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The Nature and Evolution of Vertical Specialisation: What is the Role of Preferential Trade Agreements?

Javier López González and Peter Holmes[1]

Abstract

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The concurrent international fragmentation of production structures and regionalisation of world trade suggests the need for research into the links between these processes. In this paper we develop a method allowing us to gauge the bilateral element of vertical specialisation and hence make headway into capturing its nature and evolution with particular emphasis on the regional aspect of this phenomenon. We decompose vertical specialisation into backward and forward linkages and find that, on aggregate, the nature of these linkages varies significantly according to the position of a country in the value chain. In addition, we find a statistically significant correlation between these linkages and changes in productivity growth suggesting a possible link between this process and economic growth. Where regionalism is concerned we find marked differences between European, North American and Asian vertical specialisation. Where the former two tend to be more inward oriented, the latter remains highly dependent on European and North American demand.

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1. INTRODUCTION

The unprecedented reduction in barriers to trade (bilateral and multilateral) combined with reduced communication and transport costs (*Death of Distance* (Cairncross 1997)) has presented firms with new opportunities to fragment processes of production across international borders. This has spurred a new wave of globalisation which is re-shaping the way we think about trade and the borders of production both at the country and firm level. Concurrently, the deepening and widening of regional trade agreements calls for an investigation into this disintegration of production structures across preferential partners[1], within Europe and more broadly. The simultaneous growth of "vertical specialisation" in Asia (Baldwin 2006) in conjunction with the increase in bilateral agreements in the region strongly suggests that the processes are linked. In this paper, we start from the premise that the surge in regional trade agreements coupled with the increased "depth" of the RTAs plays an important role in the growth of vertically specialised trade as documented in Feenstra (1998), Yeats (2001), Hummels et al (2001), Yi (2003) and OECD (2010). As a preliminary investigation we use extensions of the Vertical Specialisation Indicator (VSI), developed by Hummels et al (2001), to allow us to capture bilateral value chain activity to show that these processes could be linked.

The primary purposes of this paper are:

- To discuss the theoretical underpinnings of vertical specialisation whilst providing a workable definition allowing us to account for the extent, spread and evolution of vertical specialisation, and
- To shed light on the role of regional trade agreements in promoting this phenomenon.

Our secondary aim is to prepare the ground for subsequent econometric analysis on the link between vertical specialisation and regional trade agreements. To this end, the paper is divided into 6 broad sections. Section 2 provides a review of the literature on vertical specialisation and an initial appraisal on the possible role of regionalism. Section 3 then looks at the role of deep integration in the facilitation of value chain activities. Section 4 deals with challenges in measuring this type of trade. In section 5 we propose a novel way of capturing vertical specialisation across bilateral partners and differentiate across forward and backward linkages. We also present some preliminary observations on the nature of these linkages both in aggregate and across regions. The final section concludes and sets the agenda for future research in this field.

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2. VERTICAL SPECIALISATION IN THEORY

Countless names have been given to describe the widespread disintegration of production structures across countries,.ranging from *slicing up the value-added chain* (Krugman 1996) to offshoring, outsourcing, fragmentation (Jones and Kierkowski 1990 and 2001) delocalisation of production (Leamer 1996) and vertical specialisation[2] (Balassa 1967 and Hummels et al

[1] See Ethier (1996) for an account of new regionalism
[2] Term coined by Balassa (1967) but later regained by Hummels et al. (1998, 2001)

2001). They all broadly refer to the same concept of splitting up of production structures across national boundaries to gain cost advantages in production sequences. Resulting from this is an increase in intermediate goods trade where value added is performed in different countries at different stages of the value chain.

Models of the theoretical underpinnings are also numerous. These vary from standard Ricardian models (Sanyal and Jones 1982, Feenstra and Hanson 1996, Deardorff 2001, Yi 2003) to H-O frameworks (Jones and Kierzkowski 2001, Deardorff 2001, Arndt 2002, Baldwin & Robert-Nicoud 2010) passing through new trade theory (Ethier 1982, Burda and Dluhosch 2002, Lüthje 2001 and 2003, Grossman & Rossi-Hansberg 2008 and Baldwin & Robert-Nicoud 2010)[3]. The Ricardian models see technological differences as drivers of vertical specialisation. Yi (2003) puts forward a 'magnification effect' where trade occurs in several stages across countries. Lower tariffs across borders magnify technology differences between countries and lead to stronger backwards and forward linkages. Lending support to Yi's theories are various papers. Egger and Pfaffermayr (2005) conduct a study on Austrian bilateral intra-firm trade. They show that within multinationals, falling trading costs encourage these to fragment production. They identify a magnification effect associated with two-way trade of components. They find that the magnification effect is a relevant explanatory variable for bilateral intra-firm trade. Further support to this vertical specialisation explanation is given by Chinn (2005) who looks at import and export flows for the US. He argues that vertical specialisation combined with decreasing tariff rates yield more plausible estimates for income elasticities and provide smaller standard errors.

In the H-O approach presented by Deardorff (1998), vertical specialisation occurs through differences in factor endowments across countries. The US exports skilled labour intensive goods to Mexico where they are assembled by unskilled labour and re-exported back as final goods to the US (e.g. *Maquiladoras* trade). Firms take advantage of lower costs of labour to decrease costs of production. Applying the H-O framework to regionalism Arndt (2002) argues that entering into an agreement with a country with differing factor intensities and allowing for vertical specialisation in tasks results in a more efficient allocation of processes of production around countries. This leads to further specialisation which frees resources previously devoted to production of a good in its entirety to a particular process. Vertical specialisation across preferential partners with elements of deep integration will facilitate this process and will be equivalent to technical progress in both the labour intensive task and the capital intensive task. Furthermore, if size of countries varies, there could be terms of trade gains. "The combined effect of investment liberalisation and cross-border production sharing is to raise wages in both countries and to increase area-wide output of good X" Arndt (2002).

The New Trade theory approach to vertical specialisation grows from the seminal work of Krugman (1979 and 1981) and Ethier (1982) where firm and industry economies of scale and product differentiation drive trade. An interesting approach is that proposed by the concept of the 'Ideal Variety Approach'. This was first introduced by Lancaster (1979). It parallels the *love of variety approach* introduced by Dixit and Stiglitz, however applied to intermediate good production, differing conclusions arise. The ideal variety approach postulates that for every final good, there exists an ideal intermediate good that perfectly fits its requirements. Should this ideal variety not be available, firms buying intermediate goods will need to devote resources to moulding (transforming) the available intermediate good before they can

[3] These economic approaches have interchangeably used partial equilibrium, general equilibrium and econometric estimation.

assemble the final good. This transformation requires labour and capital to be used and thus affects final good production. In a very interesting set of papers Lüthje (2001 and 2003) provides an economic underpinning, in a general equilibrium framework, for intra-industry trade in intermediate goods. Contrary to the love of variety approach, the ideal variety approach suggests that an increased use of available intermediate goods does not directly translate into greater production possibilities. An increased variety of intermediate goods increases the probability of an ideal good variety intermediate good being produced, but it is not by using other combinations of non-ideal intermediate goods in different proportions that a final good producer is going to increase production. These supply side models looking at vertical specialisation follow the broad concept that trade in producer goods has advanced at a significantly faster pace than trade in consumer goods. They seek to understand fragmentation through cost minimisation of value chain activities. A very insightful look into this is that of Burda and Dluhosch (2002). They argue that fragmentation is explained by cost-competition and Smithian specialisation with economies of scale in a monopolistic competition framework. Vertical specialisation is modelled through an index of fragmentation z which denotes specialisation through stages of value added across the value chain. An increase in fragmentation has a direct effect in reducing production costs but incurs a fixed cost equivalent to the increase in coordination management of shared activities. The mathematical model identifies market size as the guiding force in trade and fragmentation. Increased market size leads to increased pressures to cut costs of production. Burda and Dluhosch envisage a world where competition takes place in production methods. Intuitively, an enlargement in the trading area, in the form of a bilateral agreement, will bring about an increase in cost savings opportunities for firms in the form of increased fragmentation of production activities. "An enlarged market associated with trade drives an endogenous evolution of technology, which in turn affects the international division of labour" (Burda and Dluhosch 2002:432). The more credible the commitment to the RTA the more securely a firm can afford to outsource. Eichengreen (2006) suggests that before 1945 European firms could simply not guarantee security of supply if they sought to base production on imported parts.

The logic in the above exposed theoretical frameworks lends itself to a simple extension with regionalism in mind. On the shallow end of integration, the bilateral reduction in tariffs across preferential partners is likely to induce a magnification effect (Yi 2003) where vertical specialisation is promoted across bilateral partners. This may result in trade creation or trade diversion effects. For the latter, countries may choose suppliers on the basis of tariff advantages alone which have made these more attractive despite being less competitive. Yi's magnification effect is then likely to increase both the trade creating and the trade diverting forces in play when vertical specialisation across preferential partners is considered. Adding to these shallow effects, the creation of a larger shared markets would increase the probability of finding 'ideal varieties' (Luthje 2001 and 2003) and promote *Smithian* specialisation (Burda and Dluhosch 2002). Where elements of deep integration are introduced, 'thicker' markets may also play an important role in arranging contractual agreements between suppliers and hence reducing transaction costs. The link between vertical specialisation and regionalism may be more far reaching if VS plays a role in productivity growth. This is suggested by Baldwin & Robert-Nicoud (2010) where productivity gains, not unlike technological change, can be reaped through engagement in value chain activity. Arndt (2002) also suggested that regionalism and vertical specialisation are linked processes where deep preferential trade agreements may lead to productivity gains by way of vertical specialisation acting as technological progress. This then hints towards a possible link between vertical specialisation and economic growth. In addition, the literature on heterogeneous firms developed by Melitz (2003) and extended by Helpman and Yeaple,

2004, Antras & Helpman (2004), Gasiorek et al (2010), may provide some supportive evidence to this thesis. This strand of literature puts forward a link between trade and productivity, and whilst the empirical investigation does not explicitly recognise vertical specialisation, it is possible that the link is driven by changes in the location of production or participation in efficient international value chains.

2.1 A CHANGE IN PARADIGM OR BUSINESS AS USUAL?

Despite Vertical Specialisation (VS) being touted as a new phenomenon, its underlying nature can be traced back to a global up-scaling of Adam Smith's (1776) *pin factory*. One should think of this up-scaling as the introduction of international competition not in the final pin market, but in the tasks that lead to the production of a pin. This international division of labour (or tasks) across process of production is desirable as it gives rise to productivity increases that generate important welfare gains that can ultimately drive economic growth. Gains would arise through; 'learning by doing' effects; technology transfers; or increased international competition translating into increased efficiency and productivity. Where these gains are amplified through natural selection forces that follow global comparative advantages, they will result in a re-shaping of global economic activity. What is particularly new about this phenomenon is that it affects a wider array of goods, services and people in a way that traditional trade theory could be ill-equipped to predict. Baldwin (2006), in an effort to summarise the *new unbundling* paradigm in which vertical specialisation falls, argues that whilst "the first unbundling allowed the spatial separation of factories and consumers. The second unbundling spatially unpacked the factories and offices themselves"[4]. This suggests that vertical specialisation is to be understood as a process that marries two important and distinct theoretical strands of economic literature, namely; industrial organisation and trade theory. It will also become evident that the potential impact of this new unbundling extends to uncharted territory not least in its distributional consequences.

The new theoretical approach to vertical specialisation suggests a changing focus from trade in goods to trade in tasks (Blinder 2006 and 2009, Grossman & Rossi-Hansberg 2006 and 2008, Baldwin 2006 and 2010 and Baldwin & Robert-Nicoud 2010). Blinder (2006) first posited that under the *new industrial revolution*, the distinction between tradable and non-tradable goods and services becomes blurred as will trade theory predictions based on the traditional factor endowment dichotomy of skilled and unskilled labour. As an economy becomes more service oriented, the dichotomy for the new paradigm should focus on personal versus impersonal services (Blinder 2006) where the latter are easily offshoreable whilst the former are not[5]. This poses novel problems for economists given the heterogeneous mix of skilled and unskilled labour embodied in tasks and makes distributional prediction of impacts harder to grasp. Supporting this line of thought Grossman and Hansberg (2006 and 2008), backed by Baldwin (2006), were the first to advocate a new theory based on *trade in tasks* as opposed to products. In their model, declining costs of 'task trade' result in productivity boosts "for the factor whose tasks become easier to move offshore". In a similar vein, Baldwin and Robert-Nicoud (2010) argue that the new paradigm can be incorporated into mainstream trade theory by considering offshoring as a productivity gain through technological change ("factor specific technical progress" Baldwin 2010 p.5) suggesting that current trade theory may not be as ill equipped to deal with this process as initially thought.

[4] Baldwin 2006:p.7 "Globalisation: the great unbundling(s)"

[5] Levy and Murnane (2006) propose distinctions along the lines of routine and non-routine tasks. Where these distinctions are not without consequence for important Balassa-Samuelson type effects (i.e. wage (productivity) differentials across types of goods (traded/non-traded, personal/impersonal and routine/non-routine))

An interesting historical anecdote is that new as this paradigm may seem, Adam Smith had already understood the importance of tasks in the production of goods:

> *"The woollen coat, for example, which covers the day-labourer, as coarse and rough as it may appear, is the produce of the joint labour of a great multitude of workmen. The shepherd, the sorter of the wool, the wool-comber or carder, the dyer, the scribbler, the spinner, the weaver, the fuller, the dresser, with many others, must all join their different arts in order to complete even this homely production."(Adam Smith 1776:p.X)*

Where it seems that in the process of developing tractable theories, some important lessons from Adam Smith's work may have been forgotten. But the new literature seems to have gone full circle leaving us where we started. At one level there is little need for a paradigm shift because trade in intermediate goods or trade in tasks is like any other form of trade, although the ability to outsource parts of a production process does potentially enlarge the scale of the tradeable sector. There is one difference however that is rarely remarked on. Vertical specialisation involves trade in complementary goods. Most of the traditional micro theory of trade works because goods are more or less close substitutes but when we have trade in intermediates we are in a world of complementarity where price effects can have unusual consequences. If the price of Chinese intermediates falls, this makes our producers of final goods more rather than less competitive, until the point where a flip occurs and final production relocates. On the other hand what is good for our final producers may be bad for our intermediate producers, recalling tensions between spinners and weavers in Smith's time.

2.2 Challenges in Capturing Vertical Specialisation

Appealing as these new theories may be, empirically, there are many obstacles in capturing vertical specialisation. For starters, a new paradigm would require data on task trade which we are unable to construct as this would necessitate knowledge on processes of production. Traditionally data is compiled at the goods level and VS analysis is approximated by tracking intermediate goods trade across national borders (Feenstra 1998 and Yeats 2001). However, this approach is also not without its problems. Trade nomenclatures were not designed to identify products according to their end use, and despite the BEC nomenclature being a widely used identifier, it has rarely been put to the test. The problem is that there are some goods which cannot be solely attributed to one end use. As an illustrative example we take the case of milk; this product is, by its own right, a final good, but it can equally serve as an intermediate good in the production of dairy products. Similarly, a set of tires can be considered a final good for the factory selling to the spare parts market, but an intermediate good for a factory that produces cars. Hence many products are non-exclusive to one category of end use. In addition, there is a growing literature highlighting the problem of 'double-counted' trade (Daudin et al 2008). This arises because the entire value of a traded good is recorded upon crossing a border and not the value added at each stage. This will inflate the actual amount of trade taking place as well as affecting possible comparative advantage statistics. Countries may be assigned comparative advantages in products where minimal processing has been carried out. Irrespective of this, there is certainly a case to be made for trade based measures of vertical specialisation, not least given the abundance of data for both developed and developing countries. Gasiorek et al (Forthcoming) use proportions of intermediate imports to total exports across industries to capture the extent of

vertical specialisation. This technique, whilst attractive for its breadth of coverage, has some important shortcomings. The first is that it relies on the BEC nomenclature which may be imperfect in identifying intermediate products as above argued. The second is that it assumes that intermediate goods are predominantly sourced from similar sectors within an industry aggregate. Whilst this is likely to be true for a significant proportion of intermediate goods it will not be so for all leaving many uncounted intermediates. Thirdly, it assumes that entering intermediate goods are then used in some productive process and subsequently exported (i.e. it assumes away the use of imported intermediates in production for domestic consumption). Fourthly, it does not take into account linkages across industries and lastly, the indicator is not bound and hence can yield an array of extreme values. Despite these challenges, a trade based measure of vertical specialisation is desirable as it allows us to create a bilateral component of vertical integration hence allowing us to investigate the role that regional integration may be playing in shaping vertical specialisation.

It is now widely acknowledged that Input-Output based measures of vertical specialisation, such as those proposed by Hummels et al (1998 and 2001), may be more accurate in capturing the extent and spread of vertical specialisation. Here the Vertical Specialisation Indicator (VSI), developed in this body of empirical literature, captures the amount of foreign value added embodied in exports. It occurs when a given country imports products which it then uses in some productive process to export. This indicator does not capture imported intermediates used in the production of output destined for home consumption. Hence it is an indicator of *interconnectedness* via production chains that can be equally be seen as the backward linkage of a country with respect to the world. However, the cost of precision comes at the expense of breadth of coverage. The calculation of the indicator hinges on the availability of input-output tables which tend to only be available for a selection of developed countries and sparsely cover 5 year periods. In addition, the relatively low level of disaggregation these come in is likely to hide important sector specific trends. However, its ability to capture the interplay between foreign and domestic value added make it an invaluable tool in analysing the surge in vertically specialised trade[6].

2.3 Trade Agreements and Vertical Specialisation

The first step towards elucidating the role of trade agreements on vertically specialised trade is that of framing the analysis under a plausible empirical framework. Our working hypothesis is that vertical specialisation and preferential trade agreements are inextricably linked. This implies an element of simultaneity where causation may run from increased integration of bilateral value chains to trade agreements and also from trade agreements to increased bilateral vertical specialisation. Recent developments in the estimation of the effects of FTAs on trade flows in the context of endogenous trade policy (Baier and Bergstrand 2007) motivate our theoretical approach. This new literature suggests that not accounting for the endogenous formation of trade agreements results in important downwards biases on the coefficients of interest of a gravity model. Additionally, Trefler's (1993) work on endogenous protection and its effects on import penetration become highly relevant in this context. Trefler postulates that a model estimating the effects of protection on imports will suffer considerable bias if the endogeneity of protection is not accounted for. Given that the process of preferential trade liberalisation deals directly with trade protection levels, be these

[6] In the discussion of Table 1 we argue how grasping the spread of vertical specialisation may hinge on tracking the location of value added.

in terms of tariff or non-tariff barriers to trade, then we must consider that the degree of vertical specialisation, which involves both exports and imports, should be approached using an endogenous trade policy framework. In this respect, we can divide the above question into two separate issues. Firstly, we must look into the determinants of regional trade agreements and then consider the possible role of vertical specialisation.

The literature treating the formation of trade agreements in the early 90's (Krugman (1991), and Frankel Stein and Wei (1995)) suggested that engaging in trade agreements was the result of an exogenous process guided by the quantification of Vinerian gains. Countries would engage in regionalism if they expected trade creation to outpace trade diversion. However this exogenous approach to FTA formation gave way to a more endogenous approach with the emergence of the notion of 'natural trading blocs'. Baldwin (1993) put forward the domino theory of FTA formation where he suggested that governments engage in FTAs by weighing up national pro-membership forces against anti membership forces (pro-membership forces can be seen as export oriented firms and anti-membership forces as import competing firms). Baldwin argued that as FTAs become bigger, the pro-membership forces of nations outside the region become stronger. This brings about incentives for countries that have been left out to try to engage in bilateral talks. Essentially, as markets get bigger through regionalism, the cost of being left out of a preferential area increases as do the benefits from being inside. This contrasts with Grossman and Helpman's (1995) political economy approach which saw FTA formation as a result of the weighted interests of domestic player's preferences i.e. voter's utilities and import competing and export firms (lobbies). FTAs are then the result of targeted trade creation benefits for exporting firms and targeted trade diversion benefits for domestic firms. However, it was not till the work of Magee (2003), Baier and Bergstrand (2002, 2004, 2007) and Baier, Bergstrand and Egger (2006) that a more endogenous approach to FTA formation was formulated.

Magee's work (2003), provided compelling evidence on the endogeneity of FTA formation and trade flows. He found that high levels of bilateral trade play an important role in increasing the probability of forming a FTA. In a cross sectional gravity model setting for the year 1980 Magee found a positive FTA coefficient for agreements that were only present in the period 1985-2001. This suggested that countries engaging in preferential trade deals were already heavily engaged in trade. Baier and Bergstrand (2001, 2004 and 2007) then developed a series of papers which sought to control for the endogenous formation of trade agreements in a gravity setting. They argued that selection into agreements (unobserved heterogeneity) is likely to be the biggest cause of endogeneity. The unobserved variables affecting trade flows are also likely to play an important role in the formation of FTAs. Hence estimating a gravity model that does not account for this is likely to yield severe downwards biases on the FTA coefficients. They also suggest that IV techniques (Magee 2003) will not adjust for the unobserved heterogeneity as well as panel estimations with fixed effects[7]. This is because using fixed effects allows for arbitrary correlation of unobservables with the FTA dummy. Baier and Bergstrand (2007) find that when one controls for endogeneity, FTAs approximately double the amount of trade between partners.

What is true for aggregate trade flows could then extend to aggregate bilateral vertical specialisation. Indeed, this type of trade is likely to be motivated both by differences in factor endowments across countries (inter industry in nature) and also by differences of the intra-industry type (product differentiation and scale economies). This would suggest that the

[7] In addition, finding appropriate instruments is an enormous challenge which has yet to be resolved

gravity model would provide an appropriate framework for the analysis of vertical specialisation. However, as in the above literature, the integration of international value chains could precede or come as a result of targeted trade policy. Unfortunately, the literature has very little to say about the determinants of this type of trade and even less about the role of trade agreements in shaping vertical specialisation. This is because it has been largely unable to disentangle vertical specialisation in a bilateral setting. One notable attempt at elucidating the role of fragmentation in RTAs is that of Daudin et al (2008). They develop a method for identifying value-added trade where trade flows are netted from the double-counting of border trade[8]. They then compute intra and extra regional value added trade aggregates. Their results suggest that 56% of the EU's value added trade comes from other EU partners. For the Americas and Asia the intra regional figures stand at 44% and 34%. Whilst the study offers an innovative approach into disentangling the location of value added, it does not however provide a formal treatment of the determinants or the causality between vertical specialisation and trade agreements. Nordas (2004), to our knowledge, provides the first empirical investigation into the determinants of aggregate vertical specialisation. His paper suggests that economically small countries with high GDP per capita and low tariffs tend to exhibit higher levels of vertical specialisation. In particular, Nordas shows that infrastructure variables such as telephone density and port efficiency are key drivers of vertical specialisation. These variables serve as instruments for delivery times and rates of fault which have been recognised as important in the value chain literature. This, in turn, suggests that the 'thickness' of the market could play a decisive role in vertical specialisation. Hence we could expect that trade agreements creating common and contestable markets should be characterised by higher levels of bilateral vertical specialisation. Notwithstanding, there is also a strong scope for factor endowment differences driving the location of production. One can then decompose the effects of FTAs on vertically specialised trade into two. The first is the shallow integration effect that arises from the removal of trade barriers. This effect is not unlike the effect proposed by Yi (2003) where vertically specialised trade is magnified as a result of lower tariffs which enable an easy back and forth movement across borders. The second is the deep integration effect that removes behind the border barriers to trade and which we discuss in the following section.

3. Deep Integration and Vertical Specialisation

In considering deep integration it is clear that there is an important role for deep policy integration and harmonisation in the broad domain of what may be called "standards". Significantly, deeper integration with respect to standards is something which can be achieved either by public or private agents. It is also important to note that standards can be either barriers to trade or facilitators of trade, and it is difficult to identify beforehand their specific nature. They can be drawn up nationally, regionally, or multilaterally, or by the private sector and be either mandatory or voluntary. In the case of private standards they may be made mandatory by the market and can be both a challenge and an opportunity for developing country exporters.

International trade is increasingly based on quality and technology rather than simply on price. This claim is something of a cliché but we seek here to give it a firm basis. For an

[8] An inherent problem in using simple trade statistics to track fragmentation is that the entire value of a good is counted each time it crosses a border. Hence if country A exports semi finished ipods to country B which then exports the finished ipods to country C, trade statistics will count the value of the ipod in the border of country A and B and that of country B and C where only one ipod has moved.

increasing number of commodities public and private standards (in the broad sense of this term) are creating a situation in which the notion of a trade off between price and quality no longer applies. That is to say, price competition enters into the game only if certain minimum standards have been met. This means that in such markets there is no positive price at which certain low quality items can be sold. Such a concept runs against the orthodox precepts of neo-classical economics but is immediately intelligible when one allows for uncertainty and transactions costs. In a world of perfect information and no transactions costs, standards would not be necessary. Buyers would be able to costlessly assess the quality of goods and services and evaluate and predict the adverse cost of lower quality. In real life consumers and users do not know the consequences of certain health or breakdown risks and are willing to pay a premium for standardized commodities, including the assurance of homogeneity from a particular supplier even if their product differs from others'. Moreover there are certain risks of breakdown that one would not take at any price. For those who can comply, externalities and increasing returns to scale from common standards may actually make the marginal cost of standardisation negative.

We can then identify what might be termed "Smithian" as opposed to "Ricardian trade"[9]. In "Ricardian trade" commodities are homogenous, or at least the quality is instantly recognisable and measurable and differs only in a quantitative way, such as in the percentage content of a certain material. In this model profit margins will not be related to quality and comparative advantage is based on cost of inputs and cost-efficiency alone. In the "Smithian" model, the assumption is that there are economies of scale and the benefits of specialisation come from chopping up the production chain. But of course as the processes are separated the outputs of one process become the inputs to another and this requires some sort of coordination mechanism between suppliers and users-consumers. There was extensive literature on transactions costs (including Williamson, 1975) which argued that the increase in transaction costs was overcome by "internalizing" them through vertical integration or through reinforced and cross-ownership structures with a consequent expansion intra-firm "trade". Williamson argued that even between firms in the same town, the problems of monitoring quality were likely to be so great that only hierarchical control of production processes could ensure quality. Hence, that the "factory system" arose not from technological economies of scale but from the need for monitoring of quality. For example if a clothing manufacturer could only see the outside of bales of cloth he would not know what they were like throughout: he would prefer to have control over the workplace where they were made. External producers were marginalized. However, new management and information systems have revitalised the subcontracting and outsourcing relationship.

Best (1990) took a complementary approach arguing that the development of technical standards in the US in the 19th century both directly raised productivity across the whole economy (because US standard screws has very well shaped threads) but also generated huge externalities as the army's demand that parts for rifles be interchangeable wherever they had been made. The result was that firms and workshops could specialise in very fine lines of activity and gain economies of scale and learning effects. The United States thus achieved true deep market integration. A viable standards system is a way to reduce the transactions costs of unreliable and potentially incompatible components. However standards without a guarantee of quality are not adequate. The entire "outsourcing" movement is based on the need to find ways round the Williamson problem.

[9] We could also have used the term "Heckscher-Ohlin trade".

The Japanese car industry has often been seen as a model for others to follow, in two respects, first the striving for zero defects and the extensive use of external supply chains. Enthusiasts for the "Toyota model" – originally based on the quality assurance ideas of the American engineer Deming, showed that there is no trade-off between physical productivity and production quality: this is because high productivity is best achieved by ensuring that all output coming off the production line can be sold without further modification. Japanese firms have been very successful in both cars and especially in electronics in extending this model to suppliers across the whole of East Asia, despite the lack of institutional support.

John Sutton's work has vividly illustrated the role of quality standards in the general sense. In an investigation of how the Indian and Chinese car component industries have developed he shows that those firms who have become successful subcontractors have done so by reducing the rejection rates of faulty products to levels comparable to US, EU or Japanese suppliers. Those who have not done so have not been able to enter the value chains.

The reason why it is necessary to use sophisticated quality assurance processes rather than simply relying on monitoring output quality is that the defects in the intermediate output may not be easily visible. One component proving defective could damage an entire production line. Similar considerations apply to consumer goods, especially food products which are increasingly being bought and sold in the same way as intermediate industrial products, in that supermarkets are imposing increasingly tight quality standards treating them as inputs into a production process. Necessary does not however mean sufficient: producers who cannot meet these quality standards will not be able to do so merely by the creation of a regional monitoring capacity, though this is clearly the first step in improving quality.

The phenomena we are analysing here leads to deeper market integration, and have to do with intra-industry trade in two ways, which we define as "horizontal Smithian trade" and "vertical Smithian trade", which is our main concern here. These are nothing more than the two well known types of intra-industry trade. The first type where producers market a finished product that fits into a highly differentiated niche where reputation, brand and quality allow a price premium to be obtained that cannot be eroded by new entry. This process is sustained by what the economists calls "love for variety", a typical feature characterizing all the so-called new trade theory models as well as recent model of industrial organization and heterogeneous firms. In this type of trade, standards work as "amplifiers" and "catalysts" by allowing the creation of recognizable "brands" and types, developing new niches that consumers can identify without incurring in screening and search costs. Consider for example the expansion of "organic" market and related standards or the "fair trade" market.

The type of intra industry trade which is our main concern is where the "value chain" is broken up, and in Adam Smith's example different parts of the pin production process are located all over the world. For this to be able to happen we need mechanism for the contracts between upstream and downstream producers to be able to be very carefully and reliably monitored and enforced. This depends on the capacity of the producers to guarantee quality, which depends both on the market and on national and global public as well as private provision of standards facilities. In such markets low wages cannot offer an alternative to compliance (cf Jaffee and Henson). This type of trade is frequently variously referred to in the literature as vertically fragmented trade, or more recently trade in tasks. The term trade in tasks emphasises the point that this type of intra-industry trade may not simply be in manufacturing but is likely to cross the boundaries between manufacturing and services.

Most trade models focus on countries as their unit of analysis, but in reality it is firms that are conducting the trade.[10] Therefore it is important to identify the types of firms involved in these different types of trade. "Ricardian trade" can in theory involve any firms. However the traditional trade models are characterized by a couple of important assumptions: perfect competition and no economies of scale internal or external. The firms involved in horizontal intra-industry trade are not necessarily internationally integrated while the ones involved in vertical intra-industry trade will normally be firms linked to foreign firms through long-term affiliations or because they are part of "global value chains" (Humphrey and Schmitz). What is important from a theoretical point of view is that these firms are characterized by economies of scale and learning processes which introduces increasing returns and the possibility of specialization.

We see however an interesting paradox as we consider the various possible effects of deeper institutional integration. Deeper institutional integration lowers transactions costs so that firms can more easily do business with others that they do not initially know. At the same time markets are clearly more integrated when they are less than totally anonymous, ie when participants have more information about each other, which is likely to increase trust. This implies that the kind of deep market integration promoted by institutions that cut transactions costs can create two forms of deep integration:

- a very comprehensive certification or standardisation regime which can permit trade between anonymous partners

OR

- networks of repeat business

This also raises the possibility that the nature of the relationship between firms is likely to be non-monotonic as deeper integration takes place. A first phase of deeper integration can lead to the possibility of investing in durable market relationships, the creation of quasi-integrated value chains; but that there could be a later step in the process where buyers and sellers can afford at very little cost to switch trading partners but still be assured of the requisite quality and reliability. Alternatively, it may be that purely market driven deep integration leads to one outcome whilst collective institutions are needed for the other.

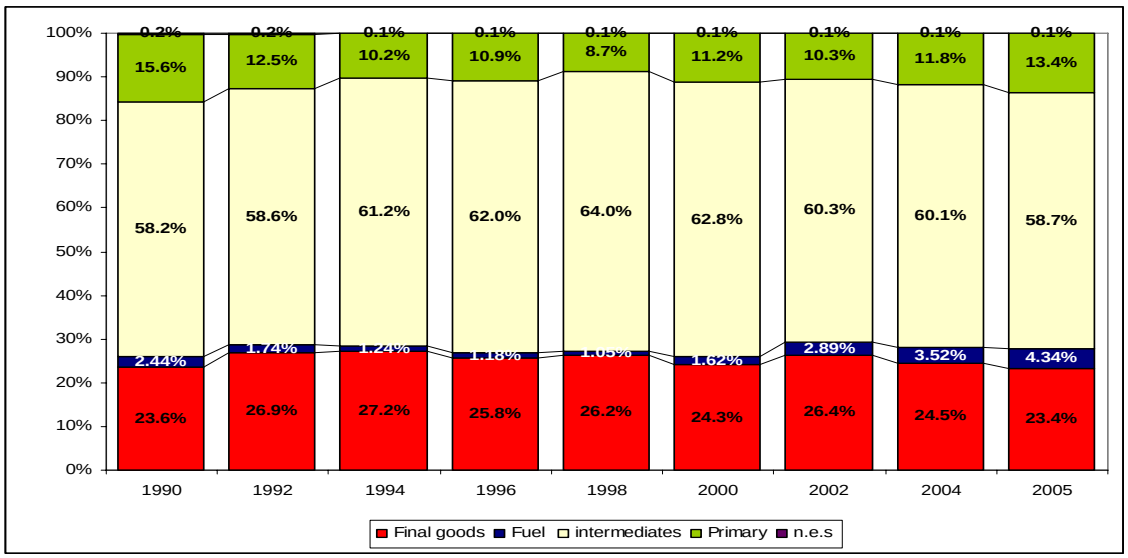
A paper by Leijonhufvud (2007) drawing on the unbundling concept surveyed by Baldwin (2006) suggests that value chains have some of the features of the intra-firm monopoly-monopsony elements that exist within firms for successive stages of the production process. Without referring to deep integration as such he suggests that the most important contribution institutions can make is to create "thick" markets where upstream and downstream partners have a free choice to switch contractors. In this scenario durable contracts and many potential partners could coexist as it would be the availability of alternatives for the other side rather than the opposite that induced each party to stay with the relationship. So, in looking at the depth of integration we need to consider the thickness as well as the depth of integration. The role for institutional deep integration may be most important in ensuring the correct balance.

[10] A number of recent theoretical models have shifted their attention from countries to firms (cf. Melitz, 2003; Melitz, Helpman and Yeaple, 2004)

4. VERTICAL SPECIALISATION IN PRACTICE

Capturing the extent and spread of vertical specialisation is challenging because products can often act as both final and intermediate goods. If intermediate goods trade is increasing at a faster rate than other types of trade (as suggested in Feenstra 1998 and Yeats 2001), we would expect a rising share of intermediates in total trade, however, looking at the evolution of world trade, in Figure 1, shows little change in the underlying trends[11]. This is counter to the perceived notion that the last decades have seen an important increase in vertical specialisation and may suggest that the BEC nomenclature is an imperfect identifier of intermediate goods trade. Alternatively it may imply that tracking intermediate goods trade is not an appropriate metric for capturing vertical specialisation[12].

Figure 1: Evolution of world imports by type



Source: Author's calculations, WITS- COMTRADE

In an effort to elucidate two separate but related issues; firstly the (true) extent of vertical specialisation and secondly to test the validity of the BEC nomenclature, we look at I-O tables and draw preliminary conclusions on the levels and evolution of intermediate goods trade. We then compare the evolution of these to that of intermediate goods as identified using the BEC nomenclature.

The OECD STAN database provides sectorally harmonised I-O tables for 42 countries. These are divided into domestic intermediates and imported intermediates spanning three points in time (circa 1995, 2000 and 2005) and include both manufacturing and services sectors[13]. We

[11] Similar results are found in OECD (2010) and Chen et al. (2005)

[12] There are important price effects taking place. These have fallen substantially for intermediate goods in the last decades. This is an important issue and comes as a corollary to our hypothesis. The allocative effect of VS would suggest that intermediates will be produced where they become cheapest, hence there will be a generalised reduction of the price of these. This is not captured in the figure as we are dealing with nominal trade flows. If the price of intermediates has fallen faster than the price of final goods, we will not capture much change in intermediate trade patterns even if the volume of these has increased. Irrespective of these price changes, the figure suggests that maybe using trade data alone to track the process of vertical specialisation may be misleading.

[13] The time delimitation of the tables is not as clear cut as presented given that some countries report slightly different years or do not report in a given year. For these countries, we assume that the values reported are similar to those reported in earlier years where there might be a year or two gap.

aggregate these tables to create an OECDX table that allows us to draw preliminary observations on the spread and evolution of imported intermediates[14]. The advantage of using these I-O tables is that they allow us to bypass trade classifications and identify the value of intermediate goods by the pure use of these in the economy rather than by suggested end use. In Table 1 we show the evolution of imported intermediates for our OECDX aggregate of the 42 countries in the three periods above delimited. We equally show the evolution of the use of domestic intermediates; total output; domestically consumed output; total exports and domestic value added. The final two panels (B and C) serve the purpose of comparing the identification of non-service sector intermediate goods across the I-O data and the BEC nomenclature essentially putting the BEC nomenclature to the test.

The input-output data reveal that, for our OECD aggregate, the share of intermediate imports to total exports has been increasing over time; however, the share of intermediate imports to total imports has witnessed a slight decrease. In parallel, we see that the share of intermediate imports in total or domestic output remains low. It has nonetheless witnessed increases which seem to be driven by the faster increase in imports than in output. The marked increase in the share of imported intermediates to domestic intermediates may be indicative of a source switching trend which is corroborated by the increase in imported intermediates as a share of domestic value added (which has increased by 24% in ten years). These trends lend themselves to the idea that vertical specialisation is not necessarily an additive process equating to increases in intermediate goods trade, but rather that there might be a substitution or complementarity of domestic value added and foreign value added. Hence it appears that the foreign value added of output is increasing to the detriment of domestic value added. This observation is not without consequence. Firstly it may be evidence of *true* gains from trade, where production is following comparative advantage and the world economy is becoming more efficient in allocation. Secondly, and following from the first point, this may be presenting developing countries with new opportunities to engage in value chain activity, and thirdly it may also mean that concerns for employment losses in the developed world are not completely unfounded.

When we turn to the trade figures as per the BEC nomenclature we note a similar pattern emerging. Imported intermediates as a share of total imports are declining. It is however striking that the evolution of intermediate imports as identified using the BEC nomenclature (C) follows a similar path to that found using the I-O data (B). Whilst it seems that the BEC nomenclature underestimates the true value of intermediate imports, it also appears to underestimate the true value of total imports by a similar proportion, hence the share of intermediate imports to total imports are comparable across the two identification methods. This in turn suggests that maybe the BEC nomenclature is not as bad a classification as it is often portrayed to be[15]. Table 1 also suggests that Yeats' findings for 1995 could be challenged, may have changed or are only valid for certain manufacturing sectors. This opens the door to a new analysis on the extent and spread of global vertical specialisation and also on the location of this. In addition, the results from Table 1 suggest that tracking imports of

[14] The 42 countries are 1) OECD: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States. 2) +12: Argentina, Brazil, Chile, China, Estonia, India, Indonesia, Israel, Romania, Russia, Slovenia, Taiwan, South Africa. The tables are in national currency and at producer prices, hence we transform these into Dollars using exchange rates extracted from the Penn World Tables.

[15] This statement has to be read with caution as the underlying trade and output data come from different sources and are subject to different collection techniques and/or estimations.

intermediate goods across borders may not be the best way of capturing vertical specialisation as the big changes seem to be happening in the location of value added, not the increase in intermediate goods trade.

Table 1: Evolution of Intermediate Goods

		1995	2000	2005	Change
I-O Tables (A)	Intermediate Imports	3428615	3689957	5916942	72.60%
	Total Imports	5382318	5999260	9404367	74.70%
	Domestic Intermediates	21770966	22900801	31787329	46.00%
	Total Output	52610565	54516731	75799556	44.10%
	Total Exports	5394328	5859587	9140678	69.40%
	Domestic Value Added	27050084	27133761	37404913	38.30%
	Int Imps/Tot Exps	0.636	0.63	0.647	1.80%
	Int Imps/ Tot Imps	0.637	0.615	0.629	-1.20%
	Int Imps/ Tot Output	0.065	0.068	0.078	19.80%
	Int Imps/ Dom Output	0.073	0.076	0.089	22.20%
	Int Imps/ Dom Ints	0.157	0.161	0.186	18.20%
	Int Imps/ Dom VA	0.127	0.136	0.158	24.80%
	Dom VA/ Tot Output	0.514	0.498	0.493	-4.00%
I-O Tables (less Services) (B)	Intermediate Imports	2883820	3162342	5022251	74.15%
	Total Imports	4759419	5282321	9191093	93.11%
	Total Exports	4243046	4500627	6889849	62.38%
	Int Imps/ Tot Imps	0.605919	0.598665	0.546426	-9.82%
	Int Imps/ Tot Exps	0.679658	0.702645	0.728935	7.25%
Comtrade (C)	Intermediate Imports	2413416	3223762	4873073	101.90%
	Total Imports	3889375	5227267	8423249	116.60%
	Total Exports	3855838	4916457	7921085	105.40%
	Int Imps/ Tot Imps	0.621	0.617	0.579	-6.80%
	Int Imps/ Tot Exps	0.626	0.656	0.615	3.90%

Source: Own calculations from OECD I-O STAN database and Comtrade. Values are in million $

Whilst it is important to note that the above analysis hides country and sector specific effects in its aggregate representation, it nonetheless poses an important question on the perception of vertical specialisation. It also underlines the importance of carefully defining the phenomenon before proceeding with a more detailed analysis of its role amongst preferential partners. As a starting point, the above table shows that foreign value added has outgrown domestic value added by a factor of 2. This can be seen by comparing the change in domestic value added to that of intermediate imports (panel A) and also by the rise in the share of intermediate imports to Domestic VA which even if averaging 15% in 2005 has grown by 25% in a decade. Which in turn suggest that more focus should be paid to the location of value added rather than the movement, across borders, of intermediate goods. We do this by looking at the Vertical Specialisation Indicator.

5. THE VERTICAL SPECIALISATION INDICATOR (VSI) AND NEW EXTENSIONS

In recent years, the preferred indicator for capturing vertical specialisation has been the VSI as developed by Hummels et al (2001). Vertical Specialisation occurs when a good is produced in at least two sequential stages involving at least two countries where value is added to imported intermediates and the resulting output is exported. In matrix notation the indicator is summarised as follows:

$$VSI = \frac{VS}{X_{tot}} = \frac{\mu A^M [I - A^D]^{-1} X}{X_{tot}} \quad (1)$$

Where μ is an *1 x n* vector of 1's, A^M is the imported technical coefficient *n x n* matrix, $[I-A^D]^{-1}$ is the *n x n* Leontief inverse, X_i is an *n x 1* vector of exports (i=n) and X_{tot} is a scalar of total exports[16]. By its definition, vertical specialisation captures the content of intermediate imports that are embodied in exports and not in final output (i.e. the sum of the domestic and external output). This suggests that the indicator is one of *interconnectedness* with respect to the world which tells us *the amount of imported intermediates needed to satisfy a given export demand vector at current technologies*. It then follows that the indicator provides a metric for the backward linkage of a country with respect to the world. The main advantage of this indicator is that it takes into account industrial linkages across sectors thus providing a more precise measure of vertical specialisation. This however comes at the cost of aggregation given the reliance on I-O tables where data is rarely aggregated beyond 50 sectors. In addition, the frequency and country availability of these tables is low.

Hummels et al (2001) underline the importance, in recent decades, of vertically specialised trade. They show that for the period 1970 to 1990, 30% of growth of 10 OECD countries' exports is due to this type of trade. Similarly, the importance of vertical specialisation is further reinforced in Yi's (2003) work. His model that allows for a non-linear response of trade to low tariffs (i.e. the magnification effects), shows that vertical specialisation accounts for 50% of growth of OECD exports.

However, the VSI, is not a bilateral measure, and in its current form, is unable to capture the possible link between vertical specialisation and preferential trade. This is because it measures global vertical specialisation. This shortcoming has not gone unnoticed in the literature and has spurred a flurry of papers that try to extend the VSI. These new bilateral indicators tend to be concerned with the location of value added across bilateral partners. In line with the evolution of these I-O based measures developed by Daudin et al (2008) and Johnson & Noguera (2009) we extend the VSI to include a bilateral element. Our analysis differs somewhat from that exposed in these two papers in that we are interested in finding a metric for the evolution of value chain activity and not tracking value added trade per se. We are particularly interested in tracking forward and backward linkages in trade rather than their total equivalent in output. In the next section, we develop a new methodology enabling us to extend the calculation of vertical specialisation to incorporate a bilateral dimension and hence allowing us to track forward linkages in vertically specialised trade[17].

5.1 AUGMENTING THE VS INDICATOR

To add a bilateral dimension to the VSI we are to develop an identification method that will allow us to approximate the value of intermediate imports used by a given country from a particular partner. To do this we use readily available trade data and exploit the technical coefficients of the import matrix in an input-output framework. This allows us to estimate the intermediate technical coefficient matrix by origin country.

[16] Equation (1) gives us the sum of all VS indices by I-O sector. To get the sectoral VS we remove the vector of 1's represented by μ and diagonalise the export vector.

[17] Hummels et al (2001) allude to these forward linkages and devise a VS1 indicator that captures them, but they do not calculate this indicator from the I-O tables as it requires tracking intermediate goods across destinations (i.e. bilaterally)

5.1.1 THE INTERMEDIATE TECHNICAL COEFFICIENT MATRIX BY ORIGIN COUNTRY

To identify the intermediate component of imports by origin we exploit the information contained in I-O tables describing the linear interlinkages between sectors in an economy[18]. Consider below the reduced I-O imported intermediate square matrix M as an *n x n* matrix where n=n=3; agriculture, industry and services:

	Agriculture	Industry	Services	total intermediate imports	total imports
Agriculture	X_{11}	X_{12}	X_{13}	IM_1	TM_1
Industry	X_{21}	X_{22}	X_{23}	IM_2	TM_2
Services	X_{31}	X_{32}	X_{33}	IM_3	TM_3
Value added	$(Z_1-\sum X_{n,1})$	$(Z_2-\sum X_{n,2})$	$(Z_3-\sum X_{n,3})$		
Total Output	Z_1	Z_2	Z_3		

Here $X_{11,}$ represents the imported intermediate products sold from the agricultural sector to the agricultural sector. X_{12} is then the imported intermediate products sold from agriculture to industry and so forth. This matrix represents the overall use of imported intermediates, by each sector and from all countries. It follows that this matrix is the sum of imported intermediates from all partners so that $M=\sum m_o$ where m_o is the imported intermediates matrix from country of origin o. We have no way of knowing what the individual m_o matrices look like, but we can maximise the use of the available information to approximate the separate m_o matrices by assuming that imports are used in the same proportions across each origin. This assumption is not uncommon in the literature and is often referred to as the fixed proportion assumption[19]. It allows us to calculate the pass-through of total imports into intermediate imports by simply dividing each entry in the above matrix by the corresponding total imports so that:

$$P_{m,n} = \frac{X_{m,n}}{TM_n} \qquad (2)$$

Where *m* is the selling sector and *n* is the buying sector. The resulting 3x3 *P* matrix will tell us how one unit of total imports from a given sector is used (on average) in production sequences across the different sectors within an economy. By post multiplying *P* by a vector of imports x_o (from country o), we then derive an approximation of the m_o matrix. This then allows us to compute an imported intermediate technical coefficient matrix by origin country: A^m_o, by dividing each element of the new m_o matrix by the total output of each sector so that:

[18] Different identification strategies to capture the amount of imported intermediates by origin country were attempted. One of these used BEC identified products matched to the I-O classification. However the match between I-O identified global intermediate inputs and BEC identified inputs was relatively imperfect where great differences were the norm rather than the exception.

[19] In Daudin et al 2009 it is noted that a similar technique is used in Campa and Goldberg (1997) and Feenstra and Hanson (1997)

$$A_o^m = \begin{bmatrix} a_{1,1} & \cdots & a_{1,m} \\ \vdots & \ddots & \vdots \\ a_{n,1} & \cdots & a_{n,m} \end{bmatrix} = \left(\frac{m_{o\,n,n}}{Z_n}\right) \quad (3)$$

This matrix tells us the amount of imported intermediates, from a given partner, used to produce one unit of output. The elements of this matrix are the technical coefficients $a_{n,n} = \frac{X_{o\,n,n}}{Z_n}$ which show us the amount of imports from a given origin and sector ($x_{o\,n,n}$) that are used in proportion to the output of that sector (Z_n). In an I-O framework, these imported intermediates have to be combined with domestic intermediates (and intermediates imported from other countries) in order to satisfy a given demand vector. The problem that then arises is that m_o will always be smaller than M. This also means that A^m_o will be a fraction of A^M. If we are then to use the imported intermediate technical coefficient matrix from an originating country in an I-O model, we are going to find that we have altered the underlying technologies. In order to keep these constant, the domestic intermediate matrix has to be altered to take into account the shortcomings arising from the difference between the total imported intermediate matrix and the imported intermediates from a given origin. The intuition behind this is relatively straight forward. If a country's technology dictates that to produce one unit of an agricultural good you need to input 0.1 units of imported intermediate industrial goods, and if you do not currently import any industrial goods from a given origin, then you need to make up for this shortcoming elsewhere. One way of dealing with this issue would be to assume some form of substitutability of goods across the I-O system. Hence one could substitute these inputs for more inputs from another industry. However, this would require computing some algebraic system with various Armington functions and assumed elasticities. Our system would then depend on how we justify the substitutability of inputs. Hence we take a different route where we assume that, in order to satisfy demand, the country has to somehow make up for this shortcoming which maintains constant technologies. We can then calculate the intermediate transformation matrix, T_o, which is the sum of the domestic matrix and the difference between the total intermediate import matrix and the imported intermediate matrix from a given origin so that $T_o = D+(M-m_o)$. We then calculate the transformation technical coefficients matrix (A^T_o) by dividing each element of this matrix by output per corresponding sector (Z_n). The natural extension of this exercise is then to re-calculating the vertical specialisation indicator for both origin of intermediate imports and destination of exports.

5.1.2 Calculating Bilateral Vertical Specialisation: The Backward Linkage

Using the bilateral imported intermediate technical coefficient matrix A^m_o and the resulting transformation technical coefficients matrix A^T_o we can identify the amount of imported intermediates necessary to satisfy the demand for exports of a chosen destination (X_j), which is the backward linkage, by the following transformation:

$$BVS - B = \frac{BVS_{i,j}}{X_{j,tot}} = \frac{A^m_{o\,i,j}\left[I - A^T_{i,j}\right]^{-1} X_j}{X_{j,tot}} \quad (4)$$

Where X_j is an *n x 1* vector of export demand from country j (i.e.the exports of each I-O industry by the reporting country to another country[20]). Dividing the BVS by total exports to that same partner will tell us the share of intermediate imports, from a given partner, that are necessary to satisfy that country's demand for our exports[21]. Being able to extend this indicator allows us to take into varying dimensions of vertical specialisation. The VSI would allow us to look solely at the backward linkage of a country with respect to the world, but our extended indicator can handle several permutations of value chain activity. For starters, it allows us to look at the forward linkage of a country with respect to the world. In addition, we can calculate an entirely bilateral indicator identifying the amount of intermediate goods from a country that are used in servicing that same country's demand for our exports. It also offers the possibility of capturing trilateral relationships between countries i.e. how imports from one country are used to produce exports to another country. Some of these combinations are summarised below.

		Exports	
		Partner	World
Imports	Partner	Partner intermediate imports used to service partner	partner intermediate imports used to produce total exports
	World	total intermediate imports embodied in exports to a given partner	Total intermediate imports used to produce total exports (Hummels et al 2001)

The calculation of this type of indicator hinges on being able to connect trade data by origin/destination to production data. Where this can be easily done for merchandise trade, complications arise when one has service sectors in an I-O model. Non merchandise inputs from the service sector feature heavily in I-O tables. However bilateral trade statistics for these sectors are not readily available. This creates an additional hurdle in the calculation of the bilateral VSI which requires making further assumptions about the remaining non-merchandise sectors in the economy. This is because the calculation of the indicator requires that the matrices be invertable (square). To surmount this issue we construct a reduced-form bilateral imported intermediate technical coefficient matrix (A^m_o) where entries in the non-merchandise sectors become zero. This implies that the import vector used to derive the A^m_o matrix is reduced to merchandise sectors only[22]. Analogously, the exports vector in equation (X_j) will also have the same format with values reported for merchandise trade and zero values for other types of non-merchandise trade. The outcome will be that we assume both zero imports and exports in these sectors, but we still allow movement of imported

[20] This procedure is similar to that presented by Dean et al (2007), however they use different methodologies to identify intermediate goods by origin.

[21] If we were to not use our transformation matrix and keep both the total imported and domestic technical coefficients tables, then our measure of VS would be one that would tell us the amount of intermediate imports from a given country that would be needed to satisfy the demand for our exports. However if we do not take into account the originating country imports matrix, we might encounter a situation where we are importing petroleum (albeit in small quantities) from the likes of Luxembourg!

[22] This means that the imported technical coefficient matrix continues to be square, but has zero values for sectors in non-merchandise trade (The import vector used to devise the imported intermediate technical coefficient by origin matrix will have positive values for merchandise trade only)

intermediates into these sectors[23]. Whilst it is somewhat problematic to only be able to capture vertical specialisation in merchandise trade, some initial investigations into the nature of vertical specialisation by sector suggests that this phenomenon is more prevalent in sectors that are engaged in merchandise trade[24]. Furthermore, where most agreements tend to focus on liberalising merchandise trade rather than services, we hope that this issue will not derail us too much from our stated objectives.

To see if our indicator provides a good approximation of the true degree of vertical specialisation we 'test' it by comparing it against one that is calculated from an I-O table that details the origin and destination of trade. The Eurostat I-O tables decompose imports and exports into intra and extra EU destinations and hence provide us with the opportunity to compare the indicator calculated using the I-O tables alone (without service trade) with that calculated using the above developed methodology. We present the table of results in the appendix, however the main conclusions are that whilst the values of the VS indicator vary somewhat, the proportions of intra and extra EU bilateral vertical specialisation remain close. This seems to suggest that our methodology serves the purpose of capturing the backwards linkages present in the EU. In passing, the data also reveals that, intra EU vertical specialisation is higher than extra EU vertical specialisation which lends some supportive evidence to our hypothesis of higher expected VS for countries engaging in regional trade agreements.

But the indicator here developed can be further extended to capture forward linkages both in aggregate and at the sectoral level.

5.1.3 The Forward Linkage and Total Vertical Specialisation

We argue, in earlier sections, that the vertical specialisation indicator captures the backward linkage of a country with respect to the world. However, to grasp the full degree of vertical specialisation, one also has to consider the possible forward linkages that occur between countries[25]. Forward linkages, as it turns out, are the inverse of the backward linkages. So the forward linkage of China to the USA is essentially the backward linkage of the USA with China. In essence then, the amount of intermediate inputs that the USA uses from China is both the US' backward linkage to China and China's forward linkage to the USA. Hence, having a metric for the bilateral backward linkage allows us to capture the bilateral forward linkages (BVS-F). This is done by taking the intermediate imports used by the US from China and dividing this by China's total exports.

$$BVS-F_{i,j} = \frac{BVS-B_{ji}}{X_{jitot}} \qquad (5)$$

[23] A second method of approaching this restriction is that of subsuming all non-merchandise sectors into an aggregate sector. This means that we reduce the size of the I-O matrices (both imported (A^M) and domestic (A^D)) to a matrix where the last row/column represents the simple sum of the missing sectors. We then conjecture about these sectors using varying hypotheses. i.e. we can proxy for trade in these sectors by assuming that it follows a similar distribution to merchandise trade. So if the USA imports an average of 30% of its intermediate merchandise goods from NAFTA, it will import roughly the same proportion of its non-merchandise intermediate goods from NAFTA. Alternatively, we can try to proxy for bilateral service trade flows by use of aggregate service trade data.

[24] See Appendix A.5.

[25] Hummels et al referred to this type of linkage as the VS1.

With these two linkages, one can then calculate the total degree of bilateral vertical specialisation (BVS-T) which becomes the sum of the backward and forward linkages net of the initial backward and forward linkages so that;

$$BVS-T_{ij} = (BVS-B_{ij}) \times \left(1-(BVS-F_{ij})\right) + (BVS-F_{ij}) \times \left(1-(BVS-B_{i,j})\right) \quad (6)$$

Where the linkages are netted to avoid double counting as both intermediate imports and exports will already contain shares of domestic and foreign value added.

5.1.4 Sectoral Vertical Specialisation: Backward and Forward Linkages

To capture the sectoral linkages across bilateral partners requires a little more thought. The first step is to use the principles from equation (4) to obtain a matrix of imported intermediates from a given partner that are used to produce exports. This is done by changing the export term from an *nx1* vector in equation (4) to a diagonalised *nxn* export matrix[26].

$$SBVS-B-SBVS_{i,j} = \frac{A^{M}_{i,j}\left[I-A^{T}_{i,j}\right]^{-1}X_{n,j}}{X_{n,tot}} \quad (7)$$

The product of this equation is then $SBVS_{j,j}$ which is an *nxn* matrix of vertically specialised trade (i.e. imported intermediates used in the production of exports) from a given partner (i,j where i=j)) to a given partner[27]. To construct the sectoral backward linkage one then takes the column sums of this new matrix and divides these, element-by-element, by a vector of exports to a given partner. This then produces an indicator that captures the share of intermediate imports from all sectors from a partner that are used to produce exports for a given sector to a partner[28]. An illustrative example is helpful here. The sectoral backward linkage of the US with respect to Mexico in the car industry is the amount of imported intermediates used from all sectors in Mexico to produce car exports to a given partner.

$$SVS-B_{n,n,i,j} = \sum_{n,tot} \frac{SBVS_{i,j}}{\square} X_{n,j} \quad (8)$$

The sectoral forward linkage on the other hand is calculated by taking the row sums of the new SBVS matrix and dividing these, element by element, by total exports for that given sector. The indicator then captures the amount of imported intermediates from a particular sector that another country uses in producing all exports to a partner. Taking the car industry example, the US' forward linkage with Mexico is the amount of intermediate car exports of the US to Mexico that then go into producing Mexican exports (i.e. all sectors) to a given partner:

[26] This methodology has been previously used by Cardaso et al (2008). The diagonalisation of the matrix follows the simple principle of the identity matrix, it allows exports to be 'fed into' the VS share matrix (i.e. $A^{M}(I-A^{D})^{-1}$ thus providing an nxn matrix of vertically specialised trade.

[27] For simplicity, we assume that i=j

[28] If instead of the column sum, you take the row sum of the imported intermediate matrix, then the interpretation of the indicator is different, it then becomes the share of intermediate imports from a given sector and partner that are used to produce total exports.

$$SVS - F_{n,s,t,f} = \sum_{n \neq ow} SBVS_{f,t} \circ \frac{\square}{\square} X_{n,f} \quad (9)$$

Being able to distinguish forward and backward linkages across sectors and across partners allows us to more accurately track value chain activity and a country's position in the production sequence. Where the aggregate measures provide a good indication of how the whole economy is moving, the disaggregate measures will more clearly capture where these moves are happening which will in turn allow us to look into the 'why' of these changes. The sectoral extension will also facilitate future econometric analysis where industry specific effects may be controlled for.

5.1.5 DATA

We rely on the OECD's STAN database for the I-O tables. These are sectorally harmonised and cover over 40 countries at three points in time (around 1995, 2000 and 2005). To create a series, we transform the tables into dollars using exchange rates from the OECD database and extend these over a certain period under the assumption that variance in technology is small in years close to the base. The tables circa 1995 are extended till 1997, whilst the 2000 tables cover the period 1998 to 2002 and the 2005 tables span from 2003 to 2007. These are then deflated to a base price in the year 2000 (using OECD aggregate producer price deflators)[29].

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[30]. 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 occurs via variations in export and import values. We however have reason to believe that

[29] We were unable to find sector specific deflators

[30] 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.

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[31]. Second, and a more general limiting factor of I-O analysis, is that technology is assumed to be linear (Leontieff). 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.

The calculation of the above exposed indicators is also reliant on being able to concord trade and production data. This is done by way of the common ISIC rev 3 nomenclature across both the I-O tables and the trade data which is extracted from the Comtrade database.

5.2 Aggregate VS by Country

The degree of aggregate vertical specialisation for a given country is the sum of its backward and forward linkages (VS-B and VS-F respectively). Country A's backward link to the world is the amount of intermediate imports that it uses from all partners to service world export demand. Its forward linkage is then the amount of intermediates it exports which are subsequently used by other countries to service world export demand. used by the world to service world demand. A simple representation of this is helpful.

Distinguishing across types of linkages is important because these are likely to be different in nature. Consider two countries at different stages of development; Country A is highly developed and has a highly skilled work force whilst Country B has a comparatively less skilled work-force. Consider now the production of a good X that can be fragmented into two processes; one a skill intensive process and one that requires a lot less skill such as assembly. In autarky, Country A produces good X as does country B. If Processes cannot be fragmented internationally and trade opens between the two countries, the standard trade theory predictions suggest that the country which has a comparative advantage in the production of good X will export this product in exchange for another good. Let us say, for argument sake, that this is country A. Once we allow for fragmentation of production structures across national boundaries then the patterns of specialisation change. Country B can now specialise in the assembly of the intermediate skill intensive products from Country A to make product X. Under this type of specialisation, country B exhibits very strong backward linkages with respect to country A but very small forward linkages. In contrast, Country A will have very strong forward linkages with country B but very small backward linkages. As country B develops its supply capacity through, for example, technological spillovers and learning by doing, it will begin learning how to produce its own intermediate products and hence will start depending less on the backward link with country A. This in turn will reduce country A's forward link to country B. The end result of this simple two step production sequence

[31] 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.

with evolution will be the initial creation of strong backward linkages of country B to country A and hence forward linkages of country A to country B. But as further fragmentation takes place these linkages will start falling. It is then conceivable that country B begins producing intermediates for country A who then uses these to produce more intermediates that are then assembled in another country (i.e. an expansion in the processes for producing good X will yield more complex specialisation patterns). The result of these interactions suggest a non-monotonic link between vertical specialisation and position in a value chain. This then suggests that it is important to analyse how these have evolved both separately and also how these make up total vertical specialisation.

As a first exercise, and given that the world's backward and forward linkages should be the same, we compute the degree of vertical specialisation for a world aggregate. We find that VS has risen from 16.8% in 1995, to 23.7% in 2000 then reaching 27.9% in 2005. The first two figures are in line with the findings of Hummels et al (2001), Yi (2003) and OECD (2010) whilst the last figure is a new extension that confirms the continuation of the upward trend in vertically specialised trade.

5.2.1 THE BACKWARD LINKAGE (VS-B)

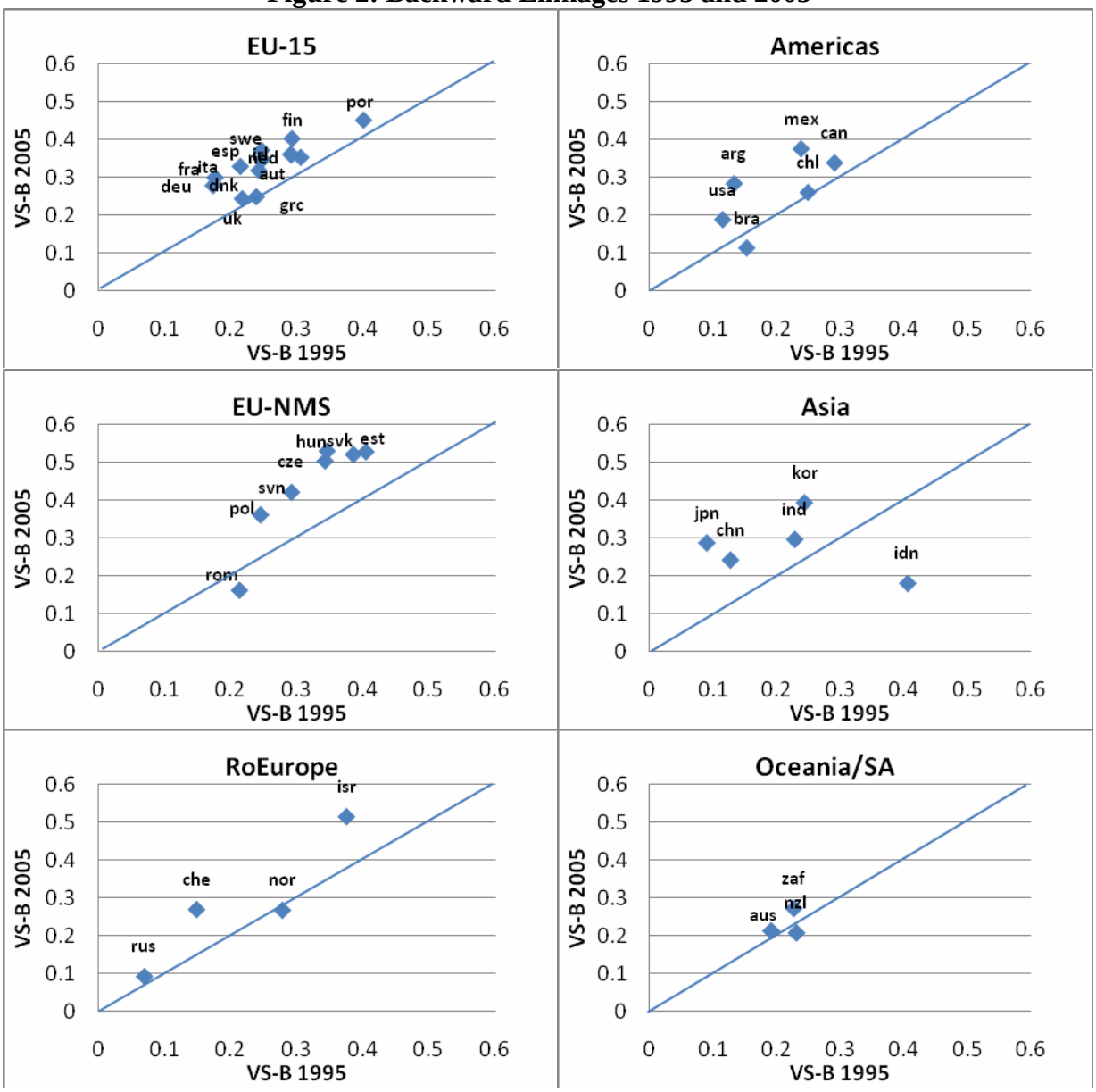
First we turn to looking at the extent of foreign value added in exports by calculating aggregate measures of the VS-B for each of the countries in our sample. This measure is in essence the backward linkage of a country with respect to the world summarising the use of imported intermediates that are needed to satisfy a vector of world demand[32]. Figure X presents the results obtained by regional grouping for a sample of countries for the years 1995 and 2005[33]. The graphical representation allows us to gauge both the level and evolution of the VSI across countries. Points lying above the 45 degree line represent countries which have witnessed an increase in the level of VS in time (the opposite holds for points below this line). It clearly depicts an increasing trend in VS-B in time for most countries (Brazil, Indonesia, Norway, New Zealand and Romania excluded). Looking at particular regions we see that the EU-15 countries exhibit high backward linkages with respect to the world where in 2005 one fourth to one third of export value added is foreign. In contrast, EU-NMS countries show even higher backward linkages with respect to the world. Foreign value added in exports of the Czech Republic, Estonia, Hungary, Slovakia and Slovenia being near the 50% mark. When turning to the Asian cohort (China, Indonesia, India, Japan and Korea) we see that Japan and China have more than doubled their backward linkages with respect to the world, but Indonesia has witnessed an important fall. In this region, Korea is the country with the highest levels of VS-B whilst Japan and India show more modest backward linkages with the world. China's figures suggest that over a fourth of its exports are made using foreign sourced parts. When we turn to the NAFTA region we note important increases in backward linkages for Mexico with more modest increases in Canada and the US.

Having a metric for the size and evolution of these backward linkages allows us to draw some preliminary observations on the nature of these linkages. A direct comparison across countries of the above presented numbers is not straightforward as countries vary in terms of size and economic conditions. As an example, EU-NMS countries are comparatively small economies. Following Nordas' (2004) suggestion that the size of countries and the degree of

[32] This measure is the VSI developed by Hummels et al (2001)
[33] In the appendix we present the figure in tabular form Table A.1

backward linkages are likely to be negatively correlated, we would expect these countries to have higher backward linkages. The intuition is that larger countries tend to exhibit lower levels of vertical specialisation because they tend to have larger domestic markets from which to draw intermediates from and are hence less reliant on international backward linkages.

Figure 2: Backward Linkages 1995 and 2005



Source: Own Claculations OECD I-O STAN database

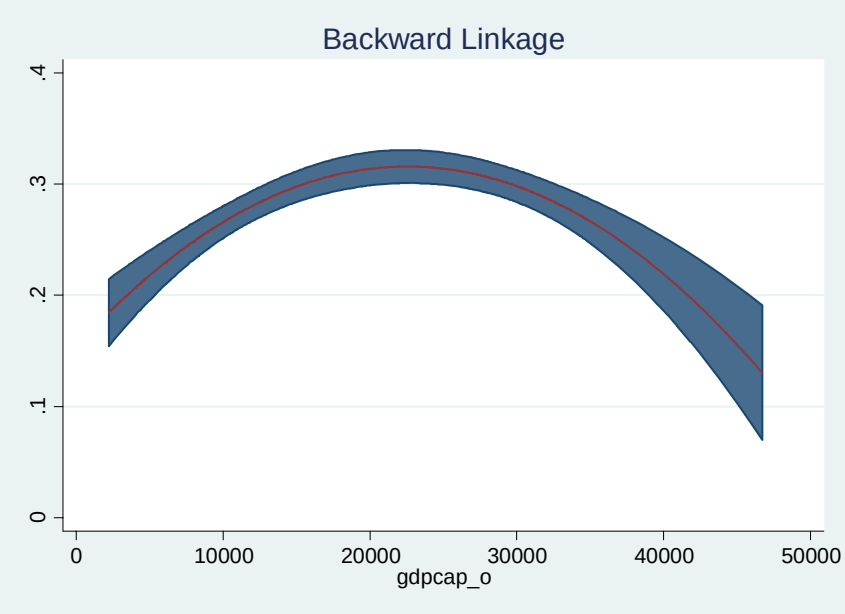
However, when we look at the correlation between GDP per capita, which is used to proxy for the degree of development and hence possibly the position of a country in the value chain, and vertical specialisation we note a distinct lack of correlation[34]. This supports our earlier argument that there is a non-monotonic relationship between vertical specialisation and levels of development. Correlation coefficients essentially impose a linear (monotonic) relationship between variables, and we have reason to believe that this may not hold in the case of

[34] The correlation coefficient is of 0.06 in 1995 and 0.205 in 2005

vertically specialised trade. This is because we expect the strength of the backward linkage (and also the forward linkage) to vary with the position of a country in an international value chain. Normally, entry into a value chain, for less developed countries, tends to occur at the assembly level. This type of production requires importing large amounts of intermediate goods, assembling them and then shipping finished products. As countries begin to specialise in assembly, they also begin to import more and more intermediate goods and hence see a rising backward linkage (rising VS-B). This continues till they have developed enough supply capacity to move up the value chain and start producing their own intermediates. At this stage countries will start reducing their assembly activities and hence will reduce their backward linkages (falling VS-B). What will then arise is an inverted U relationship between position in a value chain and levels of backward linkages. This story lends itself to the US-Mexico experience. First generation *maquiladoras* were born to be giant assembly lines, but as Mexico moved up the value chain, they evolved to specialise in higher value adding processes. Now we see new generation maquiladoras exporting high tech products to the US.

Our data supports this hypothesis. When we impose a second order polynomial relationship between VS-B and GDP per capita by regressing the VS-B against GDP per capita and its squared term, we see that the fitted values exhibit an inverted-U relationship with respect to levels of development (Figure 3)[35].

Figure 3: Inverted U relationship between VS-B and GDP per Capita



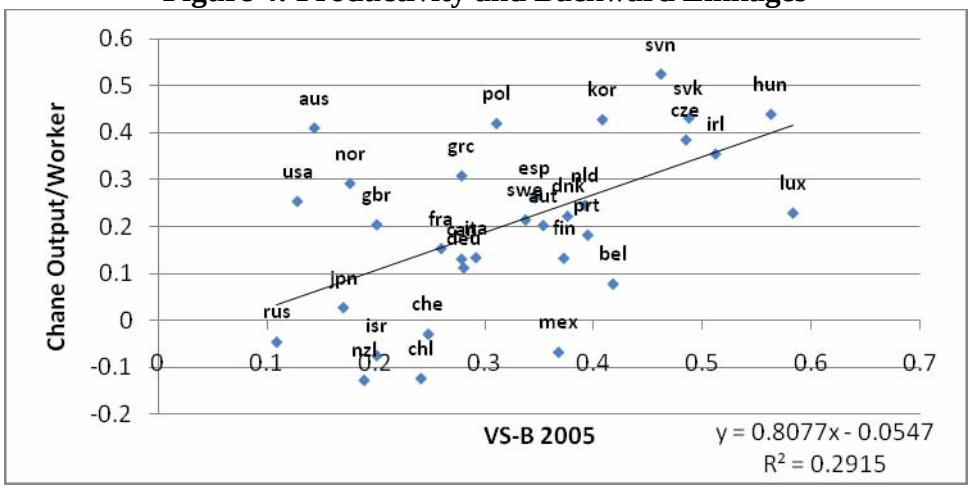
Source: Own calculations based on OECD STAN and Penn World Tables

Our initial hypothesis also suggested possible links between vertical specialisation and productivity growth. In light of the above results however, it seems that looking at changes in backwards linkages and their correlation with changes in productivity might be misleading given that VS-B is non-monotonic. Hence we look at the correlation between our backward linkage indicator in the last available year and productivity growth. This tells us if countries engaging most in international value chains are those which witness the highest changes in productivity growth. Here we find a statistically significant correlation of 0.42 between

[35] We do not report the coefficients of the regression as, in this instance, we are concerned with the shape of the relationship but both are highly significant. The sample size is of 39 countries for 12 years giving us 468 observations and an R-squared of 0.11.

changes in labour productivity and levels of VS-B in 2005. When we change our productivity metric to changes in output per worker (Figure 4) we see that the correlation becomes 0.54. The link between these processes may arise as a result of two mechanisms. Firstly, increasing the use of imported intermediates may bring about allocative efficiency gains. Outsourcing non-productive segments of production will liberate resources into the sectors that are most productive. This will increase overall productivity by the statistical effect where non-productivee sectors exit the economy, but also by the allocation of new resources in the most productive sectors of the economy. In essence, this is a pro-competitive effect that arises from the introduction of international competition in a segment of production that was previously only subject to domestic competition. In addition, and given the importance of complementarities in value chain activity, it is possible that increasing the efficiency of one segment of the value chain will increase the productivity of the chain as a whole. Secondly, there is a likely gain to be exploited via the smithian channel. The creation of tighter backward linkages can also result in finer specialisation with gains arising through learning by doing effects and technology transfers. However the correlation between the backward linkage indicator and changes in productivity is to be taken with a hint of caution. Correlation does not imply causality. But it does however suggest a possible link between these processes. This could have important consequences for the way we think about vertical specialisation, not least for assessing its welfare effects and the possible links with economic growth. It also complements the heterogenous firm literature on the links between productivity and firm level activity where there might be a case for suggesting that engaging in value chain activity delivers the empirical productivity gains found in this literature.

Figure 4: Productivity and Backward Linkages



Source: Own calculations of VS. Labour productivity, output and employment from the OECD STAN indicators (labour productivity indexed to base year 2000)

Another word of caution is advised with the measures above presented. These are aggregate in nature and hence will most certainly hide important sectoral variations that are of interest. Indeed, Yeats' (2001) empirical conclusions seemed to hold only for certain industrial sectors (as shown from the discussion around figure 1). Hence in subsequent sections we will turn to a sectoral analysis of global vertical specialisation.

5.2.2 THE FORWARD LINKAGE (VS-F)

Our forward linkage indicator (VS-F) captures the intermediate export component of a country's exports and thus represents the flip side of its backward linkage brother. The aggregate measure captures the share of total exports that are used by all other partners as

intermediate inputs in satisfying world demand for their exports. To obtain the measure one needs to track the bilateral component of vertically specialised trade. This is because, in absolute trade value terms, the forward linkage of country A with respect to country B is the backward linkage of country B with respect to country A. Hence the aggregate forward linkage of country A with the world is the absolute sum of the backward linkages of all countries with respect to country A. The VS-F is then the sum of these absolute values divided by the value of exports of country A to the world. In Table 2 we summarise the evolution of forward linkages for the years 1995 to 2005 for our sample countries. Contrasting with the results from the backward linkage section, the forward linkages are increasing in time, and quite considerably, for all countries. EU-15 individual country forward linkages increased by an order of 30% whilst the EU-NMS countries show a more modest increase. For the Asian countries, we see that Indonesia has more than doubled its forward linkage with respect to the world as has Korea whereas China and Japan have seen more modest increases. Russia stands out as the country with the largest forward linkage, however this is probably driven by the increase in price of petrol during the period under investigation. This explanation is also likely to hold for Norway. In the case of Chile the driving factor should be the hike in the price of copper which is one of Chile's largest export products. Increases in commodity prices are also likely to be driving Australia's important forward linkage growth. Apart from these outliers, a noticeable trend that emerges is that higher income countries tend to exhibit larger positive changes in their forward linkages.

Table 2: Forward Linkages by Country 1995 and 2005

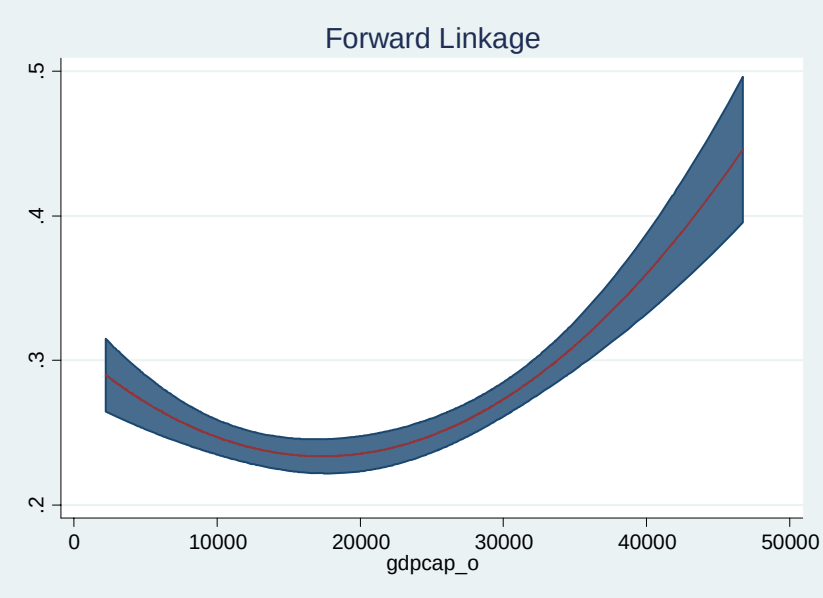
Country	1995	2005	Δ	Country	1995	2005	Δ
Argentina	0.110	0.181	0.071	**Ireland**	0.197	0.356	0.160
Australia	0.181	0.500	0.318	**Israel**	0.119	0.210	0.091
Austria	0.205	0.319	0.113	**Italy**	0.160	0.265	0.105
Brazil	0.157	0.302	0.144	**Japan**	0.124	0.208	0.083
Canada	0.128	0.234	0.106	**Korea**	0.099	0.214	0.116
Switzerland	0.216	0.333	0.117	**Mexico**	0.135	0.233	0.098
Chile	0.183	0.488	0.305	**Netherlands**	0.168	0.300	0.132
China	0.125	0.234	0.110	**Norway**	0.338	0.587	0.249
Czech Rep	0.228	0.307	0.079	**New Zealand**	0.097	0.145	0.048
Germany	0.196	0.295	0.100	**Poland**	0.213	0.296	0.083
Denmark	0.168	0.357	0.189	**Portugal**	0.180	0.343	0.162
Spain	0.190	0.294	0.104	**Romania**	0.169	0.306	0.137
Estonia	0.198	0.449	0.251	**Russia***	0.284	0.587	0.302
Finland	0.215	0.378	0.164	**Slovakia**	0.322	0.405	0.084
France	0.167	0.269	0.102	**Slovenia**	0.181	0.255	0.074
UK	0.193	0.348	0.155	**Sweden**	0.234	0.345	0.112
Greece	0.154	0.246	0.092	**Turkey**	0.145	0.245	0.100
Hungary	0.222	0.290	0.068	**USA**	0.191	0.289	0.098
Indonesia	0.150	0.435	0.285	**South Africa**	0.190	0.427	0.237
India	0.122	0.211	0.089	**World**	0.168	0.279	0.112

Source: Own Calculations using OECD STAN database and Comtrade.
* Russia value for 1995 is 1996 data

Given that the forward linkage is the counterpart of the backward linkage, we expect the nature of these to be the direct inverse of the backward linkages. This need not apply, however to the correlation between the size of a country and its forward linkages with respect to the world. Whilst it is true that large countries will have wider arrays of intermediate products produced domestically, these need not be exported. We do, however expect the forward linkage to have the opposite relation, when compared to the backward linkage, with respect to the position of a country in the value chain (as proxied by GDP per capita). Building on the earlier example, if countries at lower positions in the value chain are

increasing their use of intermediate imports and engaging in assembly, then they will be exporting larger proportions of final goods over intermediates. This will result in an initially decreasing forward linkage. As a country moves up the value chain, it will leave assembly lines for the production of higher value adding intermediates and hence will see their forward linkages increasing. In the case of forward linkages, the inverted U relationship will turn into a U relationship between the position in the value chain and forward linkages (thus emerging as the mirror image of the backward linkage story). In figure 5 we provide supportive evidence to this hypothesis by plotting the fitted values from the regression of the forward linkage indicator (VS-F) with respect to GDP per capita and its squared term[36]. Comparing this figure to that obtained for the backward linkages (Figure 3), we see how the indent in the U is less pronounced. What emerges is that countries that have higher GDP per capita do have much larger forward linkages than countries that show lower levels of development.

Figure 5: U relationship between VS-F and GDP per Capita



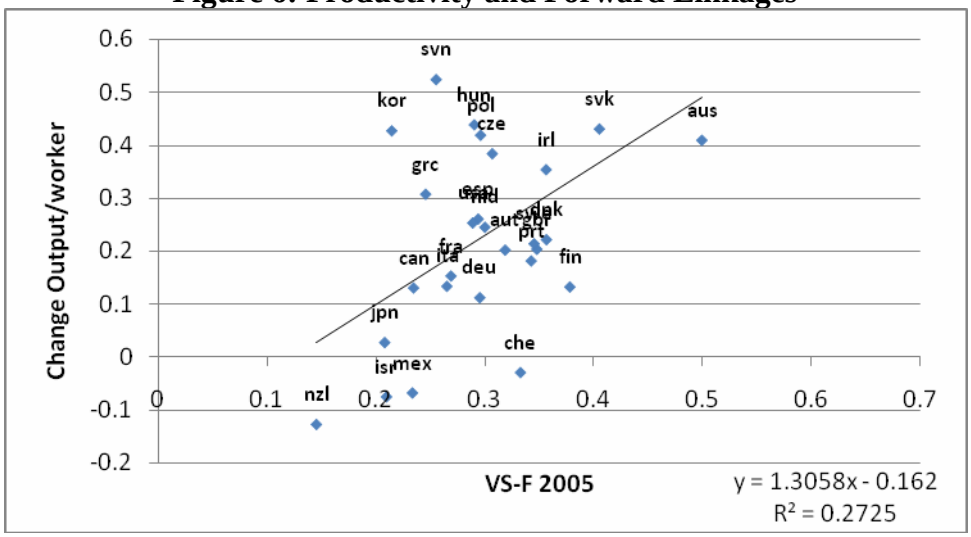
Source: Own Claculations OECD I-O STAN database

In addition, and bearing strong similarities with the backward linkage case, there is a positive and statistically significant correlation (0.52) between forward linkages and changes in productivity (as shown in Figure 6). This again lends further support to the earlier posited hypothesis of a possible link between vertical specialisation and productivity growth. Although one has to continue to bear in mind that a correlation does not imply causality and that further work will be required to establish that this is more than a spurious relationship[37]. The mechanism of the interaction between forward linkages and changes in productivity is likely to arise via similar channels to that of the backward linkages. The allocative efficiency and smithian specialisation gains are likely to be playing an important role. Also, the increased fragmentation of production is likely to yield important economies of scale in the upstream segments of production. This will be complemented with an increased range of varieties and qualities of intermediates.

[36] Here again our sample is of 38 countries for 12 years giving us 468 observations. The GDP per capita variables explain 10% of the variation in VS-F

[37] We do however remove Russia and Norway from the correlation calculation given their reliance on petroleum exports. Similarly, Chile is removed due to its dependence on copper exports.

Figure 6: Productivity and Forward Linkages



Source: Own calculations of VS. Labour productivity, output and employment from the OECD STAN indicators (labour productivity indexed to base year 2000)

5.2.3 TOTAL VERTICAL SPECIALISATION

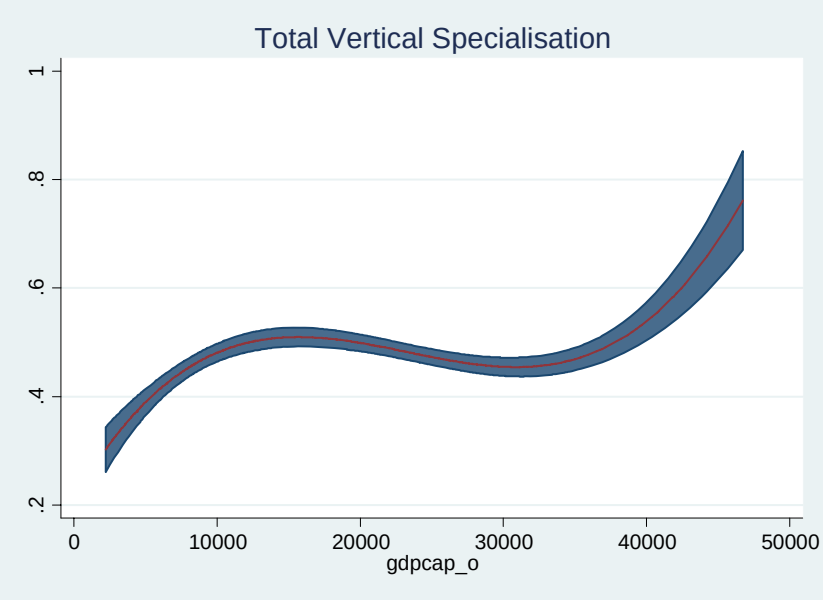
Putting the forward and backward linkages together requires adding these up and subtracting the forward linkage component of the backward linkage and the backward linkage component of the forward linkage following equation (4) (to avoid double counting). One should however be cautious in interpreting this coefficient. It captures both the foreign value of exports and the domestic value of intermediate exports. Hence, for the US, the total level of vertical specialisation with the world is the amount of intermediate inputs used from the world to service the world market, and the amount of intermediate exports that the world uses from the US to produce exports. In the appendix we present a table mapping the evolution of total vertical specialisation for our sample in 1995 and in 2005. As expected, total vertical specialisation is rising. On average, 40% of EU-15 countries' trade is vertically specialised in the year 2005, for the EU-NMS countries this figure jumps to 50%. In Asia; Korea and Indonesia show the highest levels of vertical specialisation with over 50% of their exports being engaged in international value chains. China and India follow closely with a share of 40%[38]. In the Americas, Canada and Mexico exhibit the higher numbers in the region of 50% whilst Argentina, Brazil and the US lie near the 40% mark.

In trying to discern the nature of vertically specialised trade, and given the non-monotonicity of the backward and the forward linkages, we plot, in figure 7, the relationship between our total vertical specialisation indicator and GDP per capita. Given that the backward and forward linkages have opposing shapes where one was seen to be an inverse U (Figure 3)

[38] See Table A.2 in the appendix. One has to bear in mind that petrol exporters will tend to have higher forward linkages but also that petrol importers will have larger backward linkages.

whilst the other showed a U shape (Figure 5), we give an extra degree of flexibility to the correlation by including a third degree polynomial (i.e. a cubic function)[39]. Unsurprisingly, we find that the shape adopted is that which sees an initial inverted U at lower levels of development, followed by a normal U shape as GDP per capita rises. This side-ways S shape provides some supportive evidence to our initial story that saw countries specialising in different segments of production according to their position in the value chain. What is interesting in this figure is that a story can be told whereby countries in the higher levels of development (beyond a certain GDP per capita where the function is increasing) are selling their intermediates to countries in the bottom end of the GDP per capita spectrum, hence the rise in VS at the high end could be causing the rise in VS at the low end. In addition, the upward trend in total VS suggests that, in time, processes of production are being chopped into finer pieces implying a greater spread of value added in terms of geographical location.

Figure 7: VS-T and GDP per Capita



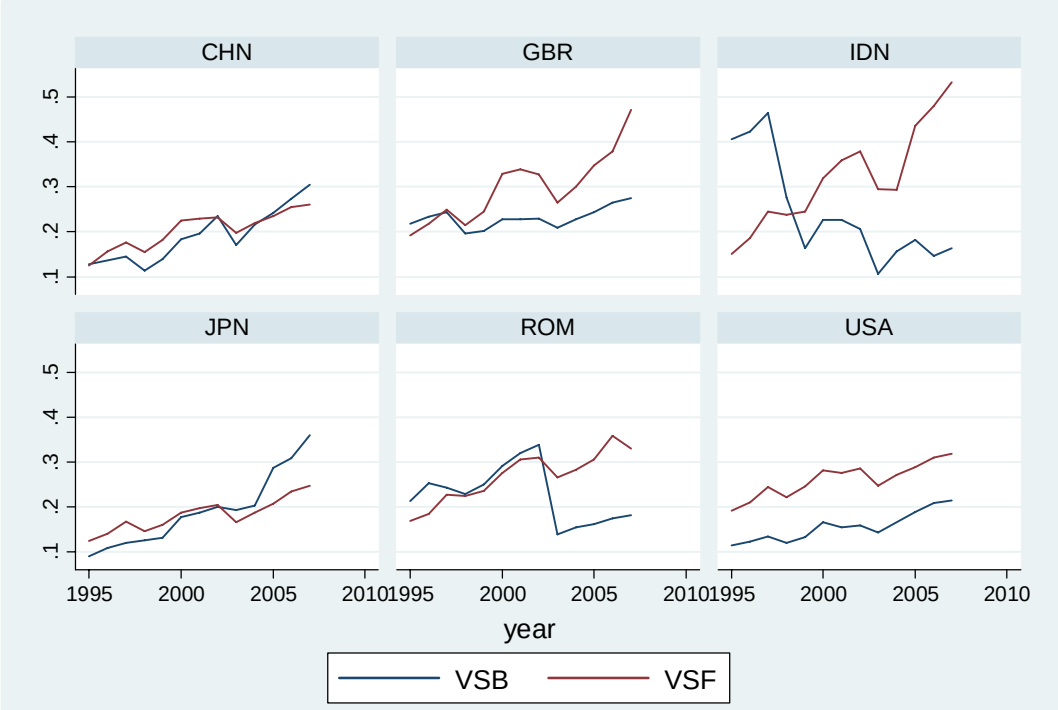
Source: Own Claculations OECD I-O STAN database

The above figure remains an aggregate representation of the countries in the sample. It captures average effects and insofar as countries cluster along different points in the GDP per capita spectrum. However the individual country effects will differ greatly. In Figure 8 we track the evolution of forward and backward linkages for a selection of 6 countries with different economic and geographic characteristics. The Indonesian (IDN) case is of particular relevance as it provides a good representation of our story. Initially we see the backward linkages far outpacing the forward linkages; however, as time evolves Indonesia sees an important fall in its backward linkages with the world with a concurrent increase in its forward linkages. This example seems to be capturing the move up the value chain that is suggested in our hypothesis. Similarly, Romania (ROM) witnesses a comparable evolution in vertical specialisation. At the high end of the spectrum though, and taking the example of both the US and the UK, a different picture emerges. These more developed countries have larger forward linkages than backward linkages and there seems to be an element of co-movement. The evolution of Chinese linkages with the world somewhat suggests that the country is increasingly importing and exporting intermediates which would be in line with its

[39] The estimation is carried out on 468 data points. The GDP per capita variables explain 15% of the variation in VS-T.

development and possible position around the middle part of the value chain as some sectors begin to climb the value chain whilst others remain in assembly activities. An interesting result is that of Japan which initially saw stronger forward linkages which is time give way to higher backward linkages. A possible fitting story to this evolution is that Japan specialised in selling intermediate products to its East Asian partners which were then exported to western countries as finished products. As these East Asian countries begin to climb the value chain, Japan increases its backward linkages with these countries.

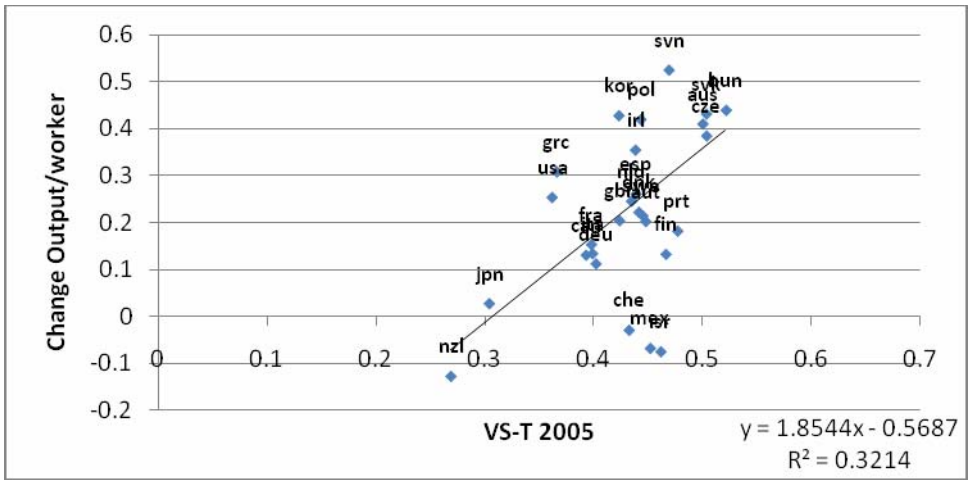
Figure 8: Backwards and Forwards linkages for a selection of countries 1995-2007



Source: Own Claculations OECD I-O STAN database

Given the correlation found between the different linkages and changes in productivity, it comes as no surprise that a positive correlation remains between total vertical specialisation and changes in productivity. The driving culprits being a mix of allocative efficiency gains through increased exposure to international competition; economies of scale; niche specialisation; and technology transfers to name but a few. In Figure 9, we present a graph mapping this correlation (correlation coefficient of 0.57) lending continued support to the hypothesis of a link between these processes.

Figure 9: Productivity and Total Vertical Specialisation



Source: Own calculations of VS. Labour productivity, output and employment from the OECD STAN indicators (labour productivity indexed to base year 2000)

5.3 BILATERAL VERTICAL SPECIALISATION

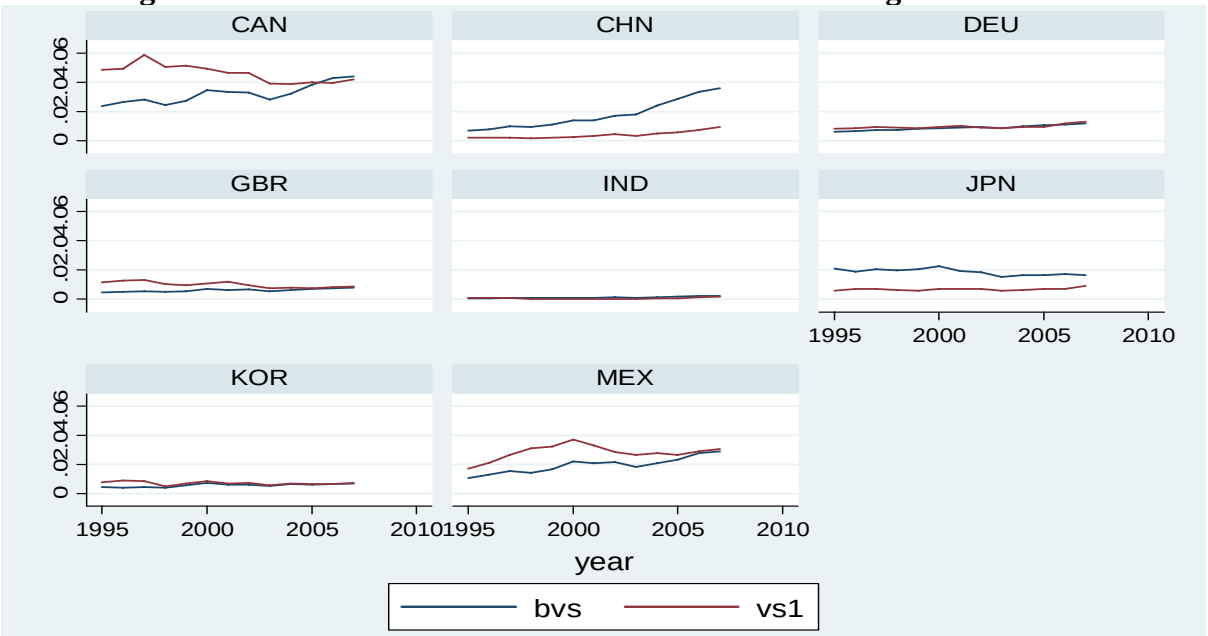
One of the main advantages of the technique developed in this paper is that it allows us, not only to capture the forward and backwards linkages with respect to the world, but also with respect to any partner in our sample. This means that we can make comparisons of the types of VS within and between regional blocs, prior to exploring the casual links in later work.

5.3.1 NORTH AMERICAN FREE TRADE AREA

As a first exercise, we take the tractable example of NAFTA as it involves only three countries and can be easily presented. In particular we compare the US's bilateral vertical specialisation with respect to its main preferential partners (Mexico and Canada) and other non-preferential partners (China, Germany, Japan, Korea and the UK)[40]. The vertically specialised linkages in this example are those tracking the bilateral component of intermediates used to service world demand for exports. Hence in Figure 9 the first graph tells us the amount of imported and exported intermediates to and from Canada as a proportion of US total exports to the world. What is particularly interesting in this figure is the evolution of the linkages with the US' preferential partners. For Canada and Mexico we see an initially falling forward linkage and a rising backward linkage which suggests a changing pattern of vertical specialisation between preferential partners. Whilst the US would export intermediates to these destinations for them to be assembled, we are increasingly seeing that the patterns of specialisation are tending more and more towards the US buying intermediates from these countries which could be indicative of this move up the value chain. Also interesting is the evolution of the backward linkage with respect to China where we see a rising reliance in intermediate imports from China. This is somewhat contrary to what we would expect. We often assume that the US imports final goods from China, but what we are seeing is that more and more the US is importing intermediates which it uses in productive processes that are subsequently re exported. From Figure 10 we also see that the linkages with European economies remain small, whilst those with Japan have seen little movement in time.

[40] Korea only became a preferential partner very recently and has been included in the example to see if we can already discern any increasing linkages before the agreement was put into force

Figure 10: USA's bilateral backwards and forward linkages 1995-2007

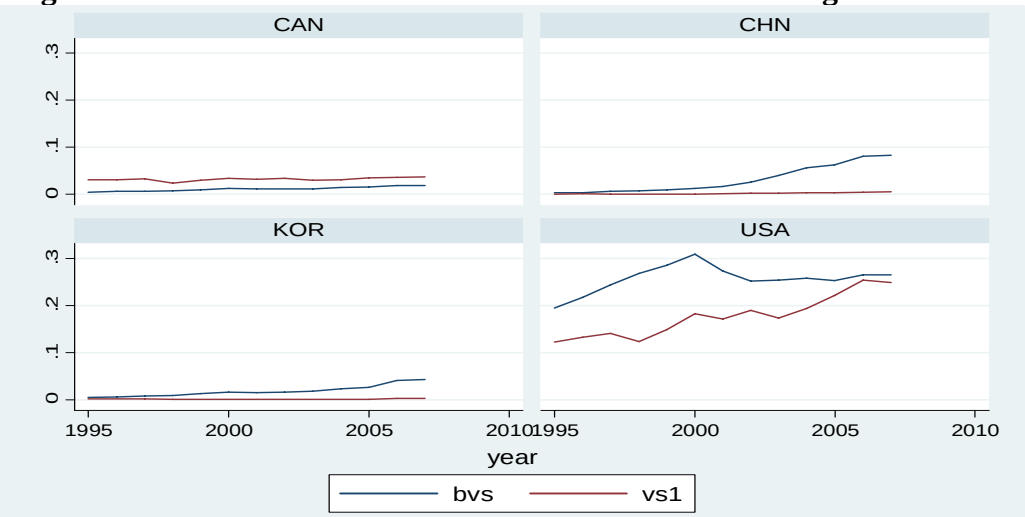


Source: Own Claculations OECD I-O STAN database

Where Mexico is concerned, Figure 11 supports the hypothesis that Mexico is moving up the value chain. Whilst Mexico remains highly reliant on its backward linkages with the US, it is also increasingly developing its forward linkages. This is to the extent that in 2005 over 25% of Mexico's total exports are produced with American value added. Similarly, over 20% of its exports are then incorporated into production sequences in the US for servicing world export demand. However the story does not a priori appear to be a completely preferential one as Mexico is increasingly reliant on intermediate imports from China and Korea. In particular, we see that as the backward linkages with the US fall, those with China increase. One can then conjecture that there might be a substitution taking place where Mexico is increasingly importing Chinese intermediates and then exporting these processed products to the US. Where this may be a move from an assembly specialisation to a higher position in the value chain. Where Canada is concerned, Mexico's backwards linkages with this country are

lower than its forward linkages but the values are both low and stable in time suggesting that patterns of specialisation in the region are predominantly driven by relations with the US.

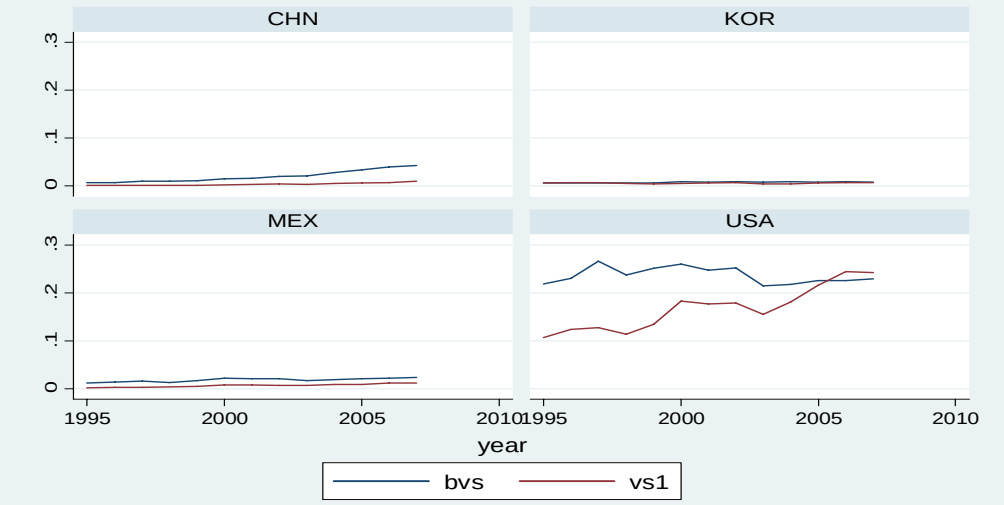
Figure 11: Mexico's bilateral backwards and forward linkages 1995-2007



Source: Own Claculations OECD I-O STAN database

The Canadian example (Figure 12) also reveals the dominance of the US as a source and destination of intermediates. In 2005 around 22% of total export value added comes from the US whilst 22% of total Canadian exports are being used by the US in export oriented production sequences. The Canadian example is also one that lends itself to the climbing of the value chain story. Here we are witnessing a change in bilateral vertical specialisation where the forward linkages with the US are becoming more and more prevalent. Where Mexico is concerned as a bilateral partner, Canada seems to be more reliant on its backward link with this country than on its forward link. However the share of trade that is occupied in this type of trade is relatively small. Smaller than the bilateral vertical specialisation with respect to China which is increasing on the back of a rising backward linkage. The very low rate of bilateral vertical specialisation between Canada and Mexico casts a doubt on the hypothesis that the process of vertical specialisation is driven or precedes the preferential status of countries. However many other controls are to be applied for us to make any association between preferential status and vertical specialisation such as geographical location or differences in factor endowments. Where the latter may be driving the perceived increase in the backward linkages with respect to China.

Figure 12: Canada's bilateral backwards and forward linkages 1995-2007

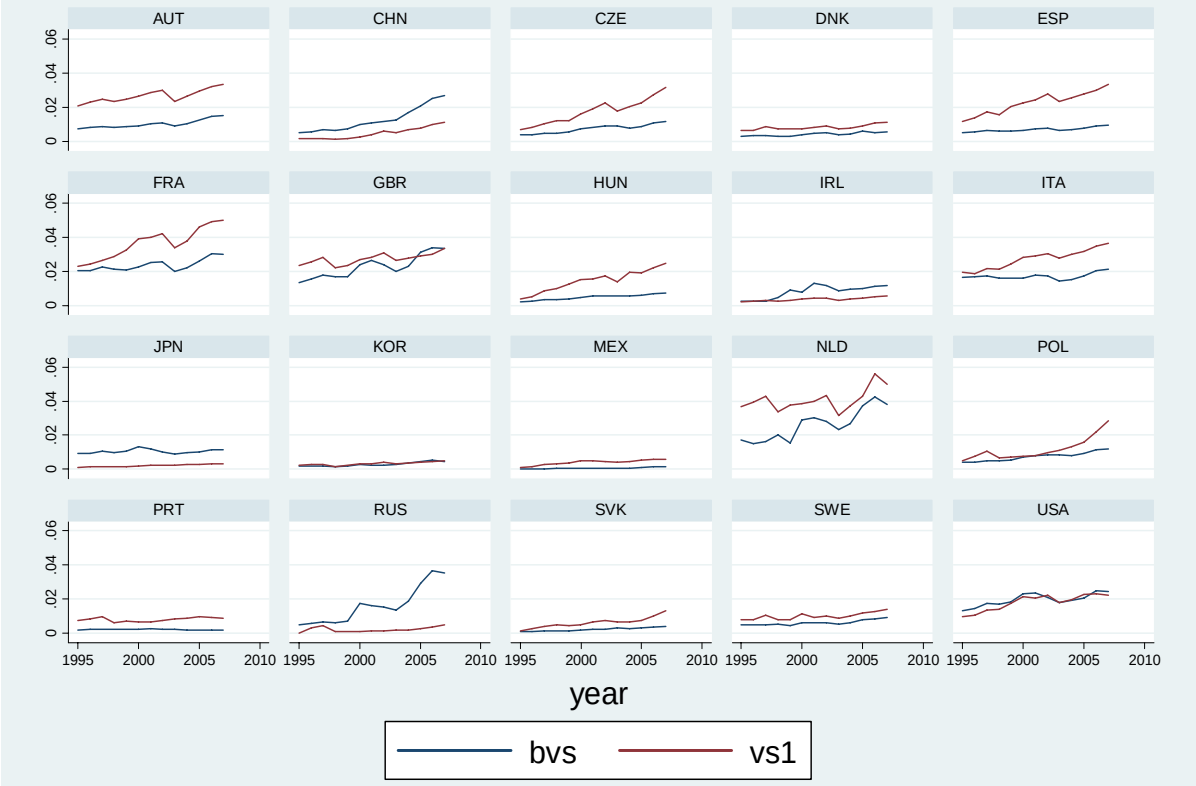


Source: Own Claculations OECD I-O STAN database

5.3.2 THE EU AND THE NEW MEMBER STATES

We first look at German backward and forward linkages which present some noteworthy observations. In Figure 13 we see how Germany appears as a leading supplier of intermediate products with respect to the EU-15 countries where the main forward linkages are with Austria, France, Italy, Netherlands and Spain. There is also anecdotal evidence of substantial growth in forward linkages with Eastern European countries such as Czech Republic, Hungary, Poland and Slovakia. Where backward linkages are concerned, there is an increasing reliance in China as a source of intermediate inputs. Equally, Russia appears as an important partner in this respect. However, the nature of the linkages with China and Russia are likely to differ. China will be more engaged in supplying intermediate products whilst Russia will be providing petroleum. Where the preferential element is concerned, here we clearly see that Germany's vertical specialisation is greater with its European partners. But these countries are also geographically close. Whether this perceived regional vertical specialisation is driven by the depth of the agreements in the region or other time invariant factors remains an empirical question to be treated. What does emerge is the growing importance of Eastern European countries in German links. In particular, there is some supportive evidence pointing to these increases occurring after 2004 i.e. after membership of these countries to the EU was complete. This may, in turn provide some supportive evidence on the role of deep integration in the stabilisation and creation of value chains. Tariff barriers to trade already having been dismantled prior to these years, the big change between he relations of these eastern countries and the EU was the implementation of the *acquis communautaire* or the body of EU law into national legislation. The new laws and standards governing the internal market may have had an effect on the creation of new value chain activity.

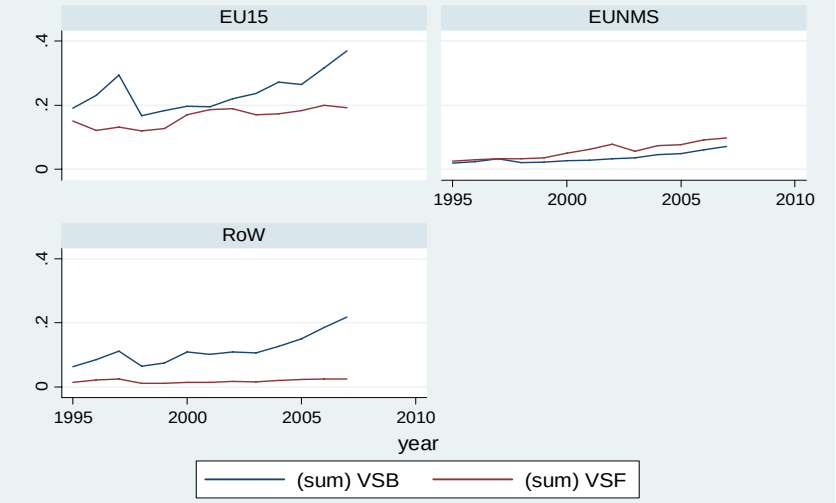
Figure 13: Germany's bilateral backwards and forward linkages 1995-2007



Source: Own Claculations OECD I-O STAN database

But it is also important to look at the evolution of the linkages from the perspective of an Eastern European country. Here we take the patterns of specialisation for Poland and confirm the continued dominance of the EU15 cohort as both source and destination of intermediates. However there are differences in the patterns of specialisation between these traditional EU partners and the new member states. The growing backward linkage with EU15 countries are concurrent with a relatively stable forward linkage pointing to an increasing backward dependence with these partners. In contrast patterns of specialisation with other new member states show a prevailing forward linkage where Poland exports more intermediate products to these partners than it uses from them. In addition, and turning to changes in trends with respect to the EU-15 partners, there is evidence that the rate of growth of backwards linkages has been greater in the period after 2004 than in the previous years. Which, as earlier suggested, provides anecdotal evidence on a possible link between deep integration and vertical specialisation. Where the adoption of the EU's body of rules and regulations may have had a positive impact on delocalisation forces by magnifying differences in factor endowments across countries. In terms of the evolution of Polish linkages with respect to the rest of the world we note little movement in forward linkages but a rising dependence in backward linkages which is driven by imports of petroleum from Russia.

Figure 14: Poland's bilateral backwards and forward linkages 1995-2007



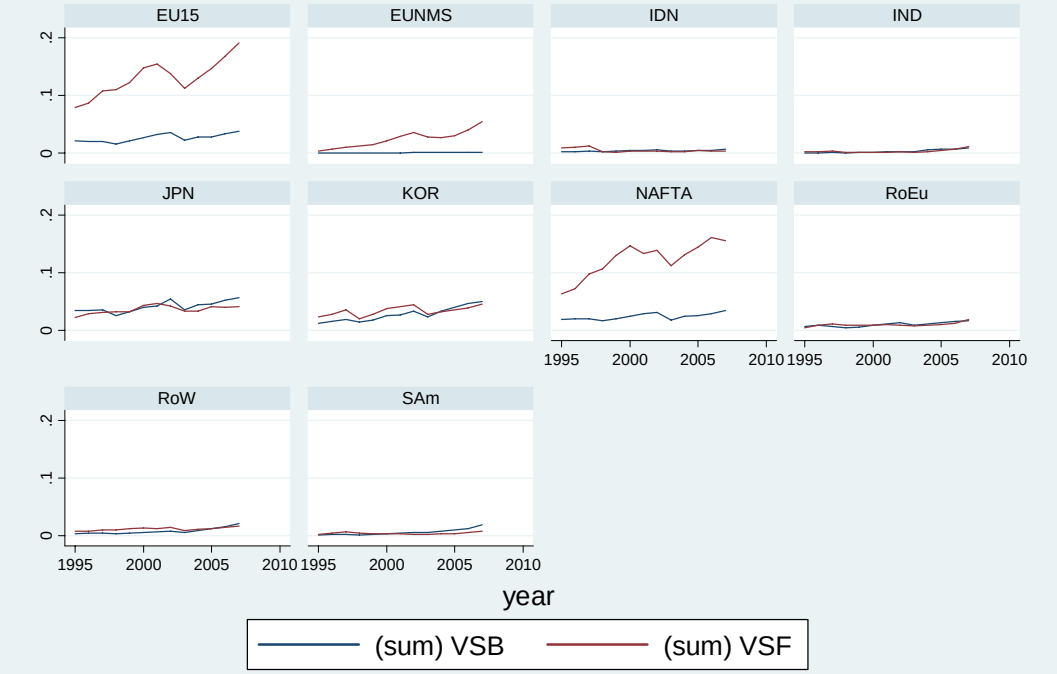
Source: Own Claculations OECD I-O STAN database

5.3.3 *EAST ASIA: CHINA AND KOREA*

We now consider the evolution of vertical specialisation in a group of Asian countries. It has often been said that there are significant differences between the process of integration in this region and those of the EU. In Asia, private firms are at the forefront of specialisation patterns and trade policy ends up playing catch-up. This contrasts with the process of integration in the EU which is led by public institutions. A priori, the results show high rates of vertical specialisation within both these regions. Hence a salient question to look at in future work might be whether there exists scope for an interventionist trade policy or whether a *laissez-faire* policy might be more effective in promoting this type of trade.

We first look at China's vertical specialisation patterns. Earlier analysis showed that China was increasingly becoming a source of intermediate goods for both the EU and NAFTA. This trend is confirmed in Figure 15 where China's forward linkages are high and growing with respect to these partners. What is striking is the unidirectional nature these intermediate flows highlighted by the difference between the very low intermediate use and the very high intermediate supply to these destinations. The rise in the latter is important but it is also worthwhile noting that China remains a large exporter of final goods to the EU and NAFTA. However the growing influence of its intermediate products in these markets purports a possible change in specialisation pointing to an up-scaling of Chinese activities in global or indeed inter-regional value chains. In terms of linkages with other partners within the region, Japan and Korea emerge as the strongest partners but the levels of these linkages remain small when compared to those with the EU and NAFTA. In fact, these links also appear to be of a different nature as differences between backward and forward linkages tend to be small and possibly intra-industry in nature.

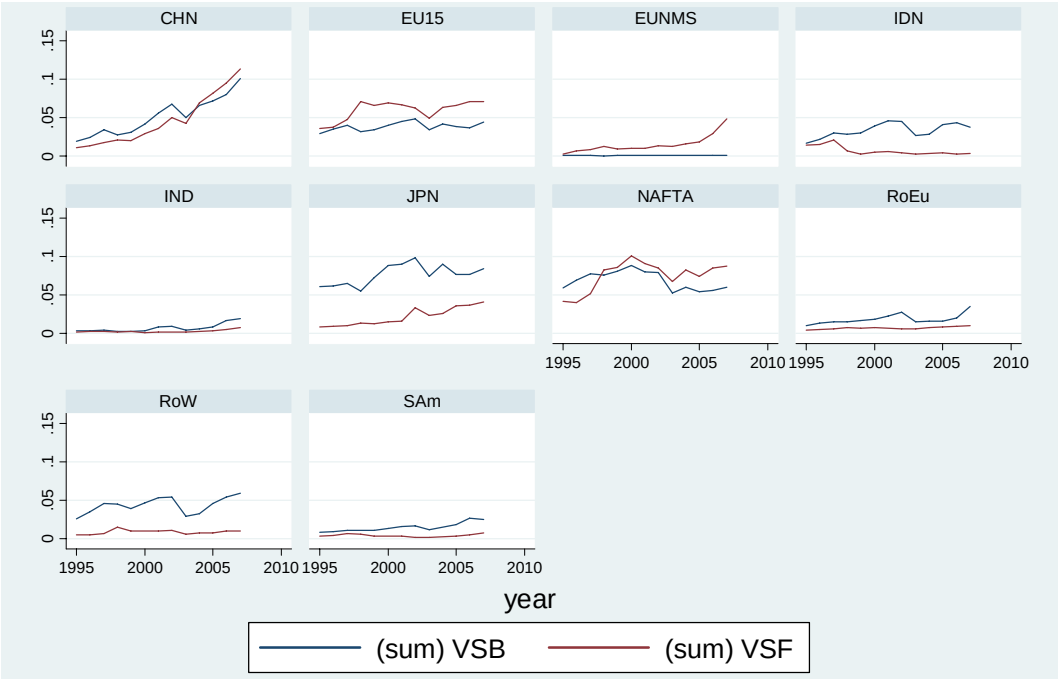
Figure 15: China's bilateral backwards and forward linkages 1995-2007



Source: Own Claculations OECD I-O STAN database

When considering Korea's vertical specialisation patterns in Figure 16 we note that these have changed most with respect to China where both forward and backward linkages are growing fast and at similar paces. Within the region, Korea also shows strong backward linkages with respect to Japan, Indonesia and to a much lesser extent India. However forward linkages prevail with partners outside the region, and in particular the EU and NAFTA where FTA negotiations are being negotiated (in the case of the EU) or have concluded (in the case of the US).

Figure 16: Korea's bilateral backwards and forward linkages 1995-2007



Source: Own Claculations OECD I-O STAN database

5.3.4 INTERREGIONAL COMPARISONS

Several salient observations emerge from the above regional treatment of forward and backward linkages. These are easier to understand when we subsume changes in specialisation into two broad categories. The first is the consolidation of linkages where existing trends are amplified whilst the second sees changing patterns in specialisation (exemplified by changes in the dominating link). The first type, where links follow a consolidating pattern, is that witnessed in the EU where Germany increasingly supplies intermediate products to its preferential partners. The second, where patterns of specialisation are changing, can be seen in the NAFTA region with Mexico and Canada becoming suppliers of intermediates to the USA rather than users. Intra-regionally, what emerges is that the EU process of integration is at a stage of inward consolidation whilst that of Asia and NAFTA is witnessing important changes in specialisation. Where inter-regional flows are concerned, China is consolidating its role as a supplier of intermediate products where these are predominantly towards the EU and NAFTA.

East Asia itself is increasingly vertically specialised but with respect to extra-regional partners. Just as Mexico has progressively become a source of intermediates to the rest of NAFTA, so China is also increasingly looking like a source of components rather than a mere assembler, which Korea is still for Japan. Meanwhile within the EU, we note that Germany is importing intermediates from Japan and China and using them for its exports to other countries, notably developed EU partners. Poland as we expect is an assembler.

6. CONCLUSIONS AND FURTHER WORK

This paper's contribution to the literature on vertical specialisation is twofold. The first is the development of a method that enables the extension of available indicators to capture the bilateral element of vertical specialisation which treats forward and backward linkages

separately. This approach combines the use of trade data and input-output data in an innovative way. The second is the provision of a discussion on interrelationship between these processes and the role of trade agreements.

We have indentified some important new dynamics in the role of VS in highly integrated regions. Traditionally we expect low wage economies to be net importers of intermediates which they can re-export to developed countries as assembled goods. In fact we find that in the case of US, China, Mexico relations it is no longer the case that less developed regions just act as assembly lines for high value intermediate goods produced by more developed partners. They are becoming exporters of intermediates. We have identified some new types of trade that will be explored further later. Moreover we have also shown evidence which supports the thesis that engaging in international value chains may be linked with changes in productivity.

The initial evidence presented in this paper would, a priori, suggest that countries which are engaged in preferential trade deals show high degrees of bilateral vertical specialisation. However the emergence of East Asian countries as sources of intermediate goods and the geographical proximity of preferential partners suggests that causation is complex. Countries engaging in regional trade agreements tend to be geographically close, hence the higher degrees of bilateral vertical specialisation may come as a result of proximity and not necessarily as a result of the agreements. It is equally possible that countries choose their bilateral partners well in that they exploit complementarities. Nevertheless, one cannot discard that the perceived higher vertical specialisation with preferential partners is borne from the spread and depth of trade agreements. The empirical treatment of this question may reside in the endogenous trade policy realm where one tries to see whether trade agreements emerge as a result of increased integration of international value chains or whether these arise as a result of the trade agreements. Tackling this question will require looking at the drivers of both regionalism and vertical specialisation in a more formal econometric setting.

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APPENDIX

A.1 TESTING THE BVS INDICATOR: THE EU EXAMPLE

Table X compares the bilateral VS calculations using the EU I-O tables' delimitation of intra and extra EU trade (Panel 1) to that calculated using the methodology presented in this paper with trade data extracted from Comtrade (Panel 2). Here we only differentiate origin of intermediate imports and choose the destination of exports to be the world. Hence the sum of BVS across destination should give us the VS indicator[41]. Whilst there are differences in the numbers reported across the different panels, the underlying relation is very similar. The table shows, in the first entry, that the import content of exports to the world amounts to 30% for Austria where 20 percent (68% of the total) comes from intra EU partners and 10 percent (32% of the total) from extra-EU partners. The second panel estimates the degree of vertical specialisation of Austria at 0.36 where 68% of intermediate imports come from EU partners and the remaining 32 from non-EU partners. The table serves two purposes, firstly that of evaluating and comparing the above outlined methodology and secondly that of investigating the current degree of vertical specialisation in the EU and the regional component of this vertical specialisation. Where this is concerned, there is some prima-facie evidence of important intra-EU value chain activity, and whilst not exactly surprising given that most of these countries trade heavily with the EU it is nonetheless important to be able to assign a numerical value to this for subsequent formal testing.

Table A.1: Degree of intra and extra EU-15 vertical specialisation in 2000

	2000					
	EUROSTAT (1)			Eurostat + trade data (2)		
	VS	BVS EU-15*	BVS non-EU	VS	BVS EU-15	BVS non-EU
Austria	0.301	0.205	0.096	0.361	0.247	0.113
		68.13%	***31.87%***		***68.56%***	***31.44%***
Belgium	0.440	0.325	0.114	0.482	0.341	0.141
		73.99%	***26.01%***		***70.72%***	***29.28%***
Denmark	0.277	0.196	0.080	0.271	0.195	0.076
		70.97%	***29.03%***		***71.86%***	***28.14%***
Finland	0.296	0.145	0.151	0.270	0.137	0.133
		48.98%	***51.02%***		***50.61%***	***49.39%***
France	0.219	0.129	0.090	0.210	0.123	0.086
		58.76%	***41.24%***		***58.82%***	***41.18%***
Germany	0.269	0.142	0.127	0.235	0.112	0.123
		52.64%	***47.36%***		***47.62%***	***52.38%***
Ireland	0.337			0.325	0.154	0.171
					47.40%	***52.67%***
Italy	0.249			0.240	0.138	0.103
					57.24%	***42.76%***
Netherlands	0.398	0.206	0.192	0.303	0.151	0.152
		51.73%	***48.27%***		***49.90%***	***50.10%***
Portugal (1999)	0.388	0.304	0.084	0.377	0.296	0.082
		78.35%	***21.65%***		***78.32%***	***21.68%***
Spain**	0.263	0.176	0.087	0.277	0.196	0.081
		67.00%	***33.00%***		***70.72%***	***29.28%***
Sweden	0.301			0.279	0.175	0.104
					62.79%	***37.21%***
UK (1995)	0.236	0.135	0.100	0.235	0.126	0.108
		57.35%	***42.60%***		***53.88%***	***46.12%***

Source: Own calculations from Eurostat I-O tables. Trade data from Comtrade

[41] In compiling this table we use a reduced form imported intermediate matrix with merchandise trade values only. Furthermore, the export and import vectors are also only for merchandise trade. For comparability, this is done in both instances where we look at pure BVS derived from the I-O tables and that derived from extracted trade data.

*exchange rates taken from Penn World Tables
** values in tables are in € 1995 hence ECUs xchange rate from average daily ECU xchange to Dollar

The Eurostat I-O tables are more detailed than those of the OECD. They are composed of a S-U component and a further domestic and imported I-O table. The coverage in terms of sectors is extended to 59 sectors (11 more than the OECD I-O tables) identified by the CPA nomenclature (Statistical classification of Products by Activity in the European Community). As regards time coverage, there is coverage for most EU-15 countries for 1995 and 2000 (see appendix for discussion of eurostat I-O tables). The overlap between the OECD and the Eurostat tables allows us to compare 14 EU-15 countries (leaving Luxembourg out) for 1995 and 2000.

A.2 Other Measures of Vertical Specialisation

Here we focus on possible ways of capturing vertical specialisation with particular emphasis on how this may be captured across preferential partners. Adding a regional aspect to vertical specialisation has its implications and we discuss these with respect to trade and non-trade based measures of vertical specialisation.

1.1 Trade Based Measures of Vertical Specialisation

As already introduced, trade based measures of vertical specialisation are attractive for the wide coverage they offer in terms of countries and time. They are however not without their drawbacks. Having already discussed the use of the BEC nomenclature, we focus on different indicators that may be used for the identification of vertical specialisation.

1.1.1 Intra Industry Trade

When thinking of production sharing, it is not unreasonable to presume that the backwards and forward movement of goods within similar tariff lines may be able to capture some form of fragmentation of production structures across international borders. This exchange of intermediate goods across industries can be captured by way of Intra-Industry Trade (IIT) indicators. Consider the automotive industry (using the HS classification); motor vehicles lie in sector HS-87 where the final assembled motor vehicles can be found in HS-8703 whilst the parts and accessories of motor vehicles fall into the category HS-8708. Constructing an IIT indicator for sector 8703 (assembled motor vehicles) will allow us to look at the simultaneous exchange of cars across borders (e.g. Peugeots against Volkswagens). But computing an overlap indicator for the 'parts and accessories' category (HS-8708) and specifically for a given product (HS-870840 – gear boxes) may capture some form of production sharing in that it will register the exchange of say gear boxes at low levels of processing for gear boxes at higher levels of processing. The differing levels of processing can then be identified by comparing import and export unit values. Where the difference between these is above a certain threshold, then it can be surmised that the product exported is significantly different from the products imported which in turn may suggest that vertical specialisation is taking place. The crux of the identification problem is hence choosing an appropriate level of aggregation. However, even if the aggregation is properly chosen, there remains certain doubt that IIT indicators properly identify the full extent of production sharing. The main problem comes from the construction of the indicator which, by composition requires there to be both imports and exports of products in the same tariff lines. It is entirely possible that Germany sources all its gear boxes from Eastern Europe and does not export this product at all. In this instance, vertical specialisation is taking place, but the IIT indicator will be zero and hence

we will not capture any production sharing. It can, however be argued that if we increase the level of aggregation, and compute this at the 4-digit level (HS-8708) or indeed at the 2-digit level (HS-87), then we can still capture some form of vertical specialisation. The problem is that we would be mixing very different products (cf. radiators, gear boxes, brakes and bumpers) which can lead to inaccurate identification as one firm may be exporting gear boxes whilst another imports radiators. Further to this, if one considers the production of a car one needs to consider other materials such as the iron that is used to make the chassis, the plastic that is utilised for the interior, the rubber that is used to make the tyres. All these products are located in very different HS tariff codes hence the IIT indicator is likely to underestimate the true degree of vertical specialisation.

This last point becomes clearer when one looks at I-O tables. Using these we can track the share of inputs that come from the same industry and which are directly used to produce one unit of output of a given industry. This is accomplished by capturing the diagonal element of the total I-O table and dividing this by the total output of that same industry. When we carry out this exercise for the US, as shown in the table in the Appendix (Table A.1), we see that, on average, 22.1% of total inputs used in production come from the same I-O industry whilst 26.3% of imported intermediates over total imports of a given I-O sector come from the same industry. These very low values suggest that IIT indicators may be inaccurate instrument for capturing the extent of vertical specialisation[42].

1.1.2 Tariff Exemption Under Special Processing Provisions

Another way that the literature has attempted to capture the extent of vertical specialisation is by looking at special processing provisions. The EU allows tariff exemption under a provision known as Outward Processing Trade (an equivalent provision for the US is the Offshore Assembly Provision). Under these provisions, tariff exemption is applied for certain goods allowing temporary export of intermediate goods for processing in a foreign country followed by re-importation under partial or complete tariff exemptions (or drawback).

In the EU, outward processing activities are mediated under the Community Customs Code[43]. Provisions exist for both outward processing and inward processing respectively known as OPX(or M) and IPX(or M). Inward processing imports, as opposed to outward processing exports as explained above, captures intermediate imports from a foreign country for home-processing with a subsequent re-export to the country of origin with tariff exemption. Processing authorisation is granted under special conditions where a particular tariff line is created for repair of goods; otherwise goods have to undergo an economic examination before authorisation is granted. The latter evaluates possible disadvantages of foreign processing on domestic processing firms. The conditions under which outward processing may be granted are also limited by type of processing and detailed annexes provide a list of possible processing activities covered. Outward processing takes place in 3 distinct phases.

- Community goods are exported temporarily to a territory outside the EC customs territory.
- Goods exported undergo processing

[42] It is important to consider that the back of the envelope calculation provided is one taking into account the direct requirements in production. Whilst one should also consider the indirect requirements (i.e. the second round effects) However, these are likely to be smaller and hence the validity of the argument is likely to remain.
[43] COUNCIL REGULATION (EEC) No 2913/92 of 12 October 1992 establishing the Community Customs Code (OJ L 302, 19.10.1992, p. 1)

- The permit holder re-imports processed products

Under the community legislation there exists scope for full or partial relief of duties depending on the type of processing.

Egger and Egger (2005) analyse the evolution of OPT in the EU with respect to CEECs and other Western European countries. Their aim is to elucidate the motivation behind this type of trade by looking at 4 different models attempting to explain outsourcing. Firstly, the standard Hecksher-Ohlin model, then new trade theory models, followed by politico-economic models and then models with infrastructure as predominating determinant of processing trade. Their evidence suggests that OPT does not seem to be affected by the standard H-O framework, i.e. factor costs do not tend to influence OPT. Furthermore, they find little evidence supporting market size as guiding processing trade patterns thus arguing that new trade theory models are not well suited to deal with this type of trade. The main determinants of OPT appear to be tax savings on profits and exchange rate ratios. In contrast, Yeats (2001), evaluates processing trade as a measure of vertical specialisation and claims that using these indices to instrument for VS significantly *understates the importance* of global production sharing. In effect, and in the context of identifying the role that regional trade agreements may be playing with respect to vertically specialised trade, processing trade may not be useful. This is because it only covers trade movements under the presence of tariffs hence it will not allow us to look at vertical specialisation between regional partners where tariffs have been eliminated. In addition, and to the extent that tariffs may be low, firms might not apply for these types of provisions if the administrative cost is higher that the tariff faced. This is a common issue in the rules of origin literature that can be extended to OPT. In this literature the cost of compliance has been calculated at around 3-5% of the value of the product (as suggested by Evenett(2008)). However, processing trade remains an interesting indication of outsourcing as it is partially unaffected by tariff changes and hence can provide a good indication of firm incentives to source production internationally. Bearing in mind that these goods are exempt from tariffs, the growth of OPT trade will be dependent on non-tariff barrier changes and will thus significantly rely on factor price advantages for production. This may give us an ex-ante prelude to the formation of RTAs. By checking OPT flows prior to enlargements or signing RTA agreements we can determine if the latter were precursors to the signing of the agreement and thus provide an estimate of the effects of RTAS on vertical specialisation. However processing trade will not capture the full extent of vertical specialisation as it becomes irrelevant once a preferential trade agreement has been signed.

1.1.3 Trade and Production Data

Whilst trade and production data are very different in the way that they are collected, it is possible to merge these using the ISIC nomenclature. UNIDO provides detailed information at the ISIC rev 2 and ISIC rev 3 level on industrial production which can be matched to trade data by origin and destination. This has rarely been done, however a notable exception is that provided by a World Bank working paper by Nicita and Olarreaga (2001 and 2006(?)). They use production data from UNIDO at the ISIC rev 2 and rev 3 levels and match the corresponding trade data for a selection of industrial goods. Their tables span from 1976 till 200x in their last revision. These can be used to grasp the co-movement of imports and output acting as a proxy for vertical specialisation (by calculating shares of imports over output). The caveats of this method remain that industrial interlinkages remain uncounted. It further requires a considerable amount of work in matching intermediate imports so as to derive an

indicator of vertical specialisation. This would have to be done using the BEC nomenclature. The advantage of this approach, for econometric estimation, is that it provides a harmonised nomenclature for analysing production related variables such as wage bills, employment and investment (via gross fixed capital formation). However the data availability varies greatly by country which makes obtaining a large panel a considerable challenge.

1.1.4 VERTICAL INTRA INDUSTRY SPECIALISATION

In an effort to exploit the extensive availability of trade data and move away from the somewhat restrictive country coverage of input output tables, Gasiorek et al. (2010) develop a trade based index of vertical specialisation named vertical intra industry specialisation (VIIS). This indicator exploits the presence of 'parts and components' tariff lines within broad tariff aggregates deriving a share measure of intermediate imports (identified using the BEC nomenclature) over exports by industry and country. The aggregate measure then becomes the trade weighted average of the industrial measures. The main advantage of this type of indicator is that it allows for extended analysis across developed and developing countries. In addition, it can easily be extended to consider a bilateral element of vertical specialisation thus allowing for the extension of analysis in a regional context. However, the drawbacks are that the underlying assumptions impose certain constraints requiring that imports of intermediates used in production lie within a broad aggregate industry indentified under a tariff aggregate. Furthermore it assumes that intermediate imports are being fully used to satisfy external demand and not domestic demand which in turn causes the indicators to be unbound upwards.

Despite these shortcomings, the indicator is able to capture an important aspect of vertical specialisation. The use of the BEC nomenclature seems justified (as suggested in the discussion of Table 1) and the coefficients in the estimations provided in Gasiorek et al (2010) follow the expected signs. The RTA variable in the estimation suggest a statistically significant relationship between the presence of an RTA and higher levels of VIIS. This relationship is stronger between N-N partners and is also shown to be negative between S-S partners where a N-S type agreement has a statistically insignificant positive coefficient. Whilst these findings are insightful and provide a supporting step for our underlying hypothesis, the estimation procedure could suffer from endogeneity between the VIIS variable and the RTA dummy. It is indeed possible that the decision to engage in an RTA is the product of increased VIIS between bilateral partners. Equally, it is conceivable that partners that engage in an RTA show higher VIIS levels. Whilst Gasiorek et al (2010) were not particularly interested in the possible interplay between vertical specialisation and regional trade agreements, their work paves the way for a more systematic analysis using I-O data.

Resulting from the econometric specification, Gasiorek et al (2010) suggest the possible presence of an inverted U relationship between vertical specialisation and integration into global value chains. The rationale behind this relationship sees the interplay between domestic and foreign value added as guiding forces in determining levels of VIIS. The logic is as follows: at low levels of development, countries will enter global value chains with low domestic value added (i.e. assembly) and hence import high foreign value added items hence pushing the indicator up. As countries become more integrated in value chain activity, the share of domestic value added to foreign value added increases and hence the vertical specialisation indicator falls.

1.2 Non-Trade based Measures of Vertical Specialisation

As with the trade based measures of vertical specialisation, the non-trade based measures also have their advantages and disadvantages. These are outlined below for two such measures, FDI and VSI. The main disadvantage of these non-trade based measures is that these tend to be unavailable at the bilateral level. In addition, country and time coverage of these results in important challenges for practical implementation.

1.2.1 Vertical Foreign Direct Investment

Foreign Direct Investment (FDI) flows can be a source of information in mapping vertical specialisation as they represent firm's commitments to delocalise production, partially or fully, across borders. The literature distinguishes two forms of FDI; market seeking (horizontal) and export platform seeking (vertical). The former takes place when firms decide to set-up production in another market for servicing that same market (i.e. companies recreate domestic production structures in a foreign country to gain access to that market). Vertical FDI then relates to firm incentives to source production internationally, delocalising segments of production to least cost producers in other countries. It is the latter form that captures the vertical specialisation element that we are interested in.

A firm's decision to engage in FDI hinges on choosing a production strategy that minimises production costs but maximises access to a given market. Under the presence of restrictively high trade costs (tariff, non-tariff or distance barriers) firms can engage in market seeking FDI rather than in international trade to service a given market. However as trade barriers fall, firms can prioritise minimising production costs taking advantages of factor endowment or comparative advantage differences to delocalise segments of production to where they are most efficient. Hence there appears to be an important link between FDI and trade that is mediated by trade and production costs. As market access increases by way of bilateral or multilateral negotiations firms' incentives can change and vertical FDI can be promoted.

An extensive literature review carried out by Blonigen (2005) identifies the main determinants of FDI as being exchange rates, taxes, institutions, factor endowments and trade protection. However Markussen and Maskus (2001) find that market size has a greater influence on FDI flows than do factor prices suggesting that FDI flows may be mostly market seeking (tariff-jumping or Horizontal FDI). These results may reflect the important underlying differences between the two types of FDI here exposed. The nature of FDI suggests that horizontal FDI could be larger in terms of values than vertical FDI. This is because the fixed costs of setup involved with servicing other markets in the form of *full* delocalisation of production should be larger than arms length dealings or delocalisation of *segments* of production. In the context of vertical specialisation in preferential areas, not taking account of the marked differences between types of FDI flows may be inappropriate. Flows of FDI between preferential partners could be very different in nature to those between non preferential partners. Where the former would not be market seeking as market access should be granted by virtue of the agreement. Delocalisation of production within an RTA would then generally be registered under vertical FDI. This does not preclude horizontal FDI which would occur when strong backwards and forward linkages exist in other locations across the region. However if markets are highly integrated, the costs of setting up intra-regional affiliates will not be profitable unless we assume immobility of factors of production, high transport costs and very strong backwards and forward linkages. In this context we surmise that intra RTA FDI will predominantly take the form of vertical FDI.

Blomstrom and Kokko (1997:) conclude that, within RTAs, "international differences in factor endowments should become stronger influences on investment location decisions". Conversely, when barriers to trade are high (outside RTA), firms gain advantage from setting up affiliates in other markets and reaping the benefits, through scale economies, of an extended entry into a market where the large fixed costs of setup can be recouped more easily. Dunning (1997) empirically demonstrates that RTA consolidation, the likes of the completion of the Single Market Programme, gave rise to an increase in intra and inter regional FDI. However, evidence showed that inter-regional FDI rose faster than intra-regional FDI. This finding provides some evidence to our hypothesis and suggests that analysis of vertical specialisation using FDI flows should distinguish between vertical and horizontal types.

Whilst FDI can be very informative in capturing firm incentives to delocalise production, the availability of data is limited. Generally data is not available bilaterally and lacks an adequate degree of disaggregation. In addition, there is little way in knowing which type of FDI flow is occurring as these are not generally recorded. The use of FDI as an indicator of vertical specialisation in econometric analysis is hence going to lead to misleading results given that the factors motivating these flows vary significantly according to the preferential status of bilateral partners.

A.3 Aggregate Backward Linkages by Country

Table A.2: Backward Linkages by Country 1995 and 2005

Country	1995	2005	Δ	Country	1995	2005	Δ
Argentina	0.133	0.283	0.150	**Ireland**	0.291	0.361	0.070
Australia	0.192	0.213	0.021	**Israel**	0.375	0.515	0.140
Austria	0.292	0.360	0.068	**Italy**	0.215	0.329	0.114
Brazil	0.153	0.113	-0.041	**Japan**	0.091	0.287	0.197
Canada	0.292	0.338	0.046	**Korea**	0.244	0.392	0.149
Switzerland	0.148	0.270	0.122	**Mexico**	0.239	0.375	0.135
Chile	0.250	0.260	0.010	**Netherlands**	0.306	0.353	0.047
China	0.128	0.242	0.114	**Norway**	0.278	0.268	-0.009
Czech Rep	0.343	0.504	0.162	**New Zealand**	0.231	0.208	-0.023
Germany	0.174	0.278	0.104	**Poland**	0.245	0.361	0.117
Denmark	0.243	0.318	0.076	**Portugal**	0.401	0.452	0.051
Spain	0.247	0.372	0.124	**Romania**	0.213	0.161	-0.052
Estonia	0.405	0.528	0.122	**Russia***	0.069	0.093	0.024
Finland	0.293	0.403	0.110	**Slovakia**	0.386	0.521	0.134
France	0.177	0.299	0.122	**Slovenia**	0.292	0.421	0.129
UK	0.218	0.243	0.025	**Sweden**	0.248	0.347	0.099
Greece	0.239	0.248	0.009	**USA**	0.115	0.188	0.073
Hungary	0.346	0.530	0.184	**South Africa**	0.227	0.272	0.045
Indonesia	0.406	0.181	-0.225	**World**	0.168	0.279	0.112
India	0.229	0.296	0.067				

Source: Own Calculations using OECD STAN database and Comtrade
*Russia values are 1996 rather than 1995

A.4 TOTAL VERTICAL SPECIALISATION BY COUNTRY

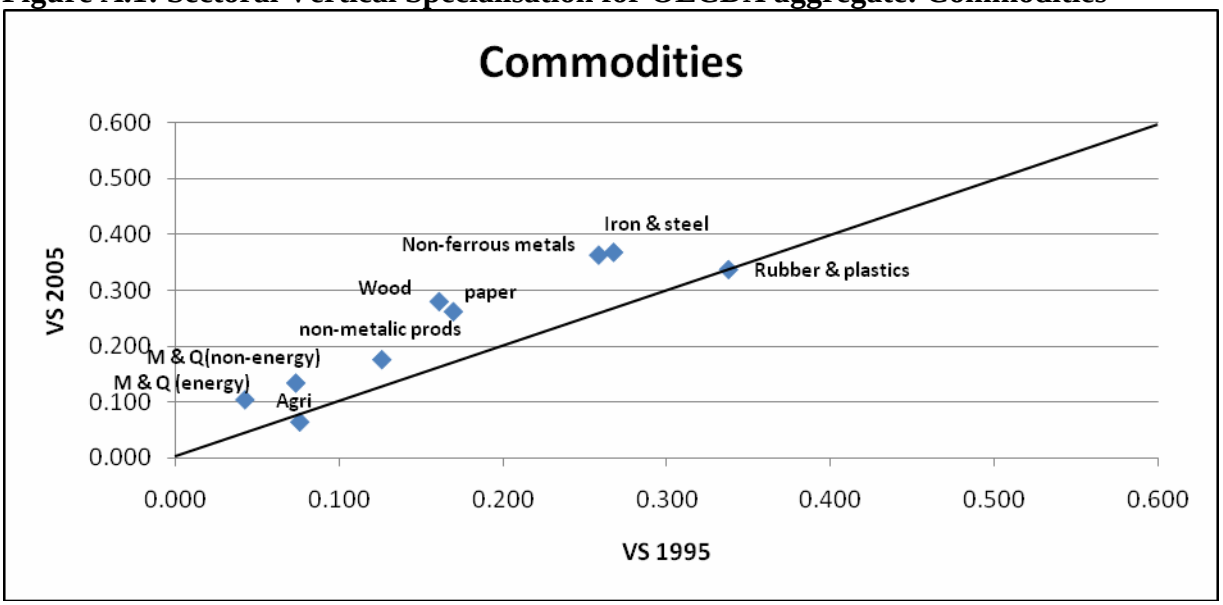
Table A.3: Total Vertical Specialisation by Country in 2005

Country	VS-B	VS-F	diff	VS-T	Country	VS-B	VS-F	diff	VS-T
Argentina	0.283	0.181	-0.102	0.413	**Ireland**	0.361	0.356	-0.005	0.589
Australia	0.213	0.500	0.286	0.606	**Israel**	0.515	0.210	-0.306	0.617
Austria	0.360	0.319	-0.041	0.564	**Italy**	0.329	0.265	-0.064	0.507
Brazil	0.113	0.302	0.189	0.380	**Japan**	0.287	0.208	-0.079	0.435
Canada	0.338	0.234	-0.104	0.493	**Korea**	0.392	0.214	-0.178	0.523
Switzerland	0.270	0.333	0.063	0.513	**Mexico**	0.375	0.233	-0.141	0.521
Chile	0.260	0.488	0.228	0.621	**Netherlands**	0.353	0.300	-0.053	0.547
China	0.242	0.234	-0.008	0.420	**Norway**	0.268	0.587	0.319	0.698
Czech Rep	0.504	0.307	-0.198	0.657	**New Zealand**	0.208	0.145	-0.063	0.323
Germany	0.278	0.295	0.017	0.491	**Poland**	0.361	0.296	-0.065	0.550
Denmark	0.318	0.357	0.038	0.561	**Portugal**	0.452	0.343	-0.109	0.639
Spain	0.372	0.294	-0.078	0.556	**Romania**	0.161	0.306	0.145	0.417
Estonia	0.528	0.449	-0.079	0.740	**Russia**	0.093	0.587	0.493	0.625
Finland	0.403	0.378	-0.025	0.629	**Slovakia**	0.521	0.405	-0.115	0.715
France	0.299	0.269	-0.030	0.488	**Slovenia**	0.421	0.255	-0.166	0.569
UK	0.243	0.348	0.105	0.507	**Sweden**	0.347	0.345	-0.001	0.572
Greece	0.248	0.246	-0.002	0.433	**Turkey**		0.245		
Hungary	0.530	0.290	-0.239	0.666	**USA**	0.188	0.289	0.101	0.423
Indonesia	0.181	0.435	0.254	0.538	**South Africa**	0.272	0.427	0.155	0.583
India	0.296	0.211	-0.085	0.444	**World**				

A.5 AGGREGATE SECTORAL VERTICAL SPECIALISATION

In order to shed light on possible sectoral specific trends in vertical specialisation we carry out a similar exercise as above but this time looking at OECD + 13 sectoral VSI aggregates in time. This is important as VS could be a sector specific phenomenon and hence mostly present in countries that engage in some types of economic activities. It also affords us the chance of looking at broad differences across broad sectoral divisions such as commodities, manufactures and services. Following the layout of Figure 2, Figure 4 maps the sectoral VSI for commodities in 1995 and in 2005 in the horizontal and vertical axes respectively. The figure depicts a noticeable increase in the VSI for all sectors except the 'Agriculture' and 'Rubber & Plastics' sectors. Despite this increase, and with the exception of ferrous and non ferrous metals, most commodities remain low in the VSI spectrum. This is unsurprising as exports of raw materials will tend to have very low levels foreign content. However, the machinery used for their extraction might largely be foreign sourced.

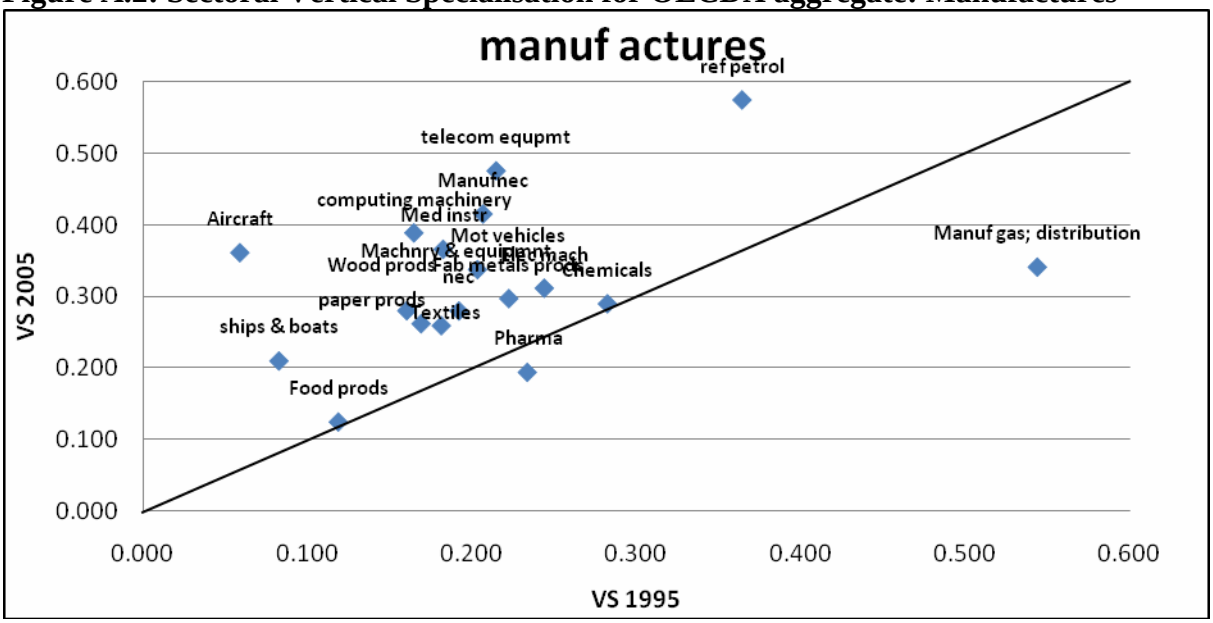
Figure A.1: Sectoral Vertical Specialisation for OECDX aggregate: Commodities



Source: Own Calculations from OECD I-O STAN database

When we look at manufactures in Figure 5 we see a higher and more dramatic increase in VS in time. Refined petroleum is the 'top-performer' showing the highest degree of foreign value added (going from just below 0.4 in 1995 to around 0.58 in 2005). It is however important to note that there might be a price effect here where the price of raw imported materials may have risen at a faster pace than the price of the finished refined petrol. Noteworthy is the near doubling in VS of sectors such as 'Telecoms equipment', 'Motor Vehicles', 'Computing Machinery' and 'Aircrafts'. Where these sectors may be considered as high-skill intensive, the important rise in VSI may point to either productivity gains or to changes in employment patterns towards non-OECD+13 countries. Perhaps a little surprising are the entries for 'Pharmaceuticals' and 'Chemicals' which lie very close to the 45 degree line and where one could expect increases in VSI from new technologies and increases in foreign skills. However, the values for these sectors are to be interpreted with caution as the construct of the OECD tables means that these sectors are interchanged for some countries in the sample. Overall, and in comparison to the commodities sectors, there seems to be much higher levels and increases in VS in time for manufactures.

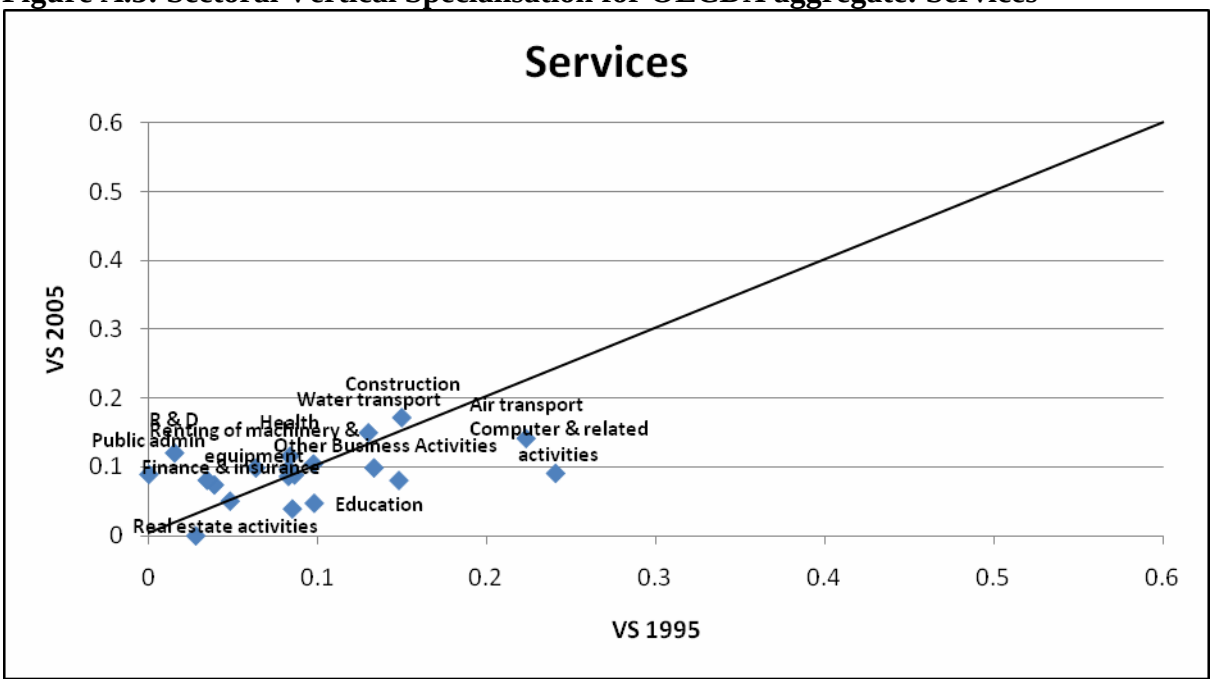
Figure A.2: Sectoral Vertical Specialisation for OECDX aggregate: Manufactures



Source: Own Calculations from OECD I-O STAN database

Figure 6 then considers the service category where we see not only lower levels of VS, but also smaller and sometimes negative changes in time. Whilst one might have expected sectors like 'Computer and related activities' to experience important increases in vertical specialisation these have gone down considerably. It is however important to note that these aggregate sectoral measures can hide important country effects, hence outsourcing computer related activities to India will be watered down in this aggregate measure. This in turn then supports the development of a bilateral measure so that we can grasp how sectors and countries are responding to this new wave of globalisation. Other financial and business sectors have also remained relatively unchanged in time but 'R&D' arises as an important 'climber' where VSI has more than quadrupled in a decade.

Figure A.3: Sectoral Vertical Specialisation for OECDX aggregate: Services



Source: Own Calculations from OECD I-O STAN database

On aggregate the above figures suggest that the increase in vertical specialisation is mostly a goods trade phenomenon (manufacturing and commodities). The service sectors seem to exhibit lower levels of vertical specialisation which have remained largely unchanged in time (or at least have not witnessed the increases seen in the other broad sectors). Overall, the above seems to suggests that there is important interplay between domestic and foreign value added, that this varies considerably across industries and that it is more prevalent in the non-service sectors of the economy.