA variable will be capturing the positive effect of the agreement but it will not control for the affinities that make country A and B trade more with each other. If these were appropriately controlled for, or if these were observed, one would expect the FTA coefficient to be lower.

[55] Clearly it is impossible to observe the degree of vertical specialisation with a given partner in the presence and absence of an FTA, but this set-up is for expositional purposes so that one can delimit the problem that arises in the estimation procedure.

[56] The independence assumption is a very strong one that has been made in the literature and that is likely to be violated in this type of estimation. Not only are trade flows not likely to be independent, i.e. if I am sourcing my intermediates from one country I am not doing so from another, but also the FTA variable may not be independent either. Baldwin (1993) suggests that engaging in an FTA comes as a result of a dynamic process where 'juggernaut' and 'domino' effects arise. These reflect the fact that being left out of a large FTA can change incentives to form or join FTAs. There is also a growing literature that is concerned with spatial

and third are similar in nature and are likely to be violated because of the aforementioned selection effects. It implies that there are variables which may be unobserved that determine both the participation and the outcome variable. If these can be controlled for, through observable covariates (i.e. selection), then it is possible to estimate the ATE as follows (provided independence holds)[57].

$$E(VS|\ x,FTA) = E(VS_0|x,FTA) + FTA[E(VS_1|x,FTA) - E(VS_0|x,FTA)] \quad (18)$$

Dealing with this unobserved heterogeneity in cross-sectional estimations has been approached in a variety of ways. For instance, Magee (2003) and Baier and Bergstrand (2004) use an IV (Instrumental Variables) approach. But the reliability of their results hinges on finding suitable instruments that are correlated with the FTA variable but not with the unobservables that are driving trade flows. Baier and Bergstrand (2007) argue that this condition is not satisfied in these papers and indeed that any IV approach is going to be complicated on account of selection variables being highly correlated with gravity variables[58]. A Heckman control function may also be problematic due to such strong correlations between the determinants of FTAs and trade flows. Hence more recently, non-parametric, matching techniques have been employed. Baier and Bergstrand (2009) do this for trade flows whilst Egger et al. (2008) look at the impact of trade agreements on the structure of trade (i.e. intra industry trade). These techniques are well suited to a cross sectional approach and are also accommodating because they do not impose constraints on the distributions of the covariates[59].

However, Baier and Bergstrand (2007) argue that cross-sectional estimations do not generally lend themselves to treating the endogeneity bias as well as panel data approaches do. If the 'true' model of intermediate goods trade in (16) has an unobservable, c_i, which is country specific, then it is possible to control for unobserved heterogeneity through the use of country specific dummy variables or fixed-effects (FE)[60]. Alternatively, if unobserved variables are also time specific, a panel data approach with country-time fixed effects would also be appropriate. Hence one should be able to "draw strong and reliable inferences about the ATE of FTAs using the gravity equation applied to panel data" (Baier and Bergstrand, 2007: p.84). Feenstra (2004) also favours such an approach arguing that it is an appropriate technique to control for multilateral resistance (Anderson and Van Wincoop, 2003). One can then test whether such methods appropriately control for unobserved heterogeneity. Baier and Bergstrand (2007) suggest that if appropriate controls have been implemented, then current

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correlation in gravity models. A thorough analysis of these is beyond the scope of this paper, but it is important to note that this may be an issue in the estimation.

[57] We are equally interested in the average treatment effect on the treated (ATET) which specifies the effects of an FTA on vertically specialized trade in the presence of an FTA

[58] Baier and Bergstrand (2007) argues that Magee's (2003) use of GDP similarities or Intra industry trade in the selection equation does not remove the problems associated with unobserved heterogeneity given that the instruments used do not satisfy the independence conditions. These are likely to be correlated with the formation of FTAs and also the factors that cause trade.

[59] Such techniques are also useful because they can capture non linearities that may arise as discussed in Baier and Bergstrand (2009).

[60] Fixed effects are directly introduced because it is implicit that a model where the unobservables are allowed to be correlated with the covariates is preferable. Random effects models assume no correlation. Which is preferable can be determined on econometric grounds through a Hausman test. Another approach is the use of difference in difference techniques.

trade flows should be uncorrelated with future FTAs, and this can be easily tested econometrically.

Estimating gravity models conjures other challenges. One is the presence of zeros in the trade matrix. This affects the log-linearisation of the model and results in zero trade flows being indeterminate. Generally, the ad hoc solution of dropping the observations where trade flows are inexistent, or adding a marginal value to these is used[61]. But this approach does not deal with the reason behind the presence of zeros. The severity of the problem is proportional to the amount of zero's in the sample and to the underlying reasons for the presence of these. Although Silva and Tenreyro's (2006) Poisson Pseudo Maximum Likelihood (PPML) estimator facilitates the estimation of gravity in the presence of zero trade flows, it does not get to the bottom of the reasons for the presence of zero trade between countries. Helpman et al. (2008), in a gravity model that is derived from the heterogeneous firm literature, use a Heckman (1979) selection equation where the first step models the probability of trade occurring between two partner countries and the second step then uses the mills-ratio from this first step in a gravity equation.

Another challenge that has recently surfaced in the gravity estimation literature is to do with spatial correlation. In particular, most gravity models assume that the FTA variable is independent so that the formation of a trade agreement between two countries is determined by the characteristics of these countries alone. However there is a growing literature on the impact of trade agreements on third countries and indeed some models of FTA formation (Baldwin, 1993) suggest that the incentives to form, or join, a trade agreement change as a result of neighbours' engagement in preferential trade deals. Behrens et al. (2007) suggest that spatial autocorrelation models may be useful in dealing with such issues[62].

6.1. DATA

Several measures of vertically specialised trade, which track the use of intermediate imports in the production of exports, are used in the empirical analysis. These are calculated from equation 1 using the Input-Output (IO) tables of the OECD STAN database. Without going into great detail on how these are calculated (see Lopez-Gonzalez and Holmes 2011), a few salient characteristics of the dataset are herein recalled. First, all IO matrices used are reduced to 25 sectors (25x25) which are homogeneous across all countries. This is done so as to match the trade data to the IO tables. The outcome largely reflects a manufacturing world where all service sectors are condensed into one sector[63]. Data is available for a selection of 39 countries and a period of 14 years (1995-2008)[64]. Because the IO tables are only available in periodic (generally 5 year) intervals, they are extended annually so as to obtain yearly

[61] Given that the natural logarithm of zero is undefined, adding a small value of trade to all observations can resolve this issue. Although this simple fix is useful, it does not take into consideration the fact that zero trade flows are indeed important because they can come as a result of selection effects.

[62] The incorporation of spatial correlation into gravity estimations is implicit in AvW who suggested that trade flows depended not only on the proximity of a partner but also on the distance to other third markets.

[63] This means that there is no service trade between countries. Given that the aggregate indicator is a weighted average of the sectoral VS, removing these can cause either an upward or downward bias in the actual degree of VS depending on the importance of service sectors in i) total trade and ii)vertically specialised trade. Preliminary observations suggest that VS in services seems to be lower than that of manufacturing.

[64] The countries in the sample are Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States, Argentina, Brazil, Chile, China, Estonia, India, Indonesia, Israel, Romania, Russia, Slovenia, and South Africa.

estimates of the desired dependent variables. The extensions are based on the 1995 tables for observations from 1995 to 1997; those between 1998 and 2002 come from the 2000 base year tables; and the observations for 2003-2008 are from the 2005 tables. Values are deflated to 2000 prices using specific country deflators from the OECD and converted into dollars using exchange rates from the Penn World Tables.

The extension of the technological coefficients across years close to the base tables has certain implications. The first is that the technological coefficients are assumed to remain relatively stable in periods close to the base years. Although the Input Output literature suggests that this is a reasonable assumption (see Vaccara, 1986 and UN, 1999), one might expect changes in technological coefficients to be more pronounced as a result of the growing international fragmentation of production. This might result in a downwards bias in the measures of vertically specialised trade. However, the advantage of using the OECD database, as opposed to other sources of IO data such as the GTAP database, is that it covers more base years and hence allows calculated measures of VS to vary through changes in technology and also through changes in trade shares[65].

The technological constraints of the system, dictated by the proportionality assumption used, see the use of intermediate imports across origins as the same irrespective of the origin of the intermediate imports. Hence if Mexico requires 0.3 units of imported intermediates to produce one unit of output, it will import inputs in this proportion from all countries. This assumption is common in the literature and is also used in Johnson and Noguera (2011). One of the implications arising from the reliance on such assumptions is that the measures of vertically specialised trade are computed rather than observed measures. This implies that they are proxies for value chain activity.

6.1.1. Measures of Vertically Specialised Trade

The empirical analysis will begin with a calibration exercise that will use total bilateral trade flows, extracted from COMTRADE, to identify the most suited empirical approach to eliminating complications that may arise from unobserved heterogeneity. Once the appropriate empirical specification has been identified, the role of an FTA on several measures of vertical specialisation will be investigated. This will initially be done on the basis of the *value* of intermediate imports (equation 13) and subsequently on the share of intermediate imports over exports (equation 15)[66].

Four different measures of the value of intermediate goods trade between countries will be looked at. These capture the three different *uses* that can be given to imported inputs where each of these identifies different involvements in value chain activity.

1. Intimps_bec: captures the value of total intermediate imports, from a partner country, identified suing the BEC nomenclature. It does not differentiate across the use of imports

[65] Unlike the indicators calculated by Johnson and Noguera (2011) which only exhibit variations through changes in trade shares.

[66] The rationale for looking at the role of trade agreements on the value of vertically specialised trade is that it allows one to track how an FTA affects backward and forward linkages simultaneously. It is convenient to recall, from Lopez-Gonzalez and Holmes (2011), that the backward linkage of Mexico with the US is the same, in value terms, as the forward linkage of the US with Mexico. Additionally, using values as dependent variables also facilitates identifying the role of an FTA as a share measure could be affected by FTA impacts on the numerator and also on the denominator

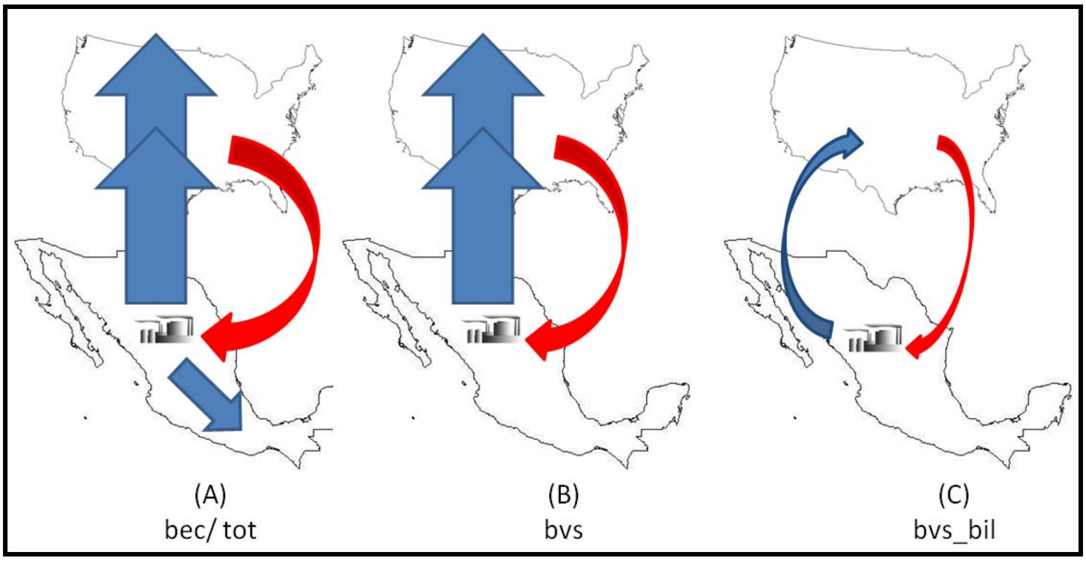
which here may serve to satisfy either domestic demand or exports. (see Diagram A in Figure 1)

2. Intimps_tot: is the same measure as above but uses IO tables to identify the value of intermediate imports rather than the BEC nomenclature[67]. (see Diagram A in Figure 1)
3. Intimps_bvs: measures the value of intermediate imports, from a partner country, that are used in the production of world exports. This measure is calculated using the OECD IO tables and trade data from Comtrade as per equation 1. (see Diagram B in Figure 1)
4. Intimps_bvs_bil: then captures the value of intermediate imports from a partner country that are used in the production of exports to that same country. This measure is calculated using equation 1 but with a different destination for export flows. (see Diagram C in Figure 1)

Figure 1 provides a visual representation of how intermediate imports can be used in productive processes using Mexico and the US as examples. The red arrows show the different intermediate import flows that the above measures capture. The difference between these is in the use that is given to the intermediate inputs which depends on the destination of the output flow here shown through the blue arrows. The first two measures (1) and (2) are depicted in the first diagram (A) of this figure. They both capture Mexico's total intermediate imports from the US but use a different identification criterion to identify imported inputs (the first using the BEC nomenclature the second using IO tables). They represent Mexico's total use of imported intermediates from the US irrespective of whether these inputs serve to produce domestic output or exports to any destination. Differentiating across identification strategy is useful because the BEC nomenclature has often been described as arbitrary and hence comparing BEC identified intermediate imports with intermediate imports identified from IO tables will help test how arbitrary this nomenclature really is. The third measure is then associated with diagram (B). It captures the value of a subset of Mexico's intermediate imports from the US, namely those that Mexico uses to produce total exports. The final measure of intermediate imports, diagram (C), then captures yet another subset of Mexico's intermediate imports from the US but in this instance those which are used to produce products that are exported back to the US. As can be seen by the size of the red arrows, the value of imported intermediates declines as a more narrow use for imported inputs is identified.

Figure 1: Value of Intermediate Imports Differentiated by Use

[67] This is essentially the sum of the calculated bilateral intermediate import matrix.



In addition to looking at the impact of an FTA on the value of intermediate imports, it is also relevant to look at how an FTA affects the structure of trade. This is done by using an indicator of bilateral vertical specialisation, bvs_bil. The numerator of this measure is the value of intermediate imports (in measure (4)) and the denominator is the exports to the destination from which these inputs originated (see also equation 15). In looking at the role of an FTA on the structure of trade it will be important to bear in mind that an FTA is likely to affect both the numerator and the denominator of this expression and hence caution will need to be taken in its interpretation.

The rationale for differentiating across the use of intermediate products is that these can identify different facets of production sharing. The first two measures capture the aggregate use of intermediates, but the final two measures may be more representative of international and bilateral value chain activity respectively. This is because both the origin of the input and the destination of the resulting output is international. FTAs may impact such flows differently.

6.1.2. Other Variables

The typical gravity variables are drawn from CEPII's gravity database. It provides the time invariant geographical indicators as well as the bilateral identifiers of the presence or absence of an FTA. This variable is coded so that it is equal to unity when there is an FTA between two partners in any given year and zero otherwise. It is extended to include the two extra years in the sample; 2007 and 2008 through imputation informed from the WTO RTA database (see appendix A2.3 for further details). This variable only captures reciprocal FTAs and hence does not identify unilateral preferences.

The theoretically derived gravity model of input trade (13) suggests that input varieties and technological constraints are also likely to be important in determining the value of intermediate imports. Partner country GDP per capita will be used as a proxy for the amount of varieties partner countries produce and non-linearities in this term will be introduced through the log of this variable squared[68]. The Finger-Kreinin (FK) indicator will be used to

[68] This is in effect a transposition of the Linder (1961) hypothesis which postulates that countries that have higher income demand more new varieties. Additionally, the correlation between varieties and GDP per capita is

proxy for reporter country preferences for partner country goods or for the technological parameters (φ)[69]. This is a bilateral measure that captures the similarity in the composition of reporter and partner exports to the world. To the extent that a more similar composition of exports might be evidence of similar factor intensities in the production structures, this indicator can be used to gauge whether trade predominantly occurs between similarly endowed countries or not. Many gravity models use a GDP per capita variable for this very purpose[70], hence including the FK variable should allow GDP per capita coefficient to more fully capture the variety effect rather than the factor endowment composition effect. The main variables used in the estimation are summarised below.

Table 1: Variables used in Gravity Model Estimation

Variable	Description	Source
Vertical Specialisation*	The import content of exports. Calculated using expression (1). (the variables used in the estimation are described in more detail below)	OECD STAN database and Comtrade. (see details in Appendix A2.3)
intermediate goods*	Calculated using expression (1) but presented in value terms rather than as a share of exports as above. (see Figure 1.)	See above.
Trade	Total exports and total imports (deflated[71])	Comtrade using WITS
GDP	PPP Constant 2000 prices (country deflators)	WDI
GDP per capita	PPP Constant 2000 prices (country deflators)	WDI
FK	Used to capture the production technologies of countries	Comtrade, calculated using TradeSift
Distance variables (trade costs)	-Contiguity =1 for contiguity -Comlang_off= 1 if same official language -Dist = Distance from capitals -Dist_w = weighted distance -Pop = population -area = area in sq kms	CEPII gravity database
FTA	-FTA=1 if countries in FTA, else =0	CEPII gravity database (extended for 2007 and 2008 using RTA database in WTO webpage)

Notes: * values deflated using OECD PPI[72]

6.1.3. Characteristics of the Database

The incidence of trade agreements in the sample is captured in Table 2. In 1995, around 25% of countries are part of a trade agreement where 192 dyad agreements are identified. This figure rises to 48% by 2008 with 357 dyads in an agreement showing the well documented

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documented in Saure (2009) who uses Feenstra and Kee (2004) for the identification of varieties and correlates this measure with per capita GDP. Funke and Ruhwedel (2001) also suggest that varieties and GDP per capita are highly correlated.

[69] Finger Kreinin indicator represents the similarity in exports to the world between country *i* and *j*: $FK_{i,wld,t} = \sum_c \min\left(\delta_{i,wld,t,c}, \delta_{j,wld,t,c}\right)$. Where $\delta_{i,wld,t,c}$ and $\delta_{j,wld,t,c}$ are the share of exports from country *i* in product *c* to the world and the share of exports from country *j* in product *c* to the world, respectively. It captures the similarity of exporting structures across two countries and hence may be indicative of similarities in the factor content of exports.

[70] See a broader discussion of including GDP per capita in Markusen (2011).

[71] Baldwin and Taglione (2007) suggest that deflating trade data using a common country's price index, such as the US deflator (commonly used in the literature) can induce biases. An appropriate use of FE may also reduce biases from using nominal values.

[72] The OECD PPI is used to deflate the trade data although it is acknowledged that the choice of deflator is important. An alternative option would have been to use country specific deflators but it is possible that these are more revealing of changes in domestic non-tradeable goods rather than internationally traded products. Given that there is little information about trade deflators we will rely on econometric techniques to minimise price effects in the estimations (i.e. through the use of country-year effects).

rise in regionalism. Table 2 also suggest that the temporal variance in the FTA variable may be small. Indeed only 22% of dyads *switch* into an agreement during the sample period so that 77% of the possible dyads are either in an agreement for the entirety of the sample time (25% of the sample) or in no agreement throughout (52% of the sample)[73]. Agreements with no temporal variation include the EU-15, NAFTA, EFTA, ANZCERTA and MERCOSUR. In addition, the sample is relatively euro-centric where, of the 196 dyad agreements in 1995, 105 involve the EU-15 agreements[74]. This may be problematic if unobservable characteristics of EU countries drive the results of the estimation. This can arise if differences in the depth of integration are important. Because an FTA between Chile and Japan is more 'shallow' than one between Germany and France, having a large set of 'deep' agreements in the sample may inflate the impact of an FTA on trade[75].

Table 2: Count of FTA variable by dyad 1995 - 2008

	YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
FTA	No	545	526	519	514	501	473	459	456	442	391	389	386	385	384
	Yes	196	215	222	227	240	268	282	285	299	350	352	355	356	357

Notes: The values show the number of dyadic agreements.

Although the sample is largely composed of developed countries from the OECD, it also comprises several emerging economies such as Brazil, China, Russia, India, South Africa and Indonesia. There are however no LDCs (due to data limitations) which implies that the analysis is constrained to a particular set of countries that have achieved a certain level of development[76]. Nevertheless, the 39 countries in the sample represent just over 80% of world trade in 2008 where the EU-27 alone represents around 37% of world trade[77]. One of the positive consequences of using such a largely industrialised-country sample is the near absence of zero trade flows. Out of over 20,000 observations there are 79 zero's in the trade matrix[78]. This suggests that the estimation of the gravity model should not concern itself too much with the presence of zero's in the trade matrix.

The geographical dispersion of the countries in the sample is shown in Figure 2. The left hand panel suggests that preferential partners tend to be geographically concentrated. However there is certainly evidence of a cluster of more distant countries engaging in preferential agreements[79]. To the extent that the gravity model will control for distance effects this should not be overly problematic.

Figure 2: Distance and FTA formation

[73] Table A2.2. in the appendix, detailing the characteristics of the variables of interest, confirms a much lower within than between variation for the FTA variable in the sample.

[74] Note that this number is smaller than what would be expected if all EU countries were in the sample (i.e. 15*14=210) because Belgium and Luxembourg do not feature.

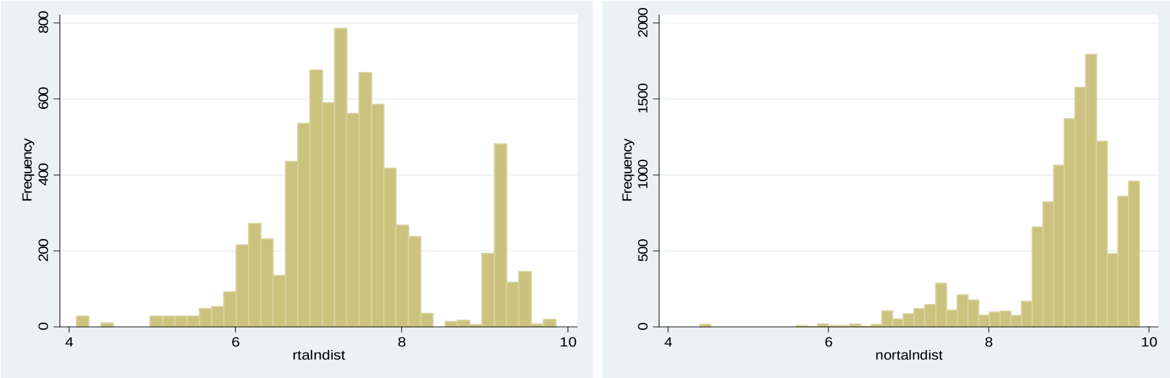
[75] Various robustness checks of the results are presented so as to ascertain that the results are not being driven by EU effects.

[76] Although we expect little value chain activity arising with these countries, not having them in the sample can be constraining. It would have been an interesting exercise to include these to relate usefulness of trade policy in promoting value chain participation in these types of countries. With our current sample we can only draw generalisations on such issues

[77] The EU represents 48% of the trade data in the sample in 2008

[78] 38 of which occur due to the lack of data for Russia in 1995

[79] This raises the issue of what distant countries are engaging in FTAs? and whether this is a new phenomenon or not. Issue that will be investigated in a forthcoming article.



Notes: The left panel shows the distance between FTA partners whereas the right panel shows the distance between countries that do not share an FTA. This is over the entire sample.

6.2. Model Specification; Choosing the Fixed Effects

The theoretical model derived in the previous section is an augmented gravity model which can be used to capture the impact of a trade agreement on intermediate goods trade. However, the empirical specification will need to be approached with care so that it accounts not only for the 'multilateral resistance' (Anderson and Van Wincoop, 2003) and 'openness' terms but also for the endogenous formation of trade agreements (Baier and Bergstrand, 2007). Furthermore, variety and technology constraints, which are not generally present in traditional gravity models, also need to be incorporated into the estimating equation. Not including these variables when looking at the impact of an FTA on intermediate goods trade could also give rise to incidences of unobserved heterogeneity (if these variables are correlated with incentives to form trade agreements).

One can mitigate, or even eliminate, many of the biases that arise from unobserved heterogeneity through the use of an appropriate set of fixed effects (see Baier and Bergstrand, 2007; Feenstra, 2004; and Baldwin and Taglione, 2007). Such models are preferable to random effects (RE) approaches because they accommodate for correlations between the unobserved variables and the FTA variable, which, according to Baier and Bergstrand (2007 - henceforth BB), are the source of the biases in such estimations[80]. BB estimate the following gravity model of trade:

$$lnM_{i,j,t} = \beta_0 + \beta_1 (lnRGDP_{i,t} * lnRGDP_{j,t}) + \beta_2 (lnDIST_{i,j}) + \beta_3 (CONTIG_{i,j}) + \beta_4 (LANG_{i,j}) + \beta_5 (FTA_{i,j,}$$

$$\beta_0 = \alpha_{i,t} + \rho_{j,t} + \sigma_{i,j}$$

(19)

Imports of country i from country j at time t (M_{ijt}) are explained by covariates that capture economic mass (GDPs of reporter and partner country); geographical barriers (distance, contiguity and language); and trade policy variables (FTA). The economic mass variable represents the demand and supply conditions whereas the remaining variables reflect trading costs. BB introduce country-year and country pair fixed effects as control measures for unobserved heterogeneity (captured here in β_0)[81].

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80 Support for the use of a FE model over a RE is also established in the basis of a Hausman test.

81 See Egger (2000) for a discussion of the superiority of FE estimation over RE models in a gravity setting.

Following an assumption that sees the consumer demand for imports as isomorphic to a country's demand for inputs, the model derived in equation 14 can be log-linearised into the following estimable gravity model of total trade:

$$lnM_{i,j,t} = \beta_0 + \beta_1 (lnGDP_{i,t} * lnGDP_{j,t}) + \beta_2 (VARIETY_{j,t}) + \beta_3 (PREF_{i,t}) + \beta_4 (CONTIG_{i,j}) + \beta_5 (LANG_{i,j}) +$$

$$\beta_0 = \alpha_{i,t} + \rho_{j,t} \quad (20)$$

The main difference between (19) and (20) is that the latter includes a variety and a consumer 'preference' variable. However, when estimated, these models are very similar. This is because BB's model incorporates country-year FEs which are collinear with the variety and 'preference' variables. This goes to show that using an appropriate set of FE can compensate for omissions in the gravity specification.

But the selection of the FE in these models needs to be approached with care. The choice of one set of FE over another will affect the variance of the variables and hence can affect the interpretation of the FTA coefficient. The fixed effects in (19) include country pair controls which introduce a variable that fixes, or is collinear with, all country pair characteristics; hence if the cause of unobserved heterogeneity is bilateral and time invariant in nature then this serves as an appropriate control for unobserved heterogeneity. However, the use of such FE also restricts the FTA variable so that it only varies in time across a given dyad. Therefore the FTA coefficient in this estimation captures the impact of *switching* into a trade agreement[82]. If the temporal variance of the FTA variable is large enough, then this is tantamount to calculating the impact of an agreement, and this is the case in BB's sample which ranges from the year 1960 to the mid 90's[83]. However in shorter panels, such as the one used here, the temporal variance of the FTA variable is restricted and hence using such FE may not capture the desired FTA effect.

The sample used in this paper contains data from 1995 to 2008, it comprises many agreements that were already in place at the beginning of the sample period and hence for which there is no temporal variance[84]. Therefore, estimating (20) using this sample and bilateral fixed effects would only capture the impact of new FTAs on trade flows, or the impact of 'switching' from no agreement to an agreement. This would imply that the effects of the EU-15, NAFTA, EFTA, MERCOSUR and ANZCERTA agreements would not be captured because these FTAs where in place before the beginning of the first year of the sample and there has been no 'switch' in these in time (i.e. FTA=1 throughout sample period). This then suggest that tackling endogeneity issues may be *preferable*, in this instance, through a model that does not use pair-wise FE[85]. For this purpose, a set of interacted FE that control for reporter-year and partner-year characteristics is proposed[86].

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[82] This transpires by virtue of the within variation estimator that is characteristic of FE models.

[83] Although it is worth stressing that BB would 'miss' the effects of the original EEC agreement.

[84] It is limited because indicators of vertically specialised trade require the use of IO tables which are not available before 1995 in harmonised formats.

[85] Another issue that arises from the use of pair-wise FE is that if the FTA variable does not exhibit temporal variance, then effectively an estimation that uses these is comparing a treated group of countries which have switched into an agreement against a control group of countries that have not switched. This control group will include countries that have not switched their preferential status but that are in an agreement throughout the

The use of these is justified on various grounds; first, on the basis that these control for the traditional country specific and time varying multilateral resistance terms. Second, that they also provide appropriate controls for other important time varying unobserved characteristics such as the amount of varieties produced across countries and specific country technologies. This choice of FEs implies that one adheres to the assumption that the determinants of FTAs are country-year specific. Or that selection into agreements and trade flows are determined by common parameters that are country year specific. But the use of these controls has to be justified, particularly in light of BB's proposed use of bilateral fixed effects. Moreover, it is also important to understand how these country-year FEs affect the variance of the FTA variable, or in other words what the FTA coefficient captures in the presence of these controls.

The introduction of country-year FE implies the use of different intercepts for each reporter-year and partner-year observation. Hence, for any given reporter-year observation, the FTA variable varies across partners in that same year. So the FTA coefficient should capture differences in trade, intermediate or not, between say Mexico's preferential partners and those with whom Mexico does not share an agreement. Effectively, one would be comparing how much more Mexico imports from the US, a preferential partner, to how much it imports from a non preferential partner such as China in a given year and controlling for the different characteristics of these partner countries[87].

Table 3 shows the results obtained from estimating equation (20) for total trade. The first column identifies the OLS estimates; the second column adds bilateral and time fixed effects (FE1); the third column includes individual country (reporter and partner) and time fixed effects (FE2); and the fourth column is the specification that includes reporter-year and partner-year fixed effects (FE3). Focusing on the FTA coefficient; the first column shows that the impact of an FTA on trade flows is of around 29%. Here there are no controls for unobserved heterogeneity or multilateral resistance and hence these estimates are likely to be biased. In the second column, the FTA coefficient captures the impact of *switching* into an agreement through the use of bilateral FE. This is associated with an 11% increase in bilateral trade[88]. In the third column, using individual reporter, partner and year effects, an FTA is seen to increase bilateral imports by 26%. The large difference between the results obtained in the previous columns may reflect the aforementioned constraints on the variance of the FTA variable imposed through the use of different FE.

The final specification then uses country-year FE. Here the sign and size of the coefficients are in line with the literature. The mass coefficient is positive and close to 1 and trade flows are decreasing in distance but increasing with contiguity and a common official language[89]. The FTA coefficient in this specification sees the impact of an FTA increasing the value of

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sample and also countries that have not switched but are not part of an agreement. This may generate a downwards bias in the estimated FTA coefficient.

[86] Baltagi et al (2003) use these in conjunction with reporter, partner, year and bilateral FE, but they are not interested in the FTA coefficient. Ruiz and Vilarrubia (2008) then suggest that country-year FE are appropriate controls for multilateral resistance terms.

[87] i.e. the within variance is country year specific with respect to partners.

[88] This is calculated by taking the exponential of the coefficient.

[89] The mass variables take on a coefficient of 1although many empirical studies find different coefficients for these. Baldwin and Taglione (2007) suggest that this may arise because of the inappropriate use of FE or indeed to an erroneous (or theoretically inconsistent) deflation of the independent variables. Other justification for coefficients above or below unity have been attributed to the importance of non-tradables within an economy.

total imports by around 27%[90]. This is somewhat lower than the FTA effect found in the OLS estimation which may reflect an upward bias in the OLS estimates. This is consistent with Baier and Bergstrand's (2004) hypothesis that countries that engage in trade agreements have chosen 'well'[91]. The variety variable here only fluctuates across partners and hence is capturing relative differences in the varieties that partners produce so that more varieties seem to increase trade flows but at a decreasing rate. The consumer 'preference' variable, which is captured by the FK and is bilateral and time-varying, appears not to be significant. This is perhaps because production structures matter predominantly for intermediate goods trade rather than total trade.

Table 3: The impact of FTAs on total imports

	Dependent Variable: lnimports			
	(1)	(2)	(3)	(4)
	OLS	**FE1**	**FE 2**	**FE 3**
		(repart)	(rep, par, year)	(repyear, paryear)
Lncombgdp	0.890***	1.014***	1.003***	1.060***
	(0.00407)	(0.0244)	(0.0466)	(0.0329)
Lndist	-0.761***		-1.063***	-1.065***
	(0.00982)		(0.0544)	(0.0171)
Contig	0.576***		0.244**	0.246***
	(0.0340)		(0.111)	(0.0316)
comlang_off	0.647***		0.564***	0.567***
	(0.0274)		(0.0984)	(0.0276)
FTA	0.254***	0.104***	0.234***	0.240***
	(0.0196)	(0.0322)	(0.0676)	(0.0331)
lngdpcap_d	-1.289***	1.215***	1.200***	1.187***
	(0.0841)	(0.183)	(0.145)	(0.386)
lngdpcap_d2	0.0676***	-0.129***	-0.128***	-0.0881***
	(0.00478)	(0.0102)	(0.00859)	(0.0218)
Lnfk	0.0920***	0.254***	0.00318	-0.0340
	(0.0180)	(0.0663)	(0.135)	(0.0411)
Constant	-21.69***	-40.39***	-31.84***	-37.84***
	(0.466)	(1.333)	(2.107)	(2.851)
FE: reporter	NO	NO	YES	NO
FE: partner	NO	NO	YES	NO
FE: Year	NO	YES	YES	NO
FE: bilateral	NO	YES	NO	NO
FE: reporter-year	NO	NO	NO	YES
FE: partner-year	NO	NO	NO	YES
Observations	20,631	20,631	20,631	20,631
R-squared	0.801	0.540	0.836	0.843
r2_o	.	0.388	0.867	0.809
r2_w	.	0.540	0.836	0.843
r2_b	.	0.383	0.951	0.799

Notes: Standard errors in parenthesis and clustered across groups (G). *** p<0.01, ** p<0.05, * p<0.1. Coefficients on Dummy variables not reported for brevity

The results presented in this final column are fairly standard. They will serve as a benchmark for future reference and also as a tool for testing whether the proposed FE resolve problems that arise from the endogeneity of the FTA variable. Recalling that BB used bilateral FE in addition to the country-year effects raises the question of whether the latter alone provide appropriate controls for the biases caused by unobserved heterogeneity. It is possible to test whether these biases are accounted for by re-estimating equation 20 with the incorporation of

[90]The results in this column also appear to yield lower standard errors on the time varying coefficients when compared to column (3). Although the standard errors are bigger on the GDP per capita variable. This is due to the fact that this variable is only fluctuating across partners in this specification.

[91] i.e. the FTA coefficient is higher in the OLS estimates because countries that share trade enhancing unobserved characteristics are more likely to engage in FTAs. Because the OLS estimation does not control for these factors, it attributes the higher trade flows to the FTA and hence the coefficient is upward biased.

a future FTA variable (FTA+5 – which captures FTA status five years into the future). Baier and Bergstrand (2007:90) suggest that "if FTA changes are strictly exogenous to trade flow changes, [a future FTA (FTA+5)] should be uncorrelated with the concurrent trade flow"[92]. Hence appropriate controls will have been provided if the future FTA variable is not significantly correlated with current trade flows.

Implementing this test requires some additional thought, particularly when the FTA variable exhibits a small temporal variance. If the FTA and the FTA+5 variables are highly correlated then the test may not capture whether the set of FE used control for unobserved heterogeneity. This is because a high correlation between these variables results in the FTA+5 variable behaving like the FTA variable which should be associated with positive trade effects. An example can help illustrate this. In 1995 Mexico shares an agreement with both the US and Canada and hence the FTA dummy is equal to one with each of these countries. Because Mexico still shares these agreements in the year 2000 then effectively the FTA and the FTA+5 variables are the same and this leads to a high correlation between FTAs and their future lags as shown in Table 4 (think of a similar issue also arising with the EU countries). This implies that the test might fail to capture whether the issue of unobserved heterogeneity has been resolved and that this failure will be due to the implementation of the test on a sample with a large prevalence of trade agreements before the sample period.

Table 4: Correlation Coefficients between FTA variable and its forward lags

	Fta	fta+3	fta+4	fta+5	fta+6	fta+7
fta	1					
fta+3	0.830	1				
fta+4	0.791	0.953	1			
fta+5	0.759	0.914	0.959	1		
fta+6	0.736	0.886	0.930	0.970	1	
fta+7	0.717	0.864	0.907	0.946	0.975	1

Source: Own calculations
Note: number of observations 15260

When this test is carried out on the full sample, the FTA+5 coefficient is indeed positive and significant (see Appendix A2.4)[93]. And this may occur even when issues related to unobserved heterogeneity have been resolved. The question that is being asked from the data is whether a future FTA affects current trade flows, hence it seems reasonable that such a test be carried out on countries where the FTA variable has some temporal variance (i.e. for countries that are not in an agreement at the beginning of the sample)[94]. Effectively, refining the above question, what needs to be asked is whether countries that were *not* in a trade agreement exhibited high trade volumes with each other *before* an agreement was implemented. This suggests that the test should be carried out on a sample of countries that did not share an agreement at the beginning of the sample period. If appropriate controls for the sources of unobserved heterogeneity are provided, or controls for the reasons that cause countries to trade more or less with each other before and agreement, then the FTA+5 coefficient should not be significantly different from zero.

[92] This is effectively a test for reverse causality
[93] See appendix A2.4 for a full sample table and a discussion
[94] The selection criteria that are used identifies countries that had not signed an agreement by 1995. This includes country pairs that have no agreement throughout and also those that switch into an agreement during the sample period.

The results of this test, for this reduced sample of countries which were not in an agreement in 1995 are shown in Table 5. The positive coefficient on the FTA+5 variable in the first column suggests that countries that trade more are also more likely to form trade agreements. This OLS estimation does not control for the reasons behind countries trading more with each other pre-agreements and hence unobserved heterogeneity remains. The remaining columns of Table 5 show the results of incorporating the future FTA variable to the same estimations that were presented in Table 3. It shows that the two first sets of FE, namely bilateral FE combined with year dummy's (FE1) and individual country and time effects (FE2), continue to yield a positive FTA+5 coefficient and hence provide inappropriate controls for unobserved heterogeneity. However when the FE are country-year specific (FE3), the FTA+5 loses significance and the FTA variable recaptures its significance[95]. This implies that this type of FE control for the reasons that make countries trade more pre agreement and hence that suitable controls for the problems arising from unobserved heterogeneity have been provided, at the very least for the sample that is used in this paper[96].

Table 5: Exogeneity test with FTA forward lag

	Dependent Variable: lnimports			
	(1)	(2)	(3)	(4)
	OLS	**FE1**	**FE 2**	**FE 3**
VARIABLES		(repart)	(rep. Par, year)	(repyear, paryear)
Lncombgdp	0.893***	0.909***	0.898***	0.815***
	(0.00944)	(0.0458)	(0.0744)	(0.0814)
Lndist	-0.853***		-1.411***	-1.415***
	(0.0193)		(0.101)	(0.0365)
Contig	0.611***		0.240	0.233***
	(0.0873)		(0.193)	(0.0656)
comlang_off	0.943***		0.838***	0.841***
	(0.0655)		(0.132)	(0.0425)
FTA	0.146***	0.00597	0.0918	0.224***
	(0.0351)	(0.0324)	(0.0548)	(0.0681)
FTA+5	0.262***	0.183***	0.228***	0.0183
	(0.0498)	(0.0615)	(0.0810)	(0.0777)
lngdpcap_d	-4.974***	0.794*	0.675	
	(0.303)	(0.433)	(0.599)	
lngdpcap_d2	0.265***	-0.103***	-0.0960***	-0.00751
	(0.0166)	(0.0230)	(0.0334)	(0.00660)
Lnfk	-0.200***	0.237	0.289**	0.284***
	(0.0357)	(0.155)	(0.140)	(0.0651)
Constant	-4.649***	-33.30***	-22.02***	-17.11***
	(1.512)	(2.650)	(4.702)	(4.099)
Observations	4,550	4,550	4,550	4,550
R-squared	0.745	0.517	0.847	0.864
r2_o	.	0.395	0.797	0.764
r2_w	.	0.517	0.847	0.864
r2_b	.	0.389	0.735	0.671

Notes: Standard errors in parenthesis and clustered reporter-year, *** p<0.01, ** p<0.05, * p<0.1

6.3. *RESULTS*

The previous section was concerned with establishing the credentials of using a country-year FE approach to resolve issues that might arise from unobserved heterogeneity. In this section,

[95] A set of sensitivity test, using other future lags for the FTA variable can be found in the appendix (A2.4).

[96] Removing countries from the sample to carry out such a test may be problematic; it involves some form of selection. If this selection is driven by common factors then this test may be invalidated as it might not reflect whole sample properties. However the fact that the FTA+5 variable exhibits the desired insignificant coefficient implies that the proposed FE are appropriate for the sample that is used in this paper.

this model is used to estimate the impact of a trade agreement on vertically specialised trade[97].First this will be done for measures that capture the value of intermediate trade flows and subsequently the impact of an FTA on the structure or trade, captured through an indicator measure of vertical specialisation, will be investigated.

6.3.1. THE IMPACT OF AN FTA ON THE VALUE OF INTERMEDIATE IMPORTS

The impact of an FTA on the value of intermediate goods trade is considered first through the log-linearisation of equation (13):

$$ln I^{I}_{i,j,t} = ln(C_{i,t}\, C_{j,t}) + (2-\sigma)\ln(n_{i,j,t}) + (2-\sigma)\ln(\varphi_{i,o,t}) + (1-\sigma)ln(\tau_{i,j,t}) - ln(\Omega_{o}) - \ln(P^{1-\sigma})$$

(21)

The dependent variable is the natural logarithm of the value of intermediate imports of country i from country j. This is a function of; supply and demand forces, $C_{j,t}$ and $C_{i,t}$ respectively; the amount of varieties that countries i and j produce, n; and their technologies, φ. The rest of the terms capture the typical trade cost variables subsumed in τ, and the multilateral resistance and openness terms. One of the first hurdles faced in this estimation is the choice of the 'mass' variables that capture the supply and demand conditions for intermediates. Baldwin and Taglione (2011) suggest that using the log of the reporter and the partner GDP is likely to be an inappropriate measure because "trade is measured on a gross sale basis whilst GDP is measured on a value added basis". Additionally, the theoretical model herein derived suggested that the mass variables need to be chosen with care as the general equilibrium conditions were set with respect to the gross use of inputs rather than a net measure of income which is calculated from the OECD IO tables[98]. Using per capita GDP to capture the number of input varieties and the FK indicator to measure differences in technologies suggest the estimation of the following gravity model of input trade:

$$ln I_{ijt}^{I} = [\alpha_{(i,t)} + \rho_{(j,t)} + \beta_{1} (lnmass)_{(i,j,t)} + \beta_{2} (lnGDPcap)_{(j,t)}] + \beta_{3} (\ln FK$$

(22)

Table 6 presents the results of the estimation of equation (22) for four separate measures of intermediate imports that were discussed in the data section. The dependent variable in the first column is the log of the value of total intermediate imports identified using the BEC nomenclature (lnintimps_bec). In the second column, a similar dependent variable is used but it captures the log of the value of total imported intermediates identified using IO tables (lnintimps_tot). It is expected that differences in the reported coefficients of these estimations reveal the presence of systematic problems in the use of the BEC nomenclature. The third column then uses the log of the value of intermediate imports that are used to produce total exports to the world as the dependent variable (lnintimps_bvs). In the final column the dependent variable is the log of the value of intermediate imports that are used to produce exports to the same partner from which the inputs originated (lnintimps_bvsbil). Differences in the coefficient estimates between the estimations of these measures are expected to reflect how the use of intermediate imports might matter and in particular if there are differences between participating in an international value chain or in a bilateral value chain. The final

[97] A test for endogeneity is also undertaken when the dependent variable is intermediate goods trade and can be found in the appendix A2.4 tables A2.6 and A2.7.
[98] It is calculated by subtracting the value added of the economy from its gross output.

measure is expected to show some evidence of 'magnification' because it reflects production sequences characterised by a back and forth movement of products.

Comparing the first two columns of Table 6 reveals little differences between the coefficient estimates in a model that uses the BEC nomenclature to identify intermediate products and one that uses IO tables. This suggests that there is little evidence of the BEC nomenclature being a 'bad' identifier of intermediate products[99]. Although this point may seem trivial, it provides a degree of comfort to the studies that rely heavily on this identification method. The FTA coefficient in both equations is of a similar size and suggests that countries import 25% more inputs, in value, from preferential partners than from non-preferential partners all else being equal. The comparison of these results with those obtained in Table 3 reveal that there are little differences in the impact of an FTA on total and intermediate imports and that, if anything, FTAs affect total imports more than they affect intermediates imports (this is in line with the results obtained by Orefice and Rocha, 2011).

Turning then to column (3), which reflects international value chain activity with respect to the world, it can be seen that the impact of an FTA exceeds that which was earlier reported. The effect of an FTA is 5 percentage points higher when intermediate products are used as part of an international value chain[100]. This, a priori, suggests that vertically linked trade is more sensitive to trade policy than normal trade in intermediates or that an FTA promotes this type of activity more than it promotes total or intermediate imports. Turning then to column (4), where the dependent variable is the value of the import content of exports from the same origin/destination, the effects of an FTA are seen to be much more pronounced. Here the FTA coefficient doubles so that an agreement increases the value of the intermediate imports used in a bilateral value chain by over 65%. The mass and distance coefficients also increase considerably which may reflect that this type of trade might be more sensitive to supply and demand conditions, as well as trade costs, than the other types of intermediate goods trade. Moreover, the positive coefficient on the variable capturing technology differences, the FK indicator, suggests that this term is a significant determinant of this type of trade where more similar exporting structures are associated with higher levels of vertically specialised trade.

These results are consistent with Yi's (2003) magnification effects. The large coefficient on the mass variable suggests a higher elasticity between this type of trade and GDP than that of normal trade. Yi argues that the presence of these magnification effects, which arise in vertically specialised modes of production, can help explain why world trade has grown faster than world GDP during the last decades. The coefficient on the mass variable is consistent

[99] Notionally, perhaps both identification strategies are as bad as each other though! The correlation coefficient between these measures is 0.97.

[100] Chaney (2006) predicts that the elasticity of substitution across products affects the responsiveness of trade to changes in trade barriers differently due to opposing effects on the intensive and extensive margins of trade. The simple explanation for this is that when one allows for firm heterogeneity, a high degree of substitution reduces the associated profits that a firm can derive due to the intense competition in the market. Lowering trade barriers would then result in more competition which would in turn dampen the intensive margin of trade. In parallel a reduction in tariff barriers to trade increases the possibility of new entrants to capture market shares through higher associated profit prospects. This implies that "the elasticity of substitution magnifies the sensitivity of the intensive margin to changes in trade barriers, whereas it dampens the sensitivity of the extensive margin". If there are differences between elasticities of substitution across intermediate and final goods then the above is relevant for this investigation. To the extent that the elasticity of substitution of intermediate inputs may be lower than that of the associated final good then we can expect a higher responsiveness of new varieties entering the market through the reduction of tariff barriers. This may explain why intermediate goods trade is more sensitive to the FTA variable.

with these predictions. Yi also suggests that these types of flows should be more sensitive to changes in trading costs and this is also supported by the data. Hanson et al. (2005) also provide evidence of this, in the case of multination activity in the US, as do Egger and Pfaffermayr (2005) and Chinn (2005) who identify magnification effects associated with two way trade in components.

Table 6: The impact of an FTA on the value of intermediate imports

	(1) lnintimps_bec	(2) lnintimps_tot	(3) lnintimps_bvs	(4) lnintimps_bvsbil
Lnmass	1.062***	1.016***	1.018***	1.919***
	(0.0299)	(0.0298)	(0.0316)	(0.0420)
Lndist	-1.041***	-1.093***	-1.107***	-2.176***
	(0.0189)	(0.0176)	(0.0184)	(0.0373)
Contig	0.253***	0.257***	0.207***	0.413***
	(0.0315)	(0.0328)	(0.0333)	(0.0581)
comlang_off	0.534***	0.541***	0.561***	1.082***
	(0.0272)	(0.0282)	(0.0305)	(0.0514)
lngdpcap_d	1.133**	0.648*	0.500	1.302**
	(0.504)	(0.365)	(0.384)	(0.600)
lngdpcap_d2	-0.0798***	-0.0488**	-0.0384*	-0.0874**
	(0.0276)	(0.0213)	(0.0224)	(0.0341)
Lnfk	0.142***	0.0483	-0.0721	0.217***
	(0.0447)	(0.0441)	(0.0506)	(0.0717)
FTA	0.221***	0.225***	0.266***	0.503***
	(0.0378)	(0.0346)	(0.0378)	(0.0682)
Constant	-15.67***	-19.04***	-19.23***	-46.45***
	(2.747)	(2.111)	(2.223)	(3.253)
Observations	20,624	20,631	20,631	20,590
R-squared	0.839	0.831	0.817	0.87
Number of repyear	545	545	545	545
r2_o	0.786	0.797	0.737	0.763
r2_w	0.839	0.831	0.817	0.87
r2_b	0.725	0.762	0.626	0.696

Notes: The mass variable is the log of the product of purchases of inputs in the reporter and partner countries, standard errors are clustered by reporter-year. *** p<0.01, ** p<0.05, * p<0.1

The difference between the dependent variable in column (3) and that of column (4) lies in the use that is given to the imported intermediates. Differences in the coefficient estimates suggest that traditional gravity variables affect intermediate imports in different ways according to the use that is given to these. The results suggest that the purchase of intermediate imports from preferential partners is more pronounced when the resulting output is destined to the same preferential partner. Or, that trade policy seems to have a large effect on bilateral vertical specialisation and hence that FTAs may be able to effectively promote the propagation of bilateral value chains across preferential areas.

Another possible explanation for these large effects is that they might arise from the complementarity of trade flows as discussed in Lopez-Gonzalez and Holmes (2011) and in Samuelson (2001) and Bas and Strauss-Kahn (2011). These papers suggested that importing complementary intermediate products could lead to positive effects on the competitiveness of the associated exported product. This might imply that the reduction in the cost of intermediates, accomplished though the FTA, may be increasing the efficiency of vertically specialised sequences of production and hence promoting a greater propagation of bilateral value chains.

These results may also be consistent with the recent theoretical literature that discusses offshoring in the presence of FTAs (Ornelas and Turner, 2008 and Antras and Staiger, 2011). If FTAs can mitigate 'hold-ups', through the creation of deeper agreements where common regulatory frameworks are created, then it is plausible that these have a stronger effect on vertically specialised trade than they do on normal trade (see Ornelas and Turner, 2008). Because new trade agreements involve the negotiation of deeper provisions (see WTO 2011), then they may be better at tackling the causes of these hold ups.

Two sensitivity checks are implemented in an effort to test the robustness of these results. First, it can be argued that the magnification effects identified arise from a 'double counting' of trade, or are a statistical construct. One would want to test whether these results remain when net flows, rather than gross flows, are used. Second, it is possible that the euro-centricity of the sample may be driving these results or that vertically specialised trade is only magnified in deeper pre-established agreements. One would then want to investigate whether these results remain when using a sample that does not include the large and pre-established trading areas.

The first column of Table 7 looks at whether 'double-counted' trade is driving these results by regressing a measure of intermediate goods trade that is netted from the domestic value that is embodied in the intermediate imports (lnnetintimps_bvsbil) against the same explanatory variables as above[101]. The results suggest that magnification effects remain and hence that these results appear not be driven by the 'double-counting' of trade.

The final two columns of Table 7 then attempt to identify whether the results obtained in Table 6 hold in a sample that is less EU centric. It removes all agreements that existed in 1995 so that the EU15 agreement as well as NAFTA and MERCOSUR are no longer in the sample and then re-runs the estimation of the final columns of Table 6. The results also show evidence of magnification effects. The impact of an FTA on bilateral value chain activity (lnintimps_bvsbil) is twice as large as that found for the measure of international value chain activity (lninimps_bvs). Moreover, the magnification effects remain with respect to the other coefficients. But the removal of these large pre-existing agreements also seems to affect the coefficient estimates on some of the trade cost measures. In Table 7, the coefficients on the distance measures are found to be significantly larger than those reported in Table 6. This might hint at differences in the partners that are engaging in new FTAs.

Table 7. Sensitivity tests, net flows and sample without large agreements

	(1)	(2)	(3)
	NET	NO EU15, NAFTA, MERCOSUR	
VARIABLES	lnnetintimps_bvsbil	lnintimpsbvs	Lnintimpsbvsbil
Lnmass	1.920***	0.953***	1.824***
	(0.0418)	(0.0552)	(0.0942)
Lndist	-2.166***	-1.245***	-2.413***
	(0.0374)	(0.0173)	(0.0358)
Contig	0.393***	0.279***	0.622***
	(0.0579)	(0.0450)	(0.0749)
comlang_off	1.080***	0.671***	1.293***

[101] Details on how this measure is obtained can be found in the Appendix A2.5.3

	(0.0513)	(0.0318)	(0.0447)
lngdpcap_d	1.287**	-4.150***	-1.943
	(0.600)	(1.118)	(1.191)
lngdpcap_d2	-0.0863**	0.245***	0.111
	(0.0340)	(0.0660)	(0.0734)
Lnfk	0.217***	-0.168***	0.0244
	(0.0716)	(0.0539)	(0.0680)
FTA	0.497***	0.357***	0.612***
	(0.0679)	(0.0456)	(0.0590)
Constant	-46.67***	7.942	-17.04***
	(3.268)	(5.005)	(6.212)
Observations	20,590	15,143	15,184
R-squared	0.870	0.813	0.855
r2_o	0.734	0.538	0.586
r2_w	0.870	0.813	0.855
r2_b	0.627	0.296	0.338

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

6.3.2. THE IMPACT OF AN FTA ON VERTICAL SPECIALISATION

This section looks at the impact of an FTA on the structure of trade or, more precisely, the *degree* of bilateral vertical specialisation– *bvs_bil*[102]. To this end, it is convenient to go back to the initial definition of the indicator (in equation 1). In its share format, it captures the import content of exports and has two components. The numerator is the value of intermediate imports used from a partner country to produce exports to that same partner - the *intimps_bvsbil* measure estimated in Column (4) of Table 6. The denominator is then the value of exports to the same partner where the imported intermediates originated. This is a structural measure of the degree of bilateral vertical specialisation and it can rise through:

1. Increases in the value of intermediate imports (holding the denominator constant); or
2. Reductions in export sales (holding the numerator constant); or
3. A faster growth in intermediate trade than in total trade

An FTA is likely to affect both the numerator and the denominator of this expression and hence the estimated FTA coefficients is to be interpreted as the degree to which agreements affect bilateral intermediate imports relative to bilateral total exports. Table 6 suggested that FTAs increase the value of intermediate imports used to produce exports to the same destination by 65%. The earlier results from Table 4 showed that total bilateral trade increased by 27% as a result of a trade agreement. Because the former effect is larger than the latter, then the impact of an FTA on the degree of VS is expected to be positive, i.e. larger positive impact on intermediate imports than on exports (case 3 above presented). The reduced-form equation capturing the determinants of bilateral vertical specialisation derived in equation (15) can be log-linearised to produce the following estimating equation:

$$[lnbvs_i bil]_{ijt} = [\alpha_i(i,t) + \rho_i(j,t) + \beta_1 (lnmass) + \beta_2 [(lnGDPcapdiff]_{(i,j,t)})] [+ \beta_3 (\ln [FK \quad (23)$$

[102] An estimation using a measure that tracks the import content of world exports is analogous in form to the estimation in Column 3 of Table 6. This is because total exports, which would represent the denominator of the expression, do not vary across reporter-year and hence are collinear with the set of FE used.

The mass variable that is used in this instance should capture the share of output that the reporter and partner country uses for purchases of intermediates[103]. Such a measure is computed by multiplying the gross output of the country by the share of inputs that are used by the economy. The *GDPcapdiff* variable is the log of the ratio of the GDP per capita of reporter and partner countries and the rest of the variables are the same that were used in previous estimations. Table 8 shows the coefficient estimates for this measure of vertical specialisation. The indicator of vertical specialisation is rising in economic mass and falling in distance. Lower trade costs, captured by the distance, contiguity and language variables also increase degrees of vertical specialisation. The positive coefficient on the FK variable suggests that technology differences between countries matter and that the more similar exporting structures are the large then degree of bilateral vertically specialised trade. Turning to the FTA coefficient, the results support the initial claim which posited that the impact of an FTA on the degree of VS between two countries should be positive. The bilateral vertical specialisation of preferential partners is 28.5% higher than that of non preferential partners. This give continued support to the idea that trade agreements can help in the propagation of bilateral value chains[104].

Table 8: The impact of an FTA on Vertical Specialisation

	bvs_bil
lnmassbvs_bil	1.146***
	(0.0411)
lndist	-1.119***
	(0.0191)
contig	0.168***
	(0.0328)
comlang_off	0.522***
	(0.0286)
lngdpcapratio	-0.0270
	(0.0386)
lnfk	0.241***
	(0.0466)
fta	0.250***
	(0.0381)
Constant	-23.80***
	(1.033)
Observations	20,590
R-squared	0.815
r2_o	0.389
r2_w	0.815
r2_b	0.0573

Notes: standard errors are clustered by reporter-year, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

7. CONCLUSIONS

Much has been written about the proliferation of trade agreements or the rise in vertically specialised trade. However the same courtesy has not been extended to looking at the role of trade agreements in this process. This paper set out to fill this gap. The results suggest that countries involved in a preferential agreement import more intermediate inputs from each other than from non-preferential partners. This is not a surprising result but this paper is one

[103] This is to reflect the mass variables in equation 15: $\frac{C_j C_i}{Y_j Y_i}$

[104] The estimates of an equation that places the bilateral use of intermediates to produce total exports as a proportion of total exports is omitted. This is because, with the use of the country-year FE, this expression is exactly like the one presented in the results of Table 6 column (3). This is because these fixed effects are collinear with the denominator of this expression and hence that the estimated model would be exactly the same is in that table.

of the first to provide solid econometric evidence on the magnitude of this effect. What is perhaps surprising is that the impact of an FTA on total and on intermediate imports (irrespective of their use) is of a similar magnitude, and this highlights that, in general, trade agreements do not impact one type of trade more than another. However, when one differentiates across the use of imported intermediates, or when one identifies the trade flows that may be part of a value chain, this result no longer holds. An FTA has a larger impact on imported intermediates that are part of an *international* value chain and the impact of an FTA is larger still on intermediate imports that belong to a *bilateral* value chain.

Imports that belong to a bilateral value chain also appear to be much more sensitive to changes in traditional gravity variables (i.e. trade policy, trade costs and economic mass) than other types of trade as Yi's (2003) theoretical paper predicted. Such magnification effects occur only when production sequences exhibit multiple border crossings and suggest that the removal of barriers may have large effects on this type of production sequences (evidence of similar magnification effects can be found in Egger and Pfaffermayr, 2005 and Chinn, 2005). What is most important about these results is that these effects appear to be driven by the presence of an FTA and not by other characteristics of partners which predisposes them to engage in an FTA or to have higher degrees of vertically specialised trade. This then points to an important role for trade policy in shaping patterns of bilateral vertical specialisation.

Although the derivation of a gravity model of intermediate goods trade from the perspective of the producer is novel, the theoretical contribution of this paper in this area is modest. Some of the base assumptions require a little more theoretical treatment. One of the weaknesses of the model is that the assumption that countries produce different numbers of varieties has not been backed by an appropriate supply side model that explains how these heterogeneities in production arise. Such a supply side model of vertical specialisation is desirable although beyond the scope of this paper. However, it seems reasonable that such a model would be based on the heterogeneous firm literature drawing on insights from the Economic Geography literature. This model would link the process of vertical specialisation to the productivity differences that firms exhibit within countries and would see more vertically specialised firms as having higher productivity draws. The recent paper of Bas and Strauss-Kahn (2011) is a good starting point for looking into this.

This paper would benefit from a greater focus on issues of spatial correlation and how this affects the dependent and the FTA variable. The rise in vertically specialised trade should lead to a greater co-movement of international business cycles and this should lead to elements of spatial correlation. Furthermore if the process of VS and FTAs is indeed highly linked, then signing an FTA with one partner and not another is likely to have repercussions that go beyond the two countries involved in the FTA. Capturing the average treatment effect of an FTA rests on the assumption that the FTA variable is independent but evidence on the contrary is increasingly coming to light. Indeed Baldwin's domino theory of regionalism is a good example of how the independence assumption is violated. Similarly, because fragmentation takes place between more than two countries, it is possible that dynamic effects arise and that exports to a third destination determine the demand for imports from any given partner. The incorporation of FDI flows into this type of analysis would also be desirable, particularly in light of Markusen's (1989) Knowledge-Capital model and the role of investment in the incomplete contract theory of offshoring and FTAs (Antras and Staiger, 2011). This paper has not focused on FDI on the basis that it is hard to differentiate between investment flows that serve create a production platform for value chain activity or those that serve relocate entire production processes in an effort to 'jump' barriers to trade (tariff or non tariff measures). This paper has also said very little about the organisational choices of firms which are likely to matter considerably, and particularly if the impact of deep integration is to be captured. Looking into these issues generally requires detailed firm level data.

Nevertheless, this paper makes some important methodological contributions to the literature. The first is that it shows that the use of country-year fixed effects provides appropriate controls for the unobserved heterogeneity that afflicts the estimation of the effect of FTAs on trade flows. The more traditional method that has been proposed by the literature deals with these issues through the use of additional pair-wise fixed effects (Baier and Bergstrand, 2007), however this may not be appropriate when the variance of the FTA variable is temporally limited. This is particularly important when using shorter panels. It is likely that newer proxies for vertically specialised trade cannot be calculated for as long a period as trade flows are available for and hence that the temporal variance of the FTA variable is going to become an issue in future studies. As more and more countries engage in regionalism, the temporal variance of bilateral FTAs is going to decrease. To the extent that bilateral pair-wise fixed effects only capture variance if there is a 'switch' from no agreement to an agreement, such a technique for controlling for unobserved heterogeneity has its days counted.

Another methodological contribution is that two different identification strategies for capturing the value of bilateral intermediate goods trade have been tested. The more traditional BEC nomenclature approach has often been criticised as an 'ad hoc' way of identifying these products (Hummels et al., 2001), but it is shown that it performs relatively well when compared to a method that identifies intermediate products through Input-Output tables. However, insofar as this paper suggests that the use that is given to the intermediate inputs is important, the BEC nomenclature, which fails to differentiate across the use of intermediate imports, may miss these important subtleties and hence is not a good identifier of value chain activity.

This paper has provided a solid econometric analysis of the role of trade agreements in the propagation of vertical specialisation but the reverse causality is equally interesting. Is it the presence of a trade agreement that leads to higher vertical specialisation or does prior vertical specialisation set in motion further demand for regionalism? The contrasting paths of integration of the European Union and ASEAN countries suggest that either path is possible hence looking at the role of vertical specialisation on the formation of trade agreements will be helpful in understanding the full link between these two processes. An interesting result that emerged from this paper is that the gravity coefficients obtained from a reduced sample of countries that have not yet engaged in trade agreements are somewhat different to those of the full sample. This points to the possible existence of differences in the characteristics of new preferential partners. This may then suggest that the changing nature of trade may be affecting the determinants of new regionalism.

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APPENDIX A2

A2.1. NET/GROSS FLOWS

To illustrate the circumstances under which the net/gross distinction may be problematic, two separate scenarios are considered. In the first, the distinction between these flows is of a 'measurement error' nature whereas in the second, a net flow is a proportion of the gross flow.

Measurement error case

Imagine that the theoretical models suggest that the empirical analysis should be done on the basis of net trade flows. Consider then a true model of intermediate goods trade taking the following form[105]:

$$M_{ij}{}^{*} = X_{ij}\beta + u_{ij} \tag{A2.1}$$

The net amount of intermediate goods trade M* is determined by a set of typical gravity covariates X and an independent and normally distributed error term u_{ij} exhibiting the typical properties. If gross trade in intermediates, as recorded by trade statistics, has the form $M_{ij} = M_{ij}{}^{*} + v_{ij}$. The model estimated becomes:

$$M_{ij} = X_{ij}\beta + v_{ij} + u_{ij} \tag{A2.2}$$

This provides little complications if the error term v_{ij} is assumed to be independent. However there are two probable violations of this independence. The first is that there is a likely correlation of the unobserved component v_{ij} with the independent variables in X. Not netting out the value added of any preceding stage of production implies that the observed gross measure can contain imports from country i itself. If this value added is determined by characteristics that also determine the amount of trade between two countries, then estimating this equation using OLS will provide biased coefficients. To the extent that the amount of value added can be a function of factor endowments or economies of scale which also serve to determine trade then the independence assumption may be violated. One can think of the error term v_{ij} as containing previous imports in a sequenced production hence also determined by similar covariates that determine M*. Capturing net flows, or where trade is only in final goods without international value added that is double counted, makes this error redundant, but given the perceived fragmentation of production across international borders the "measurement error" could have consequences on gravity type estimations. The second source of violation of independence transpires through the possible correlation between the terms v_{ij} and u_{ij}. If there are unobservables that determine imports, and which are uncorrelated with the covariates in X for simplicity, and that are captured in the term u_{ij} but also in v_{ij}, then biased coefficients will also arise in estimation (unobserved heterogeneity). The violation of this independence is likely because unobservables such as institutional arrangements, legal ties or other such deep integration issues are likely to determine both the amount of intermediate goods trade AND the levels of value added done at each stage of an international production sequence. The importance of the first type of complication will be an increasing function of the degree of fragmentation between two countries whilst that of the second will increase with the degree of integration across two countries. One can circumvent the first complication by using an approach that identifies net trade flows, or international value added

[105] A priori this is equally applicable to an estimation of total trade.

rather that gross flows whereas the second will be discussed in more depth below where we look at unobserved heterogeneity.

The case where net flows are in proportion to gross flows

Consider now a similar setting where the theoretical model suggests that it is on the basis of net trade flows that the estimation is to be undertaken so that A2.1 continues to be the 'true model'. If net flows are a share of gross flows so that

$$M_{ij}^* = (a_i)\, M_{ij} \tag{A2.3}$$

and the model is estimated on the basis of gross flows rather than net flows then one would need to estimate the following:

$$M_{ij} = (1/a_i) X_{ij}\beta + u_{ij} \tag{A2.4}$$

This implies that the coefficients will be biased by $(1/a_i)$. Hence if theory tells us that the true model is to be estimated through net flows rather than gross, then biases will arise in the estimated coefficients. Hence if the net flows are half of the gross flows, the estimated coefficients will be double what they ought to be. It is important to note that these biases can also be controlled for through fixed effects or through a logarithmic transformation of the data.

To obtain the demand for varieties from a particular country one minimises the cost function with respect to the production function so that the Lagrangian becomes:

$$L = \sum_M n_j \varphi_j p_{i,j}(x) x_{i,j} + \lambda \left[Y - A_i \left(\sum_M n_j^{\frac{1}{\sigma}} \varphi_{i,j}^{\frac{1}{\sigma}} x_{i,j}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \right]$$

(A2.5)

The partial derivatives for goods from location i and j are obtained so that

$$\frac{n_j \varphi_j p_j(x)}{n_i \varphi_i p_i(x)} = \frac{n_j^{\frac{1}{\sigma}} \varphi_j^{\frac{1}{\sigma}} x_j^{-\frac{1}{\sigma}}}{n_i^{\frac{1}{\sigma}} \varphi_i^{\frac{1}{\sigma}} x_i^{-\frac{1}{\sigma}}}$$

(A2.6)

Hence

$$\frac{n_j^{-1} \varphi_j^{-1} x_j}{n_i^{-1} \varphi_i^{-1} x_i} = \left(\frac{n_j \varphi_j p_j(x)}{n_i \varphi_i p_i(x)} \right)^{-\sigma}$$

(A2.7)

Singling out x_j

$$x_j = n_j^{1-\sigma} \varphi_j^{1-\sigma} p_j(x)^{-\sigma} n_i^{\sigma-1} \varphi_i^{\sigma-1} p_i(x)^{\sigma} x_i$$

(A2.8)

Multiplying this expression by $n_j \varphi_j p_j$ gives us:

$$n_j \varphi_j p_j(x) x_j = n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma} n_i^{\sigma-1} \varphi_i^{\sigma-1} p_i(x)^{\sigma} x_i$$

(A2.9)

Summing up across origins:

$$C_i = \sum_M n_j \varphi_j p_j(x) x_j = \sum_M \left(n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma} \right) n_i^{\sigma-1} \varphi_i^{\sigma-1} p_i(x)^{\sigma} x_i$$

(A2.10)

Inverting this gives the demand for a particular variety from country j

$$x_{i,j} = \frac{n_j^{1-\sigma} \varphi_j^{1-\sigma} p_{i,j}(x)^{-\sigma}}{\left[\Sigma_M \left(n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma} \right) \right]} C_i$$

(A2.11)

To determine the minimum cost function to obtain a unit of X_i one should substitute this expression into the production function which is recalled to be:

$$X_i = A_i\left[\sum_M n_j^{\frac{1}{\sigma}} \varphi_j^{\frac{1}{\sigma}} x_{i,j}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

(A2.12)

So that:

$$x_{i,j}^{\alpha} = \frac{n_j^{(1-\sigma)\alpha} \varphi_j^{(1-\sigma)\alpha} p_{i,j}(x)^{1-\sigma}}{\left[\sum_M \left(n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma}\right)\right]^{\alpha}} C_i^{\alpha}$$

(A2.13)

Where

$$\alpha = \left(\frac{\sigma - 1}{\sigma}\right)$$

(A2.14)

Then

$$n_j^{\frac{1}{\sigma}} \varphi_j^{\frac{1}{\sigma}} x_{i,j}^{\frac{\sigma-1}{\sigma}} = \frac{n_j^{2-\sigma} \varphi_j^{2-\sigma} p_{i,j}(x)^{1-\sigma}}{\left[\sum_M \left(n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma}\right)\right]^{\alpha}} C_i^{\alpha}$$

(A2.15)

And summing across countries so that

$$\sum_M n_j^{\frac{1}{\sigma}} \varphi_j^{\frac{1}{\sigma}} x_{i,j}^{\frac{\sigma-1}{\sigma}} = \left[\sum_M \left(n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma}\right)\right]^{1-\alpha} C_i^{\alpha}$$

(A2.16)

Therefore

$$X_i = A_i\left[\sum_M n_j^{\frac{1}{\sigma}} \varphi_j^{\frac{1}{\sigma}} x_{i,j}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = A_i\left[\sum_M \left(n_j^{2-\sigma} \varphi_j^{2-\sigma} p_j(x)^{1-\sigma}\right)\right]^{\frac{1}{\sigma-1}} C_i$$

(A2.17)

This is the minimum cost function that is required to obtain a unit of X_i.

A similar model can be obtained without having to rely on technological differences so that if technology is fixed by country and not by the desirability of the product one can use the following production function:

$$X_i = A_i\left[\varphi_j^{\frac{1}{\sigma}} \sum_M n_j^{\frac{1}{\sigma}} x_{i,j}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

(A2.18)

The cost/revenue function the becomes:

$$C_i = R_i = \sum_M n_j p_j a_j \tau_{i,j} x_{i,j}$$

(A2.19)

Yielding an input demand function:

$$V_{i,j} = \frac{n_j^{2-\sigma}\left(a_j p_j \tau_{i,j}\right)^{1-\sigma}}{\left[\sum_M [n_j^{2-\sigma}(a]_j p_j \tau_{i,j}\right)^{1-\sigma}\right]} C_i$$

(A2.20)

And a minimum cost function:

$$A_i\left[\sum_M \left(n_j{}^{2-\sigma} p_j (x)^{1-\sigma}\right)\right]^{\frac{1}{\sigma-1}} C_i$$

(A2.21)

Here it is easier to see how a greater availability of intermediate products reduces the cost of producing a unit of X_i although this only happens when the elasticity of substitution is above 2.

A2.3: DATABASE

A2.3.1. THE VERTICAL SPECIALISATION INDICATORS

The Input-Output database of the OECD is used to construct the different measures of vertical specialisation (using equation 2.1). The database contains information for 42 countries at various intervals in time. See Table A1.2 for country and year coverage of the OECD IO table database.

The calculation of the indicators of vertical specialisation is carried out for 39 of these countries (excluding Taiwan, Belgium and Luxembourg) in the following steps:

- We reduce all the matrices to a 25x25 square matrix that captures manufacturing trade. This requires aggregating certain manufacturing sectors and also aggregating the service sectors to one sector only.
- The base tables are then extended these so that we can obtain a yearly tables
- These are then deflated, using country specific deflators from the WDI database, to a base year 2000 and converted into dollars using exchange rates from the Penn World Tables database. The conversion is necessary so that we can merge the IO tables with the trade data in dollars
- The trade data is also deflated, but here we use an aggregate OECD deflator.
- Once the data has been fully treated, we use equation 1 to calculate the difference indicators BVS, VS1 and TVS.

The use of I-O tables for this type of analysis needs to be accompanied by some cautionary words, some to do with the OECD database and others of general consideration when using I-O tables. Firstly, given that the OECD tables are based on countries voluntary submission, the harmonisation of these requires applying various transformations which may reduce their individual precision at the benefit of the collective harmonisation. For example, countries use different collection methods and sectoral classifications hence harmonisation is sometimes difficult[106]. Some report Supply-Use tables at purchasing prices rather than basic prices and transformations need be implemented to remove VAT and other types of subsidies. Secondly, the compilation of I-O tables is costly and is thus carried out across large time intervals. They provide a 'snapshot' of economic activity in a given year making the extension of these to obtain a panel highly reliant on restrictive assumptions. Extrapolating I-O tables can be done by a 'double deflation' methodology or alternatively require assuming constancy of technical and interdependence coefficients over time. For the purpose of our analysis we choose the latter technique but we need to understand how variation in technology may arise. UN (1999) puts forward that variation in technological coefficients can arise as a result of three circumstances: Firstly through changes in technology, secondly through changes in relative prices, and thirdly through imperfect data. The first is impossible to control for as the only information that we possess is based on the technology present in the base year of the I-O table. The second can be dealt with by using deflators to produce tables in constant price values given a base year whilst the third is also beyond our control. Choosing this methodology for extending the I-O tables is hence not without implications. First, we are constraining technological changes in the sample to three base years for which we have base I-O tables. This means that variation in our linkage indicators between these base years only

[106] Adding to this, sometimes there are holes in the I-O tables which are filled using varying estimation techniques. This means that for some sectors, missing values are not necessarily recorded, but rather are estimated.

occurs via variations in export and import values. We however have reason to believe that whilst this is a limiting factor, annual variation in technologies is small. Vaccara (1986) suggests that technical coefficients vary annually in the region of 2% and UN (1999) also suggest that changes are fairly gradual[107]. Second, and a more general limiting factor of I-O analysis, is that technology is assumed to be linear (Leontief). This implies that intermediate imports are required in fixed proportions to output or alternatively that there is no substitution between inputs used to produce output.

A2.3.2 THE GRAVITY VARIABLES

Most of the gravity variables are obtained from the CEPII database. As many of these are time invariant they are easily extended, however country specific time varying variables are drawn from other sources (see below). We use the FTA variable from the CEPII dataset to identify the presence or absence of a trade agreement between country pairs. It is however only available till 2006 and hence needs to be extended to incorporate years 2007 and 2008. We do this by imputing the values using the WTO RTA database (http://www.wto.org/english/tratop_e/region_e/summary_e.xls). In the process of this imputation we also correct several inconsistencies in this variable given that the following agreements do not feature:

NOR-KOR (2006): (Through EFTA)
CHE-KOR (2006): (Through EFTA)
JPN-MEX (2005):
IDN-CHN (2003): (Through ASEAN)
CHL-CHN (2006)

Added Agreements:
JPN-IDN (2008)
CHL-JPN (2007)

The GDP, per capita GDP and Population data is extracted from the WDI webpage. All trade data is downloaded using WITS from the COMTRADE database.

Agreements covered:

[107] However, the variations in Vaccara (1986) are calculated during the 50's and 60's. There is reason to believe that the 90's saw much higher variation through the introduction of new Information Technology such as the internet.

Table A2.1: Agreements in Sample in 2008

ARG-BRA	BRA-ARG	CHE-SWE	CHL-USA	DEU-CHE	DNK-ESP	ESP-GBR	EST-ISR	FIN-NOR	FRA-SVK	GBR-ZAF	HUN-CZE	IRL-DNK	ISR-FRA
ARG-CHL	BRA-CHL	CHE-TUR	CHN-CHL	DEU-CHL	DNK-EST	ESP-GRC	EST-ITA	FIN-POL	FRA-SVN	GRC-AUT	HUN-DEU	IRL-ESP	ISR-GBR
AUS-NZL	CAN-CHL	CHL-ARG	CHN-IDN	DEU-CZE	DNK-FIN	ESP-HUN	EST-MEX	FIN-PRT	FRA-SWE	GRC-CHE	HUN-DNK	IRL-EST	ISR-GRC
AUS-USA	CAN-ISR	CHL-AUT	CZE-AUT	DEU-DNK	DNK-FRA	ESP-IRL	EST-NLD	FIN-ROM	FRA-TUR	GRC-CHL	HUN-ESP	IRL-FIN	ISR-HUN
AUT-CHE	CAN-MEX	CHL-BRA	CZE-CHE	DEU-ESP	DNK-GBR	ESP-ISR	EST-NOR	FIN-SVK	FRA-ZAF	GRC-CZE	HUN-EST	IRL-FRA	ISR-IRL
AUT-CHL	CAN-USA	CHL-CAN	CZE-CHL	DEU-EST	DNK-GRC	ESP-ITA	EST-POL	FIN-SVN	GBR-AUT	GRC-DEU	HUN-FIN	IRL-GBR	ISR-ITA
AUT-CZE	CHE-AUT	CHL-CHE	CZE-DEU	DEU-FIN	DNK-HUN	ESP-MEX	EST-PRT	FIN-SWE	GBR-CHE	GRC-DNK	HUN-FRA	IRL-GRC	ISR-MEX
AUT-DEU	CHE-CHL	CHL-CHN	CZE-DNK	DEU-FRA	DNK-IRL	ESP-NLD	EST-ROM	FIN-TUR	GBR-CHL	GRC-ESP	HUN-GBR	IRL-HUN	ISR-NLD
AUT-DNK	CHE-CZE	CHL-CZE	CZE-ESP	DEU-GBR	DNK-ISR	ESP-NOR	EST-SVK	FIN-ZAF	GBR-CZE	GRC-EST	HUN-GRC	IRL-ISR	ISR-NOR
AUT-ESP	CHE-DEU	CHL-DEU	CZE-EST	DEU-GRC	DNK-ITA	ESP-POL	EST-SVN	FRA-AUT	GBR-DEU	GRC-FIN	HUN-IRL	IRL-ITA	ISR-POL
AUT-EST	CHE-DNK	CHL-DNK	CZE-FIN	DEU-HUN	DNK-MEX	ESP-PRT	EST-SWE	FRA-CHE	GBR-DNK	GRC-FRA	HUN-ISR	IRL-MEX	ISR-PRT
AUT-FIN	CHE-ESP	CHL-ESP	CZE-FRA	DEU-IRL	DNK-NLD	ESP-ROM	EST-TUR	FRA-CHL	GBR-ESP	GRC-GBR	HUN-ITA	IRL-NLD	ISR-ROM
AUT-FRA	CHE-EST	CHL-EST	CZE-GBR	DEU-ISR	DNK-NOR	ESP-SVK	EST-ZAF	FRA-CZE	GBR-EST	GRC-HUN	HUN-MEX	IRL-NOR	ISR-SVK
AUT-GBR	CHE-FIN	CHL-FIN	CZE-GRC	DEU-ITA	DNK-POL	ESP-SVN	FIN-AUT	FRA-DEU	GBR-FIN	GRC-IRL	HUN-NLD	IRL-POL	ISR-SVN
AUT-GRC	CHE-FRA	CHL-FRA	CZE-HUN	DEU-MEX	DNK-PRT	ESP-SWE	FIN-CHE	FRA-DNK	GBR-FRA	GRC-ISR	HUN-NOR	IRL-PRT	ISR-SWE
AUT-HUN	CHE-GBR	CHL-GBR	CZE-IRL	DEU-NLD	DNK-ROM	ESP-TUR	FIN-CHL	FRA-ESP	GBR-GRC	GRC-ITA	HUN-POL	IRL-ROM	ISR-TUR
AUT-IRL	CHE-GRC	CHL-GRC	CZE-ISR	DEU-NOR	DNK-SVK	ESP-ZAF	FIN-CZE	FRA-EST	GBR-HUN	GRC-MEX	HUN-PRT	IRL-SVK	ISR-USA
AUT-ISR	CHE-HUN	CHL-HUN	CZE-ITA	DEU-POL	DNK-SVN	EST-AUT	FIN-DEU	FRA-FIN	GBR-IRL	GRC-NLD	HUN-ROM	IRL-SVN	ITA-AUT
AUT-ITA	CHE-IRL	CHL-IRL	CZE-MEX	DEU-PRT	DNK-SWE	EST-CHE	FIN-DNK	FRA-GBR	GBR-ISR	GRC-NOR	HUN-SVK	IRL-SWE	ITA-CHE
AUT-MEX	CHE-ISR	CHL-ITA	CZE-NLD	DEU-ROM	DNK-TUR	EST-CHL	FIN-ESP	FRA-GRC	GBR-ITA	GRC-POL	HUN-SVN	IRL-TUR	ITA-CHL
AUT-NLD	CHE-ITA	CHL-JPN	CZE-NOR	DEU-SVK	DNK-ZAF	EST-CZE	FIN-EST	FRA-HUN	GBR-MEX	GRC-PRT	HUN-SWE	IRL-ZAF	ITA-CZE
AUT-NOR	CHE-KOR	CHL-KOR	CZE-POL	DEU-SVN	ESP-AUT	EST-DEU	FIN-FRA	FRA-IRL	GBR-NLD	GRC-ROM	HUN-TUR	ISR-AUT	ITA-DEU
AUT-POL	CHE-MEX	CHL-MEX	CZE-PRT	DEU-SWE	ESP-CHE	EST-DNK	FIN-GBR	FRA-ISR	GBR-NOR	GRC-SVK	HUN-ZAF	ISR-CAN	ITA-DNK
AUT-PRT	CHE-NLD	CHL-NLD	CZE-ROM	DEU-TUR	ESP-CHL	EST-ESP	FIN-GRC	FRA-ITA	GBR-POL	GRC-SVN	IDN-CHN	ISR-CHE	ITA-ESP
AUT-ROM	CHE-NOR	CHL-NOR	CZE-SVK	DEU-ZAF	ESP-CZE	EST-FIN	FIN-HUN	FRA-MEX	GBR-PRT	GRC-SWE	IDN-JPN	ISR-CZE	ITA-EST
AUT-SVK	CHE-POL	CHL-POL	CZE-SVN	DNK-AUT	ESP-DEU	EST-FRA	FIN-IRL	FRA-NLD	GBR-ROM	GRC-TUR	IRL-AUT	ISR-DEU	ITA-FIN
AUT-SVN	CHE-PRT	CHL-PRT	CZE-SWE	DNK-CHE	ESP-DNK	EST-GBR	FIN-ISR	FRA-NOR	GBR-SVK	GRC-ZAF	IRL-CHE	ISR-DNK	ITA-FRA
AUT-SWE	CHE-ROM	CHL-SVK	CZE-TUR	DNK-CHL	ESP-EST	EST-GRC	FIN-ITA	FRA-POL	GBR-SVN	HUN-AUT	IRL-CHL	ISR-ESP	ITA-GBR
AUT-TUR	CHE-SVK	CHL-SVN	CZE-ZAF	DNK-CZE	ESP-FIN	EST-HUN	FIN-MEX	FRA-PRT	GBR-SWE	HUN-CHE	IRL-CZE	ISR-EST	ITA-GRC
AUT-ZAF	CHE-SVN	CHL-SWE	DEU-AUT	DNK-DEU	ESP-FRA	EST-IRL	FIN-NLD	FRA-ROM	GBR-TUR	HUN-CHL	IRL-DEU	ISR-FIN	ITA-HUN

Table A2.1: Agreements in Sample in 2008 (cont)

ITA-IRL	MEX-GBR	NLD-ITA	NOR-POL	POL-SVN	ROM-AUT	SVK-EST	SVN-GRC	SWE-ITA	TUR-ROM
ITA-ISR	MEX-GRC	NLD-MEX	NOR-PRT	POL-SWE	ROM-CHE	SVK-FIN	SVN-HUN	SWE-MEX	TUR-SVK
ITA-MEX	MEX-HUN	NLD-NOR	NOR-ROM	POL-TUR	ROM-CZE	SVK-FRA	SVN-IRL	SWE-NLD	TUR-SVN
ITA-NLD	MEX-IRL	NLD-POL	NOR-SVK	POL-ZAF	ROM-DEU	SVK-GBR	SVN-ISR	SWE-NOR	TUR-SWE
ITA-NOR	MEX-ISR	NLD-PRT	NOR-SVN	PRT-AUT	ROM-DNK	SVK-GRC	SVN-ITA	SWE-POL	USA-AUS
ITA-POL	MEX-ITA	NLD-ROM	NOR-SWE	PRT-CHE	ROM-ESP	SVK-HUN	SVN-MEX	SWE-PRT	USA-CAN
ITA-PRT	MEX-JPN	NLD-SVK	NOR-TUR	PRT-CHL	ROM-EST	SVK-IRL	SVN-NLD	SWE-ROM	USA-CHL
ITA-ROM	MEX-NLD	NLD-SVN	NZL-AUS	PRT-CZE	ROM-FIN	SVK-ISR	SVN-NOR	SWE-SVK	USA-ISR
ITA-SVK	MEX-NOR	NLD-SWE	POL-AUT	PRT-DEU	ROM-FRA	SVK-ITA	SVN-POL	SWE-SVN	USA-MEX
ITA-SVN	MEX-POL	NLD-TUR	POL-CHE	PRT-DNK	ROM-GBR	SVK-MEX	SVN-PRT	SWE-TUR	ZAF-AUT
ITA-SWE	MEX-PRT	NLD-ZAF	POL-CHL	PRT-ESP	ROM-GRC	SVK-NLD	SVN-ROM	SWE-ZAF	ZAF-CZE
ITA-TUR	MEX-SVK	NOR-AUT	POL-CZE	PRT-EST	ROM-HUN	SVK-NOR	SVN-SVK	TUR-AUT	ZAF-DEU
ITA-ZAF	MEX-SVN	NOR-CHE	POL-DEU	PRT-FIN	ROM-IRL	SVK-POL	SVN-SWE	TUR-CHE	ZAF-DNK
JPN-CHL	MEX-SWE	NOR-CHL	POL-DNK	PRT-FRA	ROM-ISR	SVK-PRT	SVN-TUR	TUR-CZE	ZAF-ESP
JPN-IDN	MEX-USA	NOR-CZE	POL-ESP	PRT-GBR	ROM-ITA	SVK-ROM	SVN-ZAF	TUR-DEU	ZAF-EST
JPN-MEX	NLD-AUT	NOR-DEU	POL-EST	PRT-GRC	ROM-NLD	SVK-SVN	SWE-AUT	TUR-DNK	ZAF-FIN
KOR-CHE	NLD-CHE	NOR-DNK	POL-FIN	PRT-HUN	ROM-NOR	SVK-SWE	SWE-CHE	TUR-ESP	ZAF-FRA
KOR-CHL	NLD-CHL	NOR-ESP	POL-FRA	PRT-IRL	ROM-POL	SVK-TUR	SWE-CHL	TUR-EST	ZAF-GBR
KOR-NOR	NLD-CZE	NOR-EST	POL-GBR	PRT-ISR	ROM-PRT	SVK-ZAF	SWE-CZE	TUR-FIN	ZAF-GRC
MEX-AUT	NLD-DEU	NOR-FIN	POL-GRC	PRT-ITA	ROM-SVK	SVN-AUT	SWE-DEU	TUR-FRA	ZAF-HUN
MEX-CAN	NLD-DNK	NOR-FRA	POL-HUN	PRT-MEX	ROM-SVN	SVN-CHE	SWE-DNK	TUR-GBR	ZAF-IRL
MEX-CHE	NLD-ESP	NOR-GBR	POL-IRL	PRT-NLD	ROM-SWE	SVN-CHL	SWE-ESP	TUR-GRC	ZAF-ITA
MEX-CHL	NLD-EST	NOR-GRC	POL-ISR	PRT-NOR	ROM-TUR	SVN-CZE	SWE-EST	TUR-HUN	ZAF-NLD
MEX-CZE	NLD-FIN	NOR-HUN	POL-ITA	PRT-POL	SVK-AUT	SVN-DEU	SWE-FIN	TUR-IRL	ZAF-POL
MEX-DEU	NLD-FRA	NOR-IRL	POL-MEX	PRT-ROM	SVK-CHE	SVN-DNK	SWE-FRA	TUR-ISR	ZAF-PRT
MEX-DNK	NLD-GBR	NOR-ISR	POL-NLD	PRT-SVK	SVK-CHL	SVN-ESP	SWE-GBR	TUR-ITA	ZAF-SVK
MEX-ESP	NLD-GRC	NOR-ITA	POL-NOR	PRT-SVN	SVK-CZE	SVN-EST	SWE-GRC	TUR-NLD	ZAF-SVN
MEX-EST	NLD-HUN	NOR-KOR	POL-PRT	PRT-SWE	SVK-DEU	SVN-FIN	SWE-HUN	TUR-NOR	ZAF-SWE
MEX-FIN	NLD-IRL	NOR-MEX	POL-ROM	PRT-TUR	SVK-DNK	SVN-FRA	SWE-IRL	TUR-POL	
MEX-FRA	NLD-ISR	NOR-NLD	POL-SVK	PRT-ZAF	SVK-ESP	SVN-GBR	SWE-ISR	TUR-PRT	

Table A2.2: Descriptive stats of variables

Variable		Mean	Std. Dev.	Min	Max	Observations
gdp_o	overall	8.47E+11	1.74E+12	5.68E+09	1.17E+13	N = 20748
	between		1.72E+12	8.78E+09	1.01E+13	n = 1482
	within		3.07E+11	-1.21E+12	3.24E+12	T = 14
gdpcap_o	overall	18345.4	14111.63	449.2205	65065.73	N = 20748
	between		13293.71	541.9631	48210.3	n = 1482
	within		4746.177	7363.714	57828.14	T = 14
rta	overall	0.385965	0.486834	0	1	N = 20748
	between		0.438271	0	1	n = 1482
	within		0.212241	-0.54261	1.314536	T = 14
lnimports	overall	13.02743	2.188095	0.275356	19.6913	N = 20669
	between		2.105007	4.76718	19.23532	n = 1482
	within		0.623321	8.535602	16.38206	T-bar = 13.9467
lnintimps_tot	overall	5.507109	2.168155	-7.30772	12.11262	N = 20669
	between		2.105339	-3.14625	11.7615	n = 1482
	within		0.546298	1.03493	9.235838	T-bar = 13.9467
lnintimps_bvs	overall	5.022131	2.327805	-9.13527	11.2558	N = 20669
	between		2.099616	-4.33347	10.76319	n = 1482
	within		1.021737	-2.13908	9.519779	T-bar = 13.9467
lnintimps_bvsbil	overall	-0.16405	3.735303	-19.0436	11.27024	N = 20590
	between		3.560454	-12.5373	10.70017	n = 1482
	within		1.180842	-7.98824	5.579733	T-bar = 13.8934
bvs_bil	overall	0.010385	0.027173	0	0.493401	N = 20748
	between		0.024175	3.29E-06	0.301734	n = 1482
	within		0.012422	-0.226	0.347093	T = 14
vs1_bil	overall	0.009767	0.027427	0	0.653405	N = 20748
	between		0.024767	7.51E-06	0.384454	n = 1482
	within		0.0118	-0.29576	0.278718	T = 14
tvs_bil	overall	0.01999	0.039551	0	0.662952	N = 20748
	between		0.03521	3.47E-05	0.394959	n = 1482
	within		0.018037	-0.28627	0.377034	T = 14
lndist	overall	8.351051	1.111235	4.087945	9.88258	N = 20748
	between		1.111583	4.087945	9.88258	n = 1482
	within		0	8.351051	8.351051	T = 14
fk	overall	0.24458	0.103939	0.036093	0.635668	N = 20672
	between		0.100973	0.047272	0.614871	n = 1482
	within		0.024973	0.091334	0.370834	T-bar = 13.9487
ov_o (gross output)	overall	1598452	3243938	11806.67	2.18E+07	N = 20748
	between		3137179	18741.2	1.83E+07	n = 1482
	within		829102.4	-2450593	1.01E+07	T = 14
va_o (value added)	overall	799475.6	1720307	4674.632	1.17E+07	N = 20748
	between		1667872	7456.221	9831393	n = 1482
	within		423558.3	-1401713	5726734	T = 14

A2.4. EXOGENEITY OF THE FTA VARIABLE

To test that the particular set of FE that have been used control for unobserved heterogeneity Baier and Bergstrand (2007) suggest using a future FTA variable arguing that future FTAs should not affect current trade flows. If this variable is uncorrelated with current trade flows then appropriate controls have been provided for the unobserved heterogeneity. However, given the variance of the FTA variable in the sample, it is probable that such a test will not be conclusive if carried out on the full sample. The reason is that the correlation coefficient between the FTA and an FTA+5 variable is high (0.72). This implies that even if unobserved heterogeneity has been controlled for, a test on the full sample will not capture this because the FTA+5 will be effectively acting like the FTA variable. The table below shows the results obtained from carrying out this test on the full sample. Here it is seen that the FTA+5 is significant throughout. This does not mean that the set of FE does not control for the endogenous formation of FTAs, but rather that the test is an inappropriate one owing to the correlation between the FTA and the FTA+5 variables.

Table A2.3: Exogeneity test on full sample

	(1)	(2)	(3)	(4)
Dep var: lnimports	OLS	FE1	FE2	FE3
lncombgdp	0.918***	1.024***	1.008***	1.125***
	(0.00486)	(0.0271)	(0.0497)	(0.0528)
lndist	-0.784***		-1.172***	-1.180***
	(0.0123)		(0.0476)	(0.0159)
contig	0.646***		0.336**	0.334***
	(0.0618)		(0.152)	(0.0457)
comlang_off	0.699***		0.671***	0.675***
	(0.0321)		(0.0946)	(0.0270)
fta	0.170***	0.0778***	0.0880*	0.113**
	(0.0348)	(0.0301)	(0.0469)	(0.0462)
fta+5	0.187***	0.212***	0.291***	0.257***
	(0.0314)	(0.0568)	(0.0964)	(0.0411)
lngdpcap_d	-1.285***	1.168***	1.223***	2.393***
	(0.100)	(0.206)	(0.157)	(0.895)
lngdpcap_d2	0.0673***	-0.127***	-0.130***	-0.141***
	(0.00575)	(0.0115)	(0.00906)	(0.0527)
lnfk	-0.0335	0.214***	-0.105	-0.149***
	(0.0216)	(0.0776)	(0.131)	(0.0402)
Constant	-23.19***	-41.29***	-31.27***	-46.91***
	(0.548)	(1.489)	(2.128)	(5.243)
Observations	15,143	15,143	15,143	15,143
R-squared	0.772	0.529	0.835	0.843
r2_o	.	0.493	0.859	0.811
r2_w	.	0.529	0.835	0.843
r2_b	.	0.495	0.925	0.823
Number of repart		1,090		
Number of repyear				545
Number of rep			39	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the paper, it is suggested that the test be carried out on a subsample of countries where the FTA variable exhibits some variance. What is done is that all agreements that do not vary in the sample are removed, hence if the FTA variable was equal to 1 between a dyad throughout the entire sample, the dyad was dropped. Such a selection is indeed problematic because it is possible that common factors that are unobserved explain why countries do not engage in an FTA till the mid 90's. However this selection affords us to test whether the endogenous formation of trade agreements has been controlled for. The table bellow shows the correlation coefficient between the FTA variable and its future lags in the sumsample. Here it is patent that the correlation coefficients are lower that those reported in Table 4.

Table A2.4: Correaltion Coefficient betwee FTA and future lags in reduced sample

	rta	rtaplus3	rtaplus4	rtaplus5	rtaplus6	rtaplus7
rta	1.0000					
rtaplus3	0.6449	1.0000				
rtaplus4	0.5444	0.8442	1.0000			
rtaplus5	0.4499	0.6977	0.8265	1.0000		
rtaplus6	0.3714	0.5759	0.6822	0.8255	1.0000	
rtaplus7	0.2961	0.4591	0.5438	0.6580	0.7972	1.0000

When the test is performed on this subsample, it is shown that the FTA+5 loses significance only when the country-year FE are used which supports the hypothesis that these provide appropriate controls for unobserved heterogeneity.

The table below then carries out a robustness check on different forward lags of the FTA coefficient on the subsample of countries showing that when the interacted country-year fixed effects are used, most lags of future FTA remain insignificant.

Table A2.5. Robustness check on different FTA forward lags

	(1)	(2)	(3)	(4)	(5)
VARIABLES	lnimports	lnimports	lnimports	lnimports	lnimports
lncombgdp	0.816***	0.815***	0.815***	0.811***	0.815***
	(0.0829)	(0.0817)	(0.0814)	(0.0811)	(0.0816)
lndist	-1.415***	-1.416***	-1.415***	-1.414***	-1.415***
	(0.0367)	(0.0367)	(0.0365)	(0.0363)	(0.0362)
contig	0.233***	0.233***	0.233***	0.233***	0.233***
	(0.0657)	(0.0657)	(0.0656)	(0.0655)	(0.0656)
comlang_off	0.842***	0.842***	0.841***	0.841***	0.842***
	(0.0427)	(0.0427)	(0.0425)	(0.0426)	(0.0427)
lngdpcap_d2	-0.00763	-0.00763	-0.00751	-0.00624	-0.00757
	(0.00649)	(0.00650)	(0.00660)	(0.00708)	(0.00687)
lnfk	0.284***	0.285***	0.284***	0.282***	0.283***
	(0.0648)	(0.0649)	(0.0651)	(0.0647)	(0.0646)
fta	0.222***	0.225***	0.224***	0.222***	0.225***
	(0.0739)	(0.0704)	(0.0681)	(0.0677)	(0.0678)
ftaplus3	0.0134				
	(0.0816)				
ftaplus4		0.00178			
		(0.0754)			
ftaplus5			0.0183		
			(0.0777)		
ftaplus6				0.0559	
				(0.0916)	
ftaplus7					0.0385
					(0.104)
Constant	-17.10***	-17.04***	-17.11***	-17.07***	-17.11***
	(4.179)	(4.127)	(4.094)	(4.062)	(4.086)
Observations	4,550	4,550	4,550	4,550	4,550
R-squared	0.864	0.864	0.864	0.864	0.864
Number of repyear	504	504	504	504	504
r2_o	0.763	0.762	0.765	0.763	0.762
r2_w	0.864	0.864	0.864	0.864	0.864
r2_b	0.669	0.669	0.673	0.668	0.668

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The tables below shows the outcomes of the test for controls of unobserved heterogeneity when the dependent variable is intermediate goods trade. This is performed for the full sample first (Table A.4.4) and for the reduced sample (Table A.4.5). In the tables the dependent variables for the different estimations are as follows:

(1) intermediate goods identified using BEC
(2) intermediate goods identified using IO tables (total use)
(3) intermediate goods used in the production of total exports (bvs)
(4) intermediate goods used in the production of exports to the same destination as these originated from (bvsbil)

Table A2.6: Test for exogeneity of FTA coefficient in the case of intermediate goods on full sample

	(1)	(2)	(3)	(4)
lncombgdp	1.169***	1.098***	1.104***	1.925***
	(0.055)	(0.060)	(0.062)	(0.089)
lndist	-1.151***	-1.205***	-1.216***	-2.422***
	(0.018)	(0.016)	(0.017)	(0.037)
contig	0.334***	0.352***	0.298***	0.588***
	(0.048)	(0.047)	(0.045)	(0.077)
comlang_~f	0.641***	0.640***	0.671***	1.297***
	(0.026)	(0.029)	(0.032)	(0.044)
rta	0.085*	0.097**	0.121**	0.207***
	(0.049)	(0.048)	(0.051)	(0.069)
rtaplus5	0.257***	0.273***	0.324***	0.543***
	(0.044)	(0.044)	(0.050)	(0.062)
lngdpcap_d	3.086***	1.705*	1.666*	2.829*
	(0.805)	(0.941)	(0.954)	(1.574)
lngd~ap_d2	-0.182***	-0.100*	-0.098*	-0.160*
	(0.047)	(0.055)	(0.056)	(0.093)
lnfk	-0.023	-0.064	-0.161***	0.027
	(0.044)	(0.044)	(0.053)	(0.067)
_cons	-52.378***	-49.846***	-50.620***	-94.547***
	(4.963)	(5.717)	(5.883)	(8.997)
N	15136	15143	15143	15102
R-sq	0.831	0.828	0.814	0.873

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table A2.7: Test for exogeneity of FTA coefficient in the case of intermediate goods on reduced sample

	(1)	(2)	(3)	(4)
lncombgdp	1.002***	0.815***	0.836***	1.244***
	(0.144)	(0.088)	(0.115)	(0.240)
lndist	-1.447***	-1.448***	-1.437***	-2.884***
	(0.031)	(0.037)	(0.038)	(0.054)
contig	0.200***	0.284***	0.221***	0.270**
	(0.067)	(0.067)	(0.072)	(0.114)
comlang_~f	0.809***	0.810***	0.880***	1.653***
	(0.045)	(0.045)	(0.051)	(0.066)
rta	0.109	0.208***	0.206***	0.415***
	(0.068)	(0.070)	(0.071)	(0.111)
rtaplus5	-0.059	0.033	0.023	0.084
	(0.092)	(0.085)	(0.089)	(0.144)
lngdpcap_d	.	.	.	.
	.	.	.	.
lngd~ap_d2	-0.003	-0.009	-0.006	0.026
	(0.007)	(0.007)	(0.010)	(0.023)
lnfk	0.452***	0.375***	0.334***	0.865***
	(0.079)	(0.068)	(0.080)	(0.118)
_cons	-27.426***	-24.035***	-25.942***	-41.992***
	(7.369)	(4.424)	(5.752)	(11.726)
N	4546	4550	4550	4536
R-sq	0.827	0.849	0.823	0.889

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

The results are similar in nature to those obtained from the total trade specification.

A2.5: Results

A2.5.1: The choice of a FE model

The use of a FE model over a RE one is preferred on conceptual grounds because it is desirable that there the unobservables are allowed to be correlated with the dependent variables. It is also justified through a Hausman Test performed on the basis of equation (20):

```
                      b = consistent under Ho and Ha; obtained from xtreg
         B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

             chi2(59) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =     1213.52
            Prob>chi2 =      0.0000
            (V_b-V_B is not positive definite)
```

A2.5.2 The impact of varieties

The table below shows the results for the estimation of (19) and (20). This exercise is interesting from the perspective of understanding how varieties and preferences affect the FTA coefficient. What emerges relatively consistently is that the estimates for the FTA coefficient seem to bias upwards when these are not included. This suggest that perhaps when one does not include these important independent variables, the FTA coefficient is capturing the variety and preference effects suggesting that countries which trade more varieties and whose trading structure is preferred trade more with each other and are also likely to engage in an FTA.

Table A2.8: Impact of varieties on trade flows

	Dep var: lnimports (no variety or pref)				Dep var: lnimports (with variety and pref)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	**FE1**	**FE 2**	**FE 3**	**OLS**	**FE1**	**FE 2**	**FE 3**
VARIABLES		(repart)	(rep. Par, year)	(repyear, paryear)		(repart)	(rep. Par, year)	(repyear, paryear)
lncombgdp	0.897***	0.488***	0.488***	0.924***	0.890***	1.014***	1.003***	1.060***
	(0.00347)	(0.0313)	(0.110)	(0.0358)	(0.00407)	(0.0244)	(0.0466)	(0.0329)
lndist	-0.776***		-1.062***	-1.063***	-0.761***		-1.063***	-1.065***
	(0.00930)		(0.0569)	(0.0178)	(0.00982)		(0.0544)	(0.0171)
contig	0.592***		0.245**	0.245***	0.576***		0.244**	0.246***
	(0.0343)		(0.111)	(0.0309)	(0.0340)		(0.111)	(0.0316)
comlang_off	0.646***		0.566***	0.566***	0.647***		0.564***	0.567***
	(0.0277)		(0.0981)	(0.0274)	(0.0274)		(0.0984)	(0.0276)
rta	0.195***	0.114***	0.242***	0.238***	0.254***	0.104***	0.234***	0.240***
	(0.0195)	(0.0361)	(0.0664)	(0.0334)	(0.0196)	(0.0322)	(0.0676)	(0.0331)
lngdpcap_d					-1.289***	1.215***	1.200***	1.187***
					(0.0841)	(0.183)	(0.145)	(0.386)
lngdpcap_d2					0.0676***	-0.129***	-0.128***	-0.0881***
					(0.00478)	(0.0102)	(0.00859)	(0.0218)
lnfk					0.0920***	0.254***	0.00318	-0.0340
					(0.0180)	(0.0663)	(0.135)	(0.0411)
Constant	-28.09***	-13.14***	-3.991	-27.45***	-21.69***	-40.39***	-31.84***	-37.84***
	(0.193)	(1.649)	(5.647)	(1.929)	(0.466)	(1.333)	(2.107)	(2.851)
Observations	20,669	20,669	20,669	20,669	20,631	20,631	20,631	20,631
R-squared	0.795	0.377	0.820	0.842	0.801	0.540	0.836	0.843
r2_o	.	0.611	0.781	0.857	.	0.388	0.867	0.809
r2_w	.	0.377	0.820	0.842	.	0.540	0.836	0.843
r2_b	.	0.641	0.713	0.897	.	0.383	0.951	0.799

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

A2.5.3. REGRESSION WITH NET FLOW OF INTERMEDIATE GOODS

The net flow of intermediate goods is constructed by removing the domestic content of imported intermediates from a particular location. This is achieved by multiplying the measure intimps_bvsbil by one minus the average share of the domestic content of intermediate imports from the originating country (VS1). The results show very similar coefficients and hence imply that 'double counting' concerns may be unfounded.

Table A2.9: Impact of an FTA on gross and net flows of intermediate goods

VARIABLES	lnintimps_bvsbil	lnnetintimps_bvsbil
lnmass	1.919***	1.920***
	(0.0420)	(0.0418)
lndist	-2.176***	-2.166***
	(0.0373)	(0.0374)
contig	0.413***	0.393***
	(0.0581)	(0.0579)
comlang_off	1.082***	1.080***
	(0.0514)	(0.0513)
lngdpcap_d	1.302**	1.287**
	(0.600)	(0.600)
lngdpcap_d2	-0.0874**	-0.0863**
	(0.0341)	(0.0340)
lnfk	0.217***	0.217***
	(0.0717)	(0.0716)
rta	0.503***	0.497***
	(0.0682)	(0.0679)
Constant	-46.45***	-46.67***
	(3.253)	(3.268)
Observations	20,590	20,590
R-squared	0.870	0.870
Number of repyear	545	545
r2_o	0.763	0.734
r2_w	0.870	0.870
r2_b	0.696	0.627

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1