Global Production Sharing: Patterns, Determinants and Macroeconomic Implications

Abstract:

The paper adds to the growing literature of global production sharing. The value added of this paper are three folds: 1) this paper extends existing theories on global production sharing; 2) this paper analyses the impact of macroeconomic variables like technology, institutions and macroeconomic stability on global production sharing - these variables have so far been ignored in the empirical literature on this subject; and 3) compare the determinants of global production sharing with final goods manufacturing exports.

This paper finds that institutions, technology and macroeconomic stability play a more prominent role in augmenting global production sharing in both developed and developing countries. In addition, we find that an improvement in technology augments global production sharing more than it augments manufacturing final goods exports.

1. Introduction: Purpose and scope of the thesis

Global production sharing can be defined as splitting of the production process into discrete activities which are then allocated across countries[1]. The process of global production sharing involves extending the production process across countries to give cost advantage to firms. Under this process, each production block takes a narrow range of production activities as the production process gets sliced up to provide cost advantage.

This process can be based on allocating labour intensive activities to labour abundant countries, while allocating capital intensive activities in capital abundant countries, along the lines of Heckscher-Ohlin theorem. Alternatively, this process can be viewed under Ricardian framework(Jones and Kierzkowski, 1988) which looks at relative differences in productivity of labour (see section 2.3).

There is evidence that trade based on global production sharing ('network trade') has grown at a much faster rate than total world manufacturing trade over the past four decades owing to three mutually reinforcing development over the past few decades (Yeats, 1998, Yi, 2003). First, rapid advancements in production technology have enabled the industry to slice up the value chain into finer, 'portable', components. Second, technological innovations in communication and transportation have shrunk the distance that once separated the world's nations, and improved speed, efficiency and economy of coordinating geographically dispersed production process. This has facilitated establishment of 'services links' to combine various fragments of the production process in a timely and cost efficient manner. Third, liberalisation policy reforms in both home and host countries have considerably removed barriers to trade and investment. There is an important two-way link between improvement in communication technology and the expansion of fragmentation-based specialisation within global industries. The latter results in lowering cost of production and rapid market penetration of the final products through enhanced price competitiveness. Scale economies resulting in market expansion in turn encourage new technological efforts, enabling further product fragmentation. This two-way link has set the

[1] Global production sharing is also known as production fragmentation, vertical specialization, production sharing, intra-product specialization and slicing up the value chain.

stage for ‘fragmentation trade’ to increase more rapidly compared to conventional commodity-based trade.

Trade in parts and components behave differently to trade in final goods. For instance, variables that may play an important role in classical trade analysis i.e. home country’s gross domestic product (GDP) and exchange rate may not be very significant in explaining global production sharing. Furthermore, ‘service links’play a vital role in global production sharing(Jones and Kierzkowski, 1990) . Jones and Kierzkowski define service link activities - and their associated costs – to involve communication, transportation, information gathering and costs of coordinating production activities across countries (Jones and Kierzkowski, 1990, Golub et al., 2007). Given this, without explicitly modelling parts and components trade and the relevant variables, analysis of aggregate international trade maybe misleading. This will be particularly true for countries that have a high proportion of parts and components trade in their total share of trade. Moreover, we will disaggregate global production sharing into trade in parts and components and final assembly and see if the determinants of the two differ.

The purpose of this paper is three folds: (i) to develop and extend current theories of global production sharing; (ii) examine determinants of global production sharing based trade (network trade) with a focus on how the determinants of global production sharing are different from trade in final goods; and (iii) probe open economy macroeconomic implications of global production sharing.

The rest of the paper is organized as following: Section 1.1 gives overview of global production sharing, section 2 presents theoretical literature, while section 3 extends existing theories on global production sharing, section 4 discusses estimation methodology for analysing determinants of global production sharing, section 5 discusses data, section 6 gives empirical results and section 7 concludes.

1.1Global production sharing: An Overview

The process of slicing up production into smaller blocks internationally is not a new process and has been an important process dating back to industrial revolution. Its importancein world trade has been highlighted since at least the 1960's (Grunwald and Flamm, 1985, Helleiner, 1973). However, the modern process of global production sharing is different in that it intensively involves developing countries and the magnitude of global production sharing is significantly higher compared to historical standards. (Yi, 2003)

Global production sharing has evolved from a simple process between two or so countries to a multi-stage and multi-country process. For instance, a firm's head quarter may be in the US and involved in head quarter functions like R&D, service linkages and coordination, while parts and components are assembled in countries like South Korea, Taiwan and Malaysia before being shipped off to China for final assembly.

Following examples help to illustrate this process. Linden et al. (2009) analyse the production of iPod by the US based firm Apple. According to the industrial organization of Apple, the product design and software development are kept in the US(Linden et al., 2007, Linden et al., 2009). While other stages of production such as producing hard drive, display module, main board PCB and memory are produced in countries like Japan and Taiwan, while final assembly takes place in China.

Another example of global production sharing is that of the production of the Barbie doll (Tempest, 1996). Plastic and hair for the doll is acquired from Taiwan and Japan, while China provides cotton cloth for the dresses. Molds and paints come from the US and assembly gets done in Indonesia, Malaysia and China. This illustrates the multistage and multi country process that global production sharing has evolved into.

Given this, conventional approach of treating international trade as 'cloth for wine' (that is, the assumption that countries trade in goods produced from beginning to the end in a give country) needs to be altered to take account of global production sharing, especially as the share of trade in parts and components rises.

World trade has seen a significant increase in global production sharing (Yeats, 1998). Factors like, proliferation of globalization, reduction in transport and communication costs, trade liberalization and advancements in technology, have boosted global production sharing and its importance in international trade. For instance, trade in parts and components have grown at a faster rate than trade in final goods(Yeats, 1998).

Furthermore, between 1970 and 1990, increase in exports associated with global production sharing accounted for one third of world economic growth (Yi, 2003). This process has also expanded to include various products including automobiles, televisions, smart phones, sports and footwear items, sewing machines, cameras, office equipment, watches, etcAthukorala (2011). The impact of global production sharing on different industries has varied. Generally, industries that trade in high value to weight goods and ones where technologically it was feasible to slice up the production process have been better able to take advantage of global production sharing.

The role of service linkage costs for linking the various production units located across countries plays an important part in global production sharing (Jones and Kierzkowski, 1990). As these service linkage costs decline, due to reduction intransport and communications costs, technological breakthroughs and trade liberalization, production fragmentationwould further endorse global production sharing.

In addition, global production sharing networks have established themselves around the globe. US, Canada and Mexican firms a have strong connections in parts in component trade across the border. It is estimated that around $250 dollar worth of parts components trade between US and Mexico border (Hanson et al., 2005). In addition, East Asia regions share in total network exports increased from 22.0 % in 1992/93 to 45.7% in 2005/06(Athukorala, 2011). Moreover, there are increased linkages in production networks amongst European countries .In contrast to this, regions like South Asia and Africa have not seen a strong presence of global production sharing.

Given this, it is important to note that global production sharing’s impact has varied between industries and regions. With industries with high value to weight and technology to slice up production chains and regions like East Asia, North America and Europe taking a higher advantage from this process.

2.1 Survey of theory

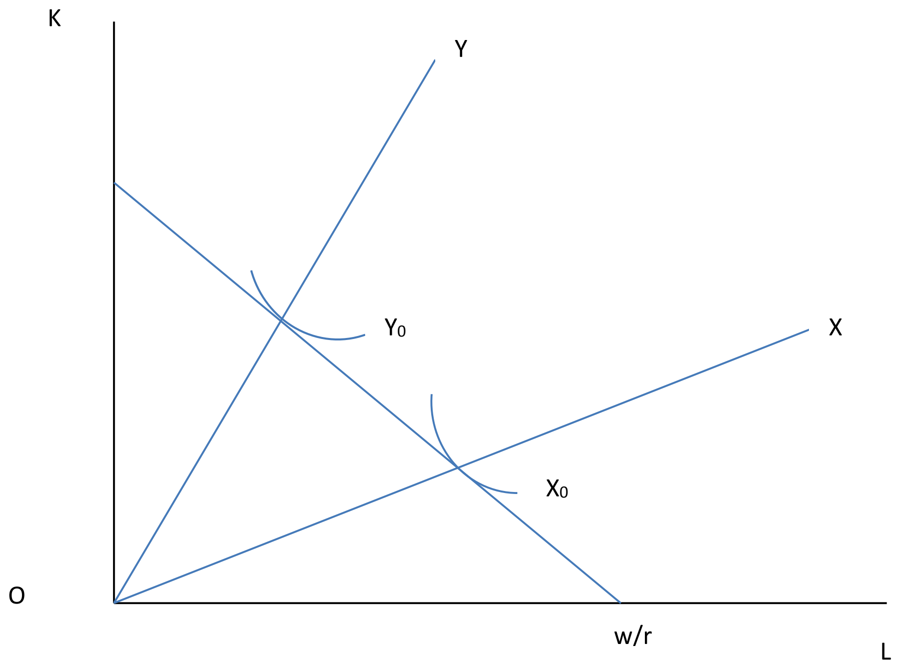
This section surveys the existing theories that have been developed for trade. Jones and Kirezkowski (1990), Arndt (1997), Venables (1999), Jones and Kirezkowski (2001a), Grossman and Rossi-Hansberg (2006) and Baldwin and Robert-Nicoud (2007), have developed frameworks and extended standard trade theory to global production sharing. This section will be expanded to form a core chapter of thesis.

2.1.1 Modelling global production sharing.

Arndt (1997) look at the impact of global production sharing on employment and wages. They use the neoclassical trade theory to decipher the impact of vertical specialization on wages and employment. According to them the decision to 'sub-contract' – sub-contract is synonymous to fragmenting the production process across countries – should be dictated by considerations of comparative advantage.

To build their model they assume two factors of production capital (denoted K) and labour (denoted L). They further assume two goods, X and Y, with unit value isoquants X_0 and Y_0 depicted in figure 2.1.1 below. As drawn, they assume that X is labour intensive, while good Y is capital intensive, while factor price ratio is given by the straight line w/r.

Figure 2.1.1



In figure 2.1.2 they assume that each good, X and Y, can be further broken down into two sub stages of production, which can be either subcomponents or services. They call these sub stages X_1 and X_2 and Y_1 and Y_2, the factor intensities of these sub stages are shown infigure 2.1.2. Given this, when sub stages of production differs in factor intensities, then the final goods expansion path is just the weighted average of the factor intensities of its various stages.Arndt (1997) initially assume, that due to transportation and communication costs off shoring the various sub stages of production is not feasible. Overtime, this assumption is relaxed, and due to technological break throughs and reductions in transportation costs, off shoring becomes feasible.

The firm can subcontract activities/components to other countries based on comparative advantage. The example they give is that of Boeing, which is based in a capital abundant country – US. Given the differing factor intensities of various stages, Boeing can relocate labour intensive stages of production to labour abundant countries, while keeping capital intensive stages of production at home (which capital abundant).

To understand the process more, assume that home country are prices takers in the world economy. To gauge the effect of off shoring, it is now assumed that due to technological breakthrough and reductions in communications costs, subcontracting of the sub stages of product X becomes feasible. Given this, the firm can subcontract the labour intensive stage of X, X_1,to labour abundant country. In this analysis, then domestic production of good X solely involves X_2which includes final assembly.

Fragmentation process like this would yield cost reductions for good X, which is shown by the inward shift of isoquant for good X in figure 2.1.2. Then the factor price ratio in the economy will be given by w/r' line, which shows that the labour's relative price increases.

However, the price of commodity X is still unchanged as the home country is a price taker. To reconcile the change in factor price ratio with the relative prices of goods, firms will substitute away from labour to capital, this change is shown by the shifting of expansion paths to y' and X'_2in figure 2.1.3

Due to these changes, labours employment will increase. This happens because producing X becomes more attractive to producers. This is because the price of good X has not changed, but its cost of production has decreased. This will encourage producers to make more of X and less of Y. As X is still relatively labour intensive, compared to Y, this will raise the demand of labour. This shows that sub-contracting in an economy, like the one mentioned above, can yield both wage increases and increase in labour employment.

Figure 2.1.2

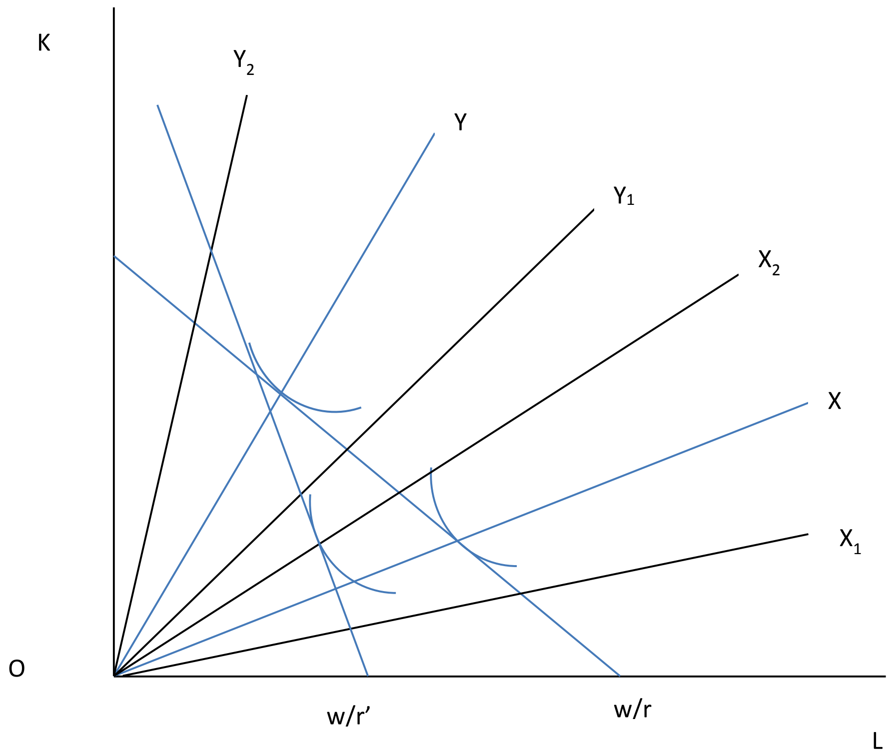
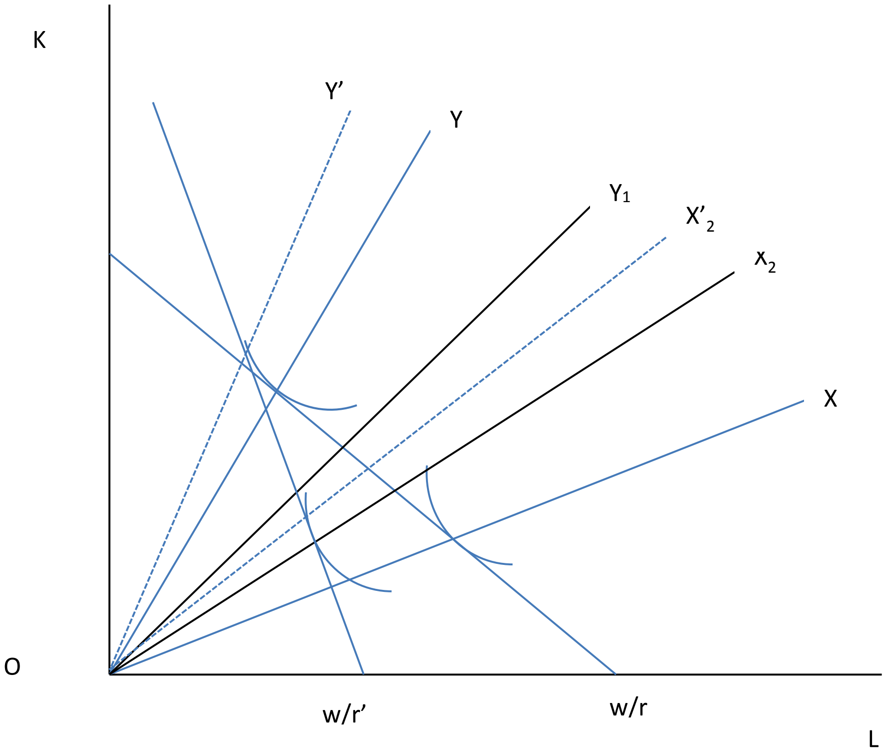


Figure 2.1.3



However, these inferences are not robust (Yamashita, 2010). If production fragmentation is possible in both goods and if the least capital intensive component of Y, $Y_1$is less skillintensive than X_2, then fragmentation of good X and Y can yield to a reduction in wage/price ratio. This shows that the effects of fragmentation dependsignificantly on the factor intensities of various sub stages.

Another problem with the above framework is that it does not explicitly include the costs of linking the various stages of production like transportation, communication, trade and transaction costs. These costs are shown to be important for global production sharing (Hanson et al., 2005, Helleiner, 1973, Hillberry, 2011, Golub et al., 2007, Feenstra, 1998, Jones and Kierzkowski, 1990).

Grossman and Rossi-Hansberg (2008)build a model to look at the impact of global production sharing on factor prices in the source country. They find a productivity effect resulting from the global production sharing. They show that this productivity effects augments the productivity of factors whose tasks can be easily split up in international value chains.

Global production sharing can also be model based on a continuum of goods and activities in the production process. (Feenstra, 2003, Feenstra and Hanson, 1995, Feenstra and Hanson, 1997).Feenstra and Hanson (1995) and (1997), build a model with a continuum of inputs over unit interval as shown below. Where z is an index denoting various activities undertaking in the design, creation, production and delievery of the final good.

$z\epsilon\ [0,1]$ 2.2.1

They rank all these activities, z, in the increasing order of skilled/unskilled labour. Example used to explain this ranking iswhere assembly may be the most unskilled labour intensive activity, while R&D may be the most skilled labour intensive activity. Furthermore, they define x(z) as the quantity of each one of these inputs. While $a_h(z)$ and $a_l(z)$ are the skilled and unskilled labour required to produce one unit of x(z).

They assume two countries, foreign and domestic. The production function they use has the same Hicks-neutral productivity parameter in each country. In addition, the production function has Leontief technology between the two types of labour and Cobb-Douglass between the overall labour and capital, as shown by equation 2.2.2. It is assumed in this model that assembly is costless, so it does not matter which country undertakes assembly.Their production function is given below:

$x(z)=A[\min(\frac{L(z)}{\mathrm{al(z)}},\frac{H(z)}{\mathrm{ah(z)}})]^{\phi}K^{1-\phi}$Where $z\epsilon[0,1]$ 2.2.2

To analyse the allocation of activities to various countries it is easier to analysetheunit cost functions given below for each activity.

$C(w,q,r,z)=B[wa_l(z)+qa_h(z)]^{\phi}r^{1-\phi}$ 2.2.3

Using Feenstra (2003) notatios, we use astericks to denote foreign country, while the non-asteriked variables denote home country. Feenstra (2003) assume the following:

$q/w<q^*/w^*$ 2.2.4

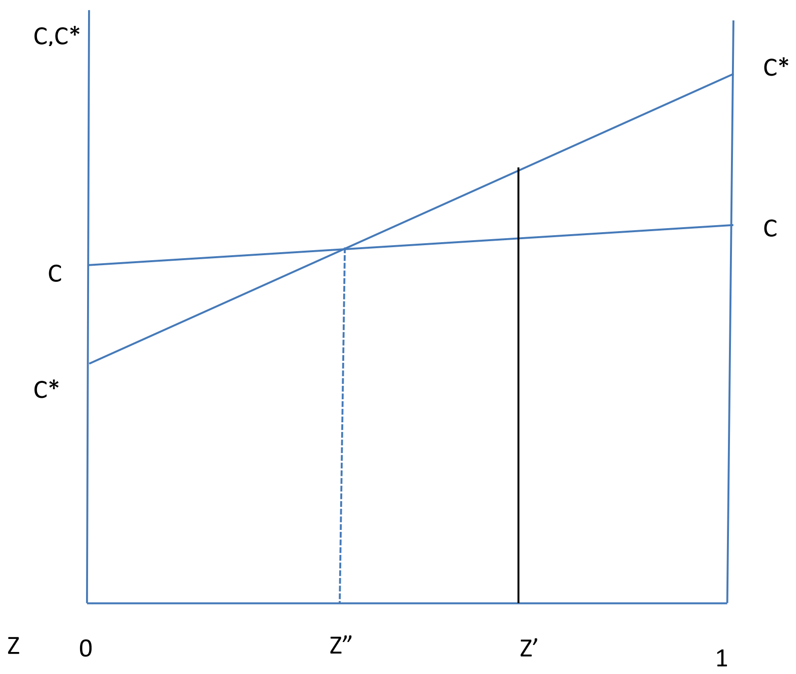
$r<r^*$ 2.2.5

The first assumption above says that skilled labour is relatively cheaper at home, and second assumption says that rental rate for capital is also cheaper at home. The example they give to help understand the example above is of US and Mexico, with US being the home country where skilled labour and captial rental rate are relatively cheaper compared to Mexico.

Given equation 2.2.2 to 2.2.4, the unit cost functions can take various shapes. But to keep analysis simple they look at continuous upwards sloping functions like the figure 2.1.4. Where CC line denotes unit costs for the home country, while the line C*C* is the counterpart for the foreign country.

If the unit cost functions are lower for all activities for the home country, the whole production process will happen in home country, and vice versa. For global production sharing to happen, it must be that some activities are cheaper to produce at home and some are cheaper to produce in the foreign country. Given this, the lines CC and C*C* intersect atleast once to make global production sharing feasible.

Figure 2.1.4



The intersection of line CC and C^*C^* happens at point Z^*, where $C(w,q,r,z)=C(w^*,q^*,r^*,z^*)$. Then if we look at a point like Z', where $Z'>Z''$, which has a slightly higher skilled/unskilled level. Then, given our assumions (2.2.4 and 2.2.5), higher skilled/unskilled requirements should have a greater impact on foreign cost than at home. Which would translate to $C(w,q,r,z)<C(w^*,q^*,r^*,z^*)$ for all $Z>Z''$, and vice versa.

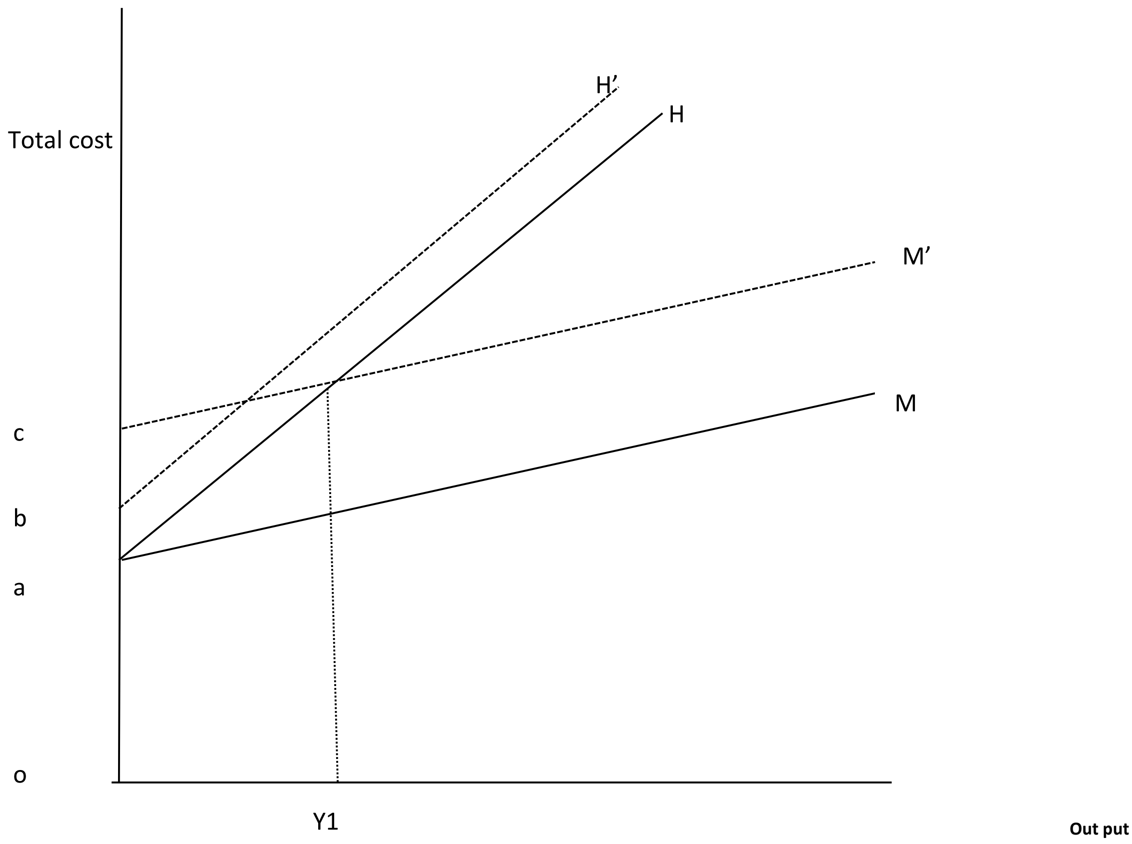
Given this, home country will espcialize in goods that are more skilled intensive, so that $Z>Z''$, and forieng country will espciallize in goods that more unskilled labour intentive, such that $Z<Z''$. Given this difference of factor prices, and our assumptions, will make global production sharing feasible.

However, the above model does not deal with fixed costs and sunks costs that would be pertinent for setting up multiple production plants across several countries (Jones and Kierzkowski, 1990, Jones and Kierzkowski, 2001).

2.2.1 Global production sharing with fixed costs and service link costs.

Jones and Kirezkowski (1990) focus on different production blocks and services link costs in the theory of global production sharing. Their paper describes how increasing output levels, increasing returns to scale and the advantages of specialization of factors within a firm can lead to a fragmented production process. They further postulate that trade liberalization and declines in the cost of transportation and communication has enhanced production fragmentation. Jones and Kirezkowski (1990) use the following diagram to explain their main ideas.

Figure 2.2.1



Line H in the above diagram gives the total cost of producing the whole product in one production block in a given country, this includes fixed costs and marginal costs.If a firm is to slice the production chain and locate over two or more different locations, then it will incur service link costs. As mentioned before service link activities - and their associated costs – involve communication, transportation, information gathering and costs of coordinating production activities. Line H' shows the added costs of service links for when the production blocks are in the same country.

Line M shows lower marginal costs by undertaking global production sharing and cost saving by having two production blocks and moving one of the production blocks to a foreign country. This lower marginal cost comes from the assumption that the foreign country has lower production costs for the second production block. Line M' shows increased services costs by producing in a foreign country. This can include planning, coordination and transport costs among others. Service costs are assumed to be higherwhen a firm has production blocks located internationally, this may reflect higher coordination, legal and transportation costs.

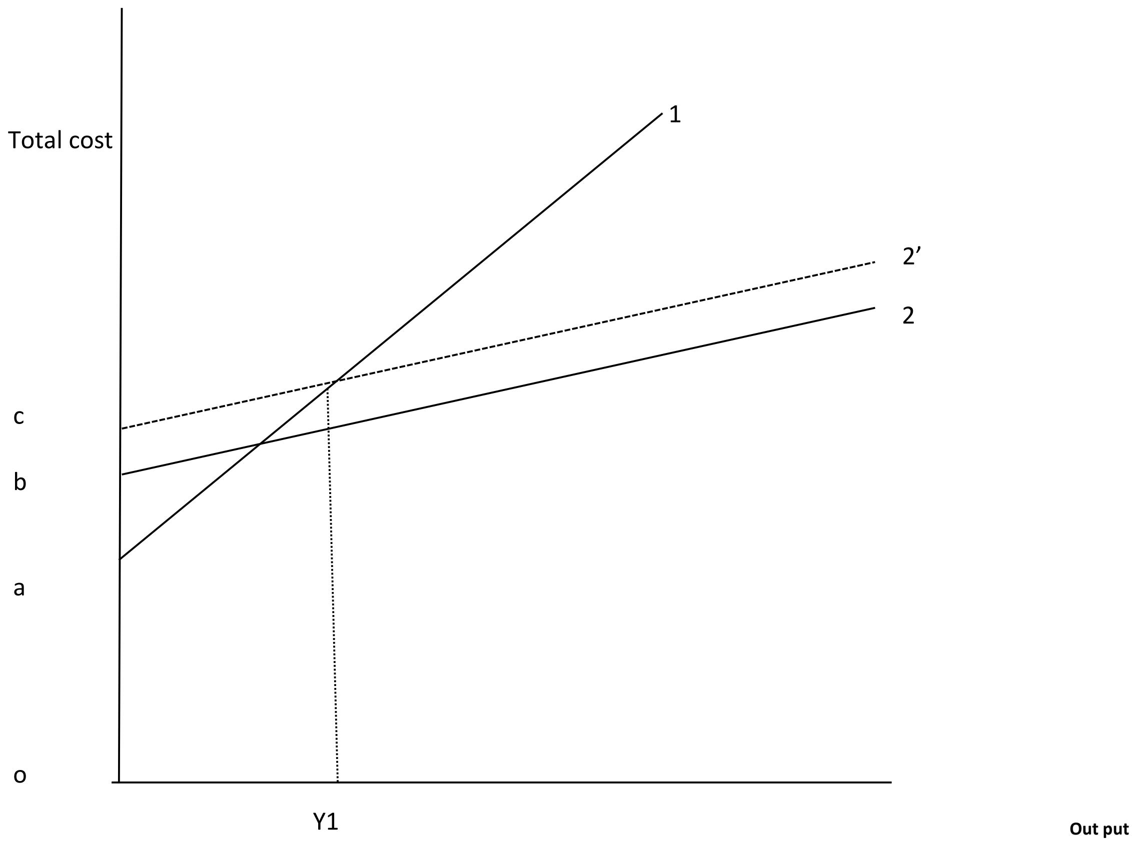
Service link costs can be shown to be increasing with output by showing steeper H' and M' lines. Furthermore, increased setup costs for global production sharing process can be shown by increasing the intercept of line M to a higher point than 'a'.

The figure below replicates another diagram of Jones and Kirezkowski (1990). This diagram helps to better explain the trade-off between lower marginal costs due to global production sharing and higher fixed costs, that a firm may face if it has 2 more or production blocks. Line 1 shows steeper marginal costs due to having just one production block, where the production process is located in one country. Line 2 is flatter due to marginal costs savings as a result of global production sharing. Lower marginal cost reflects cost savings by allocating production process such as labour intensive components and production processes to be produced in labour abundant country, and capital intensive components and production process to be produced in capital intensive countries.

However, line 2 has a higher intercept, point b, showing higher fixed costs, this may be due to the need of setting up multiple production plants. The difference between line 2 and 2' shows the costs of service links. Beyond output level Y1, it will be more feasible for the firm to undertake global production sharing rather than having only one production block.

The above point emphasis that that the scale of output becomes important for global production sharing, especially if the components are specialized and tailor made to the needs of the firm.

Figure 2.2.2



To summarize the basic idea of why the second production block can yield lower costs relates to the fact that some components and parts of the final good maybe produced cheaper in another country. This concept can be shown by using comparative advantage concepts of either Richardian or Hechsher-Ohilin (H-O) models. These frameworks are discussed below.

2.3.1Ricardian framework

Ricardian framework analysed by Jones and Kirezkowski (1990) assumes two components produced from two production blocks. Marginal labour input coefficients in each block denoted by ali for home country while foreign country it is represented by ali*. They further assume that both components need to combine in one to one ratio to produce final goods – so they assume a Leontief production function. They further assume that fixed costs within production blocks and between countries are identical.

It is also assumed that homes country has advantage in producing the complete good (equation 2.3.1 holds). Soifproduction separability is not possible, then home has advantage in producing that product.

$$\frac{(\mathrm{al1*} + \mathrm{al2*})}{(\mathrm{al1} + \mathrm{al2})} > \frac{\mathrm{w}}{\mathrm{w*}} \quad (2.3.1)$$

However, if we break down the final good into two components, then home country has advantage in producing the first component, while the foreign county has advantage in producing the second one (equation 2.3.2 holds). Given this, with production separability, we can get.

$$\frac{\mathrm{al1*}}{\mathrm{al1}} > \frac{\mathrm{w}}{\mathrm{w*}} > \frac{\mathrm{al2*}}{\mathrm{al2}} \qquad (2.3.2)$$

So that home has advantage in component one, while the foreign country has advantage in component 2, and with production separability we get the 'slicing of the value chain' into a global production sharing process.

2.3.2Heckscher-Ohlin framework

In Heckscher-Ohlin model production blocks can be located based on differences in factor endowments of the country and the factor intensities of the components. Labour intensive components can be based in labour abundant country and vice versa.

Jones and Kierzkowski (1990)use an example where the good has two components, where one subcomponent is more capital intensive than the other. Further,Jones and Kierzkowski (1990)assume that one country is so well endowed with labour that factor prices don't equalize. Given this, if the firm can create service links between the two countries, then it can use cheap labour in one country and cheap capital in the other to form a process of global production sharing. Locating production blocks based on comparative advantages of the countries can yield cost savings and a more efficient production processfor them firm. Another advantage of using the Heckscher-Ohlin model is that it can allow for many factors in the production process.

In our empirical work, we will need to empirically test whether Ricardaian or Heckscher-Ohlin framework is more important for global production sharing (Nyahoho, 2010, Leamer and Levinsohn, 1995, Davis, 1995, Bombardini et al., 2012, Morrow, 2010).

In addition to accounting for the Heckscher-Ohlin and Ricardian frameworks, our analysis will need to take into account of heterogeneity within industries. Nunn (2007) shows that industry characteristics play an important in determining trade flows. Industry fixed effects will be particularly important in global production sharing, where industries like electronics are involved in vertical specialization more compared to automobile industries due to higher value to weight ratio.

2.4.1 Industrial Organization Model

Some recent papershave also analysed global production sharing in the context of industrial organization(Baye and Beil, 2006, Antràs, 2003, Majumdar and Ramaswamy, 1994, Yamashita, 2010, Monteverde and Teece, 1982). These theories look at various options available for the firm to produce its various stages of production. Following are the various options available to firms:

- Spot exchange;
- Acquire inputs under a contract; and
- Produce the inputs internally in various countries, while taking advantage of each country's comparative advantage.

Under spot exchange, there is an informal relationship between a buyer and a seller and in which neither party is obligated to adhere to specific terms of exchange. This type of mechanism works better when the product or service to be exchange is standardized. However, the problem with this type of exchange is that firms that need specialized goods and services are not able to get highly customized products and services. This problem is over come when firms acquire sub components and services either under contract or produce them internally.

Acquiring subcomponents under contract allows firms to allocate factors according to comparative advantage, often knows as arm's length transaction. This method of obtaining contracts works well where it is easy and not costly to write contracts. However, there can be high transactions cots of writing up contracts;like time involved in writing up contracts and legal fees – especially when nature of the product is complex and there is a high degree of customization is required (Baye and Beil, 2006). In addition, transaction costs at arm'slength can cause hold ups and often contracts are not complete and they can miss important contingencies which can lead to complications.

Internally producing the components can help firms to overcome thesetransactioncosts, of writing contracts and minimize hold ups. Firms that require a higher degree of sophistication on average prefer intra-firm transaction as opposed to transactions at an arm's length (Antràs, 2003). However, then the firm needs to incur extra fixed costs to set up production plants for various stages of production in various countries. Vertical integration, can also lead to increased bureaucratic costs(Baye and Beil, 2006).

3.1 Extension of Theory

In this section, I will further refine Jones and Kirezkowski (1990) model and analyse the determinants of global production sharing. Furthermore, using these determinants, I will explicitly incorporate important variables in Jones and Kirezkowski methodology. These variables include:

1) technological change that allows for finer slicing of production sharing ;
2) Institutions;
3) Infrastructure and tariff regimes;
4) macroeconomic stability of the economy;
5) competition among foreign countries to capture some of the value added in global production sharing; and
6) exchange rate pass through

3.1.1 Determinants of global production sharing

Efficient global production assembly lines can be created if component production is locat to match the factor intensity of components to the factor abundance of countries.To analyse this phenomena and its determinants we begin by looking at the production process of a firm.

To analyse, we look at a case of 1*2*2. Where we have one final good called F1, that is composed of two subcomponents called G1 and G2, we have two factors of production Capital, K, and Labour ,L, and we have 2 countries – home country and foreign country. Home country is labour intensive and foreign country is labour intensive. The two subcomponents have different factor intensities. G1 is capital intensive and G2 is labour intensive. To produce F1, the firms need to produce G1 and G2and combine themusingfinal assembly. Final assembly is assumed to be labour intensive. It is also assumed that G1 and G2 are used in a fixe ratio to produce F1, hence the production function is assumed to exhibit a Leontief production process.

Moreover, it is assumed that marginal costs of producing G1, G2 and final assembly are constant – i.e constant returns to scale. However, service links are assumed to exhibit increasing returns to scale.

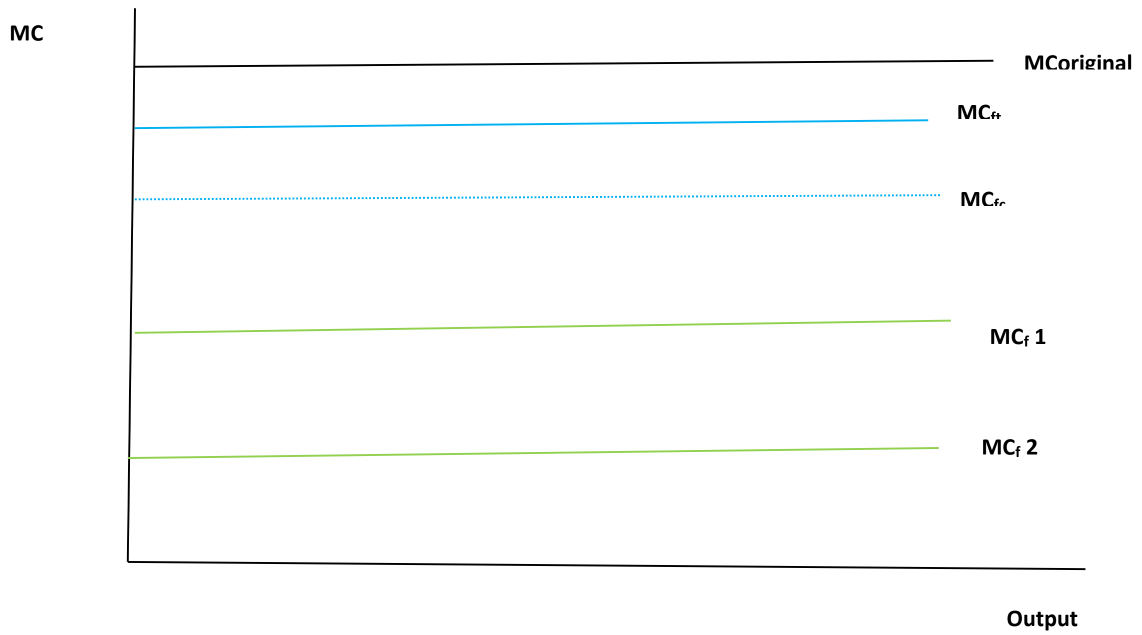
Initially, suppose that both G1 and G2 were produced in home country A. In figure 3.1.1, total marginal cost for producing F1 at home country is given by black line (MC original).

Assume now, that firm relocates the labour intensive component to foreign country B, and keeps the production of capital intensive component in home country (call home country A). Furthermore, assume that relocating the production of components yields costs savings. In the new production process the capital intensive good is produced in capital abundant country (where capital is cheaper) while labour intensive good is produced in labour intensive country (where labour is cheaper). Cost savings in the production assembly line may due to Hechsher-Ohilin theorem.

The marginal costs of each good are given by green lines $MC_{f\,1}$ and $MC_{f\,2}$.Marginal cost of producing both componentsis given by the dotted blue line, MC_{fc}, which is the vertical summation of the two green lines. The final marginal cost of the good, under fragmentation, is given by the solid blue line, MC_{fc} .The fact that $MC_{fc}<MC_{ft}$reflectsservice linkage costs including transportation, coordination and communication costs. It can also reflect assembly cost, but for simplicity at this time assume that assembly costs are negligible compared to other costs. We will relax this assumption later.

$MC_{fc}<MC_{ft}$ (3.1.1)

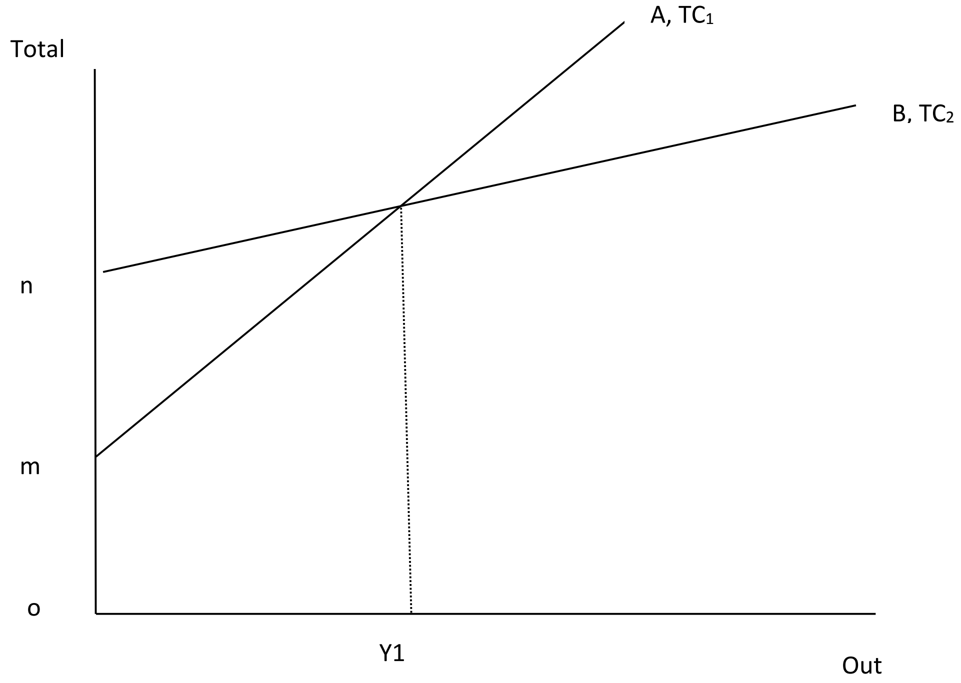
Figure 3.1.1



However, itshould be noted that equation 3.1.2 shows a necessary but not sufficient condition for the firm to embark on global production sharing. To look at the sufficiency condition we need to look at total costs and the equivalent of Jones and Kirezkowski (1990) methodology.

$MC_{ft}<MC_{original}$ (3.1.2)

Figure 3.1.2



The figure above extends Jones and Kierzkowski (1990) diagram and is similar tofigure 2.2.2. Line 2' infigure 2.2.2 is the same as BinFigure 3.1.2 and line 1 infigure 2.2.2 is the same as A in figure 3.1.2. So that in the figure above, it is assumed that line B includes service linkage costs. In figure 3.1.2, output level beyond y1 makes it feasible for the firm to relocate its production process to get cost savings, equation 3.1.3 (where Y* denotes the actual production level of the firm). To summarize, along with the necessary condition of equation 3.1.2, we need the sufficiency condition of equation 3.1.3 to make global production sharing feasible.

$$Y1 < Y^* \qquad (3.1.3)$$

Further explanation of the diagram above is as follows. Line A represents totals costs when all production takes place in one production block. It depicts how total cost expands when output increases, the slope of the line shows marginal cost. Line B, on the other hand, shows how total cost varies when production blocks are located in different countries. Higher intercept for line B reflects the fact that having more production block incurs higher fixed costs as more production plants need to be built. A flatter slope of line B, compared to line A, reveals the fact that it has lower marginal costs due to allocating good G_2 producedin country B that can make it more cheaply. While still producing the capital intensive component G_1 in country A, where capital is cheaper.

It would be helpful to draw similarities between Figure 3.1.2 and figure 3.1.1. Marginal cost when production is located in home country is given by MC original in figure 3.1.1 and is equivalent to the slope of line A in figure 3.1.2. Similarly total marginal cost under global production sharing is given by MC_{ft} in figure 3.1.1 which is equivalent to the slope of line B in Figure 3.1.2.

Mathematically, line A and B can be written down respectively as:

$$TC_1 = a + by \qquad (3.1.4)$$

$$TC_2 = c + dy \qquad (3.1.5)$$

Where a and c are fixed set up costs for production in one block and fragmented production process respectively. Variable b is the marginal cost of producing with one production block, while d is the marginal cost of production with fragmentation in two countries. These results could be generalized to more than one country.

To look at the determinants of global production sharing we equate 3.1.4 and 3.1.5 and solve for y.

$$a + by = c + dy$$

$$y = \frac{a-c}{d-b} \qquad (3.1.6)$$

So any variable that affects a, c , b and d, would affect the process of production fragmentation and the level of output at which global production sharing becomes feasible. More precisely equation (8) says that the output level at which global production sharing becomes feasible depends on the ratio of relative fixed cost over relative marginal costs.

The lower the marginal cost that firm can achieve by relocating production of some goods overseas and the lower the fixed costs of setting of production plants in foreign country, the more profitable it is to engage in global production sharing.

In section4 we look at variables that affect a,c,b and d. These include 1) infrastructure, transportation costs and tax regimes, 2)technology, 3) institutions, 4) macroeconomic stability and 5) competition among countries to capture part(s) of the value chain. In the next subsection, we develop the theory of production process more closely.

3.1.2 Production process

We have assumed that the production process is Leontief. But we only need the production process of the final good, F1, to be Leontief, while the production process for subcomponents, G1 and G2, can exhibit substitutability in inputs. To put it in another way, F1 requires a fixed ratio between G1, G2 and final assembly, while G1 and G2 themselves can be made by various combinations for capital and labour bundles. Equation3.1.7 gives the total cost of F1, it is another version of equations 3.1.4 and 3.1.5.

A more important interpretation of equation 3.1.7 is that it gives us a family of iso-cost lines. The coefficients of G1 and G2 give marginal cost of producing G1 and G2. The coefficients embody the capital and labour costs in producing G1 and G2 respectively. P gives the final assembly cost of F1. For simplicity, we assume p is negligible for this section, this assumption can hold without loss of generality.

To work with this model assume, initially assume the firm is just producing in the home country. Furthermore, assume that the firm wants to produce a given level of output for final product, call that level Y*, given by the iso-quant, IQY*, in the figure below. Given the level of the output, the firm wants to minimize it costs. Say it does that by incurring a cost of TC*, given by the iso-cost line c1 in the figure below.

$$TC_{F1} = a_1G1 + a_2G2 + PF1 \qquad (3.1.7)$$

Now assume, that the firm undertakes global production sharing, and is able to cut down labour costs in producing good G2. This means that the coefficient of G2 changes to a lower value say a_2*. Given this, the iso-cost line pivots and the horizontal intercept shifts to the new point given by x2. Now the iso-cost line is given by c2. In order to the produce the same level of output the firm moves to a lower iso-cost line (parallel shift down from c2), to a line like c3. Given this, we can see that the firm reduces costs by undertaking global production sharing. These cost reductions are given by equation 3.2.5 and the distance Y1-Y2 in the figure 3.1.7.

Where intercepts are given by the following:

$Y1=TC^*/a_1$ (3.1.8)

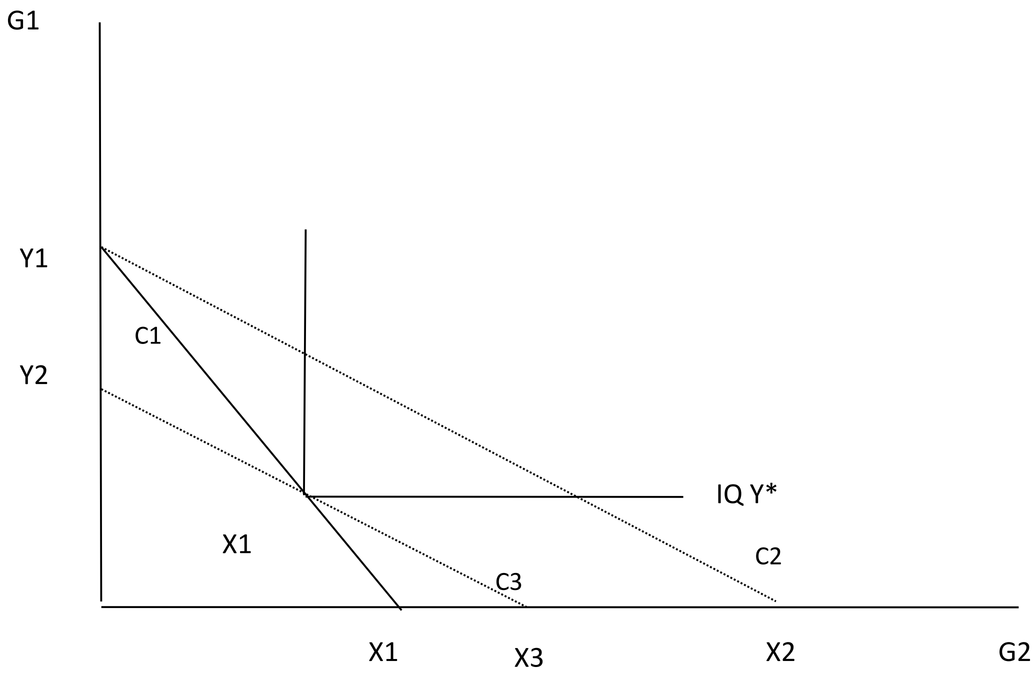
$X1= TC^*/a_2$ (3.1.9)

$X2= TC^*/a_2^*$ (3.1.10)

Cost saving is given by:

Cost savings = Y1-Y2 (3.1.11)

Figure 3.1.3



The above diagram is another way to show how the firm can achieve costs savings due to global production sharing. The next section analyses in detail the variables that affect the determinants of global production sharing, more precisely the parameters of equation 3.1.6.

3.2 Factors affecting global production sharing

3.2.1 Technology

Technological advancements that allow for finer slicing of the production chain can help amplify global production sharing. To analyse this for instance assume that the capital intensive good G_1, due to technological advancement, can be further broken into two sub-goods. Where one is relatively capital intensive (call it $G_{1,1}$) and the other is labour intensive (call it $G_{1,2}$). Then the firm will allow for further fragmentation of the production process if it finds it cheaper do so. In the following diagram, it is clear that it is cost saving to have labour intensive $G_{1,2}$ component made in country B where it labour costs are cheaper, while producing capital intensive $G_{1,1}$ in home country where it is cheaper to produce capital intensive goods.

Figure 3.2.1, gives the diagrammatic exposition of the process. MC G1, black line, is the original cost of producing inG_1 country A. MC G_{1ft} is the final marginal cost of producing

G_1 in two countries and assembling them together. Equation 3.2.1 reflects the fact that $G_{1,2}$and$G_{1,1}$need to transported to the same location and assembled together, and that this process incurs some costs.

$$MC\ G_{1ft} > MC\ G_{1,1} + MC\ G_{1,2} \qquad (3.2.1)$$

Figure 3.2.1

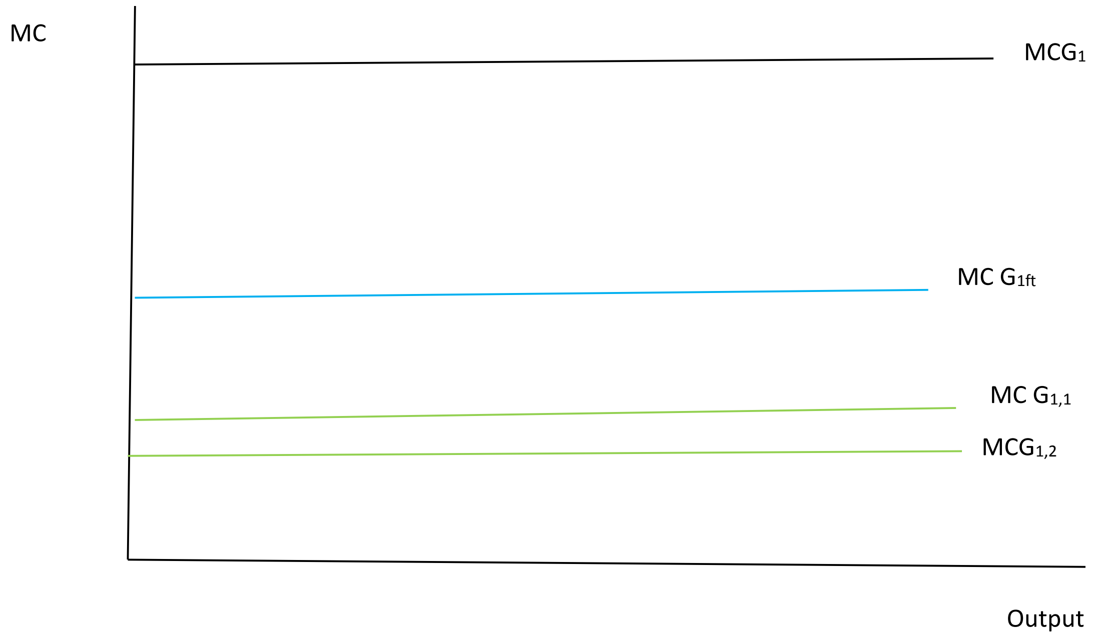


Figure 3.2.2, is analogous to figure 3.1.1 after further fragmentation of the production process. In this diagram we can see that the marginal cost of the Y is further reduced as MC_{ft} deceases due producing $G_{1,2}$ in a more cost effective manner in country B. The new marginal cost of producing good F_1 is now MC_{ft}' as opposed to MC_{ft}.

Figure 3.2.2

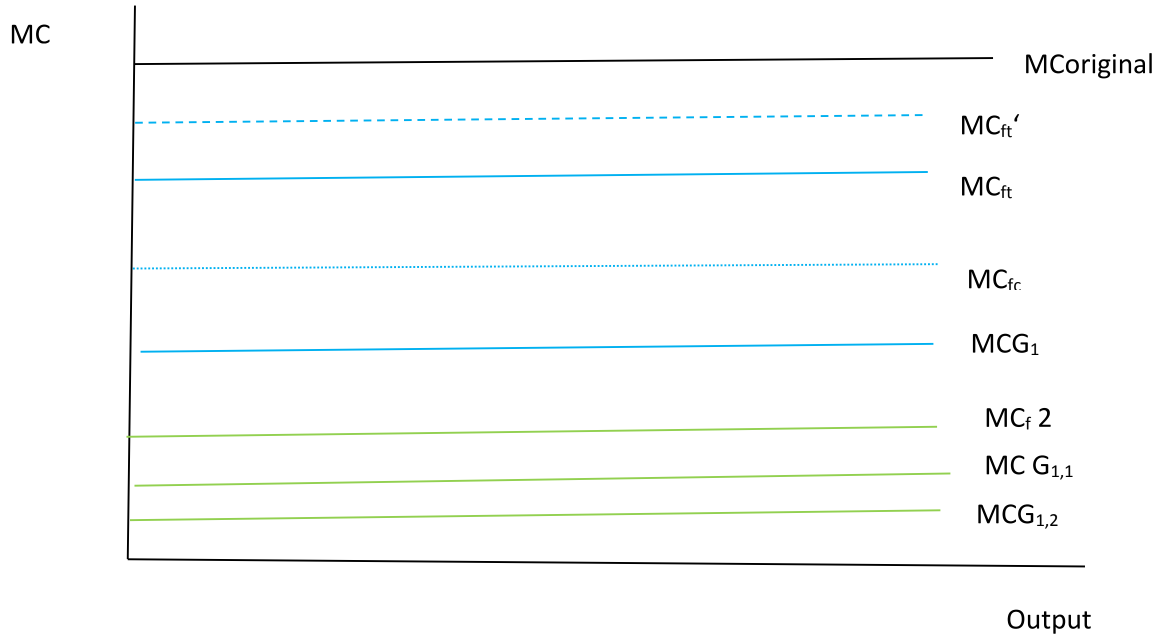


Figure 3.2.3

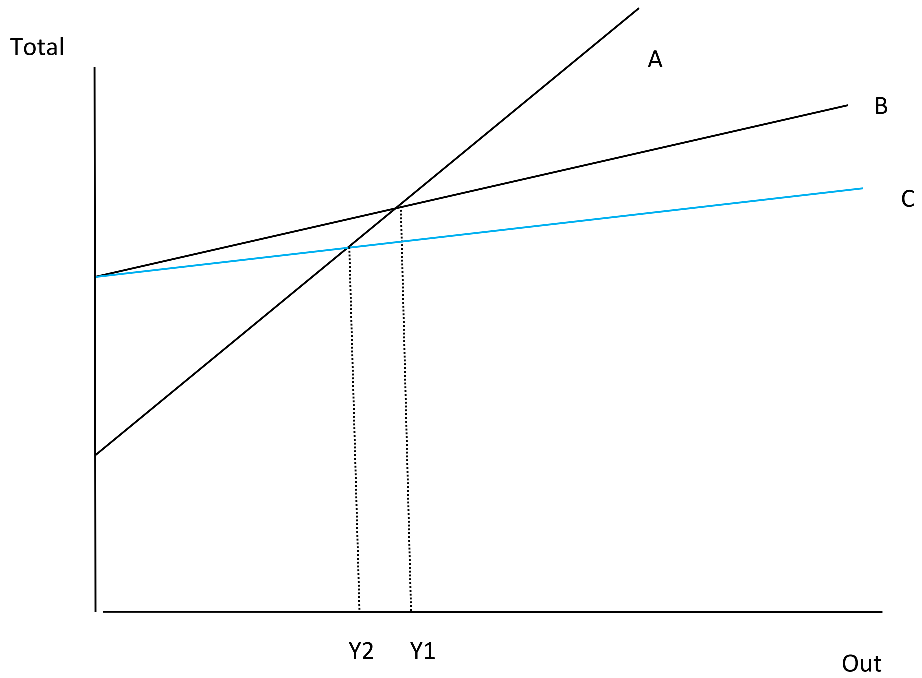


Figure 3.2.3 is the counter part of Figure 3.1.2. In this figure, line A and B are the same as they were in figure 3.1.2. However, line C represents cost reductions due to further fragmentation of the production of G_1. Flatter slope of line C represents lower marginal costs of producing good F, which have come about due to further fragmentation of the production of G_1 and having$G_{1,2}$produced in country produced in country B.

$Y2 < Y1$ (3.2.2)

Interesting thing to note is that the intersection of line A and C is at a much lower output level then intersection of line A and B. Therefore, it becomes feasible to fragment at a lower production level due to the technological advancement that allows the firm to break up G_1 into further sub components.

This diagram analysis shows that there can be increased trade between two or more nations due to technological innovations, even if GDP of each nation does not change. This divorce between home country's and destination country's GDP means that we will need to augment the standard gravity model with a relevant variable for technology.

It should also be noted that advancements in technology is likely to reduce transport costs, which will further augment global production sharing. Given this, any model designed to capture global production sharing must include a variable on technology.

3.2.2 Infrastructure, transportation costs and tax regimes

Better infrastructure can lower transportation costs which are a crucial factor for global production sharing. Furthermore, technological advances in services link sectors (like transportation and communication) andfriendly tax regimes can also lower the costs of production. All of these factors can curtail marginal costs associated with global production sharing. Diagrammatically, this will mean that as the marginal cost declines, slope of line b in figure 3.1.2 will become flatter.

Figure 3.2.4

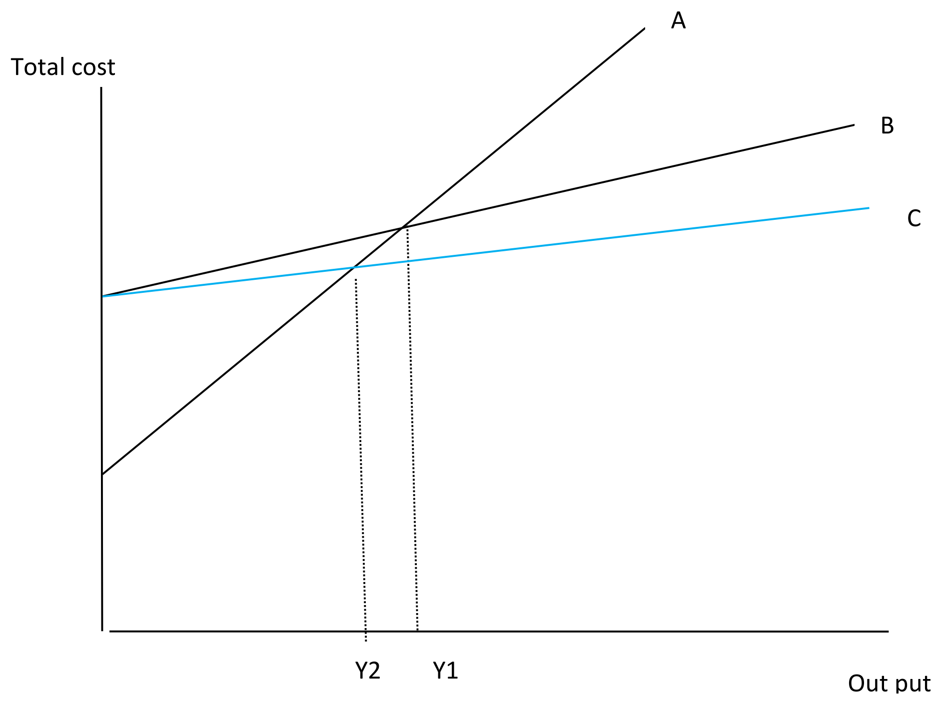
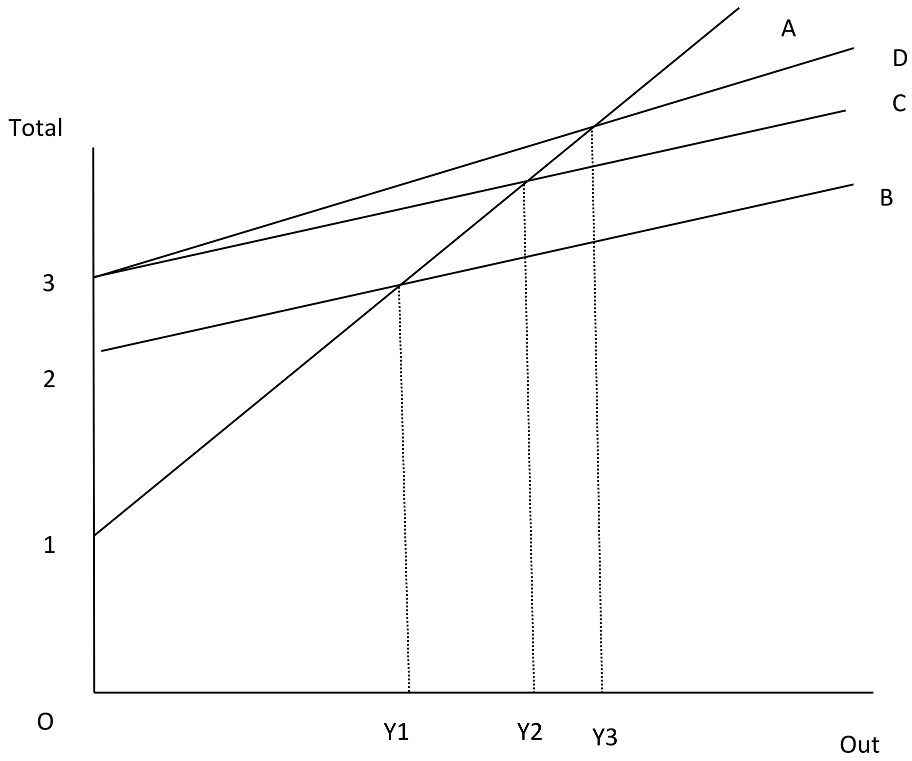


Figure 3.2.4, redraws figure 3.1.2. The only difference is line C, which is flatter than line B because now better infrastructure, lower service linkages costs and more business friendly tax regime helps to lower marginal costs of production under global production sharing. And we can see that under this regime, global production sharing becomes feasible at a lower level of output Y2 compared to Y1. Based on this, countries that have better infrastructure, cheaper service linkage costs and more friendly tax regimes are likely to capture a higher share of global production sharing.

3.2.3 Institutions

Institutions can make a significant impact on production fragmentation outcomes. For instance, corruption can increase fixed and marginal costs of production. Let's assume that corruption increases fixed costs (paying officials to buy land, get company registered etc). In figure 3.2.5, line A and B are the same as in figure 3.1.2. Corruption can increase setup costs, as mentioned before. This can be shown by a rise in the intercept from o2 to o3. As a result, line C and A intersects at a higher output level, y2. This means that firms producing between Y1 and Y2 will not be able to take advantage of lower labour costs in country B and will not fragment their production process.

Figure 3.2.5



If in addition lack of appropriate institutions also increases marginal costs, then slope of the total cost line will also increase to a line like D. In this case, there will be even fewer firms undertaking global production sharing in country B. This is evident from the fact that firms whose output level is between Y1 and Y3 will not want to setup supply chains in country B. In this case, if the firm has not already sunk costs in country B, then it may choose to locate in a different, more feasible country. We will return to this topic when we talk about competition among countries to capture value added of global production sharing.

Another channel for institutions to work is that weak institutions and bad governance can make investments more risky. Hence making the respective country less likely to get vertical FDI, which drives global production sharing. This can be modelled by building in extra costs in the total cost function. The costs can come in the form of extra costs for security, or lost output due to closed days or lost property due to unrest.

3.2.4 Macroeconomic stability

Macroeconomic stability will be quite important for a firm in deciding whether to invest part of its production chain in a given country. Say for example, a firm is deciding whether to set up a production plant in country B to produce G2 (rest of the set up is as defined before). Furthermore, country B may not have a stable macroeconomic environment, i.e fluctuating exchange rate, high or unstable inflation rate. Due to this marginal cost of producing G2 in country B may vary, which in turn would make the total marginal cost under global production sharing vary – say between a high and low scenario.

Under unstable macroeconomic conditions, the firm may decide not to invest in country B. To see why, assume under global production sharing, the firm faces two cost scenarios if it invests in country B. High cost scenario, if country B does not have macroeconomic stable conditions and a low cost scenario if country B has stable macroeconomic conditions. Under high cost scenario assume the firm has a total cost schedule given by line b in figure 3.2.6, and under low cost scenario its total cost schedule given by line c. Following equations give the total cost lines under the high and low cost scenarios, respectively. Under the assumptions of equations(3.2.3) and (3.2.4) fixed costs remain the same for different scenarios, but marginal costs increase (equation 13).

$TC_h = a + b_h y$ (3.2.3)

$TC_l = a + b_l y$ (3.2.4)

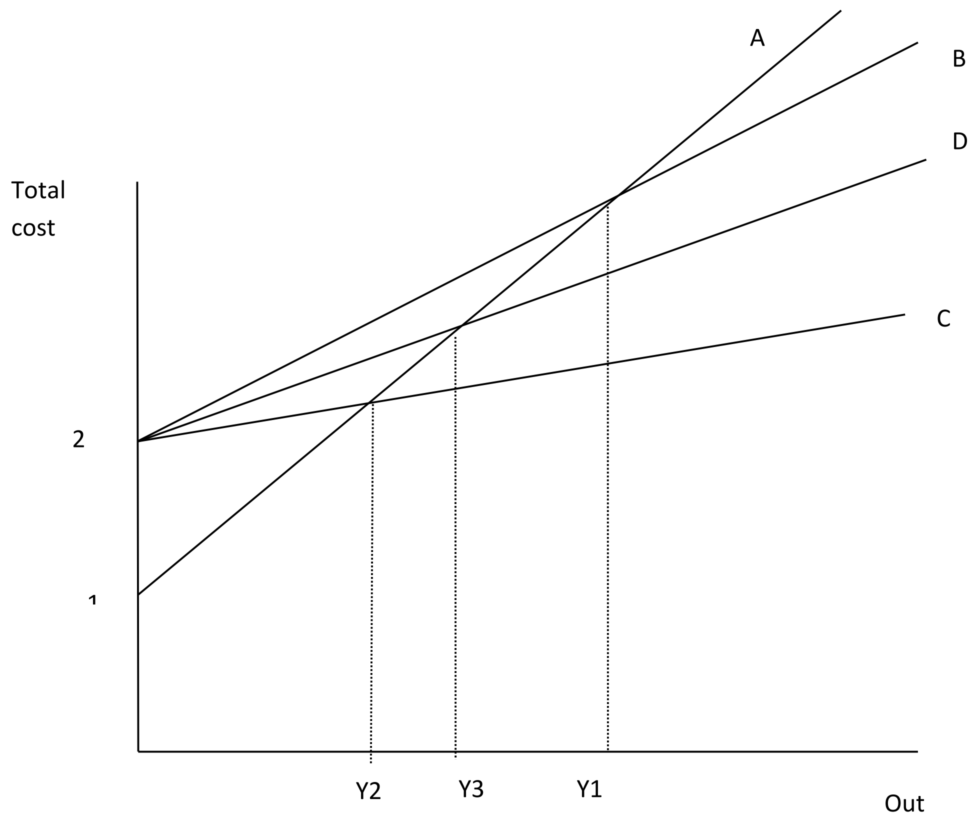
$b_h > b_l$ (3.2.5)

Further assume that both high cost and low cost scenarios are equally likely. Then given this the expected cost schedule is given by line d. Taking expectations, and attaching equal probabilities, the expected total cost schedule is given by equation 3.2.6.

$TC_e = a + 0.5(b_h + b_l)y$ (3.2.6)

In this case, if the firm expects output to be between Y2 and Y3 then it may decide not to invest in country B, and hence the global production sharing may not be undertaken by the firm, or the firm may decide to invest in a country with more sound macroeconomic fundamentals than Country B, as part of its global production sharing process.

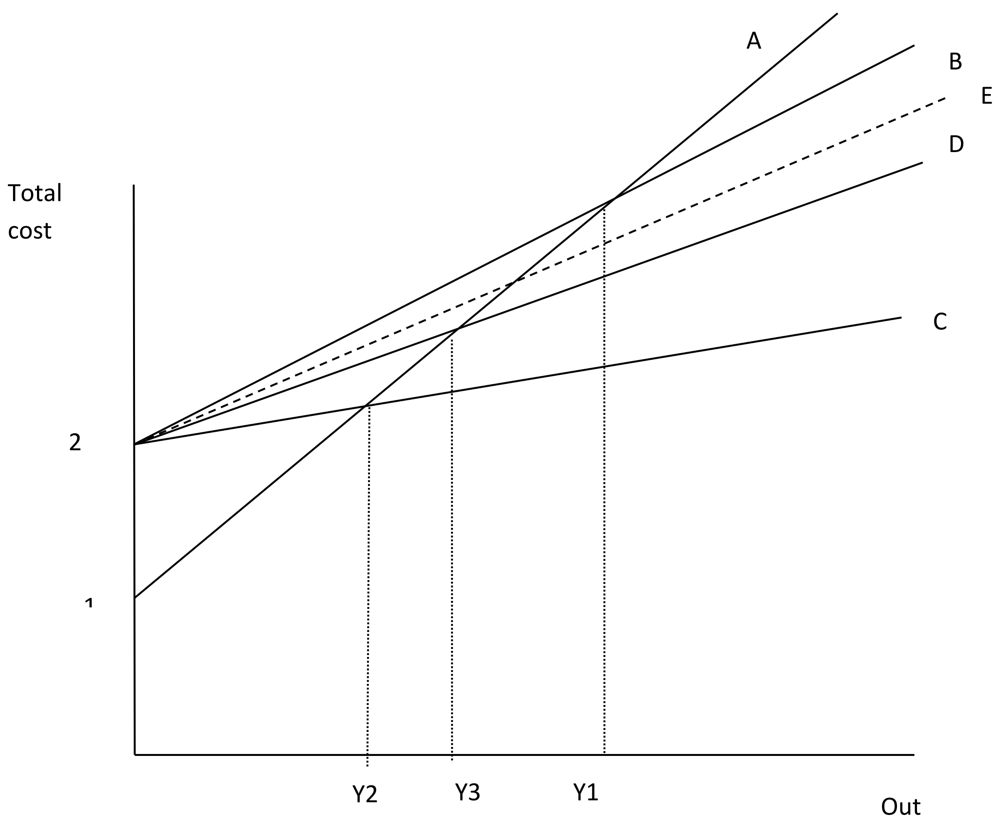
Figure 3.2.6



In addition, if volatility incurs extra cost for the firm, say in terms of menu costs, higher transaction and adjustment costs or costs in terms keeping extra cash to compensate for uncertainty then the excepted costs under global production sharing will be higher. Equation 3.2.7 gives the total costs under uncertainty, where d is the extra marginal cost incurred due to uncertainty. The dashed lined shows the expected total costs line under extra costs due to uncertainty.

$$TC_e = a + 0.5(b_h + b_l)y + dy \qquad (3.2.7)$$

Figure 3.2.7



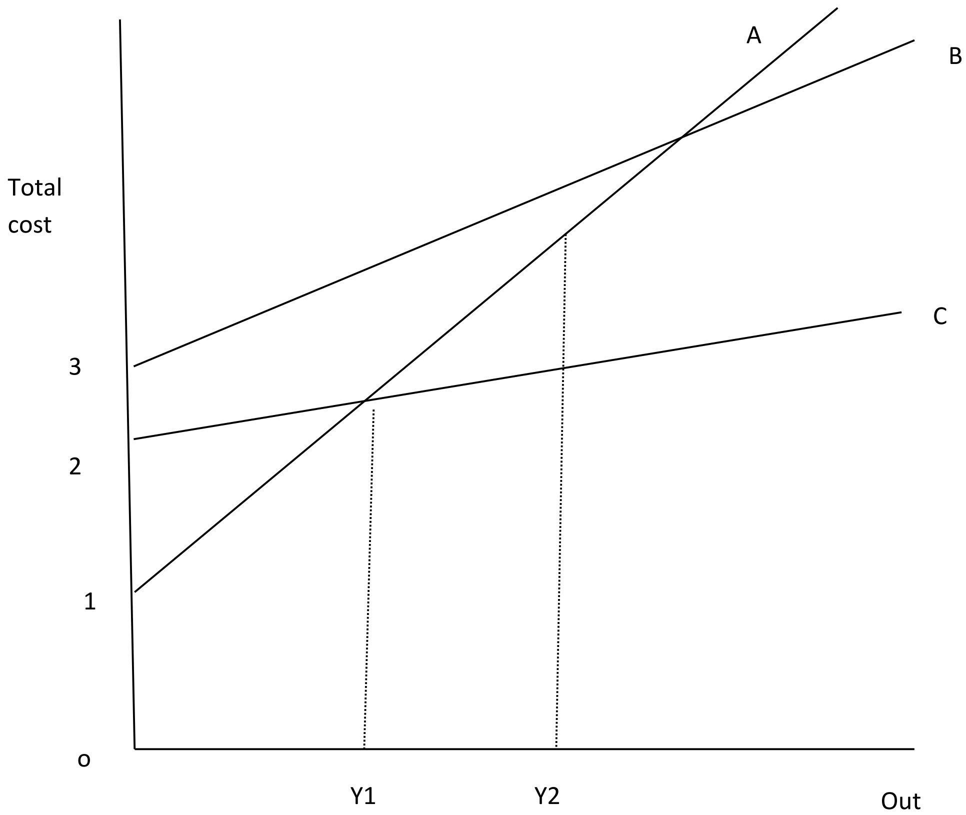
3.2.5 Policy Implications

Above results show that countries which exhibit over all good economic environments should be able to capture a bigger share of global production sharing and attract companies to invest in their economies. For instance, countries that have friendly tax regimes, better institutions, stable macroeconomic policies and better infrastructure will be more attractive destinations for global production sharing.

Figure 3.2.8 explains this point. Line A would be the cost schedule for a firm if it decides to have all the goods produced in home country. Line B would be the cost schedule for the firm if it decides to undertake global production sharing and invest in a country where fixed set up costs are high and marginal costs are high due to high tax regimes, bad institutions, unstable macroeconomic policies and lack of appropriate infrastructure. At the same time, if the firm invests in a more business friendly economy, called country C, then the cost schedule is given by line C.

Given these cost schedules, if the firms expected output level is beyond Y1 (like Y2), then the firm would prefer global production sharing and choose to invest in country C instead of country B. Indeed, for any level beyond Y1 level of output, the firm would find it feasible to invest in country C and undertake global production sharing. This shows that countries that have better business environment will be able to capture more global production sharing. (Nunn, 2007)

Figure 3.2.8



4 Determinants of Trade Patterns: Preliminary results

As discussed is section 3, variables such as technology, infrastructure, institutions and macroeconomic stability play an important role in determining global production sharing. As such, econometric models looking into global production sharing need to be augmented with these variables otherwise the model may suffer from omitted variable bias.

This paper adds to the growing literature on global production sharing. The value added of this paper are two folds: 1) we look at the impact of macroeconomic variables like technology, institutions and macroeconomic stability – these variables have so far been ignored in the literature on global production sharing and are likely to be a major contribution; and 2) we further develop the approach used by Baldwin and Taglioni (2011) to find relevant economic mass variables that should be used in the gravity model for global production sharing.

The rest of this section is organized as following: Section 4.1 develops the econometric model, section 4.2 looks into the specification of variables, sections 4.3 presents the estimation strategy.

4.1 Econometric model

This section develops the model used to look at the determinants of global production sharing. The basis of this paper's model starts with the standard gravity equation, and builds on previous studies which have used this framework to examine determinants of global production sharing based trade (Athukorala and Menon, 2010, Athukorala and Yamashita, 2009, Athukorala and Yamashita, 2006, Baldwin and Taglioni, 2011, Hanson et al., 2005). We augment the standard gravity model using the following econometric model. The variables in the equation 4.1.1 are explained in table in 4.1 and section 4.2 explains the specification of the variables.

$$lnExp_{ijt} = \alpha + \beta_1 lnSBV_{it} + \beta_2 lnDBV_{jt} + \beta_3 lnRER_{ijt} + \beta_4 SDinfrate_{it} + \beta_5 lnDistw_{ijt} + \beta_6 lns_{it} + \beta_7 lnTech_t + \beta_8 lnLPI_{ijt} + \phi' Loc_{ij} + \eta_c + \eta_t + \epsilon_{ijt} \quad (4.1.1)$$

The subscript i indexes home country, while subscript j indexes partner country and the subscript t indexes years. Furthermore, the letter "l" in equation 4.1.1 represents natural log of the relevant variable. Natural log is taken to give an elasticity type interpretation to coefficients, and they are also used to linearize variable like trade and real GDPs.

Equation 4.1.1 is run separately both for manufacturing and parts and components exports to gauge the difference between final goods and network trade in manufacturing. This paper argues that in the presence of global production sharing, an econometric models for network trade and manufacturing final goods trade should be estimated separately. Otherwise, if network trade and manufacturing final goods trade is aggregated then the models will be miss-specified.

Table 4.1

LnExp	Exports (Ex) between country i and j at time t
SBV_i	Country i supply base variable
DBV_j	Country j demand base variable
RER	Real exchange rate
SDinfrate	Standard deviation of home country's inflation rate
Distw	Population weighted distance
Ins	Institutional quality
Tech	Technology captured by patent application
LPI	Logistic performance index
LOC	Vector of geography and culture based variables
η_c	Country fixed effect
η_t	Time fixed effect
ϵ	Error term
β_K(K=1 to 8)	Relevant coefficients of the explanatory variables.
ϕ	Vector of coefficients for geography and culture based variables.
α	Constant term

4.2 Specification of variables.

This section explains the specification of equation 4.1.1 and sets out the various versions of equation 4.1.1 that will be important for our analysis. Setting out the various versions of equation 4.1.1 will help explain the estimation techniques in section 4.3.

Equation 4.1.1 is an augmentation of the standard gravity model. In standard gravity models, demand base of partner country and supply base of home country are captured by real GDP. The standard economic reasoning is that as income of partner country –as measured by real GDP – increases then it will consume more of all normal goods including imported goods, while the home country's real GDP is a good measure of what the home country can produce. This version of equation 4.1.1 is shown below.

$$\ln Exp_{ijt} = \alpha + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln RER_{ijt} + \beta_4 SDinfrate_{it} + \beta_5 \ln Distw_{ijt} + \beta_6 Ins_{it} + \beta_7 \ln Tech_t + \beta_8 \ln LPI_{ijt} + \phi' Loc_{ij} + \eta_c + \eta_t + \epsilon_{ijt} \qquad (4.2.1)$$

GDP_i	Country i's real GDP
GDP_j	Country j's real GDP
	Remaining variables same as equation 4.1.1

Baldwin and Taglioni (2011) argue that with global production sharing often demand of parts and components is being generated by the third country where final good will be consumed. As such, they argue that GDP's of home and partner country will have diminished explanation power in the presence of global production sharing. They suggest that manufacturing value added and import from other countries of parts and components should be used to augment the gravity model. In the presence of global production sharing, they show that home country's manufacturing value added along with imported parts and components is a more appropriate measure of supply base for the home country, while partner country's manufacturing value added plus import of network trade from other countries is an appropriate measure of demand base. Baldwin and Talgoni's version of equation 4.1.1 is shown below.

$$\ln Exp_{ijt} = \alpha + \beta_1 \ln MVA\_IPC_{it} + \beta_2 \ln MVA\_IPC_{jt} + \beta_3 \ln RER_{ijt} + \beta_4 SDinfrate_{it} + \beta_5 \ln Distw_{ijt} + \beta_6 Ins_{it} + \beta_7 \ln Tech_t + \beta_8 \ln LPI_{ijt} + \phi' Loc_{ij} + \eta_c + \eta_t + \epsilon_{ijt} \qquad (4.2.2)$$

MVA_IPC_i	Country i'smanufacturing value added in real terms plus gross value of imported parts and components in real terms from the rest of the world
MVA_IPC_j	Country j's manufacturing value added in real terms plus gross value of imported parts and components in real terms from the rest of the world (excluding imports of parts and components from country i. This ensures that this left hand side variable does not include the bilateral flow to be explained on the right hand side).

	Remaining variables same as equation 4.1.1

This paper uses home country manufacturing value added and partner country manufacturing value added to captures the supply and demand base variables for global production sharing respectively. This measure is conceptually more appropriate because Baldwin and Taglioni measure sums value added figure of manufacturing with gross sales value of imported parts and components. Moreover, the amount of parts and components a country imports for further processing is likely to be highly correlated with its manufacturing valued added. We also use the Baldwin and Taglioni measure along with the standard home country and partner country real GDPs to check for robustness in our regression.

$$lnExp_{ijt} = \alpha + \beta_1 lnMVA_{it} + \beta_2 lnMVA_{jt} + \beta_3 lnRER_{ijt} + \beta_4 SDinfrate_{it} + \beta_5 lnDistw_{ijt} + \beta_6 Ins_{it} + \beta_7 lnTech_t + \beta_8 lnLPI_{ijt} + \phi' Loc_{ij} + \eta_c + \eta_t + \epsilon_{ijt} \qquad (4.2.3)$$

MVA_i	Country i'smanufacturing value added in real terms.
MVA_j	Country j's manufacturing value addedin real terms.
	Remaining variables same as equation 4.1.1

For the manufacturing final goods trade, it can be argued that home country manufacturing value added is a more appropriate measure for manufacturing supply base then home country's real GDP. While partner country's real GDP is still considered a good proxy for demand for imports. As such, we use these measures to capture supply base and demand base for manufactured final goods for home and partner country respectively, this version of equation 4.1 is shown in equation 4.2.4. For a robustness check, this paper also runs a separate regression using the standard home country and partner country real GDPs. This equation is similar to equation 4.2.1, except that the dependent variable is exports of final goods in manufacturing.

$$\ln Exp_{ijt} = \alpha + \beta_1 \ln MVA_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln RER_{ijt} + \beta_4 SDinfrate_{it} + \beta_5 \ln Distw_{ijt} + \beta_6 Ins_{it} + \beta_7 \ln Tech_t + \beta_8 \ln LPI_{ijt} + \phi' Loc_{ij} + \eta_c + \eta_t + \epsilon_{ijt} \qquad (4.2.4)$$

MVA_i	Country i's manufacturing value added in real terms.
GDPj	Country j's real GDP
	Remaining variables same as equation 4.1.1

Population weighted distance is used as a proxy for transport cost and other associated time lags. As network trade involves multiple border crossings, we can hypothesize that global production sharing exports are likely to be more sensitive to transport costs than final goods manufacturing exports.

Infrastructure is another important variable in our regression. In section 3.2.2 we saw that infrastructure improvement can augment global production sharing by reducing transport cots. Moreover, in recent year, this variable has received increased importance in trade regressions (Athukorala, 2011, Athukorala and Menon, 2010, Athukorala and Yamashita, 2009, Athukorala and Nasir, 2012). Given this, this paper incorporates Logistic performance indicator (LPI) into its econometric modelling. LPI is an index that measures trade related infrastructure of the relevant country.

To look at the sensitivity of trade to macroeconomic stability we include variables like real exchange rate (RER) and standard deviation of home country inflation rate. Section 3.2.4 explained how a macroeconomic instability is likely to reduce the feasibility of global production sharing. Given this, we can hypothesize that trade in part and components will be more sensitive to a high standard deviation in inflation rate.

In addition, we look at the impact of institutions on global production sharing. We expect institutions to play a significant role in global production sharing by providing a more conducive environment to doing business. This is primarily because most of trade in global production sharing is dominated by MNEs, who would prefer to invest in a more stable environment.

Furthermore, weak institutions will lead to higher corruption which is likely to directly increase the cost of doing business. Section 3.2.4 showed how corruption and other associated costs can discourage global production sharing in particular and business in general. Improvement in institutions is also likely to make the whole production process more efficient. Based on this, we would expect that improvement in institutions is likely to support increased exports in both network and final goods trade in manufacturing.

In section 3.2.1 we saw that advancement in technology can both enable the production process to be sliced into smaller sections and reduce transport costs. Both of these processes will augment global production sharing. This is especially true for developing countries. However, for developed countries improvements in technology exerts two opposing forces. Improvement in technology reduces transport costs so it allows more trade, but improvement in technology also allows manufacturing industries to be offshored from developed countries. As such, for complete sample it is unclear whether the technology variable will have a positive or a negative sign. To capture this effect, we include a technology variable in our regression, where patent application is used as a proxy for innovation.

We also include standard geographic and cultural variables in our gravity model to capture how geographic and cultural characteristics of a country affects its trade patterns in both final goods and global production sharing.

4.3 Estimation.

We follow the growing literature of using Hausman-Taylor (hence forth HT) approach in estimating the gravity model (Athukorala and Nasir, 2012, Egger, 2004, Serlenga and Shin, 2007). There are several advantages of using HT[2] approach over a cross sectional OLS type approach for equation 4.1.1. These are as following:

[2]There is reverse causality from exports to economic mass variables which has largely been ignored in the literature. Often a pretext used to ignore the reverse causality is that individual bilateral trade is a very small part of GDP, as such the reverse causality is not very big. This paper checks for robustness of results by explicitly taking into account this reverse causality. We follow the growth literature that estimates the flip side of trade and GDP relationship SERLENGA, L. & SHIN, Y. 2007. Gravity models of intra-EU trade: application of the CCEP-HT estimation in heterogeneous panels with unobserved common time-specific factors. *Journal of applied econometrics,* 22**,** 361-381. In particular, we lag economic mass variables where our identification assumption is that current trade value cannot impact

i) There may be time-invariant country specific effects not accounted for in our regression that are correlated with the independent variables. HT approach allows us to remove this endogeneity by using internal instrument approach (see appendix 1B for further discussion); and

ii) Using a panel data approach allows us to capture the relationship between relevant variables over a longer period of time, thus allowing us to identify the role of the overall business cycles over this period. Given that global financial crises (GFC) and the Asian financial crises (AFC) happened over the time frame of our data set, accounting for business cycles will be particularly important for regressions of this paper.

We follow the standard practice of allowing for economic mass variables and RTA to be endogenous in our HT approach (Athukorala and Nasir, 2012, Serlenga and Shin, 2007) . In addition, it can be argued that additional variables used such as investment and institutions can also be endogenous to time-invariant country specific effects. As such, we allow for these variables to be endogenous as well.

Since we are interested in estimating the impact of time constant variables like distance as a proxy for transport costs and standard deviation of inflation rate as poxy for macroeconomic stability, running Fixed Effects will not be helpful as this removes time-invariant variables from our regression.

5 Data and samples

5.1 data

Data gathered is a panel data set for 44 countries covering the period 1996-2012. All countries which account for 0.01% of total parts and component exports are included in the country list. The data set contains 30854 observations. A list of the countries is given in the appendix on data.

This paper follows (Athukorala and Menon, 1994, Athukorala, 2011, Athukorala and Yamashita, 2006, Yeats, 1998, Athukorala and Nasir, 2012) in using UN trade data base to

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appropriately lagged past values GDP and manufacturing value added. These results are produced in the appendix 1c table 2 and show that our main results are still robust after accounting for reverse causality.

delineate trade in parts and components from the final goods. Parts and components are delineated from the trade data using a list compiled by UN Broad Economic Classification (BEC). This list uses Harmonize System (HS) of trade classification at the six digit level of UN trade data. In addition, World Trade Organization (WTO) Information Technology data at firm level is used to augment the BEC data. While the prices data used to deflate the trade data is taken from Bureau of Labour Statistics (BLS).

Data on GDP, manufacturing value added, LPI, investment, patent application, inflation and exchange rate is take from World Development Indicator (WDI)[3]. To look at the impact of institutions on trade and global production sharing we use the variable from World Governance Indicators (WGI) on corruption. The values for WGI are missing for 1997, 1999, 2001 and 2012. Given that institutions don't change rapidly, we have used previous year's values to fill these gaps.

We consider two samples for our regressions. One is the comprehensive sample that includes all countries and has 30854 observations. The second data set looks at developing countries only as home countries and has about 14414 observations. A list of countries classified as developing is given in the appendix.

6 Results

This section summarizes the main results. Table 6.2 and table 6.3 present the results based on this paper's preferred economic mass variable specification and Balwin and Talgoni's economic mass variable specification respectively. Our preferred results are given in table 6.2, while table 6.3 is a robustness test. Table 6.1 explains the abbreviations for the variables. As mentioned before, we use two samples, sample 1 is the complete sample and sample 2 is for developing countries.

Manufacturing value added for home county and partner country carries the apriori sign for all of our regressions and is statistically significant at one per cent level. Moreover, manufacturing value added both as a supply base variable and demand base variable lies in

[3]Data for manufacturing is missing for some of the countries for initial years.

the range of previous studies for both final goods manufacturing exports and parts and components exports.

More specifically, for parts and components, a one per cent increase in manufacturing value added of home country increases parts and components exports by 1.40 per cent for the complete sample. For developing countries, a 1 per cent increase in manufacturing value added in home country implies a 1.14 per cent increase in parts and components exports.

The elasticity of partner country manufacturing value added is also statistically significant at one per cent level and in the range of previous studies for parts and components. In particular, for the complete sample, a one per cent increase in partner country manufacturing value added implies 1.17 per cent increase for parts and components exports. While for developing country, a one per cent increase in manufacturing value added for partner country implies a 1.44 per cent increase in parts and components exports for the home country.

Our estimates for manufacturing value added for the final good manufacturing regression are also statically significant, carry the a prioi signs and the elasticities are in line with the previous studies. A one per cent increase in manufacturing value added for home country increases final goods manufacturing exports by 1.07 percent and 0.85 per cent for all countries and developing countries respectively.

While our estimates for demand base variable, real GDP, for final good manufacturing are also statistically significant and carry the a priori sign. In particular, a one percent increase in real GDP for partner country increases final goods manufacturing exports by 1.67 per cent and 1.85 per cent for all countries and developing countries respectively. The results of this paper economic mass variables, are comparable with Baldwin and Talgnoi measures in table 6.3.

For our preferred specification, the institution variable is significant at 10 per cent level in all of the parts and components regressions and is consistent with the theory developed in section 3. Ceteris paribus, a one unit increase in institution index increase parts and components exports by approximately 12 per cent for all the countries, while a similar increase in institutions increase parts and components by 47 per cent for developing countries. These are by no means unreasonable estimates. Given that the World Governance Indicators lies between -2.5 and 2.5, a one unit increase in our corruption index signifies a substantial improvement in governance. Given this, as theorized before, institutions play a significant role in determining network trade. The coefficient remains significant if we use Baldwin and Talgnoi specification for developing countries, however institutions become insignificant if we use the complete sample. This may be due to multicollinearity between the variables.

Based on our results, the institutions variables is only significant for developing countries for final goods manufacturing trade. A one unit increase in institution index increase final goods exports by approximately 9 per cent. The fact that institutions play a bigger role for network trade compared to final goods trade goes at the heart of global production sharing which is dominated by MNE's and can be hypothesized to be more sensitive to governance variables.

As hypothesized, technology plays a significant role in global production sharing and manufacturing for developing countries. A one per cent increase in patent applications for developing countries increases exports by 0.22 per cent and 0.16 per cent respectively for parts and components and manufacturing good. Improvements in technology have a stronger impact on parts and components trade than on manufacturing trade. This is in line with our theory that predicts that technological growth will lead to finer slices of production process causing an increase in global production sharing.

Another reason why technology plays a more significant role in network trade is that improvement in technology will reduce transport and communication costs which are central to service link costs (Jones and Kierzkowski, 1990).

For our complete sample, as mentioned before technology imposes two opposing forces on exports. As technology improves, trade barriers diminish and this makes exports increase overall. However, at the same time, technology helps to make offshoring feasible. This decreases exports of manufacturing goods from developed countries. As a result we can see that our technology variable is not significant at the 95 per cent level, and even has the negative sign for manufacturing final goods trade for the final sample.

The coefficient on standard deviation of domestic inflation rate is consistently negative and significant at one per cent level. Ceteris paribus, a one unit increase in standard deviation of inflation decreases parts and components exports by approximately 8 per cent for all the countries, for both developing and developed countries. In addition, a one unit increase in standard deviation of inflation decreases manufacturing final goods exports by approximately 4 per cent for complete sample and by 6 per cent for developing countries. These results remain robust even if we use Baldwin and Talgnoi specification.

RER is statistically significant in all the regressions. Where a 10 per cent appreciation in RER increases parts and components exports by 0.2 per cent and 1.0 per cent for all countries and developing countries respectively. For final manufacturing goods exports, a 10 per cent increase in RER increases exports by 0.3 per cent and 0.9 per cent for all countries and developing countries respectively.

The variable on RTA is highly significant for both parts and components and manufacturing final goods exports. This shows that trade agreements can play a big role in increasing trade. In particular, RTA is likely to increase parts and components trade by 33 for manufacturing final goods and 28 per cent for parts and components exports for our complete sample.

The variable on distance is highly significant and negative in all of our regressions. This shows that transport costs play an important role in trade flow for both manufacturing final good and parts and components exports.

Similar to previous studies, our results for other geographic and infrastructure variables are comparable to previous studies on manufacturing and parts and components trade (Athukorala, 2005, Athukorala and Nasir, 2012).

Table 6.1

lhmva	Log of home country manufacturing value added
lpmva	Log of partner country manufacturing value added
lhmvaim	Log of home country based on Balwind and Talgoni measure
lpmvaim	Log of home country based on Balwind and Talgoni measure
h_ins_corr	Institutions variable based on corruption
totalpa	Technology captured by patent application
LPI	Logistic performance index
LOC	Vector of geography and culture based variables
l	Letter 'l' before a variable signifies natural log
p and h	Letter p before a variable signifies partner country and letter h signifies home country.

Table 6.2

VARIABLES	(1) Sample1 PC	(2) Sample1 MNF	(3) Sample2 PC	(4) Sample2 MNF
ltotalpa	0.03*	-0.01	0.22***	0.16***
	(1.92)	(-1.09)	(7.04)	(9.48)
lrer	0.02***	0.03***	0.10***	0.09***
	(3.96)	(8.94)	(7.57)	(12.33)
l_h_lpi	1.09***	0.40***	1.67***	0.29
	(5.04)	(3.11)	(5.09)	(1.58)
lhmva	1.40***	1.07***	1.14***	0.85***
	(38.99)	(49.11)	(16.54)	(21.90)
lpmva	1.17***		1.44***	
	(29.73)		(20.82)	
rta	0.33***	0.29***	0.28***	0.35***
	(7.47)	(11.59)	(3.50)	(7.73)
h_ins_corr	0.12***	0.00	0.47***	0.09***
	(3.60)	(0.08)	(7.86)	(2.84)
sdinfrate	-0.08***	-0.04***	-0.08***	-0.06***
	(-5.16)	(-3.68)	(-4.19)	(-4.62)
colony	-0.48	-0.65*	-0.60	-1.36**
	(-1.00)	(-1.77)	(-0.66)	(-2.11)
ldistw	-1.19***	-1.00***	-1.83***	-1.99***
	(-12.40)	(-13.63)	(-8.41)	(-12.49)
contig	-0.34	-0.11	-1.12	-1.19**
	(-0.80)	(-0.33)	(-1.46)	(-2.01)
comlang_ethno	1.28***	0.97***	1.12***	0.67**
	(4.78)	(4.75)	(2.91)	(2.34)
lr_p_gdp		1.67***		1.85***
		(45.82)		(32.01)
Constant	-36.96***	-42.98***	-33.87***	-34.91***
	(-24.06)	(-33.42)	(-11.53)	(-16.03)
Observations	18,073	22,285	8,223	10,715
Number of pairid	1,709	1,803	811	857

z-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Sample 1 is the complete sample and sample 2 is for developing countries

Table 6.3

	(1)	(2)
VARIABLES	Sample1 PC	Sample2 PC
ltotalpa	0.06***	0.13***
	(5.13)	(4.46)
lrer	0.02***	0.09***
	(4.64)	(7.37)
l_h_lpi	1.58***	2.80***
	(8.38)	(9.66)
lhmvaim	1.46***	1.37***
	(52.86)	(22.81)
lpmvaim	1.44***	1.65***
	(31.03)	(20.05)
rta	0.31***	0.43***
	(8.04)	(5.80)
h_ins_corr	0.01	0.19***
	(0.17)	(3.40)
sdinfrate	-0.06***	-0.07***
	(-5.77)	(-5.32)
colony	-0.32	-0.76
	(-0.95)	(-1.21)
ldistw	-1.19***	-1.83***
	(-17.19)	(-11.50)
contig	-0.33	-0.90
	(-1.06)	(-1.57)
comlang_ethno	0.57***	0.48*
	(3.02)	(1.72)
Constant	-49.73***	-49.53***
	(-32.07)	(-17.54)
Observations	21,221	9,754
Number of pairid	1,800	854

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Sample 1 is the complete sample and sample 2 is for developing countries.

Table 1 in appendix 1c accounts for reverse casualty by lagging our economic mass variables. The identification assumption is that trade may impact current and future economic mass variables through technology diffusions and spill over effects, but it will not change previous year’s economic mass variables. The results shown in this table demonstrate that our mains results are still robust.

Table 2 in appendix 1c gives the results with standard real GDP as economic mass variables for comparison. All the coefficients are similar to those in tables 6.2 and 6.3 except for our technology variable for parts and components in the complete sample, which has the counter intuitive sign. This may be because, as explained before, GDP is a biased estimator of demand and supply shifters. As such economic mass variable are miss specified in these regressions and this may be a cause for bias in the coefficients.

7 Conclusion

Global production sharing has seen an increasing importance in international trade. This paper has added to the growing literature on this subject by exploring the implications of macroeconomic variables such technology, institutions, investment and macroeconomic stability on global production sharing.

It was also argued in this paper that manufacturing value added for home and partner country should be used as supply base and demand base variables respectively. This work builds on Baldwin and Taglioni (2011) who argue that for global production sharing, GDP is a biased estimator for economic mass variables in a gravity model framework.

Based on the results of this paper, there is significant evidence that technological improvement plays a substantial role in augmenting network trade. Given this, as technological innovation continues we would expect a further proliferation of global production sharing. This reflects the fact that technological advancements will further enable the production process to be sliced up into smaller sections and allocated across the world based on comparative advantage

This paper also found that institutions play a significant role in determining both manufacturing final goods and network trade. This fact shows that institutional reforms in countries can significantly augment a country's export performance. However, we found that once institutions and other important variables were accounted for, results on macroeconomic stability and investment were not robust and were sensitive to sample size and specification of the model.

This paper also confirmed previous results that transport costs played a significant role in determining bilateral trade flows. This paper found that transport costs were always highly significant and robust to different speciation. RTA was also shown to be a significant determinant in bilateral trade flows for both global productions sharing and manufacturing final goods exports. Given this, it can be argued that reducing trade related costs by reducing transport costs or signing trade agreements can augment bilateral trade flows between countries.

Appendix 1 A Data

Full data set Country name	Developing countries Country name
Argentina	Argentina
Australia	Bangladesh
Bangladesh	Brazil
Belgium	China
Brazil	Costa Rica
Canada	China, Hong Kong SAR
China	Indonesia
China, Hong Kong SAR	India
Costa Rica	Israel
Czech Rep.	Rep. of Korea
Denmark	Sri Lanka
Finland	Mexico
France	Malaysia
Germany	Pakistan
Hungary	Philippines
India	Russian Federation
Indonesia	Singapore
Ireland	Thailand
Israel	Turkey
Italy	Viet Nam
Japan	South Africa
Malaysia	
Mexico	
Netherlands	
Norway	
Pakistan	
Philippines	
Poland	
Portugal	
Rep. of Korea	
Russian Federation	
Singapore	
Slovakia	
Slovenia	
South Africa	
Spain	
Sri Lanka	
Sweden	
Switzerland	
Thailand	
Turkey	
United Kingdom	
USA	
Viet Nam	

Appendix 1 B Hausman Taylor (HT).

HT regression distinguishes between endogenous and exogenous variables. The individual effect model is written as follows:

$$Y_{ijt}= \alpha + X'_{i1t}\beta_1 + X'_{i2t}\beta_2 + Z_{i1}'\beta_3 + Z_{i1}'\beta_3 + \eta_i + \epsilon_{ijt}$$

Where X variables denote time variant variables and Z variables denote time invariant variables. Furthermore this approach assumes the following:

$E(Z_{i1}, \eta i) = 0$ and $E(X'_{i1t}, \eta i) = 0$ but Z_{i2} and $X'_{i2t}$are assumed to be correlated with η_i. HT is based on Random Effect type transformation as follows:

$$Y_{ijt}= \alpha + \tilde{X}'_{i1t}\beta_1 + \tilde{X}'_{i2t}\beta_2 + \tilde{Z}_{i1}'\beta_3 + \tilde{Z}_{i2}'\beta_3 + \tilde{\eta}_i + \tilde{\epsilon}_{ijt}$$

Where $\tilde{X}_{i1t} = \tilde{X}_{i1t} - \gamma\bar{X}_{i1}$ .This transformation ensures that time invariant variables are not dropped. Now to deal with the correlation between $\tilde{X}_{i2t}$ and $\tilde{Z}_{i2}$ with $\tilde{\eta}_{i}$.To deal with this,HT approach uses IVs. For $\tilde{X}_{i2t}$ instrument used is$\ddot{X}_{i2t}= X_{i2t}-\bar{X}_{2i}$, for $\tilde{Z}_2$ the instrument usedis$\bar{X}_{i1}$. The variable uses $\ddot{X}_{i1t}$ as an instrument for $\tilde{X}_{i1t}$andZ_{i1} as an instrument for $\tilde{Z}_{i1}$(Cameron, 2005, Cameron and Trivedi, 2009, Hausman and Taylor, 1981).

Appendix 1 C Data

Table 1

VARIABLES	(1) Sample1 PC	(2) Sample2 PC
ltotalpa	0.02	0.20***
	(1.33)	(6.25)
lrer	0.02***	0.09***
	(3.13)	(7.20)
l_h_lpi	1.10***	1.85***
	(5.43)	(5.88)
L.lhmva	1.37***	1.17***
	(38.77)	(16.84)
L.lpmva	1.12***	1.35***
	(28.95)	(19.56)
rta	0.28***	0.25***
	(6.22)	(3.06)
h_ins_corr	0.20***	0.51***
	(5.72)	(8.49)
sdinfrate	-0.07***	-0.08***
	(-4.60)	(-4.61)
colony	-0.55	-0.59
	(-1.20)	(-0.70)
ldistw	-1.20***	-1.91***
	(-13.08)	(-9.84)
contig	-0.28	-1.13
	(-0.69)	(-1.57)
comlang_ethno	1.25***	1.04***
	(4.88)	(2.85)
Constant	-35.00***	-32.08***
	(-23.41)	(-11.62)
Observations	17,977	8,206
Number of pairid	1,711	813

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2

VARIABLES	(1) Sample1 PC	(2) Sample1 MNF	(3) Sample2 PC	(4) Sample2 MNF
ltotalpa	-0.12***	-0.14***	0.16***	0.06***
	(-9.68)	(-17.36)	(5.54)	(3.74)
lrer	0.02***	0.03***	0.09***	0.07***
	(3.87)	(9.40)	(8.13)	(11.40)
l_h_lpi	1.36***	0.61***	1.62***	0.48***
	(7.73)	(5.30)	(5.78)	(2.72)
lr_p_gdp	1.66***	1.58***	1.74***	1.75***
	(34.99)	(50.56)	(19.97)	(32.60)
lr_h_gdp	1.85***	1.53***	1.57***	1.36***
	(43.47)	(53.38)	(19.00)	(24.80)
rta	0.25***	0.23***	0.25***	0.23***
	(7.16)	(10.19)	(3.91)	(5.77)
h_ins_corr	0.13***	-0.01	0.56***	0.08***
	(4.85)	(-0.37)	(11.56)	(2.92)
sdinfrate	-0.06***	-0.03***	-0.10***	-0.08***
	(-4.79)	(-3.30)	(-6.87)	(-7.27)
colony	-0.85**	-0.71***	-0.97	-1.02*
	(-2.28)	(-2.59)	(-1.45)	(-1.94)
ldistw	-1.14***	-0.96***	-1.85***	-1.79***
	(-15.23)	(-17.57)	(-11.09)	(-13.95)
contig	-0.59*	-0.19	-0.74	-0.90*
	(-1.70)	(-0.76)	(-1.22)	(-1.90)
comlang_ethno	0.74***	0.73***	0.52*	0.46**
	(3.62)	(4.80)	(1.78)	(2.04)
Constant	-66.42***	-54.26***	-56.79***	-48.11***
	(-37.45)	(-45.43)	(-17.52)	(-21.95)
Observations	25,580	26,730	11,136	12,144
Number of pairid	1,886	1,889	897	900

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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