Essays on Trade and Development

Omer Majeed

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Declaration

I certify that this is my original work except where otherwise acknowledged in the text.

Chapter 3, “Global Production Sharing: Exploring Australia’s Competitive Edge” is a joint paper with Professor Prema-chandra Athukorala and Dr. Tala Talgaswatta. My contribution in this paper is 30 percent.

Chapter 4, “Inequality or poverty: Which is Bad for Growth?” is a joint paper with Professor Robert Breunig. My contribution in this paper is 60 percent.

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Omer Majeed

May 2016

I dedicate my thesis to the poor and the underprivileged of this world. I hope to serve them my entire life.

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"Ignorance is the curse of God; knowledge is the wing wherewith we fly to heaven,"

– William Shakespeare.

The last four years have been a period of intense learning for me, not only in economics but also on a personal level. I would like to reflect on those that have supported and helped me so much throughout this period.

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Abstract

The thesis consists of four core essays which focus on important issues relating to international trade, growth and inequality. The first essay examines the determinants of trade based on global production sharing (network trade) by building a theoretical framework and empirically testing it using a panel dataset covering 44 countries over the period 1996 to 2013. Over the past four decades, network trade has grown at a much faster rate than total world manufacturing trade. Identification of the determinants of this emerging trade pattern is, therefore, important for informing trade policy debates. The model used in the empirical analysis captures a number of important explanatory variables ignored in the previous literature. A range of panel data estimation techniques are used in the model. The results suggest that technology, institutions and macroeconomic stability all play a significant role in determining inter-country differences in network trade. The paper concludes with a discussion on the challenges for policy makers in their attempt to reap gains from global production sharing.

The second essay studies the transmission of exchange rate changes into import prices (exchange rate pass-through) in the presence of global production sharing. The chapter builds and simulates a model, which postulates that exchange rate pass-through is lower for network trade compared to final goods trade. It is hypothesised that trade in parts and components, within network trade, is relatively sheltered from exchange rate movements because network trade is largely ‘relationship-specific,' including intra-firm trade. Empirically, exchange rate pass-through is examined using a new dataset of manufacturing import prices compiled from the trade price database of the US Bureau of Labour Statistics. The findings indicate that the degree of exchange rate pass-through into the import prices of parts and components is considerably lower than that for import prices of final goods. These results are robust to a number of sensitivity tests.

The third essay examines patterns and determinants of global production sharing with an emphasis on how Australian manufacturing fits into global production sharing. Though Australia is a minor player in global production sharing, there is evidence that Australian manufacturing has a distinct competitive edge in specialised, skill-intensive tasks in several industries including aircraft, medical devices, machine tools, measuring and scientific equipment and photographic equipment. Specialisation within global

production sharing in high-value-to-weight components and final goods, which are suitable for air transport, helps Australian manufacturing to overcome the 'tyranny of distance' in world trade. Being predominantly 'relationship-specific', Australian network trade exports are not significantly susceptible to real exchange rate appreciation. Institutions and technological base also give Australia a competitive edge within global production sharing.

The last essay examines the impact of inequality and poverty on economic growth. Recent research has highlighted a negative impact of inequality on economic growth. The paper re-evaluates this hypothesis, focusing on both inequality and poverty and their interaction. The econometric model controls for standard growth covariates including education, investment, trade, population growth and redistribution. The paper initially replicates previous results, showing that inequality has a negative impact on growth. However, it is shown that after taking into account both inequality and poverty, the negative effect of inequality on growth appears to be concentrated amongst countries with high poverty. This finding makes a case for policies targeted towards alleviating poverty, rather than policies that redistribute without addressing absolute poverty.

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List of Tables[1]

[1] Tables and figures in appendices are not included.

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Acronyms

AIC	Akaike's Information Criterion
BEC	UN Broad Economic Classification
BLS	US Bureau of Labour Statistics
BT	Baldwin and Taglioni
CI	Communication infrastructure
CPI	Consumer Price Index
DBV	Demand base variable
DST	Distance
EAD	East Asia dummy
ERPT	Exchange rate pass-through
FDI	Foreign direct investment
FE	Fixed effect
FF	US Federal Funds rate
FPE	Final prediction error
FTA	Free trade agreement
GDP	Gross domestic product
GDPPC	Gross domestic product per capita
GFC	Global financial crisis
GLPS	Global production sharing
GMM	Generalized methods of moments
GPN	Global production networks
HC	High composition of network trade
HT	Hausman Taylor estimation
Ins	Institutional quality
IOT	Input-Output tables

LC	Low composition of network trade
LOC	Vector of geography and culture based variables
LPI	Logistic performance index
LPI	Logistic performance indicators
LR	Likelihood ratio
MC	Medium composition of network trade
MNEs	Multinational Enterprises
MVA	Manufacturing value added
OECD	The Organisation for Economic Co-operation and Development
PC	Parts and components
PPI	Producer Price Index
PPP	Purchasing power parity
RCA	Revealed comparative advantage
RCE	Random correlated effect
RE	Random effect
RER	Real exchange rate
ROO	Rules of origin
RPGDP	Relative per capita GDP
RTA	Regional trade agreements
SBV	Supply base variable
SC	Schwarz criterion
SDinfrate	Standard deviation of home country's inflation rate
SITC	Standard International Trade Classification
SWIID	Standardized World Income Inequality Database
Tech	Technology captured by patent application
UN	United Nations
VAR	Vector autoregression

VECM	Vector error correction model
WDI	World Development Indicators
WTO	Word Trade Organization

Chapter 1
Introduction

Context

This thesis studies the subjects of global production sharing, exchange rate pass-through, inequality and economic growth. Each of these fields of study have important policy implications. Research insights from the fields mentioned above are frequently translated into hypotheses that can be tested and policy recommendations that can be applied to countries for improving welfare and increasing economic growth. In addition, recent research on topics related to global production sharing and inequality have generated renewed economic discussions. This thesis contributes new data and empirical methods that have a close link to theory and relevance to policy. I also develop a theoretical model for analysing exchange rate pass-through in the presence of global production sharing.

The thesis consists of five chapters. After this introductory chapter, Chapter two deals with the determinants of global production sharing, with an emphasis on institutional quality, technology and macroeconomic stability. The paper builds on the Jones and Kierzkowski (1990) theory of 'service links'. This is followed by extensive empirical investigation based on a dataset of 44 countries, covering the period 1996 to 2013. All countries which individually account for at least 0.01% of total world manufacturing exports are included. These countries account for over 98% of total world manufacturing exports.

There is no extensive examination in the literature of exchange rate pass-through (the responsiveness of import prices to exchange rate movements) in the presence of global production sharing. This is the topic for the third essay. Using a theoretical model and a novel, disaggregated dataset for the US, this paper studies both the parts and components trade and final assembly, within global production sharing. Empirically, exchange rate pass-through is examined by analysing various import price indices based on their share of parts and components trade for the US. This paper uses the US as a case study as it has the most disaggregated import price data available.

The purpose of the fourth chapter is to examine the implications of global production sharing for Australian manufacturing. This has important policy implications, as Australia is transitioning to a post-mining boom period. It is noteworthy that the significance of Australia's integrating into global production networks and the related policy issues have not been systematically explored. The paper undertakes an econometric study to examine the determinants of global production sharing and identifies parts and components categories where Australia has a comparative advantage.

The fifth chapter focuses on inequality, poverty and economic growth. The paper contributes to the literature by asking whether inequality and poverty jointly impact economic growth and examining the interaction between the two. We focus on extreme, absolute poverty as measured by two or three dollars per day income. Empirically, the paper asks two simple questions: is the negative relationship between income inequality and economic growth robust to the inclusion of poverty? And, is the relationship between inequality and economic growth related to the level of poverty?

The policy implications and important conclusions are given at the end of each respective chapter. The following sections give brief summaries of each chapter.

Global Production Sharing: Patterns and Determinants

There is evidence that trade based on global production sharing (that is, trade in parts and components and final assembly within global production networks, also referred to as 'network trade' or global production sharing) has grown at a much faster rate than total world manufacturing trade over the past four decades. This expansion (Yeats, 1998, Yi, 2003) has been enabled by rapid advancements in production technology, technological innovations in communication and transportation and improved speed and efficiency with which firms can coordinate across geographically dispersed production locations. Further, liberalisation and policy reforms in both home and host countries have considerably removed barriers to trade and investment. These factors have led to the fragmentation of production across international borders.

In this study, the determinants of global production sharing are examined by extending the Jones and Kierzkowski (1990) framework. In particular, variables that have helped proliferate global production sharing are analysed. As global production sharing becomes more prominent, its impacts on international trade, economic growth and integration of the world economy are likely to have important national and global policy implications.

On the empirical side, this study makes several contributions to the literature. Firstly, an extensive dataset of 44 countries engaged in global production sharing and covering 18 years (1996 to 2013) is constructed to undertake an in-depth analysis of global production sharing. Any country which has at least 0.01% share in total manufacturing is included in the data. Secondly, this paper examines important macroeconomic variables, which have so far been ignored in the literature such as regulatory institutions, macroeconomic stability, technology and stages of development. Thirdly, this paper improves on the specification of the economic mass variables (Baldwin and Taglioni, 2011) and tailors the economic mass variables to global production sharing in the gravity model framework. Lastly, I incorporate the Mundalk transformation/random correlated effect (RCE), in addition to using Hausman-Taylor (HT) estimation and random effects (RE), in the regressions to extensively test for robustness of the results. The focus in the empirical section is on trade in parts and components in global production sharing.

The results reported in the paper suggest that the average level of institutional quality, technology level in a country and macroeconomic stability play important roles in global production sharing. There is also evidence that global production sharing has a quadratic relationship with the stages of development. This partly reflects the fact that as economies develop, they transition out of manufacturing and into services, thereby reducing parts and components manufactured in their respective economies.

Exchange Rate Pass-Through for Manufacturing Imports in the Presence of Global Production Networks

This study examines exchange rate pass-through in the presence of global production sharing. There is likely to be heterogeneity in exchange rate pass-through between network trade and final goods trade. This partly reflects the fact that most of the trade in global production sharing is relationship specific, including intra-firm transactions (Chen et al., 2005, Bridgman, 2012, Helpman, 2011, Hummels et al., 2001). Given this, global production sharing is likely to be shielded from fluctuations in the exchange rate. This heterogeneity of exchange rate pass-through is expected to be more prominent for countries that have a high share of the network trade.

This paper adds to the literature in three novel ways. First, the study develops a model to examine the exchange rate pass-through in the presence of global production sharing. Secondly, this model is simulated with various scenarios to show that an increase in network trade does indeed cause exchange rate pass-through to be lower. Lastly, the paper empirically investigates the above-mentioned claim using a vector autoregression (VAR) methodology and a unique dataset created for the US. This paper uses the US as a case study because the US has the most disaggregated import price data available. The theoretical part of this paper looks at both parts and components trade and final assembly within global production sharing. However, the empirical side of the paper is limited to parts and components because price data is only available for products traded and not final assembly.

The theoretical model of this paper shows how exchange rate pass-through is lower under global production sharing. This result is further endorsed by simulating the model and by empirical analysis. Using impulse response functions from the VAR analysis, this study demonstrates that a one standard deviation shock (depreciation) in the exchange rate shows no statistically and economically significant impact on the import prices of goods with high composition of part and components trade, while goods with low composition of parts and components trade reveal an incomplete pass-through, with the impact lasting about 11 months.

Global Production Sharing: Exploring Australia's Competitive Edge

The purpose of this essay is to examine implications for Australian manufacturing of global production sharing. This is particularly important as Australia is transitioning to a post-mining boom period. It is important to note that the implications of the ongoing process of global production sharing and the related policy issues have not been systematically explored for Australia.

Australia is a small player in world manufacturing trade, accounting for around 0.28% of total manufacturing exports. However, the share of global production sharing products in total Australia manufacturing exports, increased from 0.22% to 0.25% between 1990/01 and 2012/13. This was underpinned by an increase in the share of parts and components, from 0.25% to 0.28%. Australia's share of total manufacturing exports to OECD countries increased from 0.35% to 0.54% between these years, with the share of global production sharing exports increasing from 0.27% to 0.36%. In terms of the relative importance of global production sharing products, Australia's export composition is similar to that of the OECD countries. One notable difference, which is relevant for the subsequent analysis in this paper, relates to parts and components exports. The share of parts and components in Australian exports has increased continuously, from 25.5% in 2005/06 to 27.2% in 2012/13, whereas in the OECD countries this share has declined from 31.1% to 25.4%.

Using trade data from the UN Comtrade, this essay identifies products where Australia has a comparative advantage within global production sharing and then undertakes an extensive econometric study to analyse Australia's strengths and weaknesses within global production sharing.

The results suggest that Australia seems to have a distinct competitive edge in parts and components specialisation in the following product categories: aircraft and associated equipment, internal-combustion machines, machine tools, miscellaneous machinery, taps and valves, computers, measuring equipment, machine parts, photographic equipment and electrical machinery. The results of the study also demonstrate that the 'tyranny of distance' is not a binding constraint on exporting specialised parts and components and some final assembly goods from Australia. The evidence also suggests that domestic technological capabilities are relatively more important, compared to the average global experience, in determining components exports from Australia. Further being predominantly relationship-specific, Australian exports of parts and components trade are not significantly susceptible to real exchange rate appreciation.

Inequality or Poverty: Which is Bad for Growth?

This paper studies an important link between inequality and economic growth. Recent research has re-focused attention on the impact of income inequality on economic growth. This paper analyses whether inequality and poverty jointly impact economic growth. The paper focuses on extreme, absolute poverty as measured by the proportion of people living below two or three dollars per day income. Inequality is measured using the Gini Coefficient from the Standardized World Income Inequality Database.

The paper asks two simple questions: is the negative relationship between income inequality and economic growth robust to the inclusion of poverty as an explanatory variable for economic growth? And, is the relationship between inequality and economic growth related to the level of poverty?

Economic growth regressions which control for average incomes and inequality may fail to capture the disadvantage of poverty that harms growth. By adding the percentage of people below the poverty line, the paper additionally controls for the concentration of disadvantage in the population. Theory suggests that poverty can relate to economic growth through health and human capital accumulation. These effects might be distinct from and in addition to the effects of low average incomes and inequality.

The paper finds that including poverty does matter. Specifically, results show that the negative impact of inequality on economic growth is related to the level of poverty. When poverty is low (less than 25% or so), the paper finds a statistically insignificant relationship between inequality and economic growth. For higher levels of poverty, inequality negatively impacts economic growth, and the magnitude of this negative effect increases as poverty rises. The policy implication is clear: promote growth by attacking poverty rather than by redistributing incomes.

Chapter 2
Global Production Sharing: Patterns and Determinants

1 Introduction

The rise of global production sharing has changed international trade in a substantial manner (Chen et al., 2005, Bridgman, 2012, Helpman, 2011, Hummels et al., 2001). Global production sharing can be defined as the splitting of the production process into discrete activities which are then located across countries to gain a cost advantage[2]. There is evidence that over the past four decades, trade based on global production sharing (that is trade in parts and components and final assembly within global production networks (GPN), also referred to as network trade) has grown at a much faster rate than total world manufacturing trade.

This rapid growth of global production sharing has been underpinned by three mutually reinforcing developments (Yeats, 1998, Yi, 2003, Bridgman, 2012, Helpman, 2011). First, rapid advancements in production technology have enabled industries to slice 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 the speed and efficiency with which firms can coordinate across geographically dispersed production locations. This has facilitated the establishment of 'services links' to combine various fragments of the production process in a timely and cost efficient manner. There is an important two-way link between the improvement in communication technology and the expansion of fragmentation-based specialisation within global industries. The latter results in the lowering of the cost of production and rapid market penetration of the final products through enhanced price competitiveness. In turn, scale economies resulting in market expansion encourage new

[2] Global production sharing is also known as network trade, global production networks, production fragmentation, parts and components trade, vertical specialization, production sharing, intra-product specialization and slicing up the value chain. These terms are used interchangeably

technological efforts, thus enabling further product fragmentation. This two-way link has set the stage for 'fragmentation trade' to increase more rapidly, compared to conventional commodity-based trade. Third, liberalisation policy reforms in both home and host countries have considerably removed barriers to trade and investment.

Trade in parts and components behaves differently to trade in final goods. For instance, variables that may play an important role in the standard trade analysis, such as home country's gross domestic product (GDP) and the exchange rate, may not be as relevant 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 include communication, transportation, information gathering and the cost of coordinating production activities across countries (Jones and Kierzkowski, 1990, Plümper and Troeger, 2007). Given this, modelling aggregate international trade flows without explicitly modelling network trade can be misleading. This is particularly important for countries with a high proportion of parts and components trade in their total share of trade.

As global production sharing becomes more prominent, its impact on international trade, economic growth and world's economic integration into the world economy is likely to have important national and global policy implications. Network trade opens up opportunities for countries to specialise in different segments (slices) of the value chain in line with their relative cost advantage. Developing countries get the opportunity to specialise in labour intensive segments. This leads to employment generation and hence poverty alleviation. Most of the trade within global production networks is relationship specific, and therefore takes the form of intra-firm transactions and trade based on contractual arrangements between the lead-MNEs and contract manufacturers (Hanson et al 2005, Surgeon 2002, Stergeon and Kawamami 2012). Given this, global production sharing is likely to have firm-level implications, such as cost reductions.

The contributions of this paper include theory, empirics and using a new dataset. On the theory side, the paper further extends Jones and Kierzkowski (1990) model to analyse how macroeconomic variables affect firms involved in global production sharing. While on the empirical side the paper uses new methodology including correlated random effects and incorporates macroeconomic variables, ignored so far by the literature, like technology and macroeconomics stability. The next two paragraphs further expand on these contributions.

In this paper, the determinants of global production sharing are studied by adopting the Jones and Kierzkowski (1990) framework to incorporate macroeconomic variables that are postulated to be important for global production sharing. In particular, variables including institutional quality, technology and macroeconomic stability are analysed.

On the empirical side, this paper makes several contributions to the literature. Firstly, an extensive dataset of 44 countries engaged in global production sharing and covering 18 years (1996 to 2013) is constructed to analyse global production sharing. All countries which individually account for at least 0.01% of total world manufacturing exports are included in the country list. Secondly, a number of relevant macroeconomic variables which have so far been ignored in the literature, including institutions, macroeconomic stability, technology and stage of development are incorporated in the empirical model. Thirdly, the specifications of the economic mass variables in the gravity model framework are carefully specified by taking into account the methodological issues raised by Baldwin and Taglioni (2011). Lastly, the Mundalk transformation/random correlated effect (RCE) is used, in addition to using Hausman-Taylor (HT) estimation and random effects (RE) to extensively test for the robustness of the results. The focus in the empirical section is on trade in parts and components, the most ubiquitous facet of global production sharing.

This paper finds that institutional quality and level of technology play important roles in determining network trade. Macroeconomic stability is also found to have a significant role in fostering global production sharing; this may reflect the fact that most of the trade in parts and components is dominated by multinationals which may be sensitive to the macroeconomic stability of the country. Lastly, there is evidence that global production sharing has a quadratic relationship with the stages of development. This partly reflects the fact that as economies develop, they transition out of manufacturing and into services, thereby reducing the parts and components manufactured in their economies.

The rest of the paper is organized as follows: Section 2 gives an overview of global production sharing, while Section 3 extends existing theories on global production sharing, Section 4 discusses data, Section 5 examines the patterns within global production sharing, Section 6 discusses the estimation methodology used to analyse the determinants of global production sharing, Section 7 gives empirical results and Section 8 concludes.

2 Literature Review

Global production sharing is not a new phenomenon. Network trade has been an important process dating back to the industrial revolution (Athukorala, 2014). Its importance in world trade has been highlighted since the early 1970's. 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 now significantly higher compared to historical standards (Yeats 2001).

Over the past four decades, 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 headquarter may be in the US and involved in headquarter functions such as R&D, service linkages and coordination, while parts and components are produced in countries like South Korea, Taiwan and Malaysia before being shipped off to China for final assembly. The following examples illustrate the process of global production sharing. Linden et al. (2009) analyse the production of the iPod by the US-based firm Apple. According to the industrial organisation of Apple, the product design and software development are done in the US, while hard drive, display module, mainboard PCB and memory are produced in countries like Japan and Taiwan and final assembly takes place in China (Linden et al 2007 & 2009).

Another example of global production sharing is the Barbie doll (Tempest, 1996). Plastic and the hair for the doll are acquired from Taiwan and Japan, China provides cotton cloth for the dresses, while molds and paint come from the US and assembly is in Indonesia, Malaysia and China. Most of this trade is relationship specific.

Given this, the 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 given country) needs to be altered to take account of global production sharing, especially as the share of trade in parts and components has become significant.

Factors including the proliferation of globalisation, reductions in transport and communication costs, trade liberalisation and advancements in technology, have promoted global production sharing and its importance in international trade. For instance, trade in parts and components has grown at a faster rate than trade in final goods (Yeats, 1998). Between 1970 and 1990, increases in exports associated with global production sharing accounted for one-third of world economic growth (Yi, 2003). This process has expanded to include a wide range of products including automobiles, televisions, smart phones, sports and footwear items, sewing machines, cameras, office equipment, watches, etc. (Athukorala, 2011). The impact of global production sharing on different industries has varied. Industries that trade in high value-to-weight goods and ones where technologically it is feasible to slice up the production process, have been better able to take advantage of global production sharing.

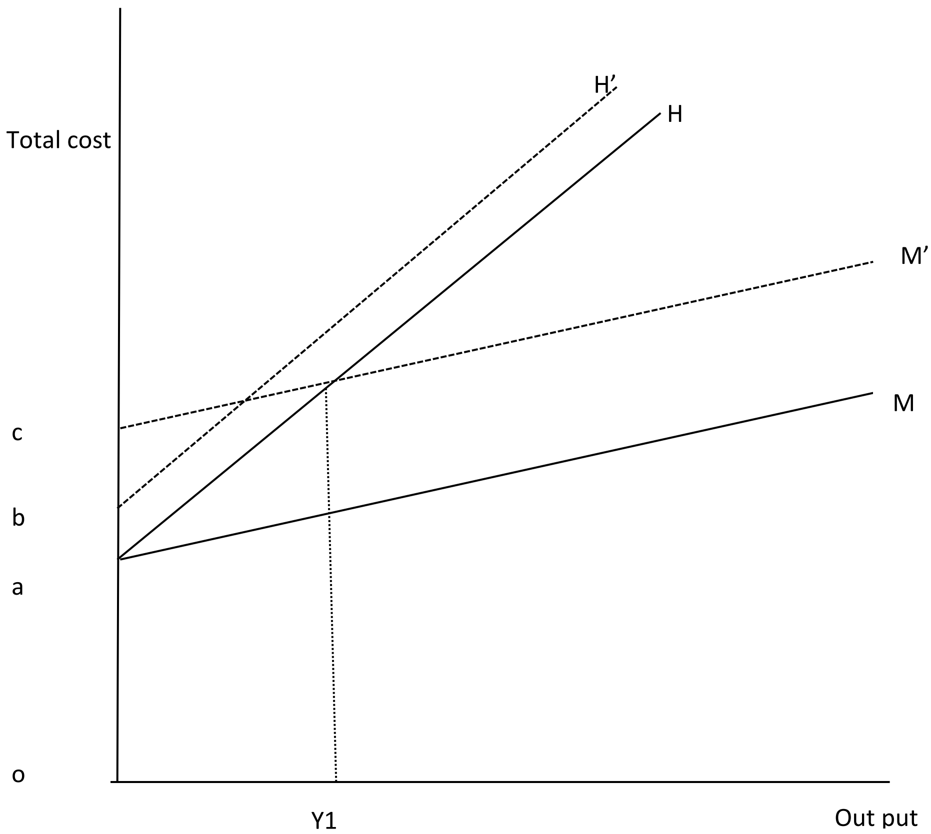
The role of service linkage costs, for connecting the various production units located across countries, play an important part in global production sharing (Jones and Kierzkowski, 1990). As these service linkage costs decline, due to reductions in transport and communications costs, technological breakthroughs and trade liberalisation, production fragmentation would further endorse global production sharing. In the Jones and Kierszkowski's model scale economy is achieved by increasing production, while the service link costs remain fixed.

In addition, global production networks have expanded throughout the world. US, Canada and Mexican firms have strong connections in the parts and components trade. It is estimated that around $250 million dollars worth of parts and components are traded through the Ambassador Bridge that connects Detriot (US) with Windsor (Canada) alone (Hanson et al., 2005). In addition, the East Asia regional share in total network exports increased from 22.0 % in 1992/93 to 45.7% in 2005/06 (Athukorala, 2011). There are also increased linkages in production networks amongst European countries. In contrast to this, regions such as South Asia and Africa have not seen a strong presence of global production sharing. Given this, global production sharing's impact has varied between industries and regions.

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. Arndt (1997) looks at the impact of global production sharing on employment and wages. He uses the neoclassical trade theory to decipher the impact of vertical specialisation on wages and employment. One problem with his framework is that it does not explicitly include the costs of linking the various stages of production like transportation, communication, trade and transaction costs. Feenstra and Hanson (1995) and (1997), build a model with a continuum of inputs over the unit interval to analyse global production sharing. However, their model also does not address fixed costs and sunk costs that are pertinent for setting up multiple production plants across several countries (Jones and Kierzkowski, 1990, Jones and Kierzkowski, 2001).

Jones and Kierzkowski (1990) focus on the role of services link costs in determining global production sharing. Their paper describes how increasing output levels, increasing returns to scale and the advantages of specialisation of factors within a firm can lead to a fragmented production process. They further postulate that trade liberalisation and declines in the cost of transportation and communications have enhanced production fragmentation by reducing service link cost. Jones and Kierzkowski (1990) use the following diagram to explain their main ideas about global production sharing.

Figure 2.1 Fragmented Production Process and Service Link Costs



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 across two or more locations, then it will incur service link costs. As mentioned before, service link activities - and their associated costs – involve communication, transportation, information gathering and the cost of coordinating production activities. Line H' shows the added costs of service links when the production blocks are in the same country.

Line M shows lower marginal costs by undertaking global production sharing and cost savings 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 link costs can be shown to be increasing with output by showing steeper H' and M' lines. Furthermore, increased setup costs for the global production sharing process can be shown by increasing the intercept of the line M to a higher point than 'a'. Given this, total costs under global production sharing are given by the line M', while the line H shows total costs in the absence of global production sharing. Using this diagram, it is clear that if output is higher than Y1, then even with higher service link costs, it would be profitable for the firm to fragment their production process, leading to an increase in the parts and components trade.

2.1 Industrial Organization Model

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

- 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 best when the products or services to be exchanged are standardised. However, the problem with this type of exchange is that firms that need specialised goods and services are not able to get highly customised products and services. This problem is overcome 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 known 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 transaction costs for writing up contracts – for example, time involved in writing contracts and legal fees – especially when the nature of the product is complex and there is a high degree of customization required (Baye and Beil, 2006). In addition, transaction costs at arm's length can cause hold ups and often contracts are not complete - they can miss important contingencies which can lead to complications.

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

3 Analytical Framework

In this section, the Jones and Kierzkowski (1990) model is extended to analyse global production sharing. Variables that explicitly determine service link cost in Jones and Kirezkowski methodology and other important variables that determine network trade are included. These variables include technological changes that allow for finer slicing of production sharing, institutions, infrastructure, stages of development and the macroeconomic stability of the economy.

3.1 Determinants of Global Production Sharing

An efficient global production process can be created if each slice of the production process is located to match the factor intensity of components to the factor abundance of countries. To analyse this phenomenon and its determinants, this study begins by looking at the production process of a firm.

The case analysed in this section has 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 (called country A) and a foreign country (called country B); or more succinctly a case of 1*2*2 (one final good, two factors of production and two countries). The home country A is capital intensive, and the 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 G2 and combine them using final assembly. Final assembly is assumed to be labour intensive. It is also assumed that G1 and G2 are used in a fixed ratio to produce F1, hence the production function is assumed to exhibit a Leontief production process. The marginal costs of producing G1, G2 and final assembly are assumed to be constant – i.e. constant returns to scale. However, service links are assumed to exhibit increasing returns to scale. These assumptions should not affect the results, but rather they make the analysis more straightforward.

Initially, suppose that both G1 and G2 are produced in the home country A. Total marginal cost for producing F1 at the home country A is given by 'MC original'. Assume now that the firm relocates the labour intensive component to foreign country B, and keeps the production of the capital intensive component in home country A. Furthermore, assume that relocating the production of components yields cost savings. In the new production process, the capital intensive good is produced in the capital abundant country (where capital is cheaper) while labour intensive good is produced in the labour intensive country (where labour is cheaper).

The marginal costs of each subcomponent under global production sharing are given by MC_{f1} and MC_{f2}. The total marginal cost of producing both components is given by MC_{fr}, which is the summation of $MC_{f1} + MC_{f2}$.

$$MC_{fr}, = MC_{f1} + MC_{f2}.$$

The final marginal cost of the good, under fragmentation, is given by MC_{ft}. MC_{ft} includes MC_{f1}, MC_{f2} and service linkage costs including transportation, coordination and communication costs. Thus yielding $MCfr<MC_{ft}$ (Equation 3.1.1). It can also reflect

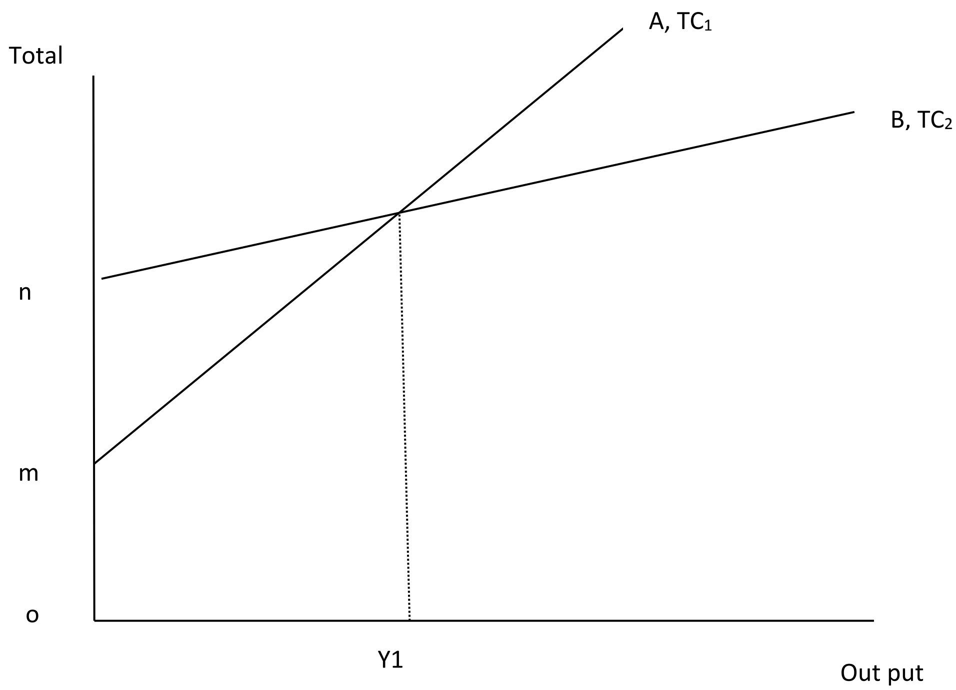
assembly cost, but for simplicity at this stage we assume that assembly costs are negligible compared to other costs. By locating the labour intensive component to the labour abundant country and the capital intensive component to the capital abundant country, global production sharing can yield cost savings, Equation (3.1.2).

$$MC_{fr} < MC_{ft} \quad (3.1.1)$$

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

However, it should 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 analyse total costs.

Figure 3.1 Fragmented Production Process and Necessary Conditions



The figure above extends the Jones and Kierzkowski (1990) diagram and is similar to Figure 2.1. Line A, TC_1 in Figure 3.1 is the same as H in Figure 2.1 and line B, TC_2 in Figure 3.1 is the same as M' in figure 2.1. Therefore in the figure above, it is assumed that line B includes service linkage costs. In figure 3.1, output level beyond y1 makes it feasible for the firm to relocate its production process to obtain cost savings, Equation 3.1.3 (where Y* denotes the actual production level of the firm). To summarise, 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. The higher intercept for the line B reflects the fact that having more production block incurs higher fixed costs, as more production plants need to be built and thus, there are higher service link costs. The flatter slope of line B, compared to line A, is based on lower marginal costs due to allocating good G_2 to a country where it is cheaper to produce it. The capital intensive component G_1 is still produced in country A, where capital is cheaper.

It would be helpful to draw similarities between Figure 3.1 and Equations 3.1.4 and 3.1.5. Marginal cost, $MC_{original}$, when production is located only in the home country is given by the slope of line A, TC_1 in Figure 3.1. Similarly, total marginal cost under global production sharing is given by MC_{ft} in Figure 3.1, which is equivalent to the slope of line B in Figure 3.1.

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 a single country and fragmented production process across two countries, respectively. Variable b is the marginal cost when production is undertaken in only one block, while d is the marginal cost of global production sharing involving two countries. These results can be generalised 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 (3.1.6) 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[3] that a firm can achieve by relocating production of some goods overseas and the lower the fixed costs of setting of production plants in a foreign country, the more profitable it is to engage in global production sharing.

So far 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 another way, F1 requires a fixed ratio between G1, G2 and final assembly, while G1 and G2 themselves can be made by various combinations of capital and labour bundles. Equation 3.1.7 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 isocost lines. The coefficients of G1 and G2 give the marginal cost of producing G1 and G2. The coefficients embody the capital and labour costs in producing G1 and G2, respectively. While 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, initially assume the firm is producing only in the home country. Furthermore, assume that the firm wants to produce a given level of output for the final product - call that level Y*, given by the isoquant, IQY*, in the Figure (3.2). Given the level of the output, the firm wants to minimise its costs. Say it does that by incurring a cost of TC*, given by the isocost line c1 in the Figure (3.2).

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

[3] Marginal costs and fixed costs can both include service links costs over here.

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 isocost line pivots and the horizontal intercept shifts to the new point given by x2. Now the isocost line is given by c2. In order to produce the same level of output, the firm moves to a lower isocost line (a 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 the distance Y1-Y2 in the Figure 3.1.7.

Where intercepts are given by the following:

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

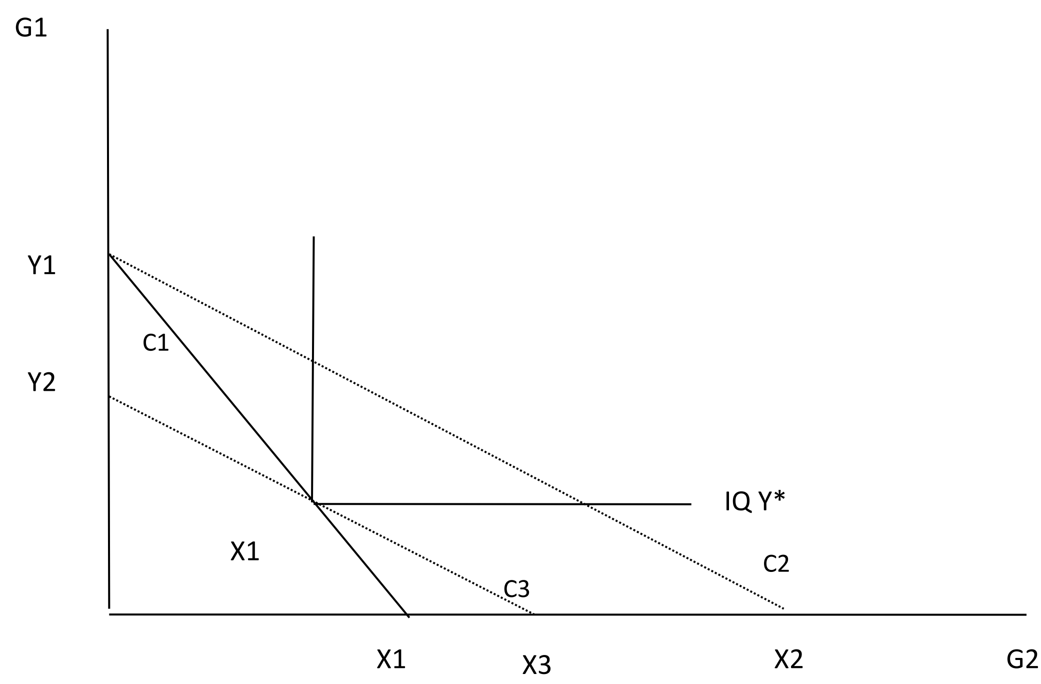
$$X1= TC^*/a_2 \quad (3.1.9)$$

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

Cost saving is given by:

$$\text{Cost savings} = Y1-Y2 \quad (3.1.11)$$

Figure 3.2 Cost Reductions Using Isocost Lines



Variables such as infrastructure, transportation costs and tax regimes, technology, institutions, and macroeconomic stability can affect fixed costs and marginal costs of a firm (specifically, they can affect a, c, b and d in Equation (3.1.6)). These variables have been largely ignored in the literature for global production sharing. The rest of this section briefly shows how these variables can affect global production sharing.

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-components. 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. The following diagram draws such a scenario where the firm achieves cost savings by relocating the production process of the labour intensive $G_{1,2}$ component to country B where labour costs are cheaper, while producing capital-intensive $G_{1,1}$ in the home country where it is cheaper to produce capital-intensive goods.

Another venue through which advancements in technology are likely to augment global production sharing is by reducing transport and other service link costs. Given this, any empirical model designed to capture global production sharing must include a variable on technology.

Figure 3.3 Cost Reductions Due to Fragmentation

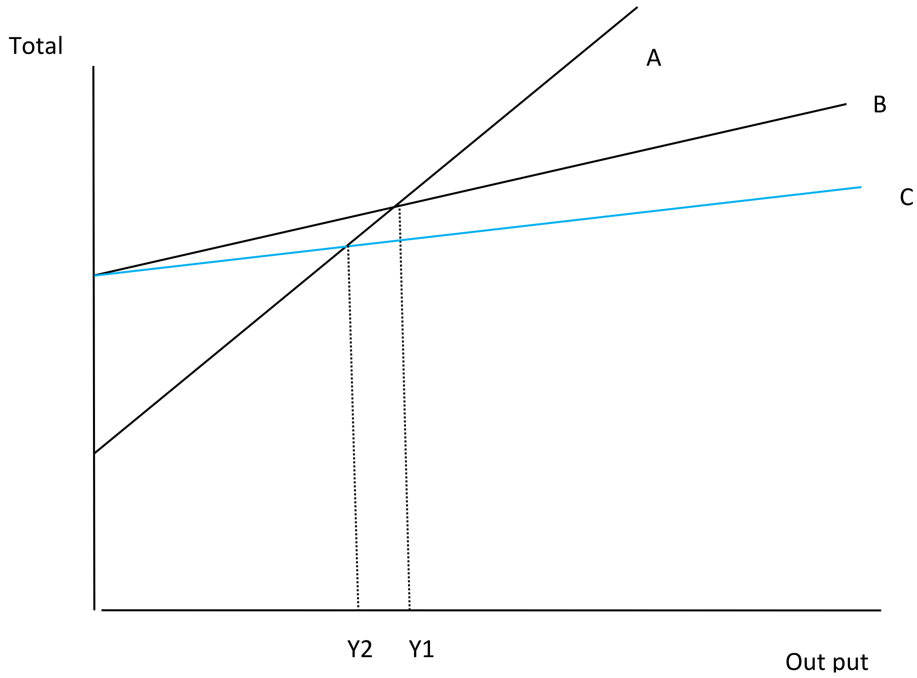


Figure 3.3 is the counterpart of Figure 3.1. In this figure, line A and B are the same as they were in Figure 3.1. However, line C represents cost reductions due to further fragmentation of the production of G_1 and lower transport and service link costs. The flatter slope of line C represents lower marginal costs of producing good F, which is due to further fragmentation of the production of G_1 and having $G_{1,2}$ produced in country B.

$$Y2 < Y1 \quad (3.2.2)$$

It is interesting to note is that the intersection of lines A and C is at a much lower output level than the intersection of lines 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 the GDP of each nation does not change. This divorce of the home country's and destination country's GDP means that we need to augment the standard gravity model with a relevant variable for technology.

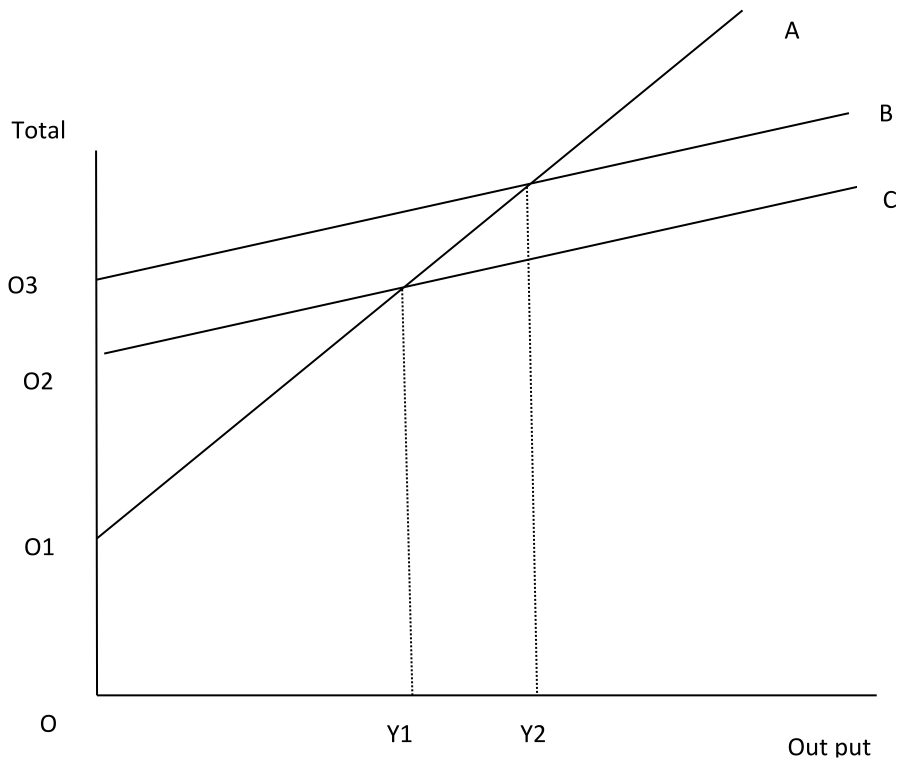
Moreover, better infrastructure can lower transportation costs which are a crucial factor for global production sharing. Technological advances in services link sectors (e.g. transportation and communication) and friendly tax regimes can also lower the costs of production. All these factors can curtail the marginal costs associated with global production sharing. Diagrammatically, this means that as the marginal cost declines, the slope of line B in Figure 3.3 becomes flatter. Line C, which is flatter than line B, in Figure 3.3 can also be used to represent the new marginal costs associated with cost reductions due to better infrastructure, reduction in transportation costs and communication costs, and reduction in tariffs. We can see that under these cost reductions, 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.

Macroeconomic instability can also induce extra costs, limiting the ability of various countries to take part in global production sharing. This is particularly true when volatility incurs extra costs for the firm, say in terms of menu costs, higher transaction and adjustment costs, or the costs of needing to keep extra capital to compensate for uncertainty. This increased cost reduces the feasibility of global production sharing.

Institutions can make a significant impact on production fragmentation outcomes. Both the fixed and marginal costs of production can be a function of institutions. For instance, political instability can deter business investments by creating uncertainty and increasing the cost of insurance for businesses. Also, bad institutions can deter investment by making regulatory framework less business friendly and by creating an environment where corruption can impact businesses and their cost structures. Let's assume that business friendly institutions decrease fixed costs (it is easier to start businesses and the business do not have to pay bribes to officials to buy land, get the company registered, etc.). In Figure 3.4, lines A and B are the same as in Figure 3.3. A business-friendly regulatory framework can reduce setup costs, as mentioned before. This can be shown by a decrease in the intercept from O3 to O2. As a result, lines C and A intersects at a lower output level, y1. This means that firms producing between Y1 and

Y2 will now also be able to take advantage of lower labour costs in country B and will fragment their production process. If in addition, improvements in institutions also decrease marginal costs, then the slope of the total cost line will become flatter, further augmenting global production sharing.

Figure 3.4 Cost Reductions in Global Production Sharing



4 Data

The dataset covers 44 countries, which individually accounted for at least 0.01% of total manufacturing exports in 2000. The time coverage is from 1996 to 2013 (18 years). There are 32,710 observations in the data relating to network trade. A list of the countries is given in the appendix. Summary of variable statistics is given in table 4.1.

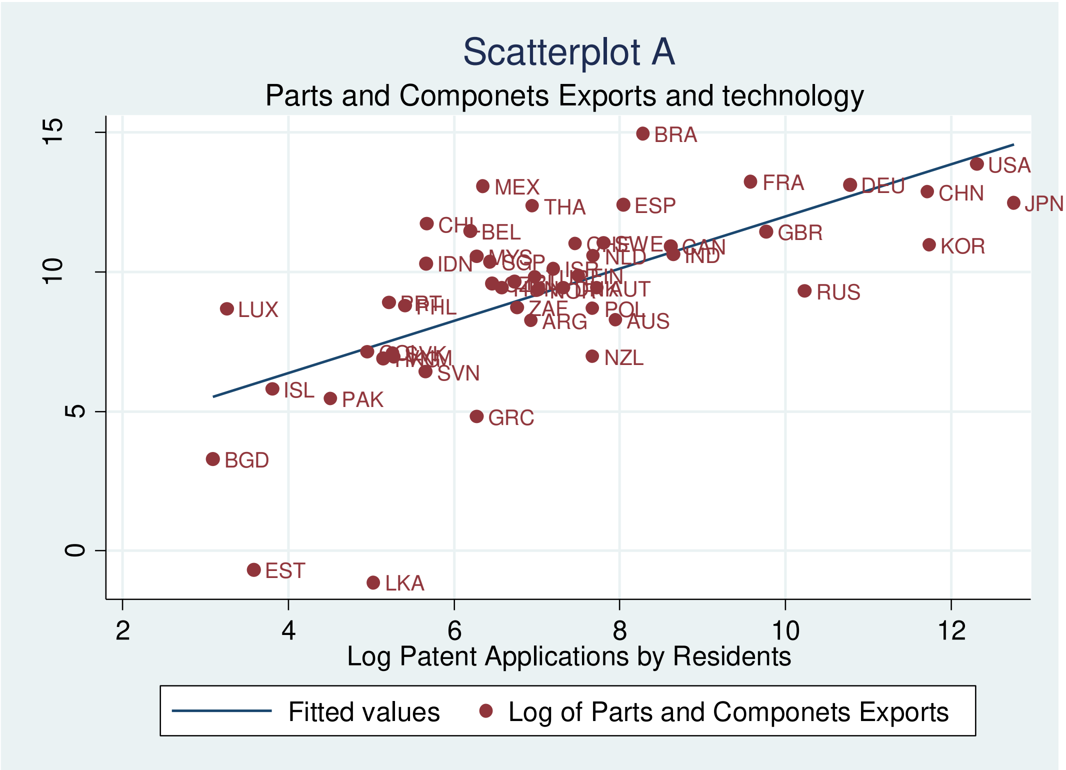
This paper follows Athukorala and Menon (1994a), Athukorala (2011), Athukorala and Yamashita (2006), Yeats (1998) in using the UN Comtrade database to delineate trade in parts and components from the final goods. Parts and components are delineated from the trade data using a list based on the UN Broad Economic Classification (BEC). This list uses the 5-dgit level of the Standard International Trade Classification (SITC). The nominal dollar value trade data are converted into real terms, using import price indices from the US Bureau of Labour Statistics (BLS). The parts and components list is given in Athukorala and Talgaswatta 2015, Appendix A-1.

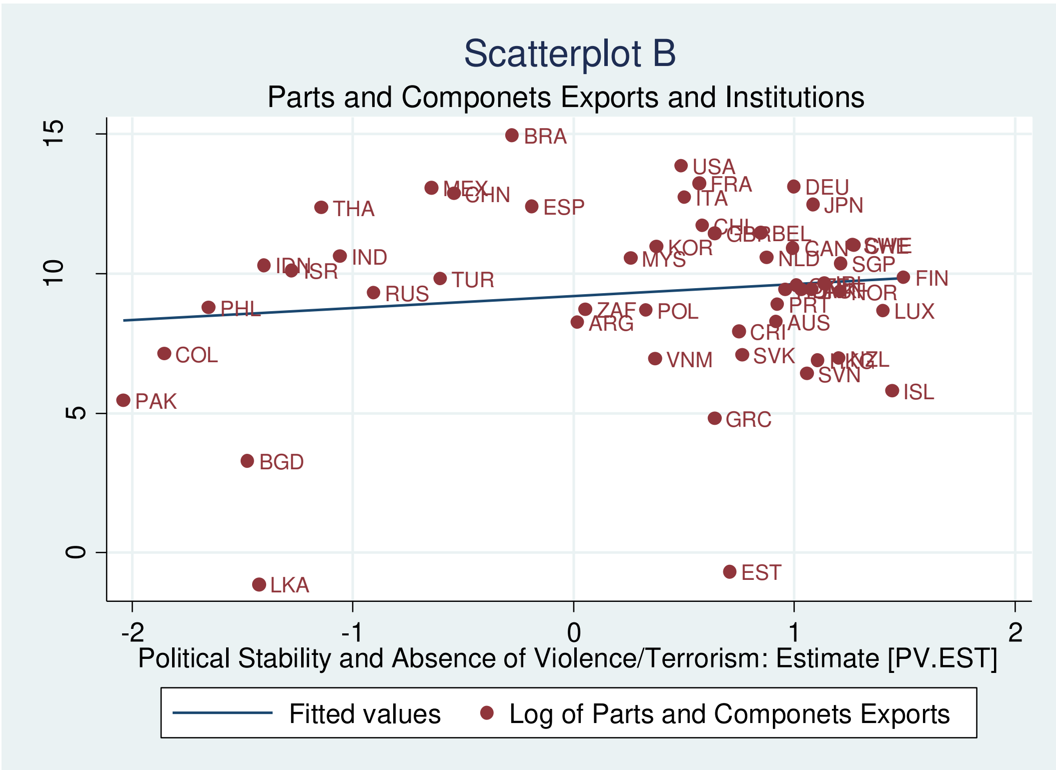
The price index for parts and components is constructed by using global trade weights from the UN Comtrade database. Data on GDP, manufacturing value added, logistic performance index (LPI), investment, patent applications, communications, inflation and the exchange rate is taken from the World Development Indicator (WDI)[4]. To look at the impact of institutions on trade and global production sharing, this study uses the variable from the World Governance Indicators (WGI) on political stability. However, the values for WGI are missing for 1997, 1999, 2001 and 2012, but given that institutions don’t change rapidly, we have used previous year’s values to fill these gaps.

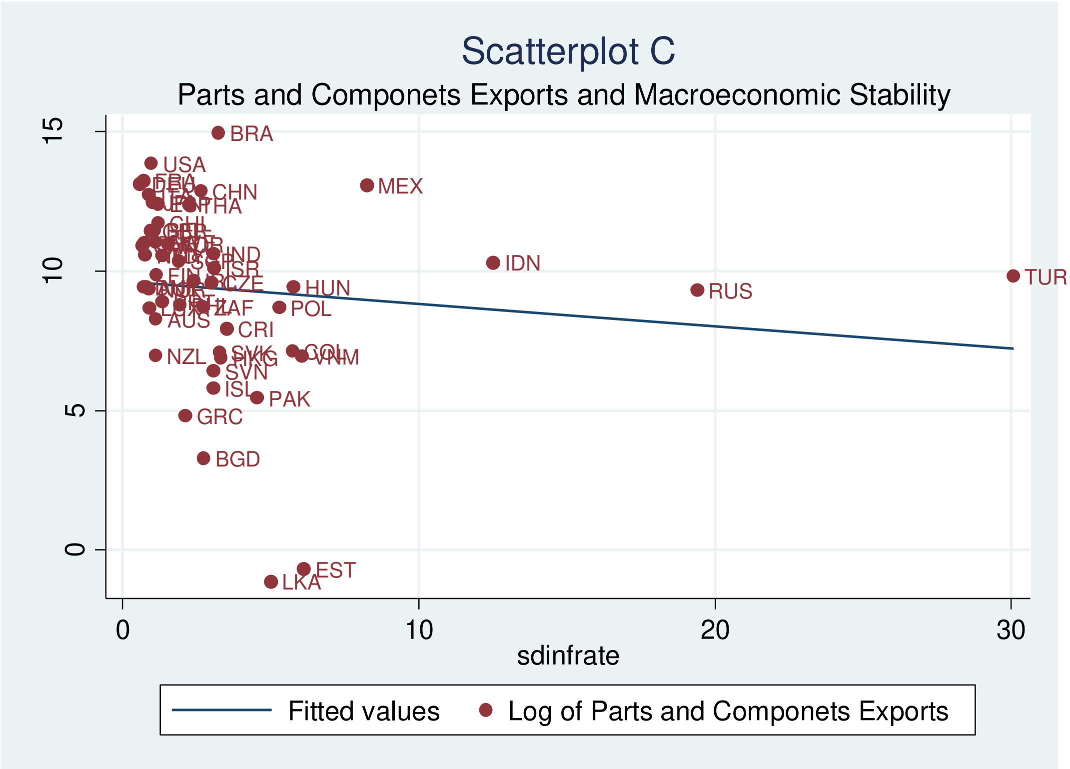
Panels A, B and C in Figure 4.1 give scatter plots depicting the relationships between parts and components exports and technology, institutions and macroeconomic stability, respectively. Panels A and B show that technology and higher quality institutions are positively correlated with exports of parts and components. Panel C, shows that higher macroeconomic instability has a negative correlation with parts and components exports.

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

Figure 4.1 Scatterplots of Parts and Components and Important Variables.







Note: Variable descriptions are detailed in the data section.

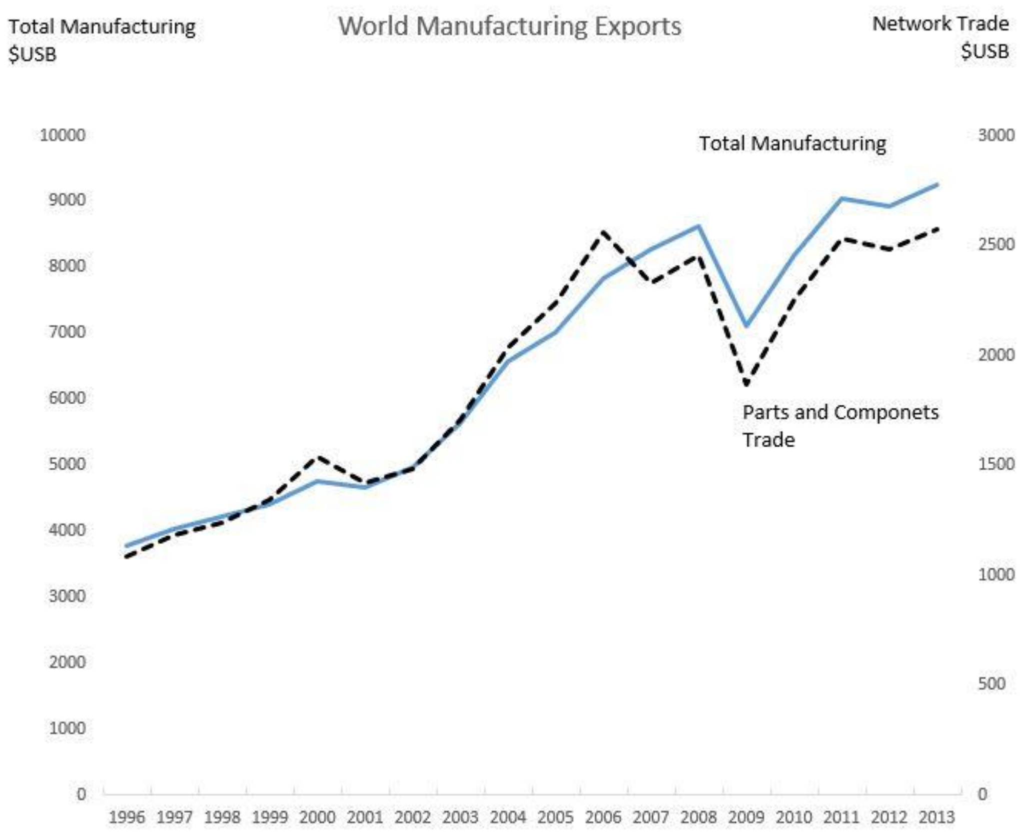
Table 4.1 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Log of parts and components exports	55,068	9.96	3.23	-5.84	18.47
Log of manufacturing exports	56,498	11.72	2.84	-4.19	19.58
Log of home country manufacturing value added	45,603	24.41	1.48	20.64	28.21
Log of partner country manufacturing value added	45,698	24.40	1.49	20.64	28.21
Log of home country GDP per capita	59,977	9.35	1.37	5.56	11.36
Log of home country GDP per capita squared	59,977	89.34	24.03	30.96	129.13
Log of communication infrastructure - internet users per 100 people	57,399	2.26	2.44	-9.86	4.59
Log of total patent applications by residents	58,125	7.08	2.24	2.08	13.47
Standard deviation of inflation rate.	47,072	3.46	4.96	0.49	30.07
Log of real exchange rate	56,040	-0.02	3.60	-10.33	10.33
Log of logistic performance indicator	61,991	1.22	0.15	0.83	1.43
Institutions variable based on political stability	47,653	0.34	0.97	-2.81	1.67
Regional trade agreements	60,420	0.15	0.36	0.00	1.00
Colony	61,991	0.03	0.18	0.00	1.00
Log of distance	61,991	8.59	0.97	5.08	9.88
Contiguity of border	61,991	0.04	0.20	0.00	1.00
Common ethnic language	61,991	0.11	0.31	0.00	1.00

5 Patterns

Between 1996 and 2013, world exports of parts and components increased by an average rate of 5.83 per cent to $2.57 trillion. Figure 5.1 shows strong upward trends in both total manufacturing and parts and components trade. The Global Financial Crises in 2008/2009 adversely affected both these trade categories. However, since 2010, the trade values have reached higher than the pre-crises levels.

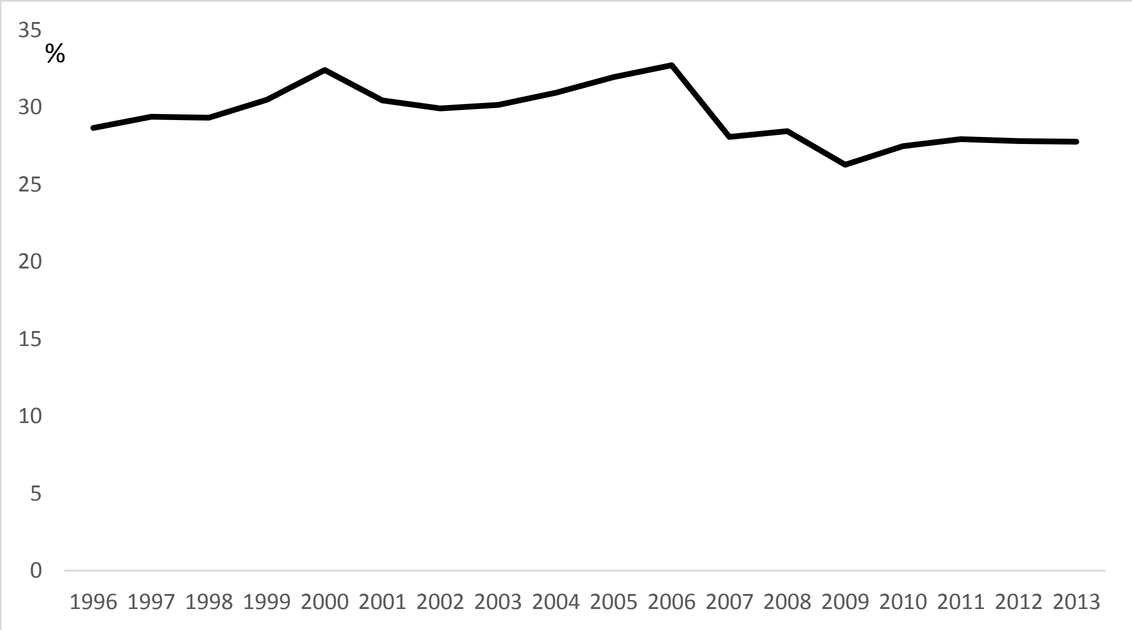
Figure 5.1 World Manufacturing Exports



Source: Comtrade Database

The share of parts and components in total manufacturing trade has remained around 30 per cent. In addition, compared to total manufacturing trade, parts and components trade was more than disproportionately affected by the Global Financial Crises (Figure 5.2). This may reflect the composition of parts and components trade, which is often concentrated in electronic goods such as computers, TVs, tablets and smartphones and these goods may have a high elasticity to income. Due to this, when incomes around the world decreased during the Global Financial Crises, parts and components trade was more than proportionately affected.

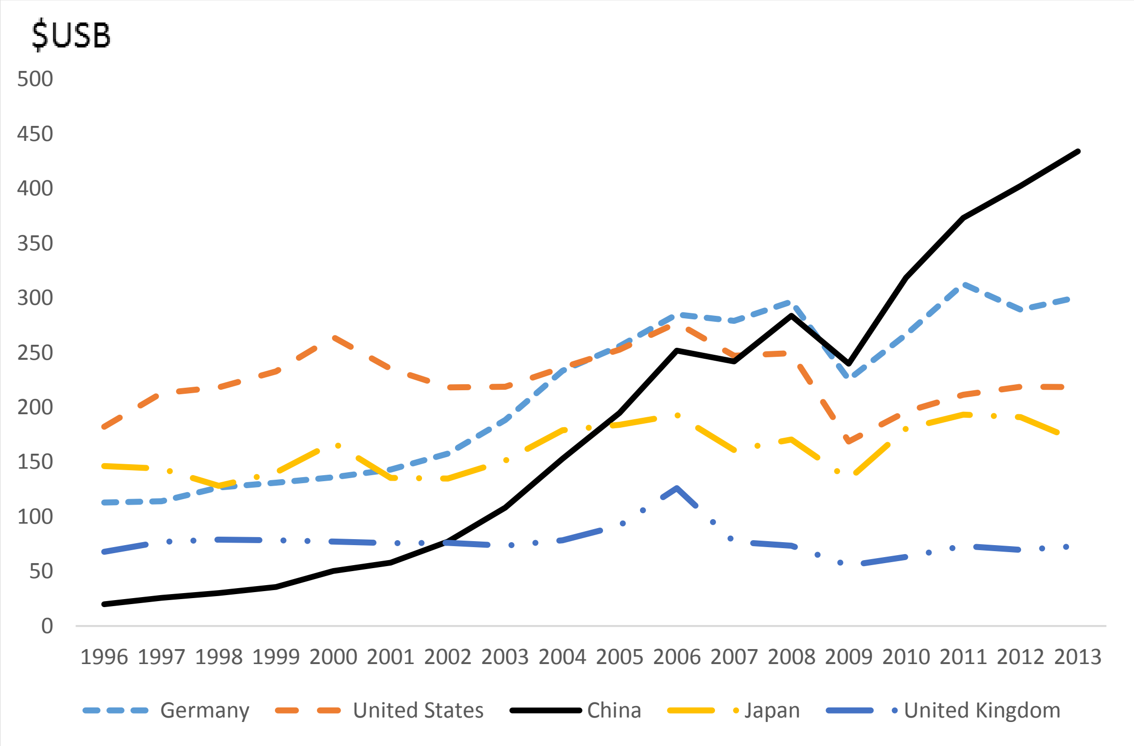
Figure 5.2 Share of Parts and Components in total manufacturing trade



Source: Comtrade Database

The patterns of the parts and components exports vary significantly by country. Figure 5.3 shows the trends in the top five countries involved in parts and components trade. The most discernible feature of this graph is the significant increase in parts and components exports from China. Barring the financial crises, Germany has also seen a sustained increase in parts and components trade. However, countries such as the UK, US and Japan do not show a clear trend. Their trade levels have fluctuated around their respective means – similar to a random walk. As the UK, the US and Japan, all have a comparative advantage in headquarter services (e.g. R&D, management and communications) their headquarter related network trade may well have increased, even if parts and components trade did not.

Figure 5.3 Parts and Components Exports



Source: Comtrade Database

6 Econometric Approach

6.1 The Econometric Model

This section develops the empirical model for examining the determinants of global production. The empirical side of the paper focuses on trade in parts and components, as they can be directly captured from the UN Comtrade database and because parts and components are the most ubiquitous part of network trade.

The empirical model is formulated by augmenting the standard gravity model through adding the relevant variables identified within the analytical framework developed in the previous sections[5]. These variables include supply base variable, demand base variable[6], distance, real exchange rate, GDP per capita, GDP per capita squared, stander deviations of inflation rate, institutions, technology, logistic performance index and geography and culture based variables (See table 6.1) The basis of this paper's model starts with the standard gravity equation[7].

$$lnExp_{ijt} = \alpha + \beta_1 lnSBV_{it} + \beta_2 lnDBV_{jt} + \beta_3 l7Distw_{ijt} + \beta_4 lnRER_{ijt} + \beta_5 lnGDPPC_{it} + \beta_6 lnGDPPC^2_{it} + \beta_7 CI_{it} + \beta_8 SDinfrate_{it} + \beta_9 Ins_{it} + \beta_{10} lnTech_{it} + \beta_{12} lnLPI_{it} + \phi' Loc_{ij} + \eta_i + \eta_t + \epsilon_{ijt} \quad (4.1.1)$$

The subscript *i* indexes home country, while subscript *j* indexes partner country and the subscript *t* indexes years. The letter "*ln*" in Equation 4.1.1 represents the natural log of the relevant variables. Natural log is taken to provide an elasticity-type interpretation to the coefficients. The natural log can also linearize variables such as trade and real GDPs. The variables in the Equation 4.1.1 are defined in Table 6.1.

[5] Previous applications of the gravity model to examine determiants of netwrok trade include Athukorala and Yamashita, 2009, Athukorala and Yamashita, 2006, Baldwin and Taglioni, 2011, Hanson et al., 2005)

[6] Further explained below, including a discussion of why these variables are included.

[7] (Athukorala and Menon, 2010, Athukorala and Yamashita, 2009, Athukorala and Yamashita, 2006, Baldwin and Taglioni, 2011, Hanson et al., 2005

Table 6.1 Variable List

LnExp	Exports (Ex) from country i to country j at time t
SBV_i	Country i supply base variable
DBV_j	Country j demand base variable
Distw	Population weighted distance
RER	Real exchange rate
SDinfrate	Standard deviation of home country's inflation rate
GDPPC	GDP per capita
$GDPPC^2$	GDP per capita squared
CI	Communication infrastructure
Ins	Institutional quality
Tech	Technology captured by patent application of home country
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.
A	Constant term

In the standard gravity model (Chaney, 2013, Feenstra et al., 2001, Head and Mayer, 2013, Anderson and Van Wincoop, 2001, Feenstra, 2003), the demand base of the partner country and the supply base of the home country are captured by real GDP. The standard economic reasoning is that as income of the 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.

Baldwin and Taglioni (2011) argue that within global production sharing often demand for parts and components is generated by the third country where the final good will be consumed. As such, they argue that the GDPs of both the home and partner countries will have diminished explanatory power in the presence of global production sharing. They suggest that the home country manufacturing production 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 the home country's manufacturing value added, along with imported parts and components, is a more appropriate measure of its supply base, while the partner country's GDP plus the import of network trade from other countries is an appropriate measure of the demand base.

This paper uses home country manufacturing value added, along with the partner country manufacturing value added, to capture the supply and demand base variables for global production sharing, respectively. This measure is conceptually more appropriate because the Baldwin and Taglioni measure sums value added figure of manufacturing with the gross sales value of imported parts and components. In addition, as this paper uses annual data, incorporating the Baldwin and Talgnoi specification will induce simultaneity bias in our results if not properly accounted for, because imports of parts and components are likely to be processed within a year and exported to other countries. Moreover, as our preferred estimation technique is the correlated random effect, whose results are exactly the same as fixed effects, the Baldwin and Talgnoi critique is not relevant to our specification (Baldwin and Taglioni, 2011). Lastly, the Baldwin and Talgnoi specification is highly correlated (above 95 per cent) with the manufacturing valued added variable, see Table 4.2. As such, manufacturing value added can serve as an appropriate substitute for the Baldwin and Talgnoi specification. Given these reasons, we prefer using manufacturing value added as the economic mass variables for our regression analysis. For completeness, this paper uses the Baldwin and Taglioni specification along with the standard home country and partner country real GDPs to check for robustness in our regression[8].

$$lnExp_{ijt} = \alpha + \beta_1 lnMVA_{it} + \beta_2 lnMVA_{jt} + \beta_3 lnRER_{ijt} + \beta_4 lnGDPPC_{it} + \beta_5 lnGDPPC_{it}^2 + \beta_7 CI_{it} + \beta_8 SDinfrate_{it} + \beta_9 l7Distw_{ijt} + \beta_{10} Ins_{it} + \beta_{11} lnTech_{it} + \beta_{12} lnLPI_{it} + \phi' Loc_{ij} + \eta_i + \eta_t + \epsilon_{ijt} \qquad (4.1.2)$$

[8] Results can be provided on request

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

Table 6.2 Correlation Matrix

	h_supply_bt	h_man_real	p_demand_bt	p_man__real
h_supply_bt	1	0.994497	-	-
h_man_real	0.994497	1	-	-
p_demand_bt	-	-	1	0.955594
p_man__real	-	-	0.955594	1

Notes: h and p stand for home and partner country respectively, man_real stands for manufacturing value added in real terms and supply_bt and demand_bt stand for Baldwin and Talgoni specification of supply and demand variables.

Population weighted distance is used as a proxy for transport cost and other associated time lags. As network trade involves multiple border crossings, this paper hypothesises that global production sharing exports are likely to be sensitive to transportation costs.

Infrastructure, both for physical goods and communications, are important variables in our regression. In Section 3.1, we saw that infrastructure improvement could augment global production sharing by reducing transport costs. Moreover, in recent years, this variable has received increased importance in trade regressions (Athukorala, 2011, Athukorala and Menon, 2010, Athukorala and Yamashita, 2009, Mundlak, 1978). Given this, this study includes LPI (Logistic Performance Index) as an explanatory variable. LPI is an index that measures physical goods trade-related infrastructure of the relevant country (Athukorala, 2011, Athukorala and Menon, 2010, Athukorala and Nasir, 2012, Arvis, 2010). In addition to this, infrastructure related to communications and service link costs is essential to global production sharing, so this paper uses communications infrastructure to capture this variable. Data for communications infrastructure and costs is not readily available. Therefore, to proxy for communications infrastructure, this paper uses internet users per hundred people.

GDP per capita is a standard variable used in gravity models to capture levels of development in an economy and is likely to have a quadratic relationship in

Equation (4.2.3). This is based on the fact that growth in economies leads to a transition away from manufacturing into services and the fact that rising wages will decrease the competitiveness of manufacturing industries. GDP per capita squared is used to capture this quadratic functional form.

In order, to look at the sensitivity of network trade to macroeconomic stability, we include the standard deviation of the home country inflation rate. Section 3.1 explained how macroeconomic instability is likely to reduce the feasibility of global production sharing. We can hypothesise that trade in parts and components will be more sensitive to a high standard deviation in the inflation rate.

The real exchange rate (RER) is incorporated to capture the impact of the competitiveness of tradable goods production on trade flows. We expect the RER to have a more pronounced impact on final goods, however, as trade in global production sharing is mostly relationship specific, including intra-firm, it is less likely to be affected by international prices (Jones, 2000a, Jones, 2000b, Arndt and Kierzkowski, 2001, Burstein et al., 2008). The reasons to expect the impact of the RER appreciation to be much weaker (or even zero) in GPN include the fact that (Jones and Kierzkowski 2004; Jones 2000, Arndt and Huemer 2007, Burstein et al 2008, Athukorala and Khan 2015) the production units of the value chain located in different countries normally specialize in specific tasks. Therefore, the substitutability of parts and components sourced from various sources is rather limited. In addition, setting up of overseas production bases and establishing the services links entail high fixed costs. Once such fixed costs are incurred, relative price/cost changes become less important in business decision making. Changes in exchange rates also have offsetting effects on imports and exports and thus, the net effect of the changes in the exchange rate changes on exports within production networks can tend to be weaker than in the standard case of producing the entire product in a given country.

This paper also examines the role of institutions within global production sharing and it is expected that institutions will play a significant role in global production sharing by providing a more conducive environment to doing business. This is primarily because most of the trade in global production sharing is dominated by MNEs, which are likely to prefer investing in stable countries.

Weak political institutions are likely to lead to higher uncertainty and increased setup and running costs for business. This is likely to directly increase the cost of doing business. Weak political institutions may also lead to corruption. Section 3.1 showed how setup costs, running costs, regulatory framework and other associated costs can discourage global production sharing in particular and businesses in general. An improvement in institutions is also likely to make the production process more efficient. Based on this, we would expect that improvements in institutions are likely to increase exports in both network and final goods trade in manufacturing. To capture institutions we use political stability and absence of violence as a measure – as taken from world governance indicators.

Advancements in technology can both enable the production process to be sliced into smaller sections and reduce transport costs. Both of these processes enhance global production sharing. To capture this effect, we include a technology variable in our regression, where patent application[9] by resident population is used as a proxy for innovation. We also include standard geographic and cultural variables in our gravity model in both final goods and parts and components trade equations.

6.2 Estimation

The regressions are run separately, both for manufacturing and parts and components exports. This paper employs the correlated random effect (CRE), Hausman-Taylor (HT) and random effect methods to estimate the empirical models (Dascal et al., 2002, Wooldridge, 2005, Athukorala and Nasir, 2012, Anderson and Van Wincoop, 2001, Wooldridge, 2012). The Hausman test favours CRE of the three estimation techniques.

There is a growing literature on using time-invariant variables in panel data approach (Krishnakumar, 2006, Mundlak, 1978, Oaxaca and Geisler, 2003, Wooldridge, 2012).

[9] The patent variable is a better measure of technological capability of the country than internet users which is more of a proxy for communications infrastructure.

Given this, this study employs the CRE approach to capture time-invariant variables.[10] The coefficients estimated using the CRE are the same as fixed effects (FE), with the added advantage that time-invariant variables are not cancelled out. Moreover, CRE allows us to control for marginal improvements, as well as the average levels of the variables that we are interested in. The other main advantages of using the CRE approach is that it allows us to test the assumptions used in the HT and RE estimations, using the Hausman Test. However, one of the problems with CRE is that because of multicollinearity, its estimates can be less precise. As such, it would be useful to supplement the CRE results with the HT and RE estimates.

The HT approach is widely used in estimating the gravity model (Chaney, 2013, Feenstra et al., 2001). It can control endogeneity in RE and Pooled OLS methodologies. In both the RE and pooled OLS approaches, there can be time-invariant country-specific effects not accounted for in the regression, that are correlated with the independent variable. The HT approach controls for endogeneity by using an internal instrument approach (see appendix 1B for further discussion) The HT approach does not control for all the endogeneity. [11] However, the results remain robust when we use CRE, HT and RE. Together this points to the fact that the results are not sensitive to the estimation methodology used.

This study follows the standard practice of allowing for economic mass variables and RTA (regional trade agreements) to be endogenous in our HT approach (Feenstra et al., 2001) . Additional variables used - such as GDP per capita, GDP per capita squared, technology and institutions [12] - can also be endogenous to time-invariant country-specific effects. This paper also presents RE for comparison and robustness of the results.

[10] The CRE approach is explained in Appendix 1B

[11]There is reverse causality from exports to economic mass variables which has largely been ignored in the literature. The reason why the reverse causality is not given so much attention is mostly because the reverse causality due to bilateral trade is a very small part of GDP, as such the reverse causality is not very large. This paper checks for robustness of results by explicitly taking into account of this reverse causality. In particular, we lag economic mass variables where our identification assumption is that current trade value cannot impact appropriately lagged past values of the GDP and manufacturing value added. These results are produced in the Appendix 1c and show that our main results are still robust after accounting for the reverse causality.

[12] These variables are treated as endogenous in the HT approach.

Furthermore, 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 the global financial crises (GFC) and the Asian financial crises (AFC) happened during the time frame of our dataset, accounting for business cycles is important.

7 Results and Robustness Tests

7.1 Results

This section summarises the main results for both parts and components and manufacturing goods trade. The estimated trade equations are reported in Table 7.2. Columns 1 and 2 in the table present the results based on CRE. While Column 3 to 6 examine robustness tests. Specifically, Columns 3 and 4 give results based on the HT estimation and Columns 5 and 6 give results based on the RE estimation. The discussion in this section focuses on the CRE estimates - this paper's preferred estimation technique.

The manufacturing output of the home country and partner country is statistically significant (at the one-percent level), with the expected sign in all our regressions. The coefficient of manufacturing output, both as a supply base variable and demand base variable, lies in the range of previous studies for both final goods manufacturing exports and parts and components exports (Athukorala, 2005, Athukorala, 2011, Athukorala and Menon, 2010, Athukorala and Yamashita, 2006, Baldwin and Taglioni, 2011).

More specifically, for parts and components, a one per cent increase in manufacturing value added of the home country increases parts and components exports by 1.58 per cent. The elasticity of the partner country manufacturing value added is also statistically significant at the one per cent level and in the range of previous studies for parts and components. In particular, a one per cent increase in partner country manufacturing value added implies a 1.16 per cent increase for parts and components exports.[13]

[13] Elasticities with regards to manufacturing value added are slightly on the higher side compared to the literature, however the HT and RE estimates are more towards the average of what most studies find.

For total manufacturing exports, a one per cent increase in manufacturing value added for the home country increases final goods manufacturing exports by 1.48 per cent and while a similar increase in partner country manufacturing value added increases final goods manufacturing exports by 1.00 per cent. A sensitivity analysis based on HT and RE estimations yields qualitatively similar results for both total manufacturing and parts and components trade.

GDP per capita and GDP per capita squared have the expected signs and are significant at the one per cent level for both parts and components exports and manufacturing final goods exports. The coefficient on GDP per capita is positive, while the coefficient on GDP per capita squared is negative, showing that the relationship between exports and GDP per capita is quadratic. This is in line with the theory that as countries develop, services sector gains in share of the GDP and crowds out the manufacturing sector. These results remain robust to HT and RE specifications.

The coefficient on distance is highly significant, with the expected negative, in all of our regressions. This indicates that transport costs play an important role in trade flow for both manufacturing final good and parts and components exports. The absolute value on the coefficient of distance is higher for parts and components than it is for final goods – which shows that parts and components trade is relatively more sensitive to transport costs. This partly reflects the fact that in network trade, parts and components have to cross multiple borders to reach the final stages of production.

Based on the CRE results, institutions play an important role in parts and components exports. Ceteris paribus, a one unit increase in the institution index increases parts and components exports by approximately 9 per cent for all the countries. This result remains fairly similar for the HT and RE estimations.

Based on CRE estimates, one per cent increase in the patent applications by residents, increases exports by 0.16 per cent for parts and components. This coefficient is statistically significant at the 1 per cent level. Moreover, estimates based on HT and RE yield statistically significant estimates for the technology variable at the 1 per cent level. These estimates are in line with this study's theory that advocates that technological growth will lead to finer slices of the 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 reduces transport and communication costs which are central to service link costs (Jones and Kierzkowski, 1990).

For manufacturing final goods exports, technology plays a relatively less important role and for the CRE estimates the technology variable is not even significant. Also noteworthy is that the technology variable is highly correlated with GDP per capita and part of the technology impact on parts and components exports and final goods exports may be captured by GDP per capita.

The coefficient of the standard deviation of the domestic inflation rate has the expected sign and is significant at the one per cent level for parts and components. Ceteris paribus, a one unit increase in standard deviation of inflation decreases parts and components exports by approximately 3 per cent. Also, results of the HT and RE approaches consistently show a negative relationship between the standard deviation of domestic inflation and exports of parts and components. This confirms our hypothesis that macroeconomic stability is important for global production sharing. In particular, as the parts and components trade is dominated by multinationals, a stable and conducive macroeconomic environment provides a safe investment atmosphere for multinationals which in turn helps to augment the parts and components trade.

The coefficient of LPI is positive but insignificant for the CRE estimates. This may reflect collinearity with the mean values[14]. However, the results for the HT and RE estimation techniques show that infrastructure plays an important role in supporting the parts and components trade. The coefficient for communications has the expected sign and is significant at the one per cent level. A one percent increase in this variable increases global production sharing exports by 0.07 per cent. As this variable is a proxy for

[14] As the LPI data has gaps, as such missing values were filled by the closest years. This may induce collinearity issues with the mean values. This is also evident as the mean value of LPI is highly significant and positive. The insignificance of the variable, may also reflect the multicollinearity between GDP per capita and LPI.

communication infrastructure, it shows that services link costs are important determinants for global production sharing.

For parts and components regression, RER is not statistically significant at the conventional levels. As a significant portion of network trade is relationship specific, including intra-firm and hence shielded by exchange rate fluctuations, RER does not seem to be an important determinant for parts and components trade. This is an important result, because it shows movements of international prices do affect trade flows within network trade.

Results for RTA shows that trade agreements are important for both the parts and components and the final goods trade. Moreover, similar to previous studies, the results for other geographic variables are comparable to previous studies on manufacturing and the parts and components trade (Athukorala, 2005, Mundlak, 1978).

Table 7.1 Variable List

lhmva	Log of home country manufacturing value added
lpmva	Log of partner country manufacturing value added
politicalstability	Institutions variable based on political stability
ltotalpa_res	Technology captured by log of patent application (residents)
l_CI	Communications infrastructure
LPI	Logistic performance index
LOC	Vector of geography and culture based variables
Ldistw	Log of Distance
GDPPC	Gross domestic product per capita
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 7.2 Results and Robustness Tests

VARIABLES	(1) PC RCE	(2) MNF RCE	(3) PC HT	(4) MNF HT	(5) PC RE	(6) MNF RE
Log of home country supply base variable	1.58***	1.48***	1.08***	1.13***	1.07***	1.10***
	(11.20)	(12.63)	(35.74)	(51.10)	(21.56)	(27.93)
Log of partner country demand base variable	1.16***	1.00***	1.17***	1.06***	0.99***	0.91***
	(14.37)	(17.70)	(39.97)	(52.30)	(28.15)	(30.63)
Log of home country GDP per capita	1.89***	1.32***	1.60***	1.25***	2.71***	0.93***
	(2.64)	(2.72)	(5.60)	(6.39)	(6.09)	(2.59)
Log of home country GDP per capita squared	-0.16***	-0.13***	-0.08***	-0.08***	-0.16***	-0.07***
	(-3.93)	(-4.62)	(-5.16)	(-7.03)	(-6.24)	(-3.19)
Log of communication infrastructure	0.07**	0.05**	0.10***	0.05***	0.10***	0.09***
	(2.52)	(2.57)	(8.15)	(6.04)	(3.70)	(4.92)
Log of total patent applications by residents	0.16***	0.02	0.16***	0.03***	0.11***	0.01
	(4.50)	(0.97)	(11.99)	(3.30)	(3.59)	(0.55)
Standard deviation of inflation rate.	-0.03***	-0.02***	-0.06***	-0.06***	-0.07***	-0.05***
	(-4.41)	(-3.04)	(-5.31)	(-6.75)	(-9.94)	(-9.06)
Log of real exchange rate	-0.01	0.01	-0.01**	0.01**	0.00	0.01**

VARIABLES	(1) PC RCE	(2) MNF RCE	(3) PC HT	(4) MNF HT	(5) PC RE	(6) MNF RE
	(-1.35)	(0.77)	(-1.99)	(2.18)	(0.20)	(2.12)
Log of logistic performance indicator	0.35	0.21	0.34**	-0.05	1.67***	0.84***
	(1.08)	(0.92)	(2.05)	(-0.46)	(5.52)	(3.81)
Institution based on political stability	0.09**	0.05*	0.07***	0.04***	0.13***	0.05*
	(2.30)	(1.95)	(4.24)	(3.28)	(3.24)	(1.80)
Regional trade agreements	0.49***	0.49***	0.45***	0.47***	0.47***	0.46***
	(4.94)	(6.86)	(12.76)	(18.94)	(5.52)	(7.06)
Colony	0.42**	0.34**	0.39	0.36	0.27	0.26
	(2.36)	(2.10)	(1.24)	(1.45)	(1.32)	(1.41)
Log of distance	-1.07***	-1.02***	-1.16***	-1.14***	-1.07***	-1.03***
	(-28.74)	(-33.67)	(-19.06)	(-23.64)	(-26.36)	(-31.82)
Contiguity of border	-0.16	0.09	-0.47	-0.41*	-0.31	-0.10
	(-0.86)	(0.64)	(-1.55)	(-1.69)	(-1.54)	(-0.70)
Common ethnic language	0.74***	0.73***	0.88***	0.87***	0.87***	0.83***
	(5.27)	(6.39)	(4.60)	(5.70)	(5.63)	(6.82)
Mean of log of home country supply base variable	-0.42***	-0.64***				
	(-2.65)	(-4.85)				
Mean of log of partner country demand base variable	-0.30***	-0.20***				
	(-3.64)	(-3.39)				
Mean of log of home country	0.15	-1.21**				

VARIABLES	(1) PC RCE	(2) MNF RCE	(3) PC HT	(4) MNF HT	(5) PC RE	(6) MNF RE
GDP per capita						
	(0.17)	(-2.17)				
Mean of log of home country GDP per capita squared	-0.01	0.10***				
	(-0.25)	(3.19)				
Mean of log of communication infrastructure	0.69***					
	(5.19)					
Mean of log of total patent applications by residents	-0.20***	0.04				
	(-3.34)	(1.00)				
Mean of log of real exchange rate	0.09***	0.06***				
	(6.24)	(5.57)				
Mean of log of logistic performance indicator	6.73***	5.11***				
	(10.35)	(9.80)				
Mean of institution based on political stability	0.16	-0.13				
	(1.32)	(-1.50)				
Mean of regional trade agreements	-0.28*	-0.48***				
	(-1.91)	(-4.22)				
All financial crises dummies			-0.12**	-0.08**		

VARIABLES	(1) PC RCE	(2) MNF RCE	(3) PC HT	(4) MNF HT	(5) PC RE	(6) MNF RE
			(-2.10)	(-2.19)		
Constant	-44.56***	-25.24***	-44.19***	-36.70***	-45.30***	-32.50***
	(-16.51)	(-14.03)	(-27.70)	(-32.85)	(-18.90)	(-16.46)
Observations	24,629	24,849	32,710	33,315	24,629	24,849
Number of pairid	1,673	1,675	2,201	2,203	1,673	1,675

Note: PC stand for parts and components, while MNF stands for final manufacturing

8 Conclusion

Global production sharing has become prominent in international trade. This paper examines determinants of trade based on global production sharing, by building a theoretical framework and empirically testing it uses a panel dataset of 44 countries, covering 18 years from 1996 to 2013. The model captures a number of explanatory variables ignored in the previous literature. This study uses a battery of estimation techniques including CRE, HT and RE to test the robustness of these results.

The evidence in the paper suggests that institutions play an important role in parts and components trade. Macroeconomic stability also plays a significant role in augmenting global production sharing. These are important results, with policy implications for countries that want to capture part of the growing network trade. In particular, these results suggest that providing with a business friendly and conducive environment is important for attracting investment from multinationals which dominate parts and components trade.

The results also support the hypothesis that technological improvements play an influential role in augmenting network trade. Given this, as technological innovations continue, we would expect a further proliferation of global production sharing. Technological advancements augment global production sharing by enabling the production process to be sliced up into smaller sections and allocated across the world, based on comparative advantage. Transport costs were found to be a significant and robust determinant of network trade. 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.

The results of the study have several policy implications for countries which want to increase exports and capture part of the network trade. In order to reap gains from network trade, countries need to reduce service link costs by improving both physical and communications infrastructure. As network trade is dominated by multinationals, thus, in order to be a part of the global production sharing process, countries need to improve institutions, provide a stable macroeconomic environment and create a conducive investment environment to attract multinationals. Attracting multinationals will also help these countries gain access to the global innovations required to foster global production sharing.

Appendix 1 A Data

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

Appendix 1 B.1 Correlated Random Effect (CRE).

This section briefly explains the CRE approach. For a detailed description see Wooldridge (2012). To explain the CRE, this section follows Wooldridge (2012). Assume, for simplicity, a case of one explanatory variable. Where a_i are unobserved country fixed effects.

$Y_{ijt}= \alpha + X'_{i1t}\, \beta_1 + a_i + \epsilon_{ijt}\, \epsilon_{ijt}$ (B.1.1)

The average of the above equation is:

$\bar{Y}_{ijt}= \alpha + \bar{X}'_{i1t}\, \beta_1 + a_i + \bar{\epsilon}_{ijt}$ (B.1.2)

Since a_i is by definition constant over time, it is correlated with the average level of explanatory variable $\bar{X}$. Following Wooldridge (2012), assume a simple linear relationship.

$a_i= \delta + \bar{X}'_{i1t}\, \beta_1 + +r_I$ (B.1.3)

Then the original equation becomes:

$Y_{ijt}= \alpha + X'_{it}\, \beta_1 + \delta + \bar{X}'_{it}\, \beta_1 + r_i + \epsilon_{ijt}$ (CRE1)

Assume that r_i is uncorrelated with X'_{it} and because $\bar{X}'_i$ is a linear function of X'_{it}, then:

$Cov(\bar{X}'_{it}, r_i) = 0$

As $Cov(X_{it}, a_i)= 0$ holds and as ϵ_{ijt} is assumed to be uncorrelated with X'_{it} and $\bar{X}'_I$, then we can estimate (CRE1) using random effects. So CRE1 is like RE estimation with the addition of $\bar{X}'_I$.

Appendix 1 B.2 Hausman-Taylor (HT)

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

$Y_{ijt} = \alpha + X'_{i1t}\,\beta_1 + X'_{i2t}\,\beta_2 + Z_{i1}'\beta_3 + Z_{i1}'\beta_3 + \eta_i + \epsilon_{ijt}$ (B.2.1)

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 a Random Effect type transformation as follows:

$Y_{ijt} = \alpha + \widetilde{X}'_{i1t}\,\beta_1 + \widetilde{X}'_{i2t}\,\beta_2 + \tilde{Z}_{i1}'\beta_3 + \tilde{Z}_{i2}'\beta_3 + \tilde{\eta}_i + \tilde{\epsilon}_{ijt}\,\epsilon_{ijt}$ (B.2.2)

Where $\widetilde{X}_{i1t} = \widetilde{X}_{i1t} - \gamma\overline{X}_{i1}$. 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 $\tilde{\eta}_{i}$. The HT approach uses IVs. For $\widetilde{X}_{i2t}$ the instrument used is $\ddot{X}_{i2t} = X_{i2t} - \overline{X}_{2i}$, for $\tilde{Z}_2$ the instrument usedis $\overline{X}_{i1}$. The variable uses $\ddot{X}_{i1t}$ as an instrument for $\widetilde{X}_{i1t}$ and Z_{i1} as an instrument for $\tilde{Z}_{i1}$ (Wooldridge, 2012, Krishnakumar, 2006, Oaxaca and Geisler, 2003).

Appendix 1 C Robustness Test Using Lagged Supply Base and Demand Base Variables.

	(1)
VARIABLES	PC
ltotalpa	0.02
	(1.33)
lrer	0.02***
	(3.13)
l_h_lpi	1.10***
	(5.43)
L.lhmva	1.37***
	(38.77)
L.lpmva	1.12***
	(28.95)
rta	0.28***
	(6.22)
h_ins_corr	0.20***
	(5.72)
sdinfrate	-0.07***
	(-4.60)
colony	-0.55
	(-1.20)
ldistw	-1.20***
	(-13.08)
contig	-0.28
	(-0.69)
comlang_ethno	1.25***
	(4.88)
Constant	-35.00***
	(-23.41)
Observations	17,977
Number of pairid	1,711

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

Chapter 3
Exchange Rate Pass-Through for Manufactured Goods in the Presence of Network Trade

1 Introduction

The fragmentation of the production process across international borders, known as global production networks (GPN)[15], has changed international trade in a substantial manner (Bridgman, 2012, Helpman, 2011, Hummels et al., 2001, Chen et al., 2005). Network trade – trade within GPN – has grown at a much faster rate than total world manufacturing trade over the past four decades (Yeats, 1998, Yi, 2003, Majeed, 2012, Bridgman, 2012). Using a theoretical model and a novel and disaggregated dataset, this paper studies exchange rate pass-through (ERPT) under the presence of network trade.

Movements in exchange rates are likely to impact import prices and domestic prices. ERPT measures how responsive domestic prices are to changes in exchanges rates. This pass-through of the exchange rate to import and domestics prices is often found to be incomplete (Burstein and Gopinath, 2013).

There is likely to be heterogeneity in the ERPT between network trade and final goods trade. Partly reflecting the fact that most of the trade in global production sharing is relationship specific, including intra-firm trade (Chen et al., 2005, Bridgman, 2012, Helpman, 2011, Hummels et al., 2001). Given this, global production sharing is likely to be shielded from fluctuations in the exchange rate. This heterogeneity of ERPT is expected to be more prominent for countries that have a high share of the parts and components trade.

There is a vast literature on ERPT (Burstein and Gopinath, 2013, Campa and Goldberg, 2005b, Choudhri et al., 2005, Dornbusch, 1987, Faruqee, 2006). These papers have focused on aggregated import and domestic prices, overlooking the impact of global

[15] Also called global production sharing.

production sharing. Given the increase in global production sharing, this is a major gap in the literature.

The study of ERPT in the presence of network trade has been limited by data availability. The only study that has tried to examine[16] this link empirically uses data based on the restrictive assumptions of Input-output tables (IOT)[17] (Powers and Riker, 2013). My study overcomes the problems faced by IOTs, by creating a unique import price database for the US[18].

The study adds to the literature in three novel ways. First, a model is developed to explain why the ERPT may be lower under global production sharing. Drawing on Dornbusch (1987), the model captures relationship specificity using intra-firm trade. Secondly, this model is simulated with various scenarios showing that an increase in network trade does indeed cause ERPT to be lower. Lastly, an empirical investigation is undertaken using a vector autoregression (VAR) methodology and a unique dataset created for the US.

The theoretical part of this paper looks at both the parts and components trade and the final assembly, within global production sharing. However, the empirical analysis of the paper focuses only on parts and components because price data is not available for final assembly. The empirical investigation is undertaken by looking at various import price indices based on their share of the parts and components trade for the US. The US is used as a case study because it has the most disaggregated import price data available.

To preview the results, theoretically, the model in this paper shows how ERPT is lower under global production sharing. This result is further endorsed by simulating the model. The final sections of this paper empirically prove the above-mentioned claim. The paper is organised as follows: Section 2 discusses the literature, Section 3 builds the theoretical

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[16] To the best of our knowledge, (Powers and Riker, 2013) is the only study on ERPT focusing on network trade.

[17] IOT assume conformity across several countries, industries and over the time. For an activity like network trade that has been shaped by rapid technological growth and has proliferated various industries and countries in different ways, the IOT assumptions are often restrictive.

[18] The US is used as a case study because it has the most disaggregated import price data available.

model, Section 4 simulates the model, Section 5 describes the empirical strategy, Section 6 analyses data, Section 7 gives the results and Section 8 concludes.

2 Literature Review

Study on ERPT for global production sharing has been limited. However, several papers have concentrated on ERPT more broadly. The following section reviews the literature.

There have been several theoretical frameworks developed to look at ERPT. Some models have looked at interactions between firms in an imperfect competition framework (Krugman, 1986), while Froot and Klemperer (1989) focus on the trade-off firms face between market shares and profits due to exchange rate movements. They use a dynamic model to investigate this relationship. Moreover, competition between foreign and domestic firms can also help explain some of the dynamics in ERPT (Dornbusch, 1987). Dornbusch (1987) also highlights some of the microeconomic fundamentals such as market structure, product substitutability and the relative number of foreign to domestic firms, as factors explaining the dynamics of ERPT. Pricing to market, or local currency pricing, can also be important both for market shares and ERPT dynamics.

Obstfeld and Rogoff (1996) use a framework of monopolistic competition and nominal prices to analyse ERPT. They examine the case where imports of intermediate goods have to undergo either further production or distribution before being consumed. This process of further production or distribution can mitigate ERPT. Campa and Goldberg (2002) and (Campa and Goldberg, 2005b) also focus on microeconomic variables to explain ERPT.

There are also macroeconomic reasons why ERPT displays dynamics. These include enhanced credibility attached to monetary policy (Taylor, 2000, McCarthy, 2007) and the role of the inflationary environment (Choudhri and Hakura, 2006).

There have been some studies looking at ERPT specifically for manufacturing prices (Athukorala and Menon, 1994b, Yang, 1997). Yang (1997) looks at the pass-through elasticities of various manufacturing industries. His analysis finds that the average short-run pass-through is about 0.32 and the average long-run pass-through is 0.42. Athukorala and Menon (1994b) find that for the Japanese manufacturing sector, a one percentage point change in Yen would result in a 0.67 per cent change in foreign currency export prices in the long run.

Several papers have tried to analyse empirically the impact of ERPT in a broader and more aggregated sense. Below is a brief summary of these studies. Burstein and Gopinath (2015) highlight some of the main findings for ERPT. They emphasise that ERPT into consumer price is lower than into border prices. Moreover, according to their study and literature survey, ERPT usually displays dynamics, is typically incomplete in the long run and varies considerably across countries. Moreover, they find that ERPT is lower for consumer prices than it is for border prices.

There have been other studies examining this relationship (Campa and Goldberg, 2002, Campa and Goldberg, 2005a, Choudhri et al., 2005, Faruqee, 2006, McCarthy, 2007, Taylor, 2000, Aleem and Lahiani, 2014). McCarthy (2007) uses a vector autoregression (VAR) methodology and incorporates distribution chain of pricing[19] to study ERPT for United States (US), Japan, Germany, France, United Kingdom, Belgium, the Netherland, Sweden and Switzerland. He finds that ERPT has a smaller effect on domestic inflation, but has a bigger impact on import prices. He also finds that ERPT is larger in countries with bigger import shares and more persistent exchange rates and import prices. For empirical purposes, this paper also follows the literature and uses distribution chain of pricing.

Kim (2003) uses a Vector error correction model (VECM) model to study the relationship between stock prices, industrial production, real exchange rate, interest rate and inflation in the US. His analysis reveals that stock prices, industrial production and inflation are the three variables in this relationship that adjust to error correct the disequilibrium.

[19] The idea of the distribution chain is that import prices affect producer prices which in turn affect consumer prices.

Choudhri et al. (2005) study the performance of various new open economy models in explaining ERPT for various prices. They compare the performance of these studies using a VAR methodology. Choudhri et al. (2005) find that the models based on local currency pricing are better able to predict the movements in domestics prices and wages when these models incorporate distribution costs for imports.

3 Theoretical Framework.

In this section, I build a model to look at how ERPT behaves in the presence of global production sharing. The model shows how slicing up the production process reduces ERPT - this is a direct result of intra-firm transactions[20] being partly shielded by exchange rate movements. The theoretical methodology is based on the model of Dornbusch (1987). The model built for ERPT under global production sharing is compared with a scenario where there is no global production sharing and products are only imported.

To analyse ERPT, we assume that there are two countries - home and foreign. There are *n* foreign firms that are involved in the export of final goods to the home country (which is the complete production of the good in the foreign country or non-network trade firms) and there are n* firms that are involved in global production sharing. The n* firms have their production processes located in both countries (headquarters in the home country and final assembly in the foreign country) and the final good produced by the n* companies is also imported into the home country. Examples of this are the car manufacturing industry in the US that has headquarters in the US and factories for assembly in Mexico like Ford (Sarmiento, 2012). Another example is Apple, with headquarters in the US and some production and assembly in China.

To analyse ERPT, I look at the Cournot-Nash equilibrium and derive price elasticity.

$$Q = a - bp \quad (1)$$

$$Q = nq + n^*q^* \quad (2)$$

[20] Intra-firm transections reflect relationship specific agreements within global production sharing.

$$\pi_i = pq_i - meq_i \quad (3)$$

$$\pi_i^* = pq_i^* - \gamma(m1 + m2e)q_i^{*21} . \quad (4)$$

Where Q is total output produced by n and n* firms, p is price, π_i *and* π_i^* are profits for foreign and global production sharing firms respectively, while q_i and q_i^* denote output by foreign and global production sharing firms respectively, m are costs that vary with level of output for the foreign firm and e is exchange rate. For network trade related firms, *m1* denotes costs that are denominated in headquarter country terms. This may include the marginal cost of production in the home country, the cost of borrowing capital both for home and foreign country plants (Satariano, November, 2013)[22], transportation costs, employees who are paid costs in terms of headquarter pricing, quality control, after sale service, professionals hired by headquarters with joint responsibility for home and foreign plants[23]; and other service costs that vary with production level and are denominated in headquarter country's currency. Next, *m2* is the cost of production and assembly of global production sharing firms in the foreign country and γ denotes the cost competiveness of global production sharing firms.

The way in which the process mentioned above captures ERPT within network trade is by creating an example of how a firm (n*) splits its production function across two countries. Where its production process in the foreign factory includes making parts and components. The example will show below (including with simulations) when parts and components costs captured by m2 increase as a proportion of total costs, ERPT falls.

Moreover, when firms allocate production factors based on comparative advantage of different countries they receive cost reductions. For instance, when labour intensive costs are shifted to labour abundant countries then there can be a substantial reduction is wage costs. This cost reduction is of efficient allocation of the factors of production

[21] This model can be extended to include multiple countries in the production sharing of global production sharing firms.
[22] To stimulate this thought following examples may be helpful, if Ford wants to set up a plant than it more likely to seek funding in the US financial markets rather to go to Mexico's financial markets, or if apple wants to set up a plant in Malaysia or China then it is more likely to get funding organized in the US.
[23] Examples of this may include Apple Hardware engineers who are based in the US but are jointly involved in monitoring projects in Asia's factories.

and production centres is captured by gamma (γ). The higher the cost competiveness of the network trade firms, the lower gamma (γ) is. Moreover, weak axiom of cost minimization (WACM) is used, (Varian, 1992, Varian and Repcheck, 2010, Mas-Colell et al., 1995), according to which Equation (5) holds. Combined, Equation (5) and WACM indicates that the choice of firm production process reveals cost minimization behaviour. In essence, if a firm undertakes network trade, then it must be because network trade yields a lower cost compared to producing in only one country.

$$\gamma(m1 + m2e) \leq \ me \tag{5}$$

Using Equation (2) and (3), I get (6).

$$\pi_i \ = \frac{(a - q_i - \sum q_j - n^* q_i^*)(q_i)}{b} + meq_i \tag{6}$$

Where i,j = 1,2,3,…,n; i≠j

Maximization of profit yields the following FOC:

$$q_i \ = \frac{a - n^* q_i^* - meb}{1+n} \tag{7}$$

Similarly, for global production sharing firms, profit is given by:

$$\pi_i^* \ = \frac{\left(a - q_i^* - \sum q_j^* - nq_i\right)(q_i^*)}{b} + (m1 + m2e)\ q_i^* \tag{8}$$

Taking FOC to get:

$$q_i^* \ = \frac{a - nq_i - \emptyset b}{1+n^*} \tag{9}$$

Where $\emptyset = \ \gamma(m1 + m2e)$

Equations (7) and (9) give us reaction functions respectively. Using the reactions functions to get:

$$q_i = \frac{a - meb}{1+n} - \ \frac{n^*\ (a - nq_i - \emptyset b)}{(1+n)(1+n^*)} \tag{8}$$

This can be simplified to get:

$$q_i = \frac{a - meb\ (1+n^*) + \emptyset bn^*}{(1+n+n^*)} \tag{9}$$

Similarly for $q_i{}^*$:

$$q_i = \frac{a - \emptyset b\ (1+n) + nmeb)}{(1+n+n^*)} \tag{10}$$

Deriving an equation for price using Equations (1), (9) and (10) to get:

$$p = \frac{\mathrm{a}}{\mathrm{b}} - \frac{\left\{\frac{n[\mathrm{a} - \mathrm{meb}(1+n^*) + \emptyset bn^*]}{\mathrm{N}} + \frac{n^*[\mathrm{a} - \emptyset b(1+n) + mebn]}{\mathrm{N}}\right\}}{b} \tag{11}$$

Where N = $1 + n + n^*$

Simplifying we get:

$$p = \frac{\mathrm{a}}{\mathrm{bN}} + \frac{[\gamma m1n^* + e(nm + \gamma n^*\mathrm{m2})]}{N} \tag{12}$$

The elasticity of equilibrium prices with respect to exchange rate is given by:

$$\frac{\partial p}{\partial e}\frac{e}{p} = \frac{[mn + \gamma m2n^*]e}{Np} \tag{13}$$

Where $n\ and\ n^*$ can be seen as a proxy for supply variables.

Next, I compare the elasticity of prices with respect to exchange rate in the simple case where the good is imported into the home country and is produced completely in the foreign country by foreign firms – i.e., there is no global production sharing. We assume $\tilde{n}$ for number of foreign firm, exporting to the home country. To make the analysis comparable it is assumed that $\tilde{n} = n + n^*$. The cost and profit functions are similar to exporting firms in the previous set up. For completeness, I reprint the equations below.

$$Q = a - bp \tag{14}$$

$$\pi'_i = pq'_i - meq'_i \tag{15}$$

Where subscript ‘ represents the scenario where there are only foreign firms exporting to the home country. Thus FOC w.r.t. to q'_i yields

$$q'^{*}_{i} = \frac{a-bem}{1+\tilde{n}} \tag{16}$$

Substituting into Equation (14) and rearranging gives:

$$p = \frac{\mathrm{a}}{\mathrm{b}} - \frac{\tilde{n}a}{b(\tilde{n}+1)} + \frac{\tilde{n}bem}{b(\tilde{n}+1)} \tag{17}$$

Price elasticity w.r.t to e gives

$$\frac{\widetilde{\partial p\, e}}{\partial e\, p} = \frac{(m\tilde{n})e}{(\tilde{n}+1)p} \tag{18}$$

Where $\frac{\widetilde{\partial p\, e}}{\partial e\, p}$ is the elasticity of prices with respect to the exchange rate in the scenario where the good is imported into the home country completely produced by foreign firms. It can be shown that price elasticity with respect to exchange rate is smaller under global production sharing than the case where the good is completely imported into home country, or in other words, Equation (18) is less than Equation (13) for the same values of *e* and *p*.

Proof:

I prove by contradiction. For the same values of e and p, if Equations (18) > (13) then:

$$\frac{[mn+\gamma m2n^{*}]}{N} > \frac{(m\tilde{n})}{(\tilde{n}+1)}$$

Plugging in $\tilde{n} = n + n^{*}$ and $\mathrm{N} = 1 + n + n^{*}$ gives

$$\frac{[mn+\gamma m2n^{*}]}{1+n+n^{*}} > \frac{m(n+n^{*})}{(n+n^{*}+1)}$$

Next, simplifying and rearranging gives:

$$\frac{\gamma m2n^{*}}{1+n+n^{*}} > \frac{mn+mn^{*}-mn}{(n+n^{*}+1)}$$

This means that

$$\frac{\gamma m2n^{*}}{1+n+n^{*}} > \frac{mn^{*}}{(n+n^{*}+1)}$$

is a contradiction as m2 < m and $0 < \gamma < 1$.

Hence, this proves that $\frac{\partial \widetilde{p\,e}}{\partial e\, p} > \frac{\partial p\, e}{\partial e\, p}$ - that is ERPT is mitigated under global production sharing.

Based on the model above and previous ERPT models (Blanchard and Quah, 1988, McCarthy, 2000, Dornbusch, 1987) and adjusting for global production sharing (Athukorala, 2014) we can see that import price elasticities depend on Equation (2.1)

$$\mathrm{p}_i = f\left(S, D, e, \mathrm{p}_p\, \mathrm{p}_c\, \mathrm{p}_w\right)$$

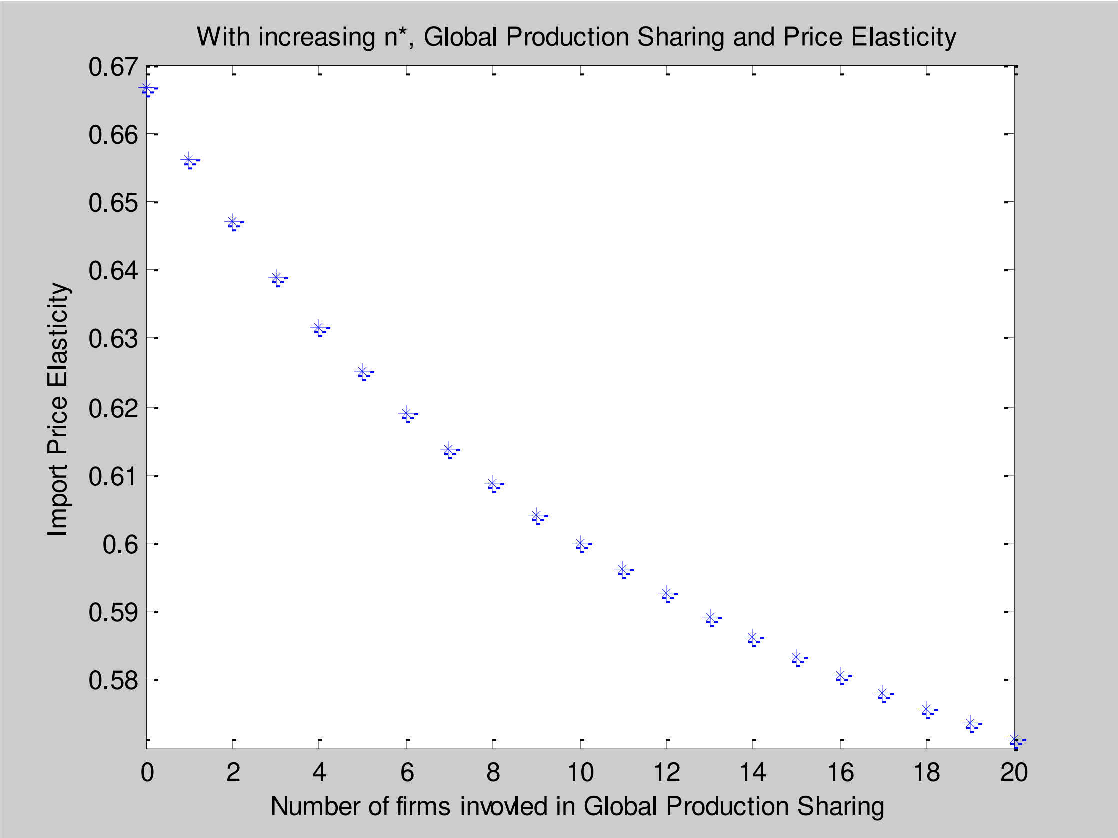
Where p_i is import prices , S is used to capture supply shock, D is demand shock, e is trade weighted exchange rate, $\mathrm{p}_p, \mathrm{p}_c$, p_w are domestic producer prices, consumer prices and trade wieghted world manufacturing producer prices, respectively.

4 Simulation

In this section, I simulate the model developed in Section 3 to show how an increase in global production sharing can reduce the extent of ERPT. I do this by altering three aspects in the model presented above. First, I increase the number of firms involved in global production sharing, while holding firms not involved in network trade constant. Secondly, I increase the share of output for firms involved in global production sharing by making them more competitive (reducing γ). In both cases, the simulation shows how ERPT decreases as the extent of global production sharing increases. Lastly, I show how increasing the proportion of headquarter cost reduces ERPT.

I start the analysis by simulating the case where the number of global production sharing firms varies between 0 and 20, while holding the number of the other firms fixed. As the number of firms involved in global production sharing increases, the ERPT drops as illustrated by the price elasticity to exchange rate in Figure 4.1.

Figure 4.1 Simulation 1



Data does not exist for global production sharing firms to calibrate most of the values of the model in section 2. As such we use a set of sensible values for the above simulation (Table 3.1). The value of n* is varied between 0 and 20. Changing the values of Table 4.1 does not qualitatively change the results of our analysis.

Table 4.1 Calibration Variables

Variable name	Value
A	500
B	2
E	1
N	10
M	50
γ	1

Secondly, we increase the share of global production sharing output by making the firms more competitive. We do this by varying γ between 0 and 1. n* is fixed at 10, while other values remain the same as in Table 4.1. The lower the value of γ the more competitive the firms are under global production sharing. As the firms involved in global production sharing become more cost competitive, their share of output rises and ERPT falls (figures 4.2 and 4.3).

Figure 4.2 Simulation 2

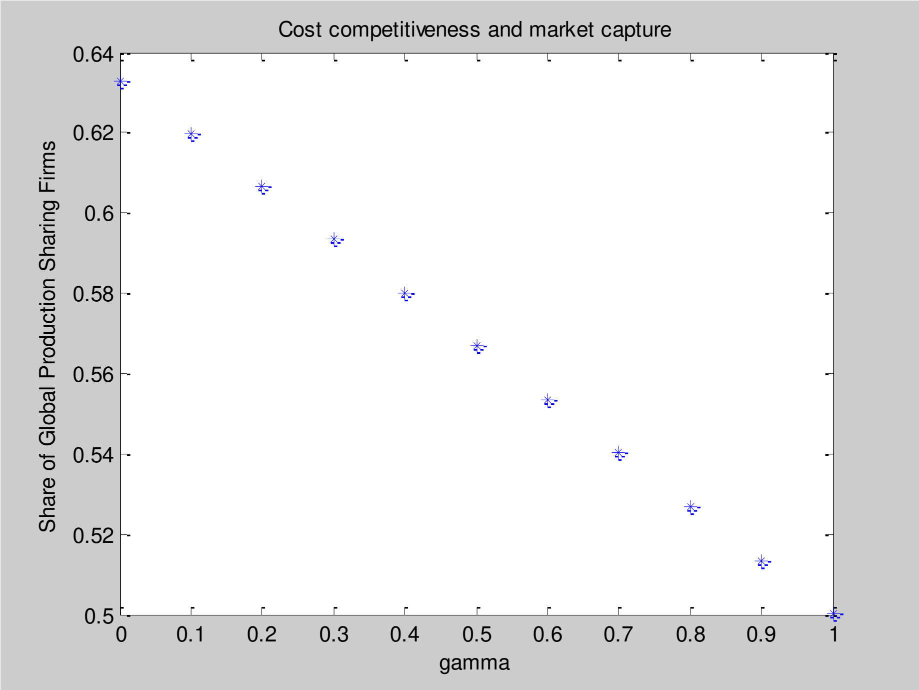
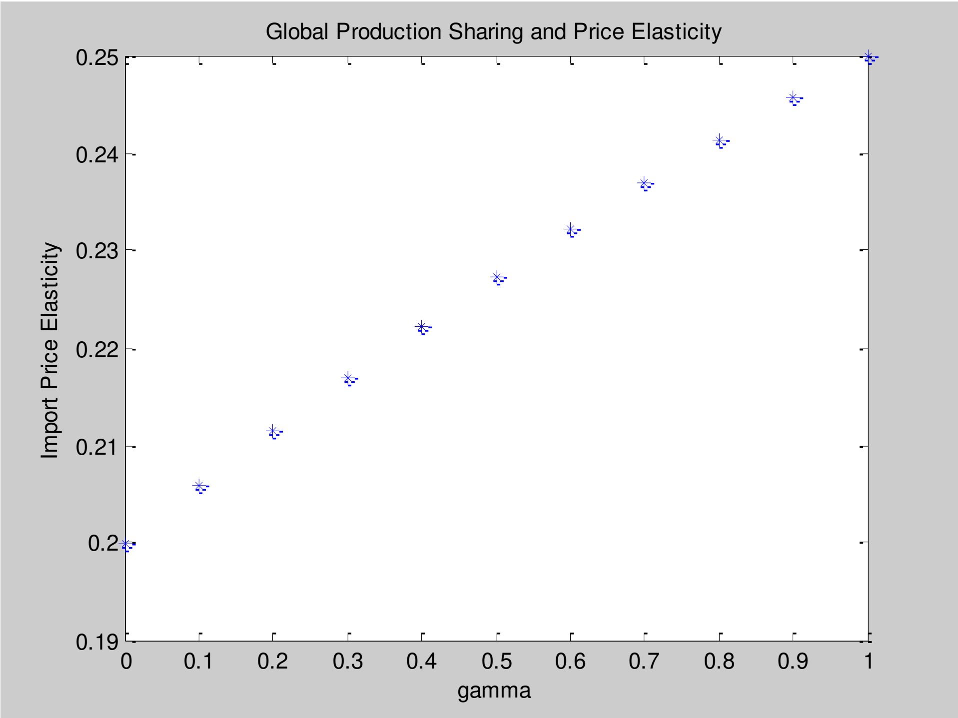
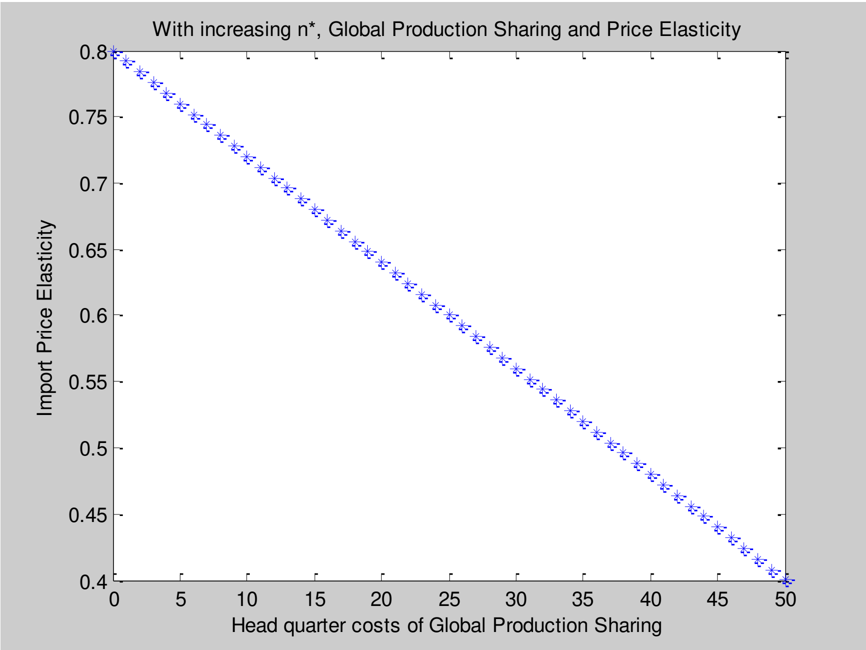


Figure 4.3 Simulation 3



Furthermore, in the model above, if we increase the proportion of headquarter costs for global production sharing firms then ERPT also falls (figure 4.4). As the proportion of the headquarter costs of these global production sharing firms rise, ERPT displays a steady decline. In order to vary costs denominated in headquarter costs, I vary m1 between 0 and 50. n* is fixed at 10, while other values remain the same as table 4.1.

Figure 4.4 Simulation 4



The above analysis shows various ways in which ERPT can be mitigated under global production sharing. In fact, Figures 4.1 – 4.3 show how increasing the extent of global production sharing will always lower ERPT.

The next section shows empirically that ERPT is indeed lower under global production sharing. As mentioned before, that while data does not exist on the marginal costs of firms involved in global production sharing, headquarter costs, the number of firms involved in global production sharing, we can still look at product categories that are involved in global production sharing and their respective prices to look at the extent of ERPT.

5 Empirical Methodology

To estimate the sensitivity of prices to the exchange rate, Equation (5.1) is estimated. Where $\Delta \mathrm{p}_t$ is the change in prices, Δe_{t-k} is the change in exchange rate and X_t is a vector of control variables that includes the output gap of GDP to capture demand in the economy, output gap of industrial activity to capture supply, percentage change in manufacturing prices, percentage changes in producer prices, consumer prices, trade weighted world manufacturing prices and dummies to capture recessions during the sample period.

$$\Delta \mathrm{p}_t = \acute{\alpha}_i + \sum_{k=0}^{T} \acute{\beta}_k \, \Delta e_{t-k} + \mu_t X_t + \acute{\varepsilon}_t \qquad (5.1)$$

I employ a VAR modelling framework[24] to analyse the relationship in Equation 5.1. The VAR framework has several important advantages over other methodologies. For one, it can be used to analyse both the short-term and long-term impacts of ERPT. Moreover, it can account for the simultaneity of variables. There have been several studies that have used either a VAR or VECM methodology to study ERPT (An and Wang, 2012, Choudhri et al., 2005, Faruqee, 2006, Kim, 2003, McCarthy, 2007, Burstein and Gopinath, 2013, Choudhri and Hakura, 2015). A significant number of the papers use the distribution chain within the framework of a VAR (Clark, 1999, McCarthy, 2007). The idea of the distribution chain is that import prices affect producer prices, which in turn affect consumer prices. For empirical purposes, I also follow this literature and use distribution chain of pricing.

The VAR system is given in Equation 5.2. Δp_t is change in manufacturing import prices , S is used to capture supply using the output gap of US industrial activity, *D* is output gap of real GDP[25], Δe is percentage change in exchange rate, ΔP_{p} is the inflation of domestic manufacturing producer prices, $\Delta \mathrm{P_c}$ inflation in consumer prices, ΔPw is inflation of

[24] McCarthy, J. 2000. Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies. *FRB of New York Staff Report*. proposed a VAR methodology to investigate ERPT

[25] Output gaps are tested using Hodrick-Prescott filter, robustness tests also use trend and quadratic measures to create output gaps.

trade weighted world manufacturing producer prices[26], $d_{\_rec}$ dummy for recessions in the US economy during the sample period and $\varepsilon_{i,t}$ is the error term. Where *i* subscript stands for total manufacturing import prices, *t* is subscript stands for time. For identification, a Cholesky decomposition is used in this study. The Cholesky decomposition assumes pricing along a distribution chain (McCarthy, 2007) (as discussed above). The order of the prices variables is: inflation in manufacturing import prices, inflation manufacturing producer prices, inflation in consumer prices. The results remain robust to changing the order of the variables[27]. The rest of the order of the variables is given in Equation 5.2

Impulse response functions (Enders, 2008) are generated from the above VAR system examine the response of import prices. The shock is based on a one standard deviation (depreciation) shock to the exchange rate.

$$\Delta \mathrm{p}_{i,t} = \alpha_i + \sum_{k=0}^{T} \beta_{n,k,1} \Delta S_{,t-k} + \sum_{k=0}^{T} \beta_{n,k,2} \Delta D_{,t-k} + \sum_{k=0}^{T} \beta_{n,k,3} \Delta e_{i,t-k} + \sum_{k=0}^{T} \beta_{n,k,4} \Delta P_{i,t-k} + \sum_{k=0}^{T} \beta_{n,k,5} \Delta P_{p,t-k} + \sum_{k=0}^{T} \beta_{n,k,6} \Delta P_{c,t-k} + \sum_{k=0}^{T} \beta_{l,n,k,7} \Delta P_{w,t-k} + \beta_{n1} d\_rec + \varepsilon_{i,t} \qquad (5.2)$$

Table 5.1 Variable Definitions

Variable	Definition
ΔP_i	Percentage change in total manufacturing import prices
S	Supply side – output gap of industrial activity is used to capture supply side variations.
D	Demand side – output gap of US GDP is used to capture demand side variations.
Δe_i	Percentage change in trade-weighted exchange rate
ΔP_p	Inflation in manufacturing producer prices
ΔP_c	Inflation in consumer prices
ΔP_w	Inflation in trade-weighted world manufacturing producer prices

[26] World manufacturing prices can be important for network trade. Removing the variable for world manufacturing prices does not change this paper's results qualitatively.

[27] It is not clear whether the trade weighted world manufacturing producer prices should be put towards the start of the order or the end. However, the main results remain robust regardless to the ordering of the variable

d_rec	Dummy for recessions in the global and the US economies during the sample period
$\varepsilon_{i,t}$	Idiosyncratic error term.

Notes: Where i subscript stands for total manufacturing import prices, t is subscript stands for time.

To study at ERPT for parts and components imports, the above VAR specification is modified by replacing inflation in manufacturing import prices, with the following rotating variables for manufacturing import prices for goods with high composition of parts and components content (HC), import prices with medium composition of parts and components content (MC) and import prices with of goods with low composition of parts and components content (LC) (Equation 5.3).

$$\Delta p_{l,t} = \alpha_i + \sum_{k=0}^{T} \beta_{l,n,k,1}\, \Delta S_{,t-k} + \sum_{k=0}^{T} \beta_{l,n,k,2}\, \Delta D_{,t-k} + \sum_{k=0}^{T} \beta_{l,n,k,3}\, \Delta e_{l,t-k} + \sum_{k=0}^{T} \beta_{l,n,k,4}\, \Delta P_{l,t-k} + \sum_{k=0}^{T} \beta_{l,n,k,5}\, \Delta P_{p,t-k} + \sum_{k=0}^{T} \beta_{l,n,k,6}\, \Delta P_{c,t-k} + \sum_{k=0}^{T} \beta_{l,n,k,7}\, \Delta P_{w,t-k} + \beta_8 d_{rec} + \varepsilon_{l,t} \qquad (5.3)$$

Where l = HC, MC and LC. The following paragraphs explain the remaining variables. The output gap from the manufacturing activity index for the US captures supply. For robustness, I also try using the output gap from the rest of the world's manufacturing activity – based on US's trade partners. Capturing supply side shock from trade partners can be particularly important for parts and components trade where global production sharing plays an important role. Variables like oil price inflation and federal funds (FF) rate are also added as robustness checks.

I use the output gap from the real GDP to capture demand side shocks. The output gap is constructed using the HP filter, but we also use linear and a quadratic trend estimate for robustness tests.

Various specifications using different numbers of lags are tested to check for robustness. The Likelihood ratio (LR) test, Akaike's Information Criterion (AIC) and Final Prediction Error (FPE) all favour 12 lags, while the Schwarz criterion (SC) favours 2. This paper favours 12 lags. However, we also test with 2 lags, based on SC, to look for robustness. The paper finds that the results remain robust.

6 Data

Data for this study is in monthly frequency and covers the period from December 1996 to January 2014, giving a total of 206 observations. Variable names and data sources are given in Table 6.1. All the variables involving indices were converted so that 2005 January is equal to 100. The rest of this section gives details of the variables and their sources[28].

Table 6.1 Variable Sources

Variable	Source and definition
p_p	Producer Price Index (PPI) -excludes food and energy prices; Bureau of Labour Statistics
p_c	Consumer Price Index (CPI) -excludes food and energy prices; Bureau of Labour Statistics
FF	Federal funds effective rate - Federal Reserve
e	Trade weighed exchange rate - Federal Reserve
S	Manufacturing index - output gap is constructed using HP Filter; Bureau of Labour Statistics
D	Gross Domestic Product - output gap is constructed using HP Filter; Bureau of Economic Analysis
Trade weights	Comtrade database
Total Manufacturing prices	Import Prices for total manufacturing; Bureau of Labour Statistics
HC	Import prices with high content of network trade; Bureau of Labour Statistics
MC	Import prices with medium content of network trade; Bureau of Labour Statistics
LC	Import prices with low content of network trade; Bureau of Labour Statistics

Consumer Price Index (CPI) excludes food and energy prices and is extracted from Bureau of Labour Statistics (BLS). Food and energy prices are excluded as the pass-through behaviour for these two categories differs from other products (Faruqee, 2006).

Parts and components are delineated from the reported trade data using a list compiled by mapping parts and components in the UN Broad Economic Classification (BEC) with the Standard International Trade Classification (SITC) at the five-digit level of commodity

[28] Data on price changes, output gaps, federal funds rate and exchange rate changes are all stationary according Dicky Fuller and Phillip Person unit root tests.

disaggregation. The product list of the Word Trade Organization (WTO) Information. Technology Agreement Information was used to fill gaps in the BEC list of parts and components. [29] The data on import prices are compiled from the Bureau of Labour Statistics [30](BLS) database. Four separate Import price indices[31] are constructed by applying import trade weights at the four-digit level of the Harmonised System (HS)[32]. The first category is total manufactured goods. The second price category includes low composition (LC) of parts and components in the price indices, comprising 0 to 50 per cent of parts and components traded in the categories. This category is a proxy for final goods prices. The third category has medium composition (MC) share of parts and components in the price indices, containing price indices with 51 to 95 per cent of parts and components in the categories. Lastly, price indices involving more than 95 per cent composition of parts and components are called high composition (HC).

The real gross domestic product is taken from the Bureau of Economic Analysis (BEA). This variable is available quarterly, so I interpolated[33] the data into monthly frequency. The manufacturing index, which was used to measure manufacturing activity in the US, was taken from BLS. Output gaps are constructed using Hodrick–Prescott filter. Following literature (Faruqee, 2006, McCarthy, 2000) and to remove nonlinearities, log of output gaps are used. Moreover, the output gap from the manufacturing indices for partner countries is included to capture overseas supply– which can be important for global production sharing. The overseas manufacturing index includes the same countries that are used to calculate the trade-weighted exchange rate[34].

The exchange rate series is constructed using the trade-weighted US bilateral exchange rates with Singapore, Thailand, United Kingdom, Malaysia, South Korea, Mexico, Japan,

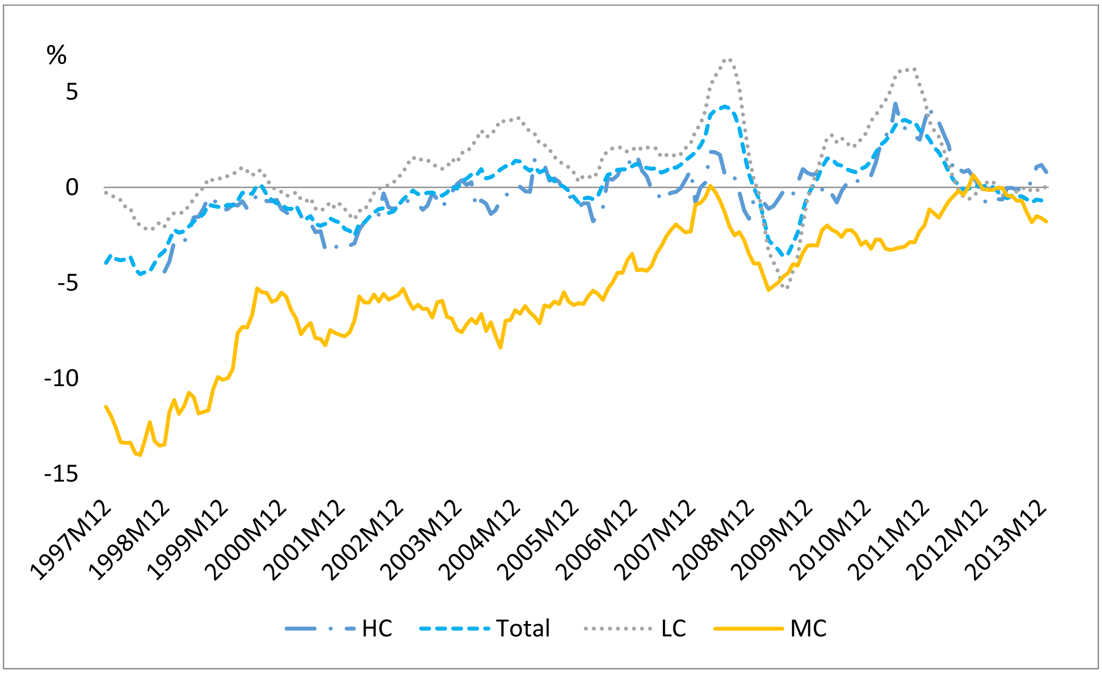
[29] The details for separating network trade from the published trade data see are given in Athukorala (2014). List of price categories is given in appendix A. The complete dataset is available on request.
[30] http://www.bls.gov/
[31] Ideally, for network trade, we would like to have just two import price indices, one for final goods prices and one for network trade prices. But this is not possible became the BLS price indices for some 4-digit HS categories cover both network trade goods and final goods.
[32] 2005 as a base year.
[33] Linear interpolation was done using the time variable and the stata ipolate command.
[34] We create two series of overseas manufacturing index. One index includes China and the other excludes China. However, the main results exclude China, as its inclusion reduces the sample size. The results of this paper remain robust whether we involve china or not.

Canada and Euro Area[35]. The import trade weights used for the construction of the four export price indices and exchange rate series were computed from the US manufacturing imports data extracted from the UN Comtrade World Integrated Trade Solutions database[36]. For prices, inflation rates (percentage changes of the indices) is used as variables in the estimation equation (Faruqee, 2006)

6.1 First Look at the Data

Import Price inflation of various manufacturing categories is depicted in figure 6.1. Total, HC[37] and LC content categories show a degree of co-movement. The standout category is MC, which shows substantial disinflation. The reason for this is that the MC category includes around 87 per cent of IT and communications sub-components. The IT and communications technology sectors have seen substantial productivity growth over the sample of this study and as such have seen significant disinflation.

Figure 6.1 Monthly Changes Manufacturing Import Prices



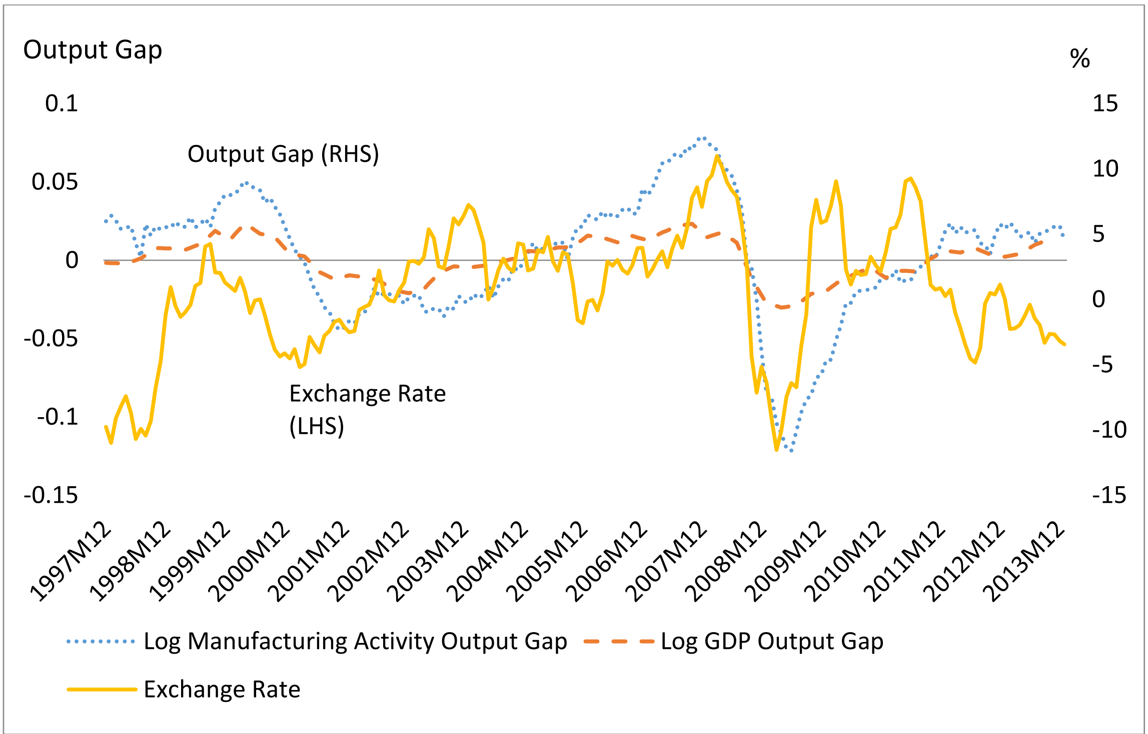
[35] As china is excluded from the overseas manufacturing index due to data limitations, the Renminbi is not made part of the real exchange rate index - to keep consistency between the lists of countries for exchange rate index and overseas manufacturing index. The results remain robust if we include the Renminbi in the exchange rate index.

[36] https://wits.worldbank.org/WITS/WITS/Restricted/Login.aspx

[37] HC category data is only available from Dec 1998 onwards.

Figure 6.2 shows the percentage change in the trade-weighted exchange rate and the output gaps of log industrial activity and log GDP. From the graph, we can see that industrial activity has a higher tendency to overshoot the GDP. Moreover, the decline in output during the Dot-Com bubble of 2001 and the global financial crises of 2007-8 recessions are clearly visible in the graph. The graph also shows that there is volatility in the trade-weighted exchange rate.

Figure 6.2 Exchange Rate and Output Gaps



Movements of the federal funds rate and annual CPI and Producer Price Index (PPI) inflation are shown in Figure 6.3. We can see that annual PPI inflation is more volatile compared to CPI inflation. Moreover, the graph shows that the federal funds rate responds to changes in consumer prices. Another interesting feature of this graph is that the federal funds rate has been close to the zero since the global financial crises. Table 6.2 gives summary statistics.

Figure 6.3 CPI, PPI and Federal Funds Rate

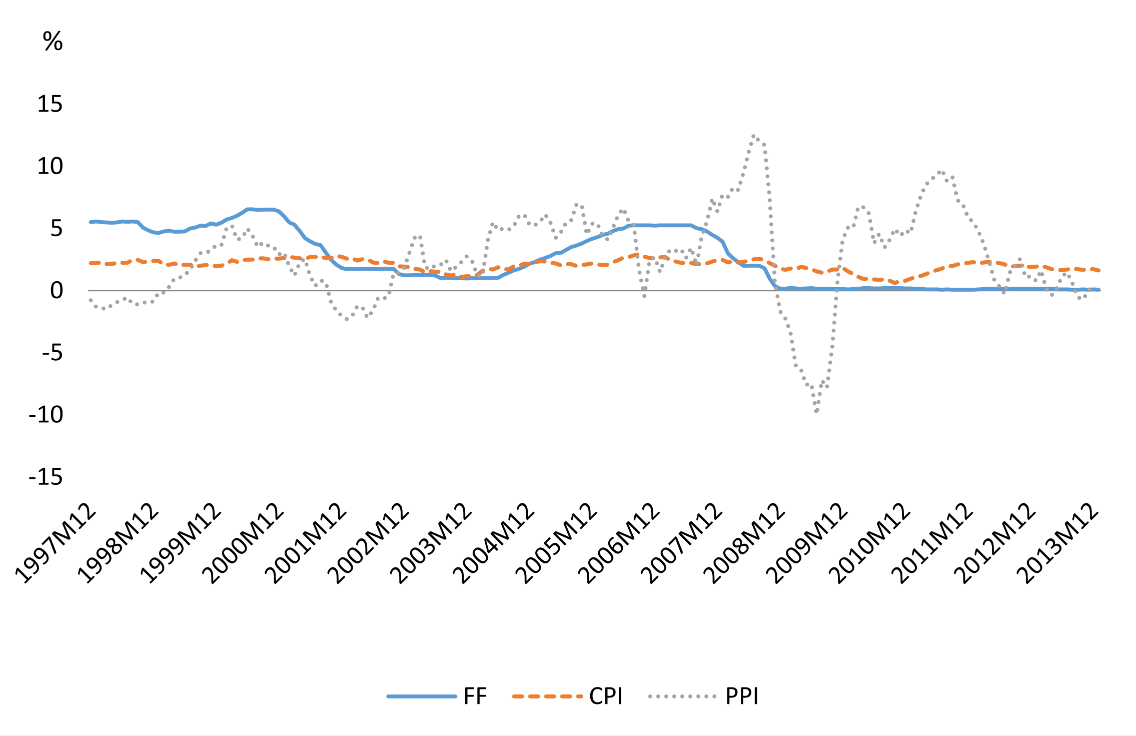


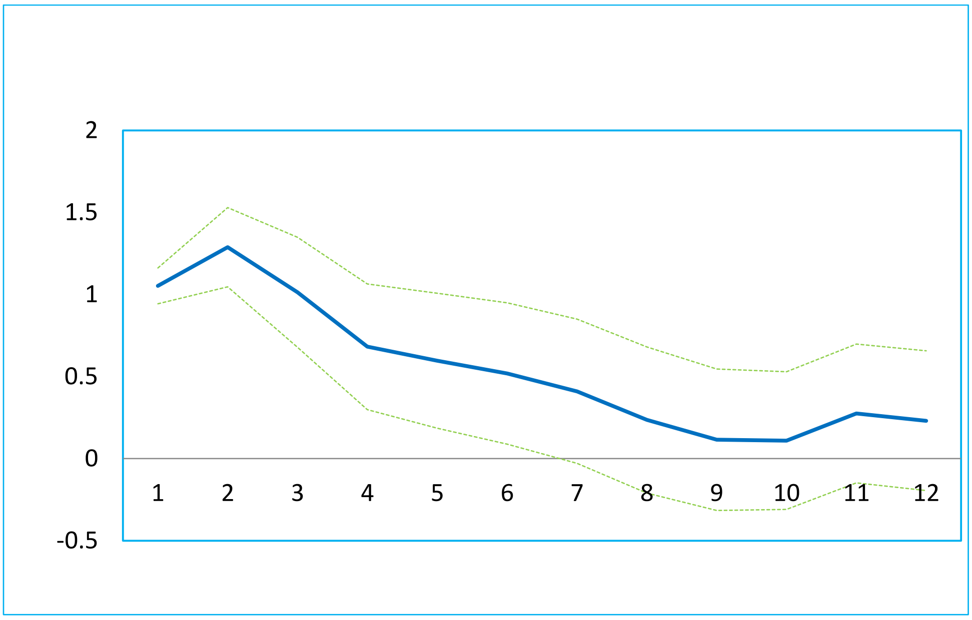
Table 6.2 Summary Statistics

Variable	Observations	Mean	Standard Deviation	Min	Max
Log output gap Manufacturing	204	.002	0.04	-0.12	0.08
Log output gap GDP	201	.0007	0.01	-0.03	0.02
Trade weighted exchange rate (percentage change)	204	0.36	4.81	-11.52	10.99
Inflation CPI	204	2.05	0.48	0.61	2.93
Inflation PPI	203	2.59	3.69	-9.97	12.55
Inflation Manufacturing prices	194	-0.14	1.87	-4.54	4.24
Inflation of Parts and Components prices (High Composition)	182	-0.22	1.51	-4.41	4.39
Inflation Medium Composition prices	204	-5.55	3.59	-14.02	0.65
Inflation Final goods prices (Low Composition)	194	1.03	2.26	-5.32	6.74

7 Empirical Results

This section looks at pass-through. I start by analysing the exchange rate shock[38] dynamics. Figure 7.1 shows that a typical shock of exchange rate to itself causes the exchange rate to peak in two months' time with a magnitude of about 1.2 units and then gradually decline. The shock lasts for about 7 months.

Figure 7.1 Response of Exchange Rate Shock to Itself



7.1 Response to exchange rate shocks

Figure 7.2 shows the response of various border prices to an exchange rate shock. The solid line in each graph shows the estimated response to the exchange rate shock, while the dashed lines give the confidence interval at the 95th percentile.

As shown in figure 7.2A, after a one standard deviation shock (depreciation) in the exchange rate, the import prices of total manufactured goods increase immediately and peaks in around 8 months. The effect lasts 11 months. However, the ERPT is incomplete, as the response of the import prices is far less than that of the exchange rate to itself. Moreover, ERPT to import prices of manufacturing final goods or low content of global production sharing (LC) prices is also immediate, with the effect being higher than for total manufacturing goods and lasting ten months. This is consistent with the theory

[38] Shock is measured using one standard deviation based on impulse response functions.

which predicts that prices for final goods will be more sensitive to exchange rate movements.

As hypothesised, ERPT to import prices of traded goods with medium and high composition of parts and components trade (categories with more than 50 percent of network trade) items is statistically and economically insignificant (Figure 7.2 E and F). An exchange rate shock of one standard deviation does not cause import price inflation in these categories for even a single month, demonstrating that import prices for network trade are largely sheltered from exchange rate movements. These results confirm this study's hypothesis that the exchange rate fluctuations are unlikely to have a major impact on prices for network trade related goods. This partly reflects that most of the network trade is relationship specific, including intra-firm trade (Chen et al., 2005, Bridgman, 2012, Helpman, 2011, Hummels et al., 2001) and hence sheltered from exchange rate movements.

These results are also consistent with the recent study on the implications of global production sharing for the measurement of trade price elasticities (Athukorala and Khan, 2016), which show that imports of parts and components are insensitive to relative price changes.

Figure 7.2 Panels A to D show exchange rate pass-through, exhibiting how import prices respond to exchange rate shocks.

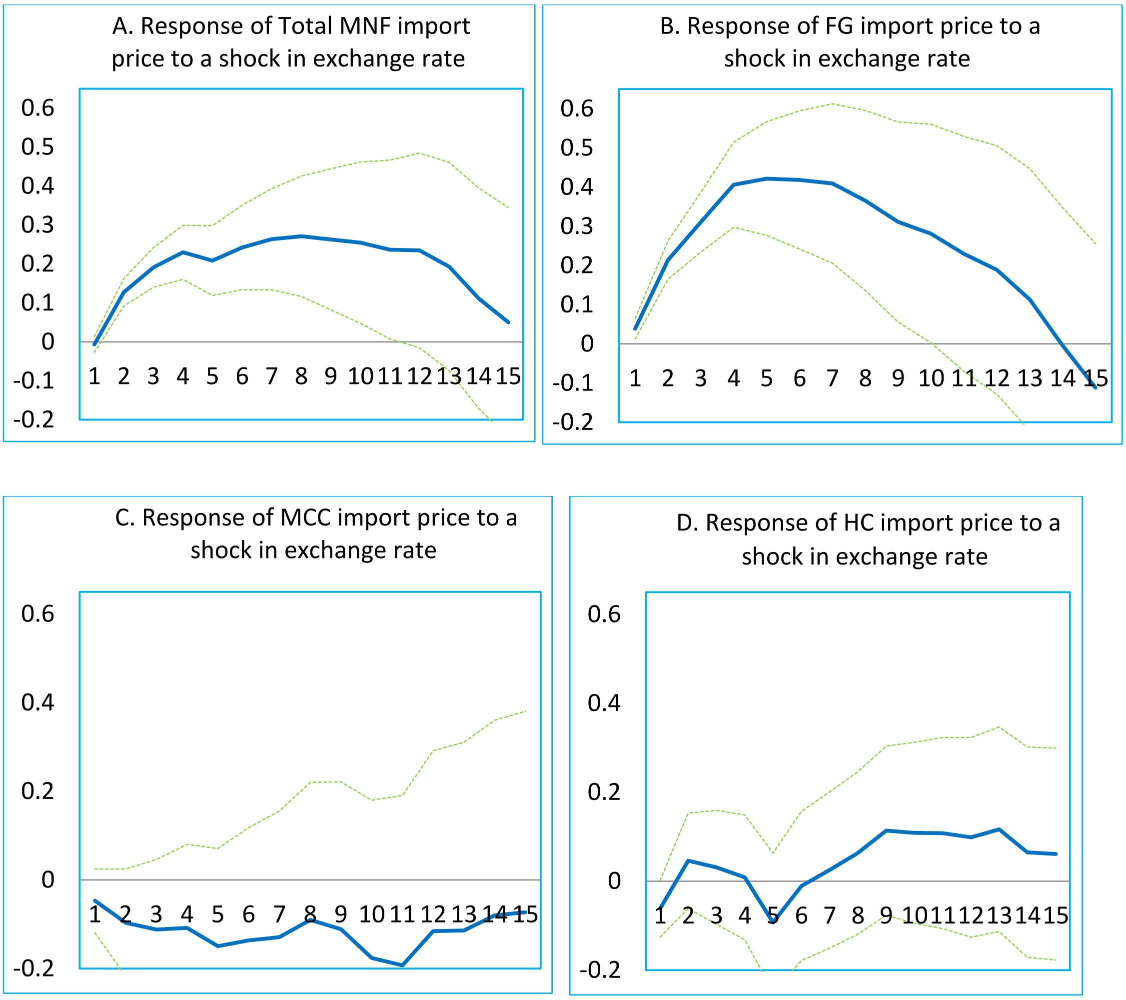


Table 7.1 Impulse Responses

Variable	Percentage of parts and components composition	t=1	t=6	t=12	t=15	Periods for which the impact stays significant	Maximum response to exchange rate shock.
Total manufacturing import prices	0 to 100%	-0.00	0.24***	0.23***	-0.05	11	0.27
Final goods manufacturing import prices	0 to 50%	0.04***	0.42***	0.19	-0.11	10	0.42
MC manufacturing import prices	51 to 95%	-0.02	-0.05	0.05	0.04	0	0.00
HC manufacturing import prices	95 to 100%	-0.06	-0.01	0.10	0.06	0	0.00

* p<0.05, ** p<0.01, *** p<0.001

8 Robustness

In this section[39], sensitivity analysis is undertaken to determine whether the results are sensitive to the inclusion/exclusion of various variables and different lag length specifications. The first sensitivity analysis is to examine whether the results hold with different lag length specifications. As mentioned previously, SBC chooses 2 lags while AIC, FPE and LR tests choose 12 lags. The results with 2 lags remain robust. Import prices with a high content of parts and components trade items exhibit much lower ERPT compared to import prices of manufacturing final goods – the same as with the case of 12 lags.

Several pass-through papers include variables to capture domestic monetary policy (An and Wang, 2012, Clark, 1999). Given this, federal funds rate is included to see if it affects the results. Another sensitivity analysis is to determine if including trade-weighted manufacturing activity of partner countries[40] makes a difference. This may be important in the context of global production sharing, where production networks span various

[39] Results from this section could be produced on request.

[40] Because of lack of data, china is excluded from this measure. China can be included in this estimate, though the total number of observations will decrease. Since the results of this paper do not change much with the inclusion/exclusion of supply variables, it is unlikely that the results will change with the inclusion of China with fewer time series observations.

countries and this variable can be an important source of supply. The results remain robust to the inclusion of these variables.

These results are also tested to see if they are sensitive to the exclusion of various relevant variables. The covariates are stripped to a baseline estimation where the supply and demand base variables are dropped. The results remain robust to these tests as well, with the ERPT higher for final goods and significantly lower for parts and components.

9 Conclusion

This paper examines the implications of global production sharing for ERPT. A theoretical model is developed showing how ERPT is lower in the presence of global production sharing. Simulating the model with various scenarios adds to this evidence. Finally, empirical analysis confirms this hypothesis using a novel and detailed dataset based on the US.

In particular, the results of this paper indicate that the degree of ERPT to final goods prices is substantially larger compared to parts and components trade prices. This is in line with the hypothesis that as GPN trade is dominated by relationship-specific transactions (including intra-firm trade), network trade is likely to be sheltered from exchange rate movements.

These results have several policy implications. Firstly, since parts and components import prices are shown to be not as responsive to exchange rate movements, trade flows pertaining to parts and components goods are also less likely to be sensitive to exchange rate movements. An important policy implication of these results, is that countries that are prone to Dutch disease (i.e. Australia) may be better off focusing on GPN trade to allow for a vibrant manufacturing sector. Further, these findings also have important implications for the use of pass-through estimates, for total trade flows, in analysing the transmission of exchange rate shocks in the context where global production sharing has become prominent. These results are likely to have greater implications for countries and regions that have a high presence of global production sharing.

Appendix A

List of components in various import price categories.

Good with low composition of parts and components or final goods	Good with medium composition of parts and components	Goods with high composition of parts and components or network trade items
30	8409	8473
38	8413	8411
39	8471	8481
40	8501	8536
48	8517	8541
61	8525	8542
62		8708
63		
64		
69		
70		
72		
76		
83		
8516		
8527		
8703		
90		
91		
94		
95		
96		

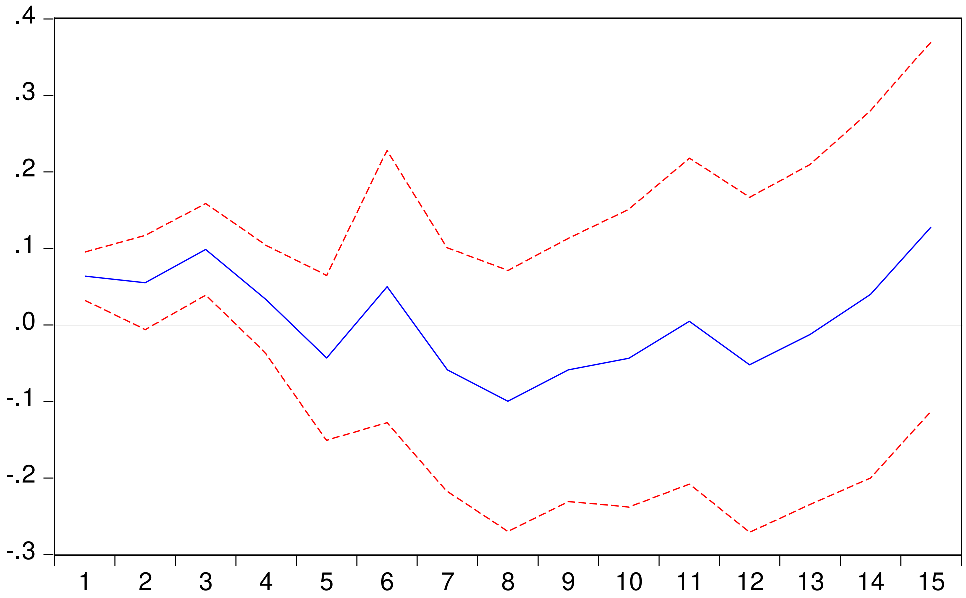
Source: Using Harmonized System of import price indexes from the BLS

Note: Several price categories contained no part and components lists in them, as such 2 digit codes could be safely used for the low content network trade classification. For the medium and high content of parts and components trade we had to rely on 4 digit Harmonized System.

Appendix B Robustness test

Results shows that the impact of exchange rate on HC import prices is almost always insignificant (based on a sample of only pre-GFC observations.)

Response of HC import price to exchange rate shock



Appendix C VAR results for high content of parts and components

Vector Autoregression Estimates
Date: 11/06/16 Time: 19:40
Sample (adjusted): 1999M12 2013M10
Included observations: 167 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LMAN_SA_HP	LGDP_HP	PERCCENT_ER_TWI_A	INFLATION_TOTALPCPI_A	INFLATION_MNF_PPI_A	INFLATION_CPI_A	INFLATION_WP_A
LMAN_SA_HP(-1)	0.646730	-0.022287	16.77593	8.694905	0.680429	3.420862	-4.120614
	(0.10978)	(0.02369)	(22.5910)	(9.29207)	(17.4833)	(1.97060)	(5.48235)
	[5.89090]	[-0.94097]	[0.74259]	[0.93573]	[0.03892]	[1.73595]	[-0.75162]
LMAN_SA_HP(-2)	0.432940	0.024036	18.83767	-9.560685	46.23985	1.179830	14.07515
	(0.13633)	(0.02941)	(28.0540)	(11.5391)	(21.7111)	(2.44713)	(6.80809)
	[3.17561]	[0.81718]	[0.67148]	[-0.82855]	[2.12978]	[0.48213]	[2.06742]
LMAN_SA_HP(-3)	-0.023890	0.078790	3.741452	20.74627	-50.03450	-1.168124	-17.96183
	(0.14312)	(0.03088)	(29.4510)	(12.1137)	(22.7923)	(2.56899)	(7.14712)
	[-0.16692]	[2.55168]	[0.12704]	[1.71263]	[-2.19524]	[-0.45470]	[-2.51316]
LMAN_SA_HP(-4)	-0.193359	-0.051281	6.990854	-12.58849	2.011511	-3.916838	1.433946
	(0.15774)	(0.03403)	(32.4594)	(13.3511)	(25.1205)	(2.83141)	(7.87720)
	[-1.22579]	[-1.50684]	[0.21537]	[-0.94288]	[0.08007]	[-1.38335]	[0.18204]
LMAN_SA_HP(-5)	-0.099850	-0.043005	-4.860429	0.579418	64.97700	1.981574	17.54541
	(0.15936)	(0.03438)	(32.7921)	(13.4880)	(25.3780)	(2.86043)	(7.95793)
	[-0.62657]	[-1.25085]	[-0.14822]	[0.04296]	[2.56037]	[0.69275]	[2.20477]
LMAN_SA_HP(-6)	0.122026	0.011882	38.39100	8.004121	-2.681877	-0.054759	1.091445
	(0.15644)	(0.03375)	(32.1915)	(13.2409)	(24.9132)	(2.80805)	(7.81219)
	[0.78002]	[0.35204]	[1.19258]	[0.60450]	[-0.10765]	[-0.01950]	[0.13971]

LMAN_SA_HP(-7)	-0.249310	0.020042	-38.11528	2.181303	-10.04699	1.905534	-5.585824
	(0.15026)	(0.03242)	(30.9204)	(12.7181)	(23.9294)	(2.69716)	(7.50371)
	[-1.65916]	[0.61823]	[-1.23269]	[0.17151]	[-0.41986]	[0.70650]	[-0.74441]
LMAN_SA_HP(-8)	0.183400	-0.026180	-22.70087	4.925897	-47.34345	-1.943029	-19.37104
	(0.14706)	(0.03173)	(30.2612)	(12.4469)	(23.4193)	(2.63966)	(7.34373)
	[1.24712]	[-0.82517]	[-0.75017]	[0.39575]	[-2.02156]	[-0.73609]	[-2.63777]
LMAN_SA_HP(-9)	0.152503	0.030904	28.03593	-3.230906	0.036953	-0.354157	7.243464
	(0.15129)	(0.03264)	(31.1313)	(12.8049)	(24.0927)	(2.71556)	(7.55490)
	[1.00803]	[0.94684]	[0.90057]	[-0.25232]	[0.00153]	[-0.13042]	[0.95878]
LMAN_SA_HP(-10)	-0.077634	0.010314	-6.949165	-3.090102	9.815565	1.803221	-1.178237
	(0.15000)	(0.03236)	(30.8658)	(12.6956)	(23.8872)	(2.69240)	(7.49046)
	[-0.51757]	[0.31872]	[-0.22514]	[-0.24340]	[0.41091]	[0.66974]	[-0.15730]
LMAN_SA_HP(-11)	0.034501	-0.024584	46.54730	3.368659	-19.00976	-2.967818	-9.778448
	(0.13580)	(0.02930)	(27.9446)	(11.4941)	(21.6265)	(2.43759)	(6.78155)
	[0.25406]	[-0.83908]	[1.66570]	[0.29308]	[-0.87900]	[-1.21752]	[-1.44192]
LMAN_SA_HP(-12)	-0.173303	-0.005478	-58.45310	-9.834409	12.29382	2.398385	10.04480
	(0.11092)	(0.02393)	(22.8257)	(9.38859)	(17.6649)	(1.99107)	(5.53929)
	[-1.56234]	[-0.22892]	[-2.56085]	[-1.04748]	[0.69595]	[1.20457]	[1.81337]
LGDP_HP(-1)	1.810752	1.828165	58.67536	-6.225901	-145.1610	-2.378958	-6.500646
	(0.51588)	(0.11130)	(106.155)	(43.6632)	(82.1536)	(9.25979)	(25.7614)
	[3.51006]	[16.4260]	[0.55273]	[-0.14259]	[-1.76695]	[-0.25691]	[-0.25234]
LGDP_HP(-2)	-1.971274	-0.895713	-164.7921	10.77118	121.1273	-11.50637	-7.142876
	(1.03900)	(0.22416)	(213.801)	(87.9401)	(165.462)	(18.6497)	(51.8849)
	[-1.89728]	[-3.99590]	[-0.77077]	[0.12248]	[0.73206]	[-0.61697]	[-0.13767]
LGDP_HP(-3)	-0.205019	-0.512985	29.42967	-45.57855	171.6931	17.60191	52.16713
	(1.04517)	(0.22549)	(215.072)	(88.4627)	(166.445)	(18.7605)	(52.1932)
	[-0.19616]	[-2.27498]	[0.13684]	[-0.51523]	[1.03153]	[0.93824]	[0.99950]

LGDP_HP(-4)	1.913839	0.939112	107.4160	44.51636	-292.9507	-8.572278	-46.37553
	(1.00250)	(0.21628)	(206.290)	(84.8506)	(159.649)	(17.9945)	(50.0620)
	[1.90907]	[4.34206]	[0.52070]	[0.52464]	[-1.83497]	[-0.47638]	[-0.92636]
LGDP_HP(-5)	-0.982435	-0.420049	-11.30304	-18.03180	164.5314	8.290160	43.69029
	(1.12778)	(0.24331)	(232.070)	(95.4543)	(179.600)	(20.2433)	(56.3183)
	[-0.87112]	[-1.72638]	[-0.04871]	[-0.18891]	[0.91610]	[0.40953]	[0.77577]
LGDP_HP(-6)	-1.477286	-0.097198	-158.8547	-50.81833	-81.11191	-10.13453	-64.21147
	(1.11566)	(0.24070)	(229.576)	(94.4285)	(177.670)	(20.0257)	(55.7130)
	[-1.32414]	[-0.40382]	[-0.69195]	[-0.53817]	[-0.45653]	[-0.50608]	[-1.15254]
LGDP_HP(-7)	2.054367	0.180212	-175.3188	25.68435	-186.0522	-7.999158	-22.65322
	(1.09785)	(0.23685)	(225.910)	(92.9207)	(174.833)	(19.7060)	(54.8235)
	[1.87127]	[0.76086]	[-0.77606]	[0.27641]	[-1.06417]	[-0.40593]	[-0.41320]
LGDP_HP(-8)	-0.474945	-0.049610	416.4197	39.88867	368.6562	15.72894	141.6220
	(1.09754)	(0.23679)	(225.846)	(92.8946)	(174.784)	(19.7004)	(54.8080)
	[-0.43274]	[-0.20951]	[1.84382]	[0.42940]	[2.10921]	[0.79841]	[2.58397]
LGDP_HP(-9)	-0.523556	-0.294082	-282.9039	-71.73563	-136.0431	2.252587	-84.08191
	(1.05216)	(0.22700)	(216.510)	(89.0543)	(167.558)	(18.8860)	(52.5423)
	[-0.49760]	[-1.29553]	[-1.30666]	[-0.80553]	[-0.81192]	[0.11927]	[-1.60027]
LGDP_HP(-10)	0.142611	0.544617	28.95895	7.312300	-296.3864	-1.618059	-69.30626
	(1.03448)	(0.22318)	(212.870)	(87.5571)	(164.741)	(18.5685)	(51.6589)
	[0.13786]	[2.44024]	[0.13604]	[0.08351]	[-1.79910]	[-0.08714]	[-1.34161]
LGDP_HP(-11)	0.087387	-0.300060	35.78563	1.008700	559.6549	-9.345050	156.2252
	(0.98989)	(0.21356)	(203.695)	(83.7832)	(157.640)	(17.7682)	(49.4323)
	[0.08828]	[-1.40502]	[0.17568]	[0.01204]	[3.55020]	[-0.52594]	[3.16039]
LGDP_HP(-12)	0.242825	0.085323	5.614162	30.05271	-240.1691	7.525112	-61.64661
	(0.56287)	(0.12144)	(115.826)	(47.6411)	(89.6380)	(10.1034)	(28.1084)
	[0.43140]	[0.70261]	[0.04847]	[0.63081]	[-2.67932]	[0.74481]	[-2.19318]

PERCCENT_ER_TWI_A(-1)	0.000585	0.000130	1.131958	0.122256	0.086672	-0.001940	0.008691
	(0.00059)	(0.00013)	(0.12080)	(0.04969)	(0.09349)	(0.01054)	(0.02932)
	[0.99706]	[1.02746]	[9.37058]	[2.46053]	[0.92711]	[-0.18413]	[0.29647]
PERCCENT_ER_TWI_A(-2)	0.000123	-0.000239	-0.227790	-0.108460	0.125788	0.033515	0.083603
	(0.00081)	(0.00018)	(0.16729)	(0.06881)	(0.12946)	(0.01459)	(0.04060)
	[0.15105]	[-1.36500]	[-1.36168]	[-1.57628]	[0.97161]	[2.29678]	[2.05935]
PERCCENT_ER_TWI_A(-3)	-0.000607	0.000401	0.099464	0.006910	-0.020546	-0.010845	-0.001819
	(0.00083)	(0.00018)	(0.17149)	(0.07054)	(0.13272)	(0.01496)	(0.04162)
	[-0.72845]	[2.23185]	[0.58001]	[0.09797]	[-0.15481]	[-0.72497]	[-0.04372]
PERCCENT_ER_TWI_A(-4)	-0.000362	-0.000274	0.066690	-0.079507	-0.110113	-0.016755	-0.074700
	(0.00081)	(0.00018)	(0.16711)	(0.06874)	(0.12933)	(0.01458)	(0.04055)
	[-0.44570]	[-1.56223]	[0.39908]	[-1.15671]	[-0.85142]	[-1.14943]	[-1.84198]
PERCCENT_ER_TWI_A(-5)	0.000764	0.000121	-0.047805	0.109922	0.011216	-0.007302	0.025011
	(0.00078)	(0.00017)	(0.15974)	(0.06571)	(0.12363)	(0.01393)	(0.03877)
	[0.98477]	[0.72128]	[-0.29926]	[1.67295]	[0.09073]	[-0.52401]	[0.64516]
PERCCENT_ER_TWI_A(-6)	0.000174	-8.69E-05	-0.096542	-0.015502	0.077588	-0.004697	0.030647
	(0.00076)	(0.00016)	(0.15561)	(0.06401)	(0.12043)	(0.01357)	(0.03776)
	[0.23059]	[-0.53261]	[-0.62040]	[-0.24220]	[0.64426]	[-0.34606]	[0.81154]
PERCCENT_ER_TWI_A(-7)	-3.13E-05	-3.75E-05	-0.016199	-0.022111	-0.028214	0.008696	0.001022
	(0.00074)	(0.00016)	(0.15325)	(0.06303)	(0.11860)	(0.01337)	(0.03719)
	[-0.04201]	[-0.23352]	[-0.10570]	[-0.35079]	[-0.23789]	[0.65055]	[0.02749]

PERCCENT_ER_TWI_A(-8)	0.000134	0.000178	-0.146960	0.029846	-0.102352	3.27E-06	-0.018716
	(0.00071)	(0.00015)	(0.14632)	(0.06019)	(0.11324)	(0.01276)	(0.03551)
	[0.18908]	[1.15868]	[-1.00435]	[0.49591]	[-0.90385]	[0.00026]	[-0.52708]
PERCCENT_ER_TWI_A(-9)	-0.000200	-0.000193	0.101042	-0.075200	-0.087607	-0.003619	0.008150
	(0.00072)	(0.00015)	(0.14783)	(0.06081)	(0.11441)	(0.01290)	(0.03588)
	[-0.27848]	[-1.24227]	[0.68349]	[-1.23674]	[-0.76575]	[-0.28066]	[0.22716]
PERCCENT_ER_TWI_A(-10)	-0.000614	9.00E-05	-0.028863	0.072239	0.037262	-0.001965	-0.019713
	(0.00074)	(0.00016)	(0.15167)	(0.06239)	(0.11738)	(0.01323)	(0.03681)
	[-0.83246]	[0.56587]	[-0.19030]	[1.15795]	[0.31745]	[-0.14854]	[-0.53558]
PERCCENT_ER_TWI_A(-11)	0.000844	-0.000171	-0.011567	-0.082323	-0.059440	-0.008334	-0.016338
	(0.00070)	(0.00015)	(0.14399)	(0.05923)	(0.11143)	(0.01256)	(0.03494)
	[1.20620]	[-1.13308]	[-0.08033]	[-1.38999]	[-0.53340]	[-0.66355]	[-0.46757]
PERCCENT_ER_TWI_A(-12)	-0.000303	0.000157	-0.082645	0.007916	0.211134	0.020755	0.103576
	(0.00054)	(0.00012)	(0.11115)	(0.04572)	(0.08602)	(0.00970)	(0.02697)
	[-0.56164]	[1.34987]	[-0.74357]	[0.17315]	[2.45457]	[2.14076]	[3.84002]
INFLATION_TOTALPCPI_A(-1)	0.001437	0.000117	-0.096595	0.905023	0.220400	-0.017071	0.113410
	(0.00148)	(0.00032)	(0.30355)	(0.12486)	(0.23492)	(0.02648)	(0.07367)
	[0.97410]	[0.36762]	[-0.31822]	[7.24856]	[0.93819]	[-0.64470]	[1.53953]
INFLATION_TOTALPCPI_A(-2)	0.000929	-0.000159	-0.251201	-0.123932	-0.540189	-0.061115	-0.119187
	(0.00191)	(0.00041)	(0.39243)	(0.16141)	(0.30370)	(0.03423)	(0.09523)
	[0.48711]	[-0.38656]	[-0.64012]	[-0.76780]	[-1.77869]	[-1.78537]	[-1.25152]
INFLATION_TOTALPCPI_A(-3)	-0.003773	-0.000267	0.025934	-0.005833	0.145983	0.084742	0.024191

	(0.00189)	(0.00041)	(0.38990)	(0.16037)	(0.30174)	(0.03401)	(0.09462)
	[-1.99135]	[-0.65229]	[0.06651]	[-0.03637]	[0.48380]	[2.49167]	[0.25567]
INFLATION_TOTALPCPI_A(-4)	0.002250	-0.000659	-0.198868	0.045469	0.390992	-0.029968	0.072641
	(0.00190)	(0.00041)	(0.39159)	(0.16107)	(0.30306)	(0.03416)	(0.09503)
	[1.18244]	[-1.60547]	[-0.50784]	[0.28229]	[1.29016]	[-0.87732]	[0.76439]
INFLATION_TOTALPCPI_A(-5)	-0.000275	0.001097	-0.024060	-0.124721	0.095504	-0.018057	0.146131
	(0.00185)	(0.00040)	(0.38030)	(0.15642)	(0.29432)	(0.03317)	(0.09229)
	[-0.14856]	[2.75153]	[-0.06327]	[-0.79732]	[0.32450]	[-0.54431]	[1.58339]
INFLATION_TOTALPCPI_A(-6)	0.000710	-0.000406	-0.551053	0.098317	-0.574865	0.040622	-0.277004
	(0.00187)	(0.00040)	(0.38504)	(0.15837)	(0.29798)	(0.03359)	(0.09344)
	[0.37940]	[-1.00691]	[-1.43117]	[0.62080]	[-1.92919]	[1.20947]	[-2.96451]
INFLATION_TOTALPCPI_A(-7)	0.001583	0.000757	0.428494	0.119929	0.073500	-0.062820	0.139060
	(0.00194)	(0.00042)	(0.39954)	(0.16434)	(0.30921)	(0.03485)	(0.09696)
	[0.81519]	[1.80776]	[1.07247]	[0.72977]	[0.23771]	[-1.80250]	[1.43420]
INFLATION_TOTALPCPI_A(-8)	-0.001985	-0.000516	0.685178	-0.244032	0.405775	0.044370	0.169663
	(0.00192)	(0.00041)	(0.39518)	(0.16255)	(0.30584)	(0.03447)	(0.09590)
	[-1.03354]	[-1.24505]	[1.73382]	[-1.50131]	[1.32678]	[1.28714]	[1.76912]
INFLATION_TOTALPCPI_A(-9)	-0.002219	-0.000739	0.003607	-0.071024	0.302365	0.024286	-0.002557
	(0.00198)	(0.00043)	(0.40799)	(0.16781)	(0.31575)	(0.03559)	(0.09901)
	[-1.11901]	[-1.72824]	[0.00884]	[-0.42323]	[0.95762]	[0.68240]	[-0.02582]
INFLATION_TOTALPCPI_A(-10)	0.003458	0.001010	-0.768829	0.115168	-0.125815	-0.018040	-0.065265
	(0.00191)	(0.00041)	(0.39375)	(0.16195)	(0.30472)	(0.03435)	(0.09555)
	[1.80727]	[2.44704]	[-1.95260]	[0.71111]	[-0.41289]	[-0.52525]	[-0.68302]

INFLATION_TOTALPCPI_A(-11)	0.000491	-0.000167	-0.107217	-0.037814	-0.997506	-0.053051	-0.187424
	(0.00198)	(0.00043)	(0.40704)	(0.16742)	(0.31501)	(0.03551)	(0.09878)
	[0.24810]	[-0.39047]	[-0.26341]	[-0.22586]	[-3.16659]	[-1.49416]	[-1.89740]
INFLATION_TOTALPCPI_A(-12)	-0.001201	-0.000345	0.266248	0.039554	0.443797	0.016567	0.081682
	(0.00134)	(0.00029)	(0.27601)	(0.11353)	(0.21360)	(0.02408)	(0.06698)
	[-0.89552]	[-1.19237]	[0.96464]	[0.34841]	[2.07767]	[0.68810]	[1.21948]
INFLATION_MNF_PPI_A(-1)	-0.001373	-0.000438	-0.289001	-0.077779	0.777980	0.000360	0.112268
	(0.00100)	(0.00022)	(0.20602)	(0.08474)	(0.15944)	(0.01797)	(0.05000)
	[-1.37095]	[-2.02738]	[-1.40275]	[-0.91785]	[4.87936]	[0.02005]	[2.24546]
INFLATION_MNF_PPI_A(-2)	0.000135	0.000184	-0.103982	-0.114147	-0.315663	3.72E-05	-0.235447
	(0.00105)	(0.00023)	(0.21661)	(0.08910)	(0.16764)	(0.01889)	(0.05257)
	[0.12830]	[0.80844]	[-0.48004]	[-1.28116]	[-1.88301]	[0.00197]	[-4.47899]
INFLATION_MNF_PPI_A(-3)	0.002353	0.000427	-0.173190	0.045921	0.037989	-0.018989	0.076559
	(0.00106)	(0.00023)	(0.21892)	(0.09004)	(0.16942)	(0.01910)	(0.05313)
	[2.21173]	[1.86028]	[-0.79112]	[0.50998]	[0.22423]	[-0.99437]	[1.44107]
INFLATION_MNF_PPI_A(-4)	0.000298	-0.000158	-0.004008	-0.044344	0.406875	0.014778	0.143301
	(0.00105)	(0.00023)	(0.21652)	(0.08906)	(0.16756)	(0.01889)	(0.05254)
	[0.28303]	[-0.69637]	[-0.01851]	[-0.49793]	[2.42819]	[0.78247]	[2.72726]
INFLATION_MNF_PPI_A(-5)	-0.002133	5.13E-05	0.095721	0.073362	-0.213328	0.013752	-0.060798
	(0.00106)	(0.00023)	(0.21813)	(0.08972)	(0.16881)	(0.01903)	(0.05293)
	[-2.01191]	[0.22438]	[0.43883]	[0.81768]	[-1.26372]	[0.72277]	[-1.14854]

INFLATION_MNF_PPI_A(-6)	-0.001325	-0.000145	-0.018705	-0.060398	-0.040675	0.007003	-0.048776
	(0.00101)	(0.00022)	(0.20858)	(0.08579)	(0.16142)	(0.01819)	(0.05062)
	[-1.30736]	[-0.66462]	[-0.08968]	[-0.70401]	[-0.25198]	[0.38493]	[-0.96363]
INFLATION_MNF_PPI_A(-7)	0.000642	-0.000113	0.136912	0.156030	0.279138	-0.005082	0.035835
	(0.00100)	(0.00022)	(0.20591)	(0.08469)	(0.15935)	(0.01796)	(0.04997)
	[0.64174]	[-0.52546]	[0.66493]	[1.84232]	[1.75172]	[-0.28297]	[0.71716]
INFLATION_MNF_PPI_A(-8)	0.000756	0.000123	0.024446	-0.050162	-0.049166	0.008272	0.026731
	(0.00101)	(0.00022)	(0.20857)	(0.08579)	(0.16141)	(0.01819)	(0.05061)
	[0.74621]	[0.56029]	[0.11721]	[-0.58473]	[-0.30460]	[0.45469]	[0.52812]
INFLATION_MNF_PPI_A(-9)	-0.000838	-0.000154	-0.144639	0.088141	-0.085915	0.017837	-0.049779
	(0.00099)	(0.00021)	(0.20398)	(0.08390)	(0.15786)	(0.01779)	(0.04950)
	[-0.84572]	[-0.72199]	[-0.70907]	[1.05052]	[-0.54424]	[1.00244]	[-1.00559]
INFLATION_MNF_PPI_A(-10)	0.001864	0.000415	0.549743	-0.067427	0.066464	-3.35E-05	0.017683
	(0.00100)	(0.00022)	(0.20542)	(0.08449)	(0.15898)	(0.01792)	(0.04985)
	[1.86710]	[1.92762]	[2.67615]	[-0.79801]	[0.41807]	[-0.00187]	[0.35472]
INFLATION_MNF_PPI_A(-11)	-0.001144	-4.16E-05	-0.287668	-0.054231	0.173310	-0.003207	0.119690
	(0.00096)	(0.00021)	(0.19792)	(0.08141)	(0.15317)	(0.01726)	(0.04803)
	[-1.18954]	[-0.20025]	[-1.45348]	[-0.66618]	[1.13149]	[-0.18577]	[2.49197]
INFLATION_MNF_PPI_A(-12)	7.14E-05	-0.000249	-0.219612	0.021923	-0.434122	-0.007782	-0.124877
	(0.00074)	(0.00016)	(0.15238)	(0.06268)	(0.11793)	(0.01329)	(0.03698)
	[0.09647]	[-1.55653]	[-1.44119]	[0.34978]	[-3.68120]	[-0.58544]	[-3.37688]
INFLATION_CPI_A(-1)	0.010837	-0.000696	-0.796254	0.277575	0.010004	0.879862	0.200698
	(0.00601)	(0.00130)	(1.23700)	(0.50880)	(0.95732)	(0.10790)	(0.30019)

	[1.80268]	[-0.53630]	[-0.64370]	[0.54555]	[0.01045]	[8.15424]	[0.66857]
INFLATION_CPI_A(-2)	-0.011027	-0.000713	0.024637	0.039585	0.178742	-0.022509	0.271243
	(0.00821)	(0.00177)	(1.68955)	(0.69494)	(1.30755)	(0.14738)	(0.41002)
	[-1.34302]	[-0.40237]	[0.01458]	[0.05696]	[0.13670]	[-0.15273]	[0.66154]
INFLATION_CPI_A(-3)	-0.000291	0.002250	0.271332	-0.267784	-1.463154	0.077759	-0.715802
	(0.00808)	(0.00174)	(1.66193)	(0.68358)	(1.28617)	(0.14497)	(0.40331)
	[-0.03600]	[1.29101]	[0.16326]	[-0.39174]	[-1.13760]	[0.53639]	[-1.77480]
INFLATION_CPI_A(-4)	0.005512	-0.001218	-0.215423	-0.734551	-0.280288	-0.116844	-0.041082
	(0.00803)	(0.00173)	(1.65183)	(0.67943)	(1.27836)	(0.14409)	(0.40086)
	[0.68662]	[-0.70301]	[-0.13042]	[-1.08114]	[-0.21926]	[-0.81092]	[-0.10248]
INFLATION_CPI_A(-5)	-0.001064	0.001038	1.546218	1.096284	2.139093	0.185426	0.649138
	(0.00778)	(0.00168)	(1.60017)	(0.65818)	(1.23838)	(0.13958)	(0.38833)
	[-0.13677]	[0.61857]	[0.96629]	[1.66564]	[1.72734]	[1.32844]	[1.67163]
INFLATION_CPI_A(-6)	-0.006361	-0.001620	0.078368	-1.172365	-1.488025	-0.094102	-0.266133
	(0.00774)	(0.00167)	(1.59346)	(0.65542)	(1.23318)	(0.13900)	(0.38670)
	[-0.82143]	[-0.96993]	[0.04918]	[-1.78873]	[-1.20665]	[-0.67701]	[-0.68822]
INFLATION_CPI_A(-7)	0.009489	0.001026	-2.451581	0.731822	2.279706	-0.096996	0.365469
	(0.00779)	(0.00168)	(1.60215)	(0.65899)	(1.23991)	(0.13975)	(0.38881)
	[1.21869]	[0.61072]	[-1.53018]	[1.11052]	[1.83860]	[-0.69405]	[0.93997]
INFLATION_CPI_A(-8)	0.003361	-0.000101	1.014971	-0.446209	-1.512089	0.037982	-0.691372
	(0.00809)	(0.00175)	(1.66512)	(0.68489)	(1.28864)	(0.14525)	(0.40409)
	[0.41540]	[-0.05809]	[0.60955]	[-0.65150]	[-1.17340]	[0.26150]	[-1.71094]
INFLATION_CPI_A(-9)	-0.010666	0.000915	0.011127	0.453615	-1.022487	0.207923	0.298479
	(0.00792)	(0.00171)	(1.62967)	(0.67031)	(1.26121)	(0.14215)	(0.39548)
	[-1.34683]	[0.53552]	[0.00683]	[0.67672]	[-0.81072]	[1.46265]	[0.75472]
INFLATION_CPI_A(-10)	-0.005833	-0.001708	-3.271324	0.185295	1.311517	-0.173622	-0.469220
	(0.00816)	(0.00176)	(1.68006)	(0.69104)	(1.30020)	(0.14655)	(0.40771)

	[-0.71438]	[-0.96980]	[-1.94715]	[0.26814]	[1.00870]	[-1.18473]	[-1.15086]
INFLATION_CPI_A(-11)	0.015158	0.000382	4.338552	-0.782306	-1.395178	-0.051198	-0.420514
	(0.00855)	(0.00184)	(1.75880)	(0.72342)	(1.36114)	(0.15342)	(0.42682)
	[1.77350]	[0.20707]	[2.46677]	[-1.08139]	[-1.02500]	[-0.33371]	[-0.98522]
INFLATION_CPI_A(-12)	-0.006054	-0.001078	-1.095832	0.120140	0.279860	-0.098934	0.826334
	(0.00647)	(0.00140)	(1.33143)	(0.54764)	(1.03040)	(0.11614)	(0.32311)
	[-0.93567]	[-0.77234]	[-0.82305]	[0.21938]	[0.27160]	[-0.85186]	[2.55745]
INFLATION_WP_A(-1)	0.005705	0.000447	0.540987	0.119319	0.280331	-0.010125	1.030487
	(0.00278)	(0.00060)	(0.57285)	(0.23562)	(0.44333)	(0.04997)	(0.13902)
	[2.04941]	[0.74443]	[0.94438]	[0.50639]	[0.63233]	[-0.20262]	[7.41259]
INFLATION_WP_A(-2)	-0.008554	-0.000645	0.804183	0.308271	0.964298	0.013866	0.252096
	(0.00384)	(0.00083)	(0.79062)	(0.32520)	(0.61187)	(0.06897)	(0.19187)
	[-2.22644]	[-0.77861]	[1.01715]	[0.94795]	[1.57599]	[0.20105]	[1.31391]
INFLATION_WP_A(-3)	-0.002309	-0.001187	-0.278806	-0.361371	-1.147563	0.029198	-0.544624
	(0.00371)	(0.00080)	(0.76265)	(0.31369)	(0.59022)	(0.06653)	(0.18508)
	[-0.62313]	[-1.48394]	[-0.36558]	[-1.15200]	[-1.94431]	[0.43891]	[-2.94267]
INFLATION_WP_A(-4)	0.004303	0.001703	-0.152143	0.207182	-0.142406	-0.001396	0.014797
	(0.00356)	(0.00077)	(0.73356)	(0.30173)	(0.56770)	(0.06399)	(0.17802)
	[1.20711]	[2.21447]	[-0.20740]	[0.68666]	[-0.25085]	[-0.02181]	[0.08312]
INFLATION_WP_A(-5)	0.002072	-0.000919	-0.493713	0.015156	-0.304951	-0.162445	0.011448
	(0.00360)	(0.00078)	(0.73985)	(0.30431)	(0.57257)	(0.06454)	(0.17955)
	[0.57636]	[-1.18458]	[-0.66731]	[0.04980]	[-0.53260]	[-2.51710]	[0.06376]
INFLATION_WP_A(-6)	-0.001878	0.000170	0.204311	0.339949	0.264715	0.109975	-0.073325
	(0.00348)	(0.00075)	(0.71631)	(0.29463)	(0.55436)	(0.06248)	(0.17383)
	[-0.53942]	[0.22641]	[0.28523]	[1.15381]	[0.47752]	[1.76007]	[-0.42181]
INFLATION_WP_A(-7)	0.002147	-3.60E-05	0.215043	-0.948472	-0.389635	0.032428	-0.077262
	(0.00336)	(0.00073)	(0.69211)	(0.28468)	(0.53563)	(0.06037)	(0.16796)

	[0.63820]	[-0.04962]	[0.31071]	[-3.33174]	[-0.72743]	[0.53713]	[-0.46000]
INFLATION_WP_A(-8)	9.94E-06	0.000969	0.100539	0.665357	0.610729	0.010124	0.338107
	(0.00364)	(0.00078)	(0.74804)	(0.30768)	(0.57891)	(0.06525)	(0.18153)
	[0.00273]	[1.23585]	[0.13440]	[2.16250]	[1.05497]	[0.15516]	[1.86252]
INFLATION_WP_A(-9)	-0.002143	-0.000426	-0.902007	-0.647760	-0.362272	-0.095296	-0.044497
	(0.00378)	(0.00082)	(0.77868)	(0.32028)	(0.60262)	(0.06792)	(0.18897)
	[-0.56643]	[-0.52156]	[-1.15839]	[-2.02246]	[-0.60116]	[-1.40299]	[-0.23547]
INFLATION_WP_A(-10)	-0.004839	-0.001309	0.448850	0.544210	-0.018225	0.004481	-0.440632
	(0.00378)	(0.00082)	(0.77767)	(0.31987)	(0.60184)	(0.06784)	(0.18872)
	[-1.28049]	[-1.60522]	[0.57717]	[1.70136]	[-0.03028]	[0.06605]	[-2.33481]
INFLATION_WP_A(-11)	0.008276	0.000986	0.636466	0.124023	0.280486	-0.032271	0.198669
	(0.00394)	(0.00085)	(0.81138)	(0.33373)	(0.62793)	(0.07078)	(0.19690)
	[2.09897]	[1.15926]	[0.78443]	[0.37163]	[0.44669]	[-0.45596]	[1.00897]
INFLATION_WP_A(-12)	-0.003615	0.000102	0.252206	-0.045203	0.227205	0.067090	0.013585
	(0.00248)	(0.00054)	(0.51122)	(0.21027)	(0.39563)	(0.04459)	(0.12406)
	[-1.45498]	[0.19025]	[0.49335]	[-0.21497]	[0.57428]	[1.50449]	[0.10951]
C	-0.002514	0.003828	-0.557870	0.558379	2.274352	0.512520	0.482685
	(0.00648)	(0.00140)	(1.33293)	(0.54826)	(1.03156)	(0.11627)	(0.32347)
	[-0.38818]	[2.73925]	[-0.41853]	[1.01846]	[2.20477]	[4.40800]	[1.49220]
DUMMY_REC	-0.001779	-0.001231	-0.032732	-0.115711	-5.68E-05	0.017152	0.155818
	(0.00230)	(0.00050)	(0.47270)	(0.19443)	(0.36583)	(0.04123)	(0.11471)
	[-0.77437]	[-2.48347]	[-0.06925]	[-0.59513]	[-0.00016]	[0.41598]	[1.35831]
R-squared	0.992853	0.996895	0.971146	0.956801	0.978445	0.984654	0.994352
Adj. R-squared	0.985354	0.993637	0.940868	0.911468	0.955826	0.968550	0.988425
Sum sq. resids	0.002069	9.63E-05	87.59832	14.82006	52.46519	0.666531	5.158907
S.E. equation	0.005054	0.001090	1.039933	0.427743	0.804810	0.090713	0.252369
F-statistic	132.3883	305.9643	32.07375	21.10624	43.25730	61.14404	167.7684
Log likelihood	706.4875	962.6093	-183.0859	-34.72472	-140.2828	224.2630	53.38924

Akaike AIC	-7.430988	-10.49831	3.222585	1.445805	2.709973	-1.655845	0.390548
Schwarz SC	-5.825315	-8.892641	4.828259	3.051479	4.315647	-0.050171	1.996222
Mean dependent	-0.000883	0.000133	1.390291	-0.111751	3.103102	2.013136	2.388098
S.D. dependent	0.041759	0.013668	4.276548	1.437582	3.829217	0.511515	2.345723

Determinant resid covariance (dof adj.)	6.13E-16
Determinant resid covariance	3.87E-18
Log likelihood	1688.981
Akaike information criterion	-13.01774
Schwarz criterion	-1.778024

Chapter 4
Global Production Sharing: Exploring Australia's Competitive Edge

1 Introduction

The cross-border dispersion of production processes within vertically integrated global industries, known as global production sharing[41], has been an increasingly important structural feature of economic globalisation in recent decades. This process of international division of labour opens up opportunities for countries to specialise in different slices (tasks) of the production process in line with their relative cost advantages. As the production processes are finely sliced across a wide range of industries, new opportunities for specialisation within global production networks (GPNs) are created. Given this structural shift in global production, the conventional approach to analysing trade patterns, which treats international trade as an exchange of goods produced from beginning to end in a given trading partner, is rapidly losing its relevance. With the rapid expansion of global production sharing, parts and components, technical and managerial know-how, and capital have become increasingly mobile across national boundaries, making trade patterns increasingly sensitive to inter-country differences in trade and investment policies (Jones and Kierzkowski 2004).

The 787 Dreamliner 'produced' by the Boeing Corporation, USA, has become an eye-catching illustrative case of how countries are engaging in an intricate web of production-sharing arrangements (Gapper 2007). Offshore production accounts for 70% of the many thousands of parts used in assembling the jet. Boeing itself is responsible for only about 10% by value of the aircraft (tail fin and final assembly), but holds the rights to the 787 technology. There are 43 parts and component suppliers spread over 135 production sites around the world. The wings are produced in Japan, the engines in the United Kingdom and the United States, the flaps and ailerons in Australia and Canada,

[41] The alternative terms used in the recent international trade literature include global production networks, network trade, international production fragmentation, intra-process trade, vertical specialization, slicing the value chain, and offshoring.

the fuselage in Japan, Italy and the United States, the horizontal stabiliser in Italy, the landing gear in France, and the doors in Sweden and France. Some parts are produced by foreign affiliates of the Boeing Corporation, while others are supplied under subcontracting arrangements. This pattern of 'outsourced production' around the world is in sharp contrast to Boeing's previous emphasis on procuring components domestically: only about 1% of the Boeing 707 was built outside the US in the 1950s. Boeing is now focussing on its own specific advantages – design, supply chain management, marketing and branding – rather than in areas where others are bound to make inroads. Airbus, Boeing's competitor, followed Boeing's lead for its A350 jet. It has closed down some component producing plants in Europe and is outsourcing work to China and elsewhere to produce this wide-body jet, which is positioned to compete with the Boeing 787.

The purpose of this paper is to examine the patterns and determinants of global production sharing with an emphasis on the implications for performance and structural change in Australian manufacturing. The study is motivated by the growing emphasis on the contemporary policy debate in Australia, on the country's industrial future in the aftermath of the cessation of the commodity boom (ACOLA 2015, PC 2014, Withers et al 2015, CEDA 2014 & 2015, Government of Australia 2012). Notwithstanding this policy emphasis, the implications of the ongoing process of global production sharing for effective integration of domestic manufacturing into GPNs and the related policy issues have not been systematically explored, this paper seeks to fill this gap in the literature.

There are intrinsic aspects about the Australian GPN that make it interesting both for research purposes and government policy. For instance, even though the export share of manufacturing activities has declined, the share of GPN goods within manufacturing goods has increased for Australia (see Section 4 for a detailed description of the profile of Australian GPNS). Further, GPN goods show less volatility than total manufacturing goods. Another interesting feature of the Australian GPNs is that they are less integrated with Southeast economies, than the other Asian countries in the region. The rest of the paper explores and studies Australian GPNs in detail.

The paper is structured as follows: Section 2 provides a stage-setting analytical overview of the process of global production sharing and emerging opportunities for countries to specialize in line with their relative cost advantage. Section 3 discusses the methodology, the procedure followed in delineating trade based on global production sharing (henceforth referred to as 'GPN trade'[42]) from total manufacturing trade flows, using data extracted from the United Nations (UN) trade database (UN Comtrade). Section 4 undertakes a comparative analysis of Australia's engagement in GPN trade, focusing on overall trends, commodity composition and directions of trade. An econometric analysis is undertaken in Section 5 using the standard gravity modelling framework to examine the determinants of inter-country differences in GPN trade. Section 6 summarises the key findings and draws policy inferences.

2 Global Production Sharing

The phenomenon of global production sharing

Global production sharing is not a new phenomenon. There is ample anecdotal evidence of evolving trade in parts and components within the branch networks of Multinational Enterprises (MNEs) dating back to the early 20th century (Wilkins1970). Kindleberger (1967) used the example of growing trade in 'semi-finished material' (parts and components) between the Ford plants at Limburg in Belgium and Cologne in Germany in the mid-1960s, to question the validity of the conventional approach to analyzing the trade-growth nexus, 'developed almost entirely on the basis of trade in final products – that is, goods wholly produced in one country and consumed in another' (p. 108-9). The affiliates of the US MNEs operating in the Australian automotive industry have been importing parts and components for local assembly operations and also exporting some parts and components produced in Australia within their global networks, from the early 1950s (Hughes 1977, Brash 1966).

What is unprecedented about the contemporary process of global production sharing is its wider and ever increasing product coverage, and its rapid spread from mature

42 Trade in parts and components and final assembly within production networks arising from global production sharing.

industrial countries to developing countries. Over the past four decades, production networks have gradually evolved to encompass many countries and spread to many industries such as sport footwear, automobiles, televisions and radio receivers, sewing machines, office equipment, electrical machinery, machine tools, cameras, watches, light emitting diodes, solar panels, and surgical and medical devices. [43]

Until about the early 1970s, production sharing was basically a two-way exchange between the home and host countries undertaken by MNEs. Parts and components were exported to the low-cost, host country for assembly and the assembled components were re-imported to the home country to be incorporated into the final product (Helleiner 1973, Grunwald and Flamm 1985, Brown and Linden 2005). As supply networks of parts and components became firmly established, producers in advanced countries have begun to move final assembly of an increasing range of products (for example, computers, mobile phones and other hand-held devices, TV sets and automobiles) to developing countries (Krugman 2008). Many of the MNEs in electronics and related industries now undertake final assembly in developing-country locations, retaining only product design, marketing and coordination functions at home.

MNE subsidiaries also started to subcontract some activities to local (host-country) firms, providing the latter with detailed specifications and even fragments of their own technology. Over time, many firms, which were not part of original MNE networks, have begun to undertake final assembly by procuring components globally through arm's-length trade, thus benefitting from the ongoing process of standardisation of parts and components.

These developments suggest that an increase in production-sharing based trade in a given country can in some cases be decoupled from increases in the stock of foreign

[43] In recent years, the popular press has begun to pay attention to the phenomenon of 'reshoring' (also termed 'reverse offshoring' or 'onshoring'), shifting back by MNEs of manufacturing facilities from overseas locations to the home country. However, whether this is a new structural phenomenon or simply media hype of some isolated cases against the backdrop of the political rhetoric in the USA of 'bringing back manufacturing home' is yet to be seen (Gray et al 2013).

direct investment (FDI) (Jones 2000, Brown et al. 2004). However, there is clear evidence that MNEs are still the leading vehicle for countries to enter global production networks. In particular, the presence of a major MNE in a particular country is vital, both as a signalling factor to other foreign firms less familiar with that country and as an agglomeration magnet for the development of new cluster-related activities and specialised support services (Dunning 2009, Ruwane and Gorg 2001, Wells and Wint 2000).

The expansion of global production sharing has been driven by three mutually reinforcing developments (Helpman 2010, Jones 2000, Jones and Kierzkowski 2004, 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 processes. This has facilitated, and reduced the cost of establishing the 'service links' needed to combine various fragments of the production process across countries, in a timely and cost efficient manner. Third, liberalisation policy reforms across the world over the past four decades have considerably removed barriers to trade and foreign direct investment (FDI). Trade liberalisation is far more important for the expansion of GPN trade compared to the conventional horizontal trade. This is because, when a slice (task) of the production chain operates with a smaller price-cost margin, the profitability could be erased by even a small tariff.

There is an important two-way link between improvement in technological innovations in communication and transportation, and the expansion of production sharing within global industries. The latter contributes to lowering the cost of both production and rapid market penetration of the final products through enhanced price competitiveness. Scale economies resulting from market expansion in turn encourage new technological efforts, enabling further product fragmentation. This two-way link has set the stage for GPN trade to expand more rapidly, compared to conventional commodity-based trade.

Policy Issues

Global production sharing opens up opportunities for countries to participate in a finer international division of labour. It may be that workers in a given country tend to have different skills from those in other countries, and the skills required in each production block differ, so that a dispersion of activity could lower marginal costs of production. Alternatively, it may be that the production blocks differ from each other in the proportion of different factors required, enabling firms to locate labour intensive production blocks in countries where the productivity-adjusted labour cost is relatively low. In contrast, product design, the manufacture of key components (such as LCDs and memory chips) and the establishment of brand names all come with high entry barriers because such activities require substantial capital and a high level of manufacturing capabilities.

Why should policy makers pay particular attention to global production sharing as part of an outward-oriented development strategy? The available evidence on the emerging patterns of global production sharing, when combined with the standard literature on gains from export-oriented development (Srinivasan 1999, Grossman and Helpman 1993), suggests that growth prospects would be greatly enhanced through engaging in this form of international exchange.

First, participation in GPNs is likely to have a favourable 'atmosphere creation' effect for domestic manufacturing. The very nature of the process of global production sharing is the continuous shake-up of the industry through the emergence of new products and production processes in place of old ones. Engaging in global production sharing is an effective way of linking domestic manufacturing to the dynamic global industries of electronics, electrical goods, medical devices and transport equipment, all of which are the incubators of new technology and managerial skills. Thus joining GPNs has the potential to yield growth externalities (spillover effects) through the transfer of technology and managerial know-how and skill development.

Second, GPN trade allows for considerable gains from economies of scale and scope that arise in wider markets. As GPN trade is often targeted to the world market, the demand for the product is not limited to one country.

Third, specialisation in parts and components within production networks has the potential to help overcome the 'tyranny of distance' - the trade cost disadvantage arising from the geographic distance to the major markets. The process of global production sharing opens up opportunities to specialise in high-value-to-weight components for which air shipment is the major mode of transport (Hummels 2009)

The second and third considerations are particularly important for Australia. The performance of Australian manufacturing has historically been constrained by the small size of the domestic market and distance-related trade cost (Gregory 1993, Krause 1984, McLean 2013, Hutchinson 2014).

3 Compilation of Trade Data

A prerequisite for analysing the patterns and determinants of GPN trade is the systematic delineation of parts and components and final assembly from the standard (customs-records based) trade data. Following the seminal paper by Yeats (2001), it has become common practice to use data on parts and components to measure GPN trade. However, parts and components are only one facet of network trade. There has been a remarkable expansion of global production sharing of parts and components production and final assembly. In this study, we define network trade to incorporate both components and final (assembled) goods exchanged within the production networks.

The data used in this study for all countries, except Taiwan, are compiled from the *UN Comtrade* database, based on Revision 3 of the Standard International Trade Classification (SITC Rev. 3). The data for Taiwan (a country which is not covered by the UN trade data reporting system) come from the database of the Council of Economic Planning and Development, Taipei.

Parts and components are delineated from the reported trade data using a list compiled by mapping parts and components in the UN Broad Economic Classification (BEC) with the SITC at the five-digit level of commodity disaggregation. The product list of the Word Trade Organization (WTO) Information Technology Agreement Information was used to fill gaps in the BEC list of parts and components. The parts and components list is given in Athukorala and Talgaswatta 2015, Appendix A-1.

It is important to note that parts and components, as defined here, are only a subset of intermediate goods, even though the two terms have been widely used interchangeably in the recent literature on global production sharing. Parts and components are inputs further along the production chain. Parts and components unlike the standard intermediate inputs, such as iron and steel, industrial chemicals and coal, are 'relationship- specific' intermediate inputs; in most cases they do not have reference prices, and are not sold on exchanges and are more demanding on the contractual environment (Nunn 2007, Hummels 2002). Most (if not all) of parts and components also do not have a 'commercial life' on their own unless they are embodied in a final product.

The BEC 'intermediate goods' list captures both the traditional intermediate goods (such as non-ferrous metal, iron and steel bars etc.) and components ('middle products' or 'goods in process') germane to global production sharing. To get an accurate picture of global production sharing, what is relevant is only the latter (Hummels 2002). Mixing the two is particularly problematic for a trade data analysis for Australia because the standard intermediate goods historically account for a large share of total manufactured exports.

There is no hard and fast rule for distinguishing in international trade data between products assembled within global production networks and other traded goods that are produced from beginning to the end in a given country. The only practical way of doing this is to focus on the specific product categories in which network trade is heavily concentrated. Once these product categories are identified, trade in final assembly can be approximately estimated as the difference between parts and components - directly identified based on our list - and the total trade of these product categories.

Guided by the available literature on production sharing,[44] we identified seven product categories: office machines and automatic data processing machines (SITC 75), telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), road vehicles (SITC 78), other transport equipment (SITC 79), professional and scientific equipment (SITC 87) and photographic apparatus (SITC 88). It is quite reasonable to assume that these product categories contain virtually no products produced from start to finish in a given country (Krugman 2008). The difference between the value of the total trade of these categories and the value of total parts and components falling under these categories is treated as the value of final assembly. Admittedly, the estimates based on this list do not provide full coverage of final assembly in world trade. For instance, outsourcing of final assembly does take place in various miscellaneous product categories such as clothing, furniture, sporting goods, and leather products. However, it is not possible to meaningfully delineate parts and components and assembled goods in reported trade in these product categories because they contain a significant (yet unknown) share of horizontal trade.

A number of recent studies have analysed trade patterns using 'value added' trade data derived by combining the standard (customs records based) trade data with national input-output tables (Productivity Commission 2014, Koopman et al. 2013, Johnson and Noguera 2012). The underlying rationale for using value added trade data is that, in the context of rapidly expanding cross-border trade in parts and components driven by global production sharing, the standard (gross) trade data (trade data based on customs records) tend to give a distorted picture of the bilateral trade imbalances of a given country[45] and the geographic profile of its global trade linkages. In other words, value added trade data are useful only for the accurate measurement of bilateral trade imbalances and to measure the impact of economic shocks stemming from the final export destination countries on a given trading nation.

[44] See Krugman (2008) and the works cited therein.

[45] In fact, this was the reason why Pascal Lamy, the former Director General of WTO, took the lead in setting up the OECD/WTO TiVD database, which has now become the main data source for value added trade analysis (Lamy 2013).

This approach of using input-output tables to measure value added is not relevant for the present study, which aims to examine the patterns and determinants of production-sharing-driven trade flows and opportunities for countries to engage in this form of international exchange. From the industry policy point of view, what is important for understanding a country's engagement in global production sharing is gross trade, separated into parts and components (rather than intermediate goods in the conventional sense) and trade in final assembly. Under global production sharing, a country specialises in a given slice (task) in the production chain, depending on the relative cost advantage and other factors, which determine its attractiveness as a production location. Trade and industry policies only have the potential to influence a country's engagement in a given slice of the value chain. Domestic value addition evolves over time as the country becomes well integrated into the value chain.[46]

4 Australian Manufacturing in Global Production Networks

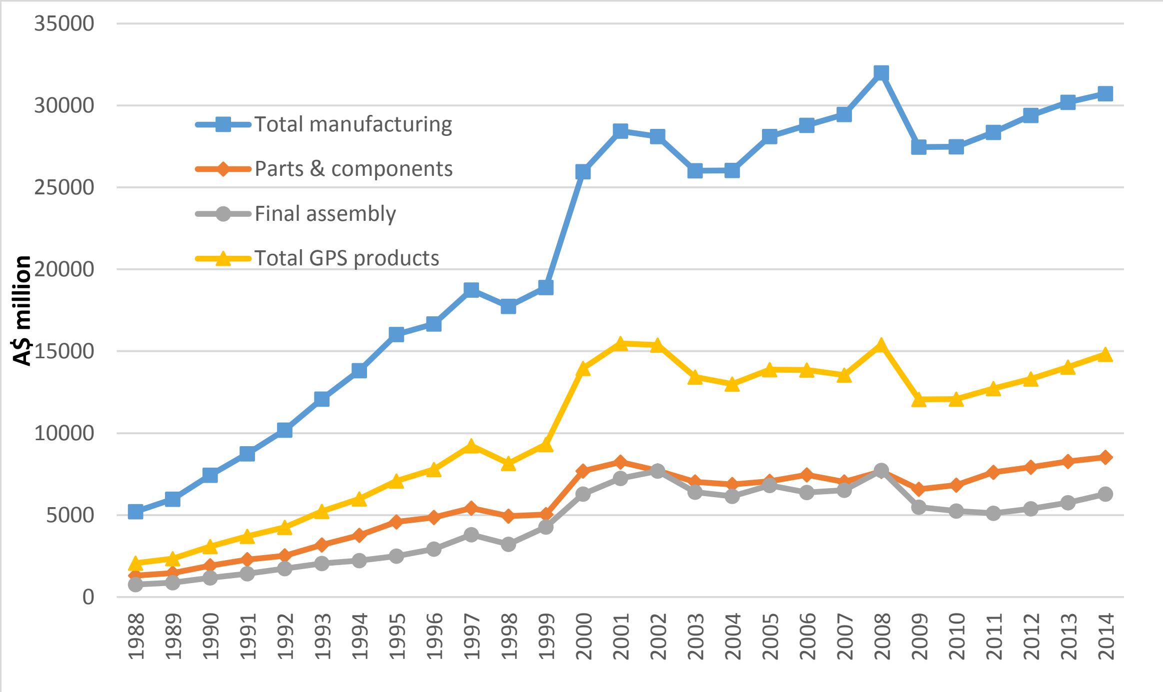
Trends

Data on manufacturing exports from Australia, disaggregated into components, final assembly and total GPN exports, are plotted in Figure 1. Between 1988/89 and 2000/01, total manufacturing exports recorded a fivefold increase, from A$5.6bn to 28.3bn, and the share of manufacturing in total merchandise trade increased from 13.4% to 23.1%. During the ensuing years, exports slowed, with a greater degree of volatility. By 2013/14 the share of manufacturing in total exports had declined to 12.4%. Interestingly, exports of GPN products, however, remained less volatile during this period and have contributed disproportionately to export expansion in recent years. The share of these products in total manufacturing exports increased from 43.8% to 47.5%, between 2009/10 and 2013/14. Within the GPN category, parts and components exports have increased at a faster rate compared than final assembly. In sum, GPN exports seem to

[46] Even for analysing bilateral trade imbalances and analysing the spillover effects of exports on the domestic economy, the available valued-added trade data need to be treated with caution because of the well-known limitations of the available I-O data and the underlying restrictive assumptions of the estimation method (Yuskavage 2013).

have been remarkably resilient to the Dutch Disease effect, the possible adverse impact of exchange rate appreciation - during the commodity boom.

Figure 1 Australian Manufacturing Exports, 1988-2014 (A$ million)



Source: Data compiled from UN Comtrade database.

There are reasons to expect the impact of real exchange rate appreciation to be much weaker (or even zero) in GPN trade for the following reasons (Jones and Kierzkowski 2004; Jones 2000, Arndt and Huemer 2007, Burstein et al 2008, Athukorala and Khan 2015). First, the production units of the value chain located in different countries normally specialise in specific tasks. Therefore, the substitutability of parts and components sourced from various sources is rather limited. Second, setting up of overseas production bases and establishing the services links entail high fixed costs. Once such fixed costs are incurred, relative price/cost changes become less important in business decision making[47]. Third, when a firm in a given country is engaged in a particular slice of production process, its export profitability depends not only on external demand and the domestic cost of production, but also on supply conditions in the countries supplying parts and components, the bilateral exchange rates between them, and the magnitude of the share of import content in the exported goods. Changes

[47] Businesses may be more mobile if such fixed costs have not been incurred.

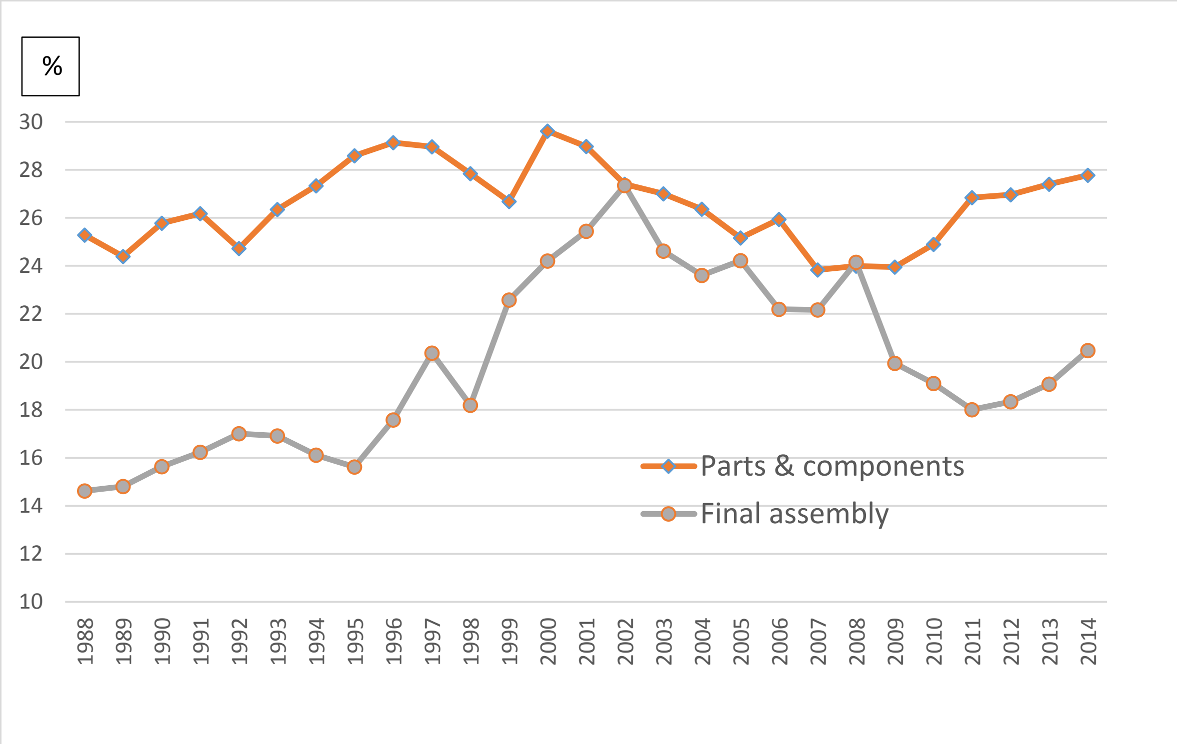
in exchange rates also have offsetting effects on imports and exports and thus, the net effect of the changes in the exchange rate changes on exports within production networks can tend to be weaker than in the standard case of production of the entire product in a given country.

Australia is a small player in world manufacturing trade (Table 1[48]). Its share in total world manufacturing remained around 0.28% during the period under study, without showing any trend. However, Australia's share of world exports of GPN products increased from 0.22% to 0.25% between 1990/01 and 2012/13, underpinned by an increase in the share of parts and components, from 0.24% to 0.28%. Australia's share of the total manufacturing exports of OECD countries increased from 0.35% to 0.54% between these years, with the share of GPN exports increasing from 0.27% to 0.36%.

The share of parts and components in total manufacturing exports from Australia, varied in the range of 23-28% during 1988-2014, showing a clear upward trend from about 2006 (Figure 2). In contrast, the share of final assembly declined continuously from about the early 2000s to 2010, and then continued to remain well below that of parts and components, notwithstanding a mild upward trend in the past three years. On the import side, we see the reverse pattern: the parts and components share has declined continuously over the past decade or so, with the share of assembly products remaining much higher (around 30%) with a mild upward trend (Figure 7 in Athukorala and Talgaswatta 2016). These contrasting patterns are consistent with the general factor proportion characteristic of parts and components production and the Australian resource endowment. Parts and components production is generally more capital and skill intensive compared to most final assembly undertaken within global production networks. Summary statistics for Australia is given in table 4.1 of this chapter, while summary statistics for the whole sample is given in chapter 2.

[48] Tables are presented at the end of the chapter.

Figure 2 Parts and Components and Final Assembly in Australian Manufacturing Exports (%)



Source: Data compiled from UN Comtrade database.

Commodity Profile

The data on the commodity profile of parts and components, and on final assembly exports from Australian manufacturing exports are summarised in Tables 2 and 3[49], in terms of three indicators: percentage composition, share in world trade and the revealed comparative advantage index (RCA). The RCA index measures Australia's export performance in a given product compared to its category's overall performance in world trade. It is simply the ratio of Australia's world market share of a given product exported, to Australia's share in total world manufacturing exports.[50]

[49] At the end of the chapter

[50] RCA = $(X_{ij}/X_{wj})/(X_{it}/X_{wt})$

where, X_{ij} denotes country *i*'s exports of commodity *j*, X_{wj} is world exports of commodity *j*, X_{it} is country *i*'s total exports, and X_{wt} is total world exports. When the value of RCA exceeds (is below) unity, country *i* is said to have a revealed comparative advantage (comparative disadvantage) in commodity *j* (Balassa 1965). This measure must be used with some caution because domestic policy measures such as production subsidies, or foreign trade barriers or trade preferences that have nothing to do with

Among the parts and components exports, the product class for aircraft parts and components (SITC 7929) stands out for its impressive growth performance. Its share in Australia's total parts and components exports increased from 8.2% in 2000/01 to 13.4% in 2012/13 (Table 2). In 2012/13, Australia accounted for 1.7% of total world exports of aircraft components, compared to 0.6% in 2000/01. As measured by the RCA index, in 2012/13 Australia's share of work exports of aircraft parts and components was almost 6 times of the Australian share in world manufacturing exports, compared to 2.1 times in 1990/91.

The emergence of aircraft components as a new dynamic item in Australia's export composition has been underpinned by the consolidation of the presence of Boeing and Airbus, the world's two major aircraft producers. Australia is well placed to benefit from the rapid global expansion of aircraft production networks, given the skill base and managerial talent developed over the past century, along with a highly successful public-private collaborative effort, to gain a global niche in the production of carbon fibre composite materials over the past two decades (See Appendix).

The other products that have indicated notable increases in export shares are parts for earth moving machines (SITC 7239), transmission apparatus for radio-telephony (SITC 7643), mineral processing machines (SITC83) and various machine tools (SITC 7429). Automobile parts (SITC 7843) account for the second largest share in exports after aircraft parts, but this share declined from 10.8% to 8.8% between 2000/01 and 20012/13.

Overall, there has been an increase in the degree of concentration of parts and component exports in the more dynamic products listed above. Their share in total parts and component exports increased from 79.1% in 1990/91 to 92.7% in 2012/13. Also, in a comparison across all products, we can see a shift away from the conventional (mostly domestic resource based) parts and components (which are classified under SITC

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comparative advantage, can influence its measured value. This limitation is not very important in its application to Australian manufacturing trade during the period under study, with the notable exception of the automobile industry.

Section 6) to more dynamic items belonging to machinery and transport equipment (SITC 7) - with the notable exception of automotive parts - and miscellaneous manufacturing (SITC 8).

Among the final assembly exports, motor vehicles (SITC 7821: goods transport vehicles and 7812: passenger cars) still account for over half of the total assembly exports, but their share has declined in recent years. Also, the RCA index for automobiles is less than unity (Table 3). This evidence suggests that the export performance of the automotive industry is predominantly driven by industry assistance provided by the government, rather than the industry's comparative advantage in world trade[51]. However, the Australian automotive industry seems to have a competitive edge in some specialised automotive parts such as parts of trucks for short distance transport (SITC 7441), vehicle rear-view mirrors (SITC 6648), engigne parts (SITC 7189) and valves (SITC 7429).

GPN products relating to medical equipment andg measuring instruments also show notable gains in exports. Between 1990/01 and 2012/13, the share of mechanotherapy exports increased from 0.3% to 7.3%, and that of medical and surgical instruments increased from 2.5% to 5.6%. In 2012/13 Australia accounted for 5.5% of the total world exports of mechanotherapy appliances, up from 0.3% in 1990/91.

The share of light aircraft (<2000kg) accounted for 3.6% of total final goods exports, compared to 1.2% in 1990/91. Australia's share in world light aircraft exports increased from 1.1% to 3.6% between 1990/91 and 2012/13.

Various categories of measuring, scientific, and medical/surgical equipment have recorded increases in their shares in total GPN final exports from Australia, as well as in total world exports. As is the case with component exports, a comparison across all GPN final products shows a shift away from the conventional (mostly domestic resource based) products to more dynamic products within global production networks. There has also been an increase in the degree of commodity concentration of final assembly

[51] The automobile industry has also been the largest beneficiary of various industry assistance programs of the Australian government (PC 2014).

exports. The share of unclassified products in Table 3 declines from 24.5% in 1990/01 to 15.9% in 2012/13.

Australia-OECD Export Similarity/Difference

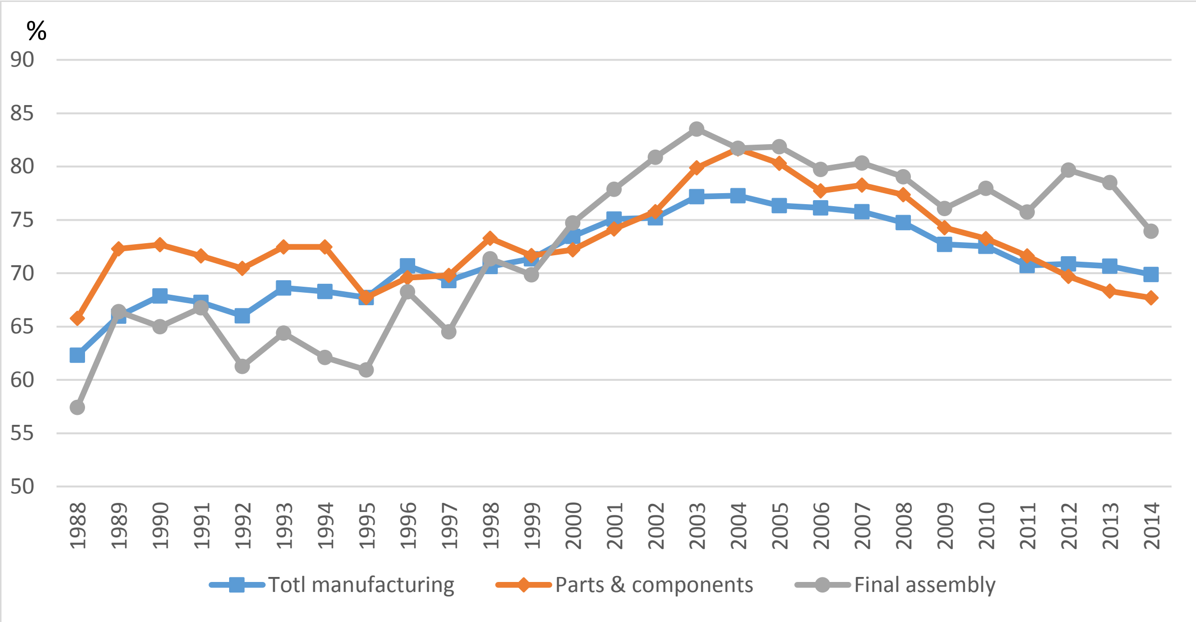
How does the commodity composition of GPN exports from Australia compare with that of OECD countries? The Finger-Kreinin export-similarity index is a useful summary measure for addressing this issue (Finger-Kreinin 1972).[52] The index calculated for Australian and OECD exports of total manufacturing, parts and components and final assembly, are plotted in Figure 3. The index is well below the level of perfect similarity (100) throughout, showing a notable difference in the commodity composition of Australia compared to the average patterns of OECD countries. The differences tended to narrow in the second half of the 1990s but have continuously widened since then. The prime driver behind the growing dissimilarities has been the emerging patterns of Australia's parts and components exports.

52 The index is defined by the formula

$$S(ab,c) = \left\{ \sum_i Minimum\left[Xi(ac), Xi(bc)\right] \right\} 100,$$

where *a* and *b* denote two countries (or country group) exporting to market *c, Xi(ac)* is the share of commodity *i* in *a*'s exports to *c*, and *Xi(bc)* is the share of commodity *i* in *b*'s exports to *c*. If the commodity distribution of a's and b's exports are identical (that is, *Xi(ac) = Xi(bc)),* the index will take on a value of 100. If *a*'s and *b*'s export patterns are totally different (that is, for each are identical *Xi(ac) > 0, Xi(bc) = 0*, and vice versa) the index will take on a value zero. The index intends to compare only patterns of exports across product categories; it is not influenced by the relative size or scale of total exports.

Figure 3 Finger-Kreinin Export Similarity Index: Australia and OECD, 1988-2013 (%)



Source: Based on data compiled from the UN Comtrade database.

A comparison of the data on the commodity composition of Australian manufacturing exports (Tables 2 and 3) with that of OECD countries (Tables A-6 and A-7 in Athukorala and Talgaswatta 2016) helps us to understand the sources of the widening divergence of the Australian GPN exports patterns from the OECD patterns. Auto parts (SITC 7843) is the single most important item on the parts and components export list of OECD countries. This item accounts for 15.5% of total parts and components exports from these countries, up from 12.9% in 1990/01. Auto parts still account for a significant share in Australian exports, but this share has declined over time. In contrast, the rapid increase in the share of aircraft parts is a unique feature of Australia's engagement in global production networks.

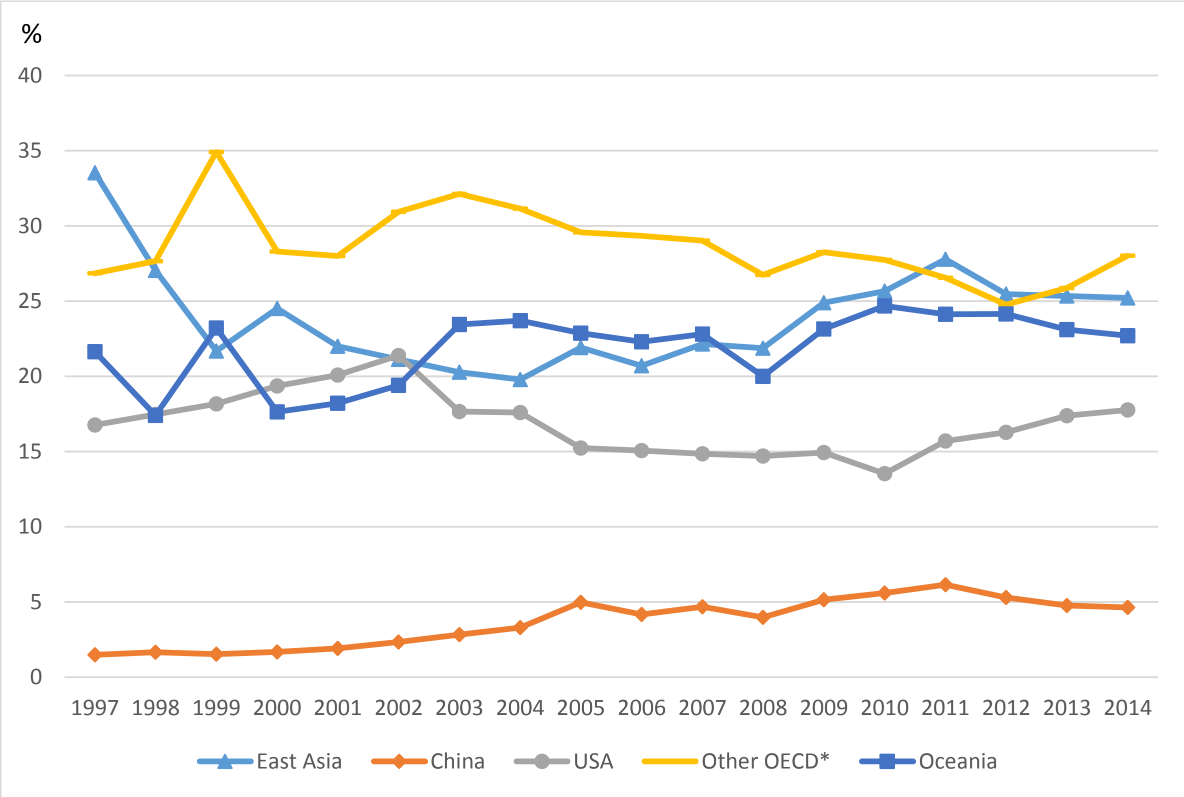
In spite of the changes in the product mix noted earlier, resource-based manufacturing industries (products belonging to SITC 6) and heavy machinery industries (roughly SITC codes 71 to 75) still account for a larger share of Australian's GPN final assembly exports. Products in which GPN trade has been heavy concentrated in OECD countries such as telecommunication and sound recording equipment (SITC 76), electrical machinery (SITC 77), professional and scientific equipment (SITC 87), and photographic equipment (SITC 88) still do not figure prominently in the Australian export product mix. Medical and surgical equipment account for a relatively larger share of GPN final assembly exports from Australia compared to the OECD average patterns.

Direction of Exports

There has been a notable shift in the source-country composition of GPN trade from advanced industrial countries to countries in East Asia (Athukorala 2014). Has this structural shift been reflected in the geographic profile of Australian exports? This issue is central to the contemporary Australian policy focus on reaping gains from the East Asian economic dynamism.

OECD countries still account for over half of total GPN exports, with the US continuing to remain the largest single destination (Figure 4), the East Asian share of total GPN exports from Australia is significantly larger (27.7% in 2012-13), when compared to the OECD average (16.2%). Surprisingly, there is no evidence of a notable East Asian bias in GPN exports from Australia, given its proximity to the region. The East Asian share of Australian GPN exports has varied in the range of 27% to 33% over the period 2000-14, without showing any clear upward trend in line with East Asia's growing importance in global production sharing. The share of exports to China has varied in the narrow range of 4% to 5.3% over the past years, notwithstanding that country's role as the major importer of components in the region, to be used in final assembly within global production networks. Among the East Asian countries, the countries in Southeast Asia account for a much larger share of manufacturing exports compared to Northeast Asia (including China).

Figure 4 Australia: Direction of GPN Exports (%)



Source: Based on data compiled from the UN Comtrade database.

One notable feature of Australia's final assembly exports is the significant share (24.4%) going to West Asia (Middle East oil rich countries). Disaggregated data shows that motor vehicles continue to account for a large share (over a half). But exports of a number of other final GPN goods to these countries have also increased in recent years. The geographic profile of Australian manufacturing exports (both GPN products and other) shows a distinct Oceania bias, with New Zealand accounting for a much larger share of Australian exports relative to that country's position in global trade. This pattern is consistent with the view that 'remoteness' from major trading centres in the world, in addition to the geographic distance, plays a role in determining bilateral trade flows (Head and Mayer 2014).

5 Determinants of Exports

In this section, we undertake an econometric analysis of the determinants of manufacturing exports, distinguishing among parts and components, final assembly and conventional (horizontal) products. The analysis is undertaken within the standard gravity modelling framework, which has now become the 'workhorse' for modelling bilateral trade flows.[53] We estimate the export equation separately for total manufacturing and the three product categories by including intercept and slope dummy variables to examine how Australian performance differs from that of the other countries. This approach is equivalent to estimating separate regressions for Australia, but it has the added advantage of providing a direct test of the statistical significance of the differences between the estimated coefficients.

Australia is likely to exhibit important differences in GPN compared to other countries as a results of tyranny of distance, fluctuations in the exchange rate caused by the commodity boom and due to relatively better institutions and human capital endowment compared to Asian countries involved in GPN in the region.

After augmenting the basic gravity model by adding a number of explanatory variables, which have been found to improve the explanatory power in previous studies, the empirical model is specified as:

$$lnEXP_{ijt}{}^{54} = \alpha + \beta_1 lnSBV_{it} + \beta_2 lnDBV_{jt} + \beta_3 DST_{ijt} + \beta_4 lnPGDP_{it} + \beta_5 lnRER_{ijt} + \beta_6 lnTECH_{it} + \beta_7 FTA_{ij} + \beta_8 INST_{it} + + \beta_9 lnLPI_{ijt} + \beta_{10} ADJ_{ij} + \beta_{11} CML_{ij} + \beta_{12} CLK_{ij} + \beta_{13} EUD_{ij} + \beta_{14} EAD_{ij} + \beta_{15} AFC_{ij} + \beta_{16} GFC_{ij} + \eta_t + \epsilon_{ijt} \quad (1)$$

where the subscripts *i* and *j* refer to the reporting (exporting) and the partner (importing) country, *t* is time (year) and *ln* denotes natural logarithms. The explanatory variables are listed and defined below, with the postulated sign of the regression coefficient in brackets.

[53] The gravity model originated in Tinbergen (1962), purely as an attempt to capture empirical regularities in trade patterns. For recent attempts to provide a theoretical justification for its formulation and applications to trade flow modelling, see various contributions in Bergeijk and Brakman (2010). Head and Mayer (2014) provide an extensive survey of the relevant literature.

[54] The dependent variable is the log of exports of country i to country j.

EXP	Bilateral exports
SBV	Supply-base variable: real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *i* (+)
DBV	Demand-base variable: real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *j* (+)
DST	The distance between the economic centres of *i* and *j* (-)
PGDP	Real per capita GDP of country i and *j* (+ or -)
RER	Real bilateral exchange rate between *i* and *j* (+)
TECH	Technological capabilities of *i* measured by resident patent registrations (+)
INST	Institutional quality of country *i* (+)
FTA	A binary dummy which is unity if both *i* and *j* belong to the same regional trade agreements (*RTA*) and 0 otherwise (+)
LPI	Quality of trade related logistics of country *i* and *j* (+)
ADJ	A binary dummy variable which takes the value one if *i* and *j* share a common land border and zero otherwise (+)
CML	A dummy variable which takes the value one if *i* and *j* have a common language (a measure of cultural affinity) and zero otherwise (+)
CLK	Colonial economic link dummy which takes the value one for country pairs with colonial links and zero otherwise (+)
EUD	A dummy variable for the European Union member countries (which takes the value one for EU member countries and zero for the other countries)
EAD	A dummy variable for the countries in East Asia (which takes the value one for the East Asian countries and zero for the other countries).
AFC	A dummy (1 for 1997 and 1998 and zero otherwise) to capture trade disruption caused by the Asian financial crisis (-).
GFC	A dummy (1 for 2008 and 2009 and zero otherwise) to capture trade disruption caused by the global financial crisis (-).
α	A constant term
η_t	A set of time dummy variables to capture year-specific fixed effects
ε	A stochastic error term, representing the omitted influences on bilateral trade

Description of Variables

The three variables, *SBV*, *DBV and DST,* are the key gravity model variables. In the standard formulation of the model, the real GDP of the reporting and partner countries is used to represent SBV and DBV. The GDP of the reporting (exporting) country is used to represent its supply capacity, whereas that of the destination nation represents the capacity to absorb (demand). The larger countries have more variety to offer and absorb in international trade than do smaller countries (Tinbergen 1962). The use of this variable in our trade equation is also consistent with the theory of global production sharing, which predicts that the optimal degree of fragmentation depends on the size of the market (Jones and Kierzkowski 2004, Grossman and Rossi-Hansberg 2013). However, for modelling trade in parts and components - which are mostly inputs in the production process - the use of GDP, to represent supply and demand, is less appropriate (Baldwin and Taglioni 2011). For this reason, we use the real manufacturing output of the reporting and partner countries as the proxies for SBV and DBV in the parts and components equation.

The geographic distance (*DST*) is a proxy measure of transport (shipping) costs and other costs associated with time lags in transportation including spoilage. Technological advances during the post-war era have contributed to the 'death of distance' when it comes to international communication costs (Cairncross 2001). However, there is evidence that geographical 'distance' is still a key factor in determining international transport costs, in particular shipping costs (Hummels 2007, Evans and Harrigan 2005). Transport cost could be a much more important influence on GPN trade than on the conventional horizontal trade, because of the multiple border-crossings involved, the need to meet delivery requirements for just-in-time production and the requirements for movement of managerial and technical manpower within global production networks.

Relative per capita GDP (RPGDP) is considered a good surrogate variable for intercountry differences in the capital-labour ratio (Helpman 1987). There are also reasons to believe that relative GDP per capita has a positive effect on GPN trade because as countries grow richer, the scale and composition of industrial output can become more conducive to production sharing. More developed countries also have higher quality ports and communication systems that facilitate production sharing by reducing the cost of maintaining 'services links' (Golub *et al*. 2007).

The real exchange rate *(RER),* measured as the domestic currency price of the trading partner currency adjusted for relative prices of the two countries, is included to capture the impact of international prices of tradable goods production on export performance. In the standard trade flow modelling, this variable is expected to have a positive impact on bilateral trade flows. However, as discussed in Section 3 of this chapter and Chapter 3, this study hypothesize this impact to be weaker (or even zero) for GPN trade.

Technological capabilities (*TECH*) is a key determinant of a country's ability to move from low-value assembly activities to high-value upstream and down-street activities within global production chains. This is particularly important for countries whose success in global production sharing does not depend on labour cost advantage. We measure *TECH* by the number of patent registrations by the residents of a given country. Further, technological improvements can be vital to the reduction of service link costs (Majeed 2015).

The free trade agreement dummy variable (*FTA*) is included to capture the impact of tariff concessions offered under these agreements. In theory, GPN trade is considered to be relatively more sensitive to tariff changes (under an FTA or otherwise) compared to the conventional horizontal trade, because normally a tariff is incurred each time a good in process crosses a border (Yi 2003). However, in reality, the trade effect of any FTA depends very much on the nature of the rules of origin (ROOs) built into it and the resultant increase in transaction costs involved in FTA implementation (Athukorala and Kohpaiboon 2013, Krishna 2006). Moreover, the process of global production sharing is characterised by the continuous emergence of new products. This naturally opens up room for unnecessary administrative delays, as well as the tweaking of rules as a means of disguised protection.

The institutional quality index (*INST)* captures various aspects of governance that directly affect property rights, political instability, policy continuity and other factors which have a bearing on the ability to carry out business transactions. This may be an important factor to attract multinationals to invest in a country.

The remaining variables represent various aspects of the cost of the service links involved in connecting production blocks/tasks within the global production networks. The logistic performance index (*LPI)* measures the quality of trade-related logistic provisions. Adjacency (*ADJ*), common business language (*CML*), and colonial links (CLK) can all facilitate trade by reducing transaction costs and through a better understanding of each other's culture and legal systems. The European Union dummy (*EUD*) is expected to capture the possible implications of economic integration among amount these countries for GNP trade. The East Asia dummy (*EAD*) is included to test whether the importance of the region as a center of regional production network's still holds after controlling for other relevant variables. Finally, *AFC* and *GFC* dummy variables are included to control for the trade disruptions during the Asian financial crisis (AFC) and the recent global financial crisis (GFC).

Data and the Estimation Method

The model is estimated using annual data compiled from the exporter records in the UN trade data system (*Comtrade* database) during the period 1996-2013. The dataset covers export trade of 44 countries, each of which accounted for 0.01% or more of total world manufacturing exports in 2005. These countries account for over 98% of total world manufacturing exports. The trade data in nominal US$ are converted into real terms using US import price indices extracted from the US Bureau of Labour Statistics database. The explanatory variables are listed along with details on variable construction and data sources in Table 4.

Of the three standard panel data estimation methods (pooled OLS, random-effects, and fixed-effects estimators), the fixed effect estimator is not appropriate for estimating the model because it contains a number of time-invariant explanatory variables, which are central to our analysis. In experimental runs, we use both pooled OLS estimator and random-effects estimator (REE). The Breusch-Pagan Lagrange Multiplier test favours the use of RE over the OLS counterpart. However, the RE estimator can yield biased and inconsistent coefficient estimates if one or more explanatory variables are endogenous (that is, if they are jointly determined together with the dependent variable). In our case, there are reasons to suspect that FTA and reporting-country GDP are potentially endogenous (Brun et al 2005; Baier and Bergstrand 2007). Given these concerns, we re-estimate the model using the instrumental variable estimator proposed by Hausman and Tayler (1981) (henceforth HT estimator). The HTE redresses the endogeneity problem in cross-section gravity models by using instruments derived exclusively from inside the model to capture various dimensions of the data. The superiority of HT estimation over RE estimation in generating consistent coefficient estimates of the gravity model has been demonstrated by a number of recent studies[55]. To make the results comparable, we also present the correlated random effects (CRE) and the specification used in Chapter 2. The results remain quantitatively similar. In the CRE estimates, because of using Australian Dummy and mean values of the covariates, several variables are dropped because of perfect collinearity.

General Inferences

The preferred HT estimates of the trade equation are reported in Table 5. The coefficient estimates for Australia derived from the overall regression are given in Table 6. Note that we have deleted the dummy variables for the Asian financial crisis and the global financial crisis (*DAFC* and *DGFC)*) from the final estimates because these two variables turn out to be statistically insignificant in experimental runs in all cases. It seems that the effects of the two crises are well captured in the model by the time dummies. The following interpretations of the regression results are arranged under two subheadings, general inferences and Australia-specific inferences. To make the results comparable with Chapter 2, and for further robustness tests, the alternative RE and CRE estimates are reported for comparison in Appendix Table A-1 and A-2. The results are qualitatively similar.

The coefficients of the standard gravity variables (SBV, DBV and *DST*) are statistically significant with the expected signs in all equations. The magnitude of the coefficient of the distance, *DST* (between -0.81 to -1.09) is consistent with the results of previous gravity model applications for modelling trade flows (Head and Mayer 2014).

The result for the relative per capita income variable (R*PGDP)* is mixed. The coefficient is statistically significant, with the negative sign in the parts and component equation suggesting a relative labour intensity bias associated with export expansion. The reverse impact seems to apply for final assembly as well, but the estimated impact is small in both cases (0.01).

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[55] See Egger (2005) and Serlenga and Shin (2007), and the works cited therein.

The results for the real exchange rate variable (*RER*) support our hypothesis that global production sharing weakens the link between international price changes and trade flows. The coefficient of *RER* is not statistically different from zero in the equation for parts and components. It is marginally significant in the equation for final assembly with the unexpected sign. By contrast, the estimated effect of RER on horizontal exports (and hence on total exports) is highly significant with the expected (positive) sign.

The coefficient of TECH is statistically significant in all four equations, suggesting that the domestic technology base is an important determinant of manufacturing export performance in general. However, the coefficient of the parts and components (0.22) is much larger compared to that of final assembly (0.05). This difference is consistent with the postulate that specialisation in parts and components within global production networks is generally more technology intensive compared to final assembly (see Box 2).

The coefficient of the free trade agreement variable (*FTA)* is statistically significant in all four equations, but it is larger in magnitude in the two GPN exports equations. This result is consistent with the fact that tariffs on final electrical and transport equipment still remain high in most countries. The coefficient of this variable for parts and components is smaller (0.47) compared to that for final assembly (0.69). This result is consistent with the fact that almost all countries permit duty-free entry of parts and components as part of their export promotion policy package (WTO 2015). These results, however, need to be interpreted with care because it could well reflect co-existence, rather than causation: there is a general tendency for trading partners with historically well-established trade links to enter into FTAs than others.

Institutional quality (*INST*)[56] seems to have a positive and statistically significant effect only on parts and component exports. Strong and business friendly institutions are important for attracting MNEs to invest in the country. Further, this is consistent with the fact that institutional quality is closely associated with the service link costs involved

[56] In experimental runs we used three other alternative indicators of institutional quality (governance), (rule of law, government effectiveness, control of corruption) from the World Bank's World Governance Indicators database. The results were comparable in the standard OLS estimation. However, we were not able to use these indicators in FE and HT estimations because of data gaps.

in global production sharing. Timely delivery of parts and components is vital for the smooth functioning of closely-knit tasks within the value chain.

The coefficient of the logistic performance variable (*LPI*) is statistically significant in all four equations. The magnitude of the coefficient of this variable for parts and components (1.02) and final assembly (1.16) is larger than that of conventional (horizontal) exports (0.79). This difference (which is statistically significant) is consistent with the view that the quality of trade related logistics is much more important for a country's success in expanding GNP trade.

The common language variable *(CML)* seems to have a highly significant impact on parts and comment exports. The use of a common language generally reduces service link cost. Surprisingly, the coefficient of this variable is not statistically significant in the equation for final assembly export. This presumably reflects China's dominance in the world final-assembly trade.

Finally, the coefficient of the East-Asia dummy (*EAS*) is highly significant with the expected sign in all four regressions. The coefficients for *EAS* in the two GPN equations are much larger than that in the horizontal export equation, indicating a strong GPN bias in intra-East Asian trade. More specifically, the results suggest that Intra East-Asia exports of GPN products are five to six times larger (whereas horizontal exports are only three times larger) than predicted by the other explanatory variables in the model.[57] Interestingly, the coefficient of the EU dummy is not statistically significant in all four regressions. It seems that there is no distinct intra-regional bias in EU exports (with the exception of parts and components) after controlling for the other explanatory variables, in particular, the *FTA* dummy.

[57] Note that, as the model was estimated using all variables (other than the dummy variables), the comparable figure for any dummy coefficient is [exp(dummy coefficient) – 1]. Thus the comparable coefficients of ESA in the four equations are 4.4, 6.2, 5.0 and 3.0, in that order.

Australia-specific Inferences

The coefficients of most of the dummy interaction variables are not statistically significant (Table 6). This suggests that the above inferences relating to these variables are generally applicable to exports from Australia as well.

A notable Australia specific finding is that the 'tyranny of distance' is a significantly more binding constraint on exports of conventional (horizontal) goods and hence on total manufacturing exports. The coefficients of DST in the equations for horizontal goods (-4.30) and total manufacturing (-3.52) are highly significant[58] and are more than three times larger in magnitude compared to the all-country coefficient (-0.95 and -0.86, respectively). By contrast, the coefficient of DST in the equations for parts and components is not statistically significant, suggesting that distance does not place Australia at a specific disadvantage in exporting parts and components compared to the all-country experience. The coefficient of DST related to final assembly exports is marginally significant (at the 10% level), presumably, because shipping is the only mode of transport for some final assembly products such as motor vehicles and agricultural machinery. However, overall, it seems that fitting into global production networks helps Australian manufacturing to circumvent the 'tyranny of distance'.

The coefficient of RGDP is statistically significant with the positive sign only in the component regression. This finding is consistent with the view that Australia has comparative advantage in the production of relatively more capital intensive parts and components within production networks compared to the other countries

The coefficient of the real exchange rate variable (RER) in the final goods equation is not statistically different from zero. It is marginally statistically significant (at the 10% level) for components with the expected (positive) sign, but the magnitude of the coefficient is small (0.07). Thus, overall, the results are consistent with our postulate that relative price competitiveness is not a major determinant of GPN trade.

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[58] Both total manufacturing and horizontal goods exports are significant at the 1 per cent level, showing that transportation costs are more binding for these categories compared to parts and components trade.

The domestic technology base seems to give an edge to Australian manufacturing in exports of both parts and components and final assembly. The estimated Australian coefficient of TECH is statistically significant and its magnitude is much larger compared to the all-country coefficients. This is consistent with the notion that technological improvements help in fragmenting the production process across countries. Overall, the Australian results relating to TECH variables are consistent with the patterns revealed in our RCA analysis. The results for the FTA variable suggest that FTA membership[59] has not so far helped the expansion of Australian manufacturing exports over and above the other determinants of trade flows.

Institution quality (INST) seems to give Australian manufacturing a distinct competitive edge in parts and components exports over other countries. The coefficient of INST for Australia in the equation for parts and components is as large as 0.98, compared to the all-country coefficient of a mere 0.04.

6 Concluding Remarks

Global production sharing has become an integral part of the global economic landscape over the past few decades. Australia is still a minor player in global production sharing, but at the disaggregated levels we can observe a number of promising signs. There are early signs of Australian manufacturing reaping gains from joining the global production networks, specifically focussing on specialised tasks which are generally consistent with the country's comparative advantage in skill-intensive production. Australia's share of total OECD exports of GPN products has doubled over the past decade.

Australia seems to have a distinct competitive edge in parts and components specialisation in several product categories: aircraft and associated equipment, internal-combustion machines, machine tools, miscellaneous machinery, taps and valves, computers, measuring equipment, machine parts, photographic equipment and electrical machinery. Among final assembly products, Australia seems to have a

[59] During the period under study, Australia has been an FTA partner with New Zealand (throughout the entire period under study), Singapore (since 2004), Thailand (since 2005), and the USA (since 2005).

competitive edge in medical devices, measuring and scientific equipment and light aircraft. In sum, the findings of the commodity-level analysis suggest that the ongoing process of global production sharing has opened up opportunities for Australia to specialise in high-value-to-weight parts and components, and final assembly, which are not generally subject to the tyranny of distance in world trade because the main mode of transport is air shipment. The 'tyranny of distance' is not a binding constraint on exporting specialised parts and components and some final assembly goods from Australia. There is also evidence that domestic technological capabilities are relatively more important, compared to the average global experience, in determining components exports from Australia.

The econometric analysis and the analytical narrative of export patterns suggest that relative price competitiveness (captured in our analysis by the real exchange rate) does not seem to be an important determinant of GPN exports. These exports are predominantly 'relation-specific' and are based on long-term supplier-producer relationships. This evidence suggests that reaping gains from both Australia's comparative advantage in primary commodity (resource-based) trade, as well as from specialisation in knowledge-intensive tasks within global production networks, are not conflicting policy goals for Australia.

Overall, our findings are consistent with the message of a recent policy report by the Committee for Economic Development of Australia that 'Rumours of the death of manufacturing in Australia, perpetuated by the media's constant reporting of factory closures, and large multinationals exiting manufacturing, is generally exaggerated' (CEDA 2014). Effective policy making in this era of global production sharing needs to be based on the identification of specific manufacturing niches through a disaggregated analysis of trade patterns rather than looking at evidence depicting the broader picture. However, in the Australian policy debate to date the term 'advanced manufacturing' has been used in the conventional sense, without distinguishing GPN trade within overall manufacturing. Our disaggregated analysis of parts and components and final assembly exports within global production networks will also be helpful in identifying specific products within advanced manufacturing for policy attention.

The findings of this study give credence to the case made in a number of recent influential studies for further reforms to improve Australia's export performance (Withers et al 2015, CEDA 2015, Government of Australia 2012). Compared to the first four decades of the post-World War II era, Australia's policy reforms since the early 1980s have certainly achieved a great deal in unshackling the economy and integration into the world economy. However, as extensively discussed in these studies, there are still many unresolved problems relating to the overall investment climate. Given the importance of 'service link' cost, the overall business climate of the host country is the ultimate draw for investors in this area: just offering incentives for investors cannot compensate for the lack of such a base.

Finally, the ongoing process of global production sharing calls for a change in national data reporting systems and the analytical and statistical tools we use to measure and understand world trade and the trade-industry nexus. Linking trade data at the firm/establishment level with production data is vital for clearly identifying the niche areas of specialisation within global production systems and to monitor the achievement of the manufacturing industry in those areas. It is also important to improve/restructure the national data reporting system in order to better capture the growing importance of the role of services in manufacturing.

Table 1 Summary Data of Manufacturing Exports: Australia - OECD Comparison

	Total manufacturing	Parts & components	Final assembly	GPN products	Other manufacturing
OECD share in world exports (%)					
1990/01	78.3	81.3	81.7	81.5	74.9
2000/01	66.6	64.7	72.5	67.6	65.2
2005/06	59.8	56.0	63.3	58.9	61.0
2012/13	48.2	45.6	48.8	47.0	49.4
Australia's share in world exports (%)					
1990/01	0.27	0.24	0.19	0.22	0.33
2000/01	0.33	0.27	0.38	0.31	0.35
2005/06	0.28	0.23	0.31	0.25	0.32
2012/13	0.26	0.28	0.23	0.25	0.28
Australia's share in OECD exports					
1990/01	0.35	0.30	0.24	0.27	0.44
2000/01	0.49	0.31	0.26	0.29	0.48
2005/06	0.47	0.33	0.29	0.31	0.52
2012/13	0.54	0.38	0.33	0.36	0.58
OECD export composition (%)					
1990/01	100	30.3	23.4	53.7	46.3
2000/01	100	34.5	23.1	57.6	42.4
2005/06	100	31.1	22.6	53.7	46.3
2012/13	100	25.4	21.8	47.3	52.7
Australia's export composition (%)					
1990/01	100	26.0	15.9	41.9	58.1
2000/01	100	29.3	24.8	54.1	45.9
2005/06	100	25.5	23.2	48.8	51.2
2012/13	100	27.2	18.7	45.9	54.1

Note: 1. Countries which became OECD member before 1990.
Source: Compiled from UN Comtrade database in current US$

Table 2 Parts and Components Exports from Australia: Composition, World Market Share and Revealed Comparative Advantage (RCA)[1] (%)

SITC code	Product description	Composition (%)			Share of world exports (%)			CRA index		
		1990/91	2000/01	2012/13	1990/91	2000/01	2012/13	1990/91	2000/01	2012/13
7929	Aircraft parts (excluding tyres and electrical parts)	8.2	7.6	13.3	0.6	1.0	1.7	2.1	2.9	5.8
7843	Motor vehicle parts other than bodies	10.2	10.8	8.8	0.2	0.4	0.2	0.8	1.0	0.7
7239	Parts of earth moving machines	3.1	2.8	8.6	0.6	0.8	1.4	2.1	2.4	4.7
7599	Parts/accessories of data processing/storage machines	9.2	13.5	7.1	0.3	0.4	0.6	1.2	1.3	2.2
7643	Transmission apparatus for radio-telephony	1.4	2.0	3.7	0.4	0.1	0.2	1.4	0.4	0.6
7283	Parts of machines for mineral processing	0.9	1.3	2.9	1.1	2.7	3.0	3.8	7.8	10.3
7132	Engines for propelling vehicles	9.8	4.6	2.4	1.0	0.6	0.3	3.4	1.8	1.0
7429	Parts of pumps and liquid elevators	1.0	0.8	2.2	0.6	0.7	1.1	2.0	2.1	3.9
7725	Electrical apparatus for switching/protecting electrical circuits	2.2	3.8	2.0	0.3	0.5	0.2	0.9	1.3	0.7
6956	Plates, sticks and tips for tools	0.7	0.9	1.8	0.2	0.3	0.4	0.6	0.9	1.5
7285	Parts of specialised industrial machinery	0.9	2.0	1.8	0.2	0.6	0.4	0.7	1.8	1.3
7726	Boards and panels for electrical control	0.5	0.5	1.7	0.2	0.2	0.3	0.6	0.6	1.0
7139	Parts for internal combustion engines	3.6	1.9	1.6	0.4	0.3	0.2	1.5	1.0	0.7
7724	Reciprocating positive displacement pumps	1.2	1.0	1.6	0.8	1.3	1.3	2.7	3.7	4.6
7478	Taps/cocks/valves	0.5	0.5	1.6	0.1	0.2	0.3	0.3	0.5	0.9
7919	Railway or tramway track fixtures and fittings	0.4	0.3	1.3	0.4	0.3	0.9	1.5	1.0	2.9

SITC code	Product description	Composition (%)			Share of world exports (%)			CRA index		
		1990/91	2000/01	2012/13	1990/91	2000/01	2012/13	1990/91	2000/01	2012/13
7523	Digital processing units	2.1	1.3	1.2	0.2	0.2	0.2	0.7	0.5	0.6
7783	Accessories of motor vehicles except bodies	0.8	0.6	1.2	0.2	0.2	0.2	0.7	0.6	0.8
7449	Parts for lifting, handling and loading machinery	0.9	0.8	1.2	0.3	0.5	0.5	1.1	1.3	1.7
7529	Data-processing equipment	0.8	1.2	1.0	0.2	0.3	0.4	0.9	0.9	1.2
7649	Parts of sound recording equipment	1.0	2.7	0.9	0.1	0.3	0.1	0.3	0.8	0.5
6299	Hard rubber parts	0.5	0.3	0.9	0.3	0.2	0.3	0.9	0.5	1.1
7763	Diodes, transistors and similar semiconductor devices	0.3	0.6	0.9	0.1	0.1	0.1	0.3	0.3	0.3
7788	Parts of electrical machinery	1.0	1.3	0.9	0.3	0.5	0.2	1.0	1.4	0.8
7731	Insulated wire, cable electric conductors	3.1	2.2	0.9	0.4	0.3	0.1	1.5	0.8	0.4
7484	Gears and gearing and other speed changers	0.6	0.1	0.9	0.4	0.1	0.4	1.3	0.2	1.3
7189	Engines and motors for electric rotary converters	0.2	0.1	0.8	0.4	0.5	1.0	1.4	1.5	3.5
6648	Vehicle rear-view mirrors	1.0	0.9	0.8	4.5	4.2	2.1	16.1	12.3	7.2
7728	Parts suitable for electrical apparatus	0.7	0.6	0.8	0.2	0.2	0.2	0.8	0.6	0.7
7489	Parts of g=ars/flywheel/sclutches	0.4	0.3	0.7	0.5	0.5	0.6	1.6	1.6	2.2
7526	Input or output units for automatic data-processing machines	0.7	0.6	0.7	0.1	0.1	0.2	0.2	0.2	0.8
7439	Parts of centrifuges and purifying machines	0.3	0.3	0.7	0.2	0.3	0.4	0.8	0.9	1.4
8741	Parts of surveying and navigating instruments	0.3	0.3	0.7	0.4	0.8	1.0	1.3	2.5	3.4

SITC code	Product description	Composition (%)			Share of world exports (%)			CRA index		
		1990/91	2000/01	2012/13	1990/91	2000/01	2012/13	1990/91	2000/01	2012/13
7479	Parts of valves, taps and cocks	0.5	0.4	0.7	0.5	0.4	0.4	1.8	1.3	1.2
7527	Data storage units	0.1	0.3	0.7	0.0	0.0	0.1	0.0	0.1	0.3
8912	Parts of military equipment	0.2	0.0	0.7	0.1	0.1	1.5	0.5	0.2	5.1
8749	Parts and accessories for other machines and appliance	1.6	1.3	0.7	4.0	3.6	1.5	14.1	10.5	5.0
7149	Parts of the engines and motors of reaction engines	1.5	0.2	0.6	0.2	0.0	0.1	0.7	0.1	0.3
7499	Machinery parts, not containing electrical connectors	0.5	0.7	0.6	0.3	0.6	0.5	1.1	1.8	1.8
7415	Air-conditioner parts	0.8	1.0	0.6	0.3	0.4	0.2	1.0	1.3	0.7
7853	Parts and accessories of cycles	0.0	0.3	0.6	0.0	0.2	0.3	0.0	0.6	1.0
7148	Gas turbines	0.3	0.3	0.5	0.2	0.2	0.3	0.6	0.6	1.1
7219	Parts of agricultural machinery	0.8	0.5	0.5	0.6	0.7	0.4	2.2	1.9	1.2
7787	Parts of electrical machines and apparatus	0.2	0.6	0.5	0.4	0.7	0.4	1.3	1.9	1.3
Other[2]		24.5	25.6	15.9	0.2	0.2	0.2	1.1	0.7	0.3
Total		100	100	100	0.26	0.28	0.30	0.89	0.82	1.02
Total $ million		1628	4325	8032						

Notes: (1) The revealed comparative advantage is an index used in international economics for calculating the relative advantage or disadvantage of a certain country in a certain class of goods or services as evidenced by trade flows. It is based on the Ricardian comparative advantage concept. Products are listed in ascending order, based on export shares for 2012/13. Figures are two-year averages.

(2) Four-digit items, each of which accounts for less than 0.5% of the total value.

Source: Compiled from the UN Comtrade database using the procedure discussed in Section 2

Table 3 Final Assembly Exports from Australia: Composition, World Market Share and Revealed Comparative Advantage (RCA)1 (%)

SITC code	Product description	Composition (%)			World export share (%)			RCA index		
		1990/01	2000/01	2012/13	1990/01	2000/01	2012/13	1990/01	2000/01	2012/13
7821	Motor vehicles for the transport of goods	25.7	29.2	28.9	0.2	0.4	0.3	0.6	1.2	0.9
7812	Passenger motor vehicles	24.5	28.3	25.3	0.2	0.5	0.3	0.7	1.4	0.9
8723	Mechanotherapy appliances[2]	0.3	0.8	7.3	0.3	1.4	5.5	1.0	4.1	18.7
8722	Medical, surgical or veterinary science instruments	2.5	3.4	5.6	0.4	0.8	0.6	1.3	2.3	1.9
7921-22	Aircrafts <2000kg	1.2	1.4	3.6	0.7	1.2	2.4	2.5	3.6	8.0
8744	Instruments/apparatus for physical or chemical analysis	2.7	2.1	3.1	0.6	1.0	0.6	2.2	2.8	2.2
7522	Digital automatic data-processing machines	3.5	0.6	2.1	0.4	0.1	0.1	1.5	0.3	0.3
7788	Electrical machinery and equipment	0.9	1.3	2.0	0.2	0.4	0.3	0.6	1.2	1.1
8742	Drawing, marking-out or mathematical calculating instruments	0.5	0.6	1.6	0.1	0.3	0.4	0.4	0.8	1.3
8741	hydrological, meteorological or geophysical instruments	0.3	0.8	1.6	0.1	0.8	1.0	0.4	2.2	3.4
7931	Yachts and other vessels for pleasure or sports	5.0	1.7	1.4	2.0	1.6	0.9	6.9	4.8	3.1
7638	Sound-recording/reproducing apparatus	0.3	0.4	1.1	0.0	0.1	0.2	0.1	0.2	0.5
7648	Telecommunications equipment	0.6	0.3	0.9	0.1	0.3	0.4	0.3	1.0	1.3
8745	Measuring, controlling and scientific instruments	0.2	0.2	0.9	0.1	0.3	0.7	0.5	0.9	2.5

SITC code	Product description	Composition (%)			World export share (%)			RCA index		
		1990/01	2000/01	2012/13	1990/01	2000/01	2012/13	1990/01	2000/01	2012/13
8746	Automatic regulating or controlling instruments	0.1	0.3	0.8	0.1	0.2	0.3	0.2	0.5	0.9
8842	Drawing, marking-out or mathematical calculating instruments	0.3	0.2	0.8	0.2	0.3	0.5	0.6	0.9	1.8
7932	Ships, boats and other vessels	6.1	4.0	0.8	0.4	0.7	0.1	1.5	1.9	0.2
7758	Electro-thermic appliances	0.9	0.4	0.8	0.2	0.2	0.2	0.6	0.5	0.5
7741	Electro-diagnostic (other than radiological) apparatus	0.5	0.4	0.7	0.2	0.3	0.3	0.6	0.8	0.9
7712	Microphones and stands therefore	1.2	0.4	0.7	0.4	0.1	0.1	1.3	0.4	0.4
7642	Wrist watches, pocket watches and other watches	0.2	0.3	0.7	0.0	0.2	0.2	0.2	0.4	0.7
7832	Semi-trailer tractors	0.1	0.4	0.6	0.0	0.1	0.1	0.1	0.4	0.3
8743	Lenses, prisms, mirrors and other optical elements	0.2	0.2	0.6	0.1	0.2	0.3	0.4	0.7	1.0
8747	Oscilloscopes, spectrum analysers and other instruments	0.9	1.2	0.6	0.3	0.6	0.3	0.9	1.7	0.9
7822	Special-purpose motor vehicles	0.6	0.3	0.5	0.2	0.4	0.3	0.8	1.1	0.9
Other[3]		21.9	20.6	7.3	0.3	0.6	0.2	1.1	1.6	0.8
Total		100	100	100	0.2	0.4	0.3	0.7	1.2	0.0
US$ million		1,331	5,096	7,193						

Notes: (1) Products are listed by ascending order based on export shares for 2012/13. Figures are two-year averages.
(2) Appliances used for exercise prescribed for heel-drop exercises for Achilles tendon injury.
(3) Four-digit items, each of which accounts for less than 0.5% of the total value.
Source: Compiled from the UN Comtrade database using the procedure discussed in Section 2

Table 4A Variable Definitions and Data Sources

Label	*Definition*	*Data source/variable construction*
EXP	Bilateral exports in US$ measured at constant (2000) price, for 44 countries: Argentina, Australia, Belgium, Bangladesh, Brazil, Canada, Switzerland, China, Costa Rica, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Hong Kong (China HKG), Hungary, Indonesia, India, Ireland, Israel, Italy, Japan, Rep. of Korea, Sri Lanka, Mexico, Malaysia, Netherlands, Norway, Pakistan, Philippines, Poland, Portugal, Russian Federation, Singapore, Slovak Republic, Slovenia, South Africa, Sweden, Thailand, Turkey, United States (USA) and Vietnam.	Exports (at CIF price, US$): compiled from UN COMTRADE database. Exports values are deflated by US import price indices extracted from the US Bureau of Labour Statistics database (http://www.bls.gov/ppi/home.htm).
GDP, RMF, PGDP	GDP, manufacturing output, and per capita GDP (at 2000 price).	World Development Indicator database, The World Bank.
DST	Weighted distance measure of the French Institute for Research on the International Economy (CEPII), which measures the bilateral great-circle distance between major cities of each country.	French Institute for Research on the International Economy (CEPII) database.
RER	Real exchange rate: $RER_{ij} = NER_{ij} * \frac{P_j^D}{P_i^W}$ where, NER is the nominal bilateral exchange rate index (value of country *j*'s currency in terms of country *i*'s currency), P^W is price level of country *j* measured by the producer price index and P^D is the domestic price index of country *i* measured by the GDP deflator. An increase (decrease) in RER_{ij} indicates improvement (deterioration) in country's international competitiveness relative to country *j.*	Constructed using data from World Bank, World development Indicators database. The mean-adjusted RER is used in the model. This variable specification assumes that countries are in exchange rate equilibrium at the mean.
TECH	Technological capability proxied by patent applications by the residents of a given country.	World Development Indicator, World Bank http://data.worldbank.org/data-catalog/world-development-indicators
FTA	A binary dummy variable which is unity if both country *i* and country *j* are signatories to a given regional trading agreement.	CEPII database
INS	Institutional (governance) quality (by political stability and absence of violence) measured on a scale of -2.5 (worst performance) to 2.5 (best performance).	World Governance Indicators database, World Bank http://data.worldbank.org/data-

		catalog/worldwide-governance-indicators
LPI	World Bank logistic performance index. Logistic quality of a country assessed on a scale of 1 (worst performance) to 5 (best performance), based on six indicators: (1) efficiency of the clearance process by customs and other border agencies; (2) quality of transport and information technology infrastructure; (3) ease and affordability of arranging international shipments; (4) competence of the local logistics industry; (5) ability to track and trace international shipments; (6) domestic logistic costs; (7) timeliness of shipment in reaching destination (Arvis et al., 2007).	LPI database, World Bank http://lpi.worldbank.org/
ADJ	A binary dummy variable which is unity if country *i* and country *j* share a common land border and 0 otherwise.	CEPII database
CML	A dummy variable which is unity if country *i* and country *j* have a common language and zero otherwise.	CEPII database
CLK	A dummy variable which is unity for country pairs with colonial links and zero otherwise.	CEPII database

Table 4B Summary statistics for Australia

Variable	Obs	Mean	Std. Dev.	Min	Max
Log of parts and components exports	1,151	9.422997	2.284659	0.011197	14.29554
Log of manufacturing exports	1,153	10.93747	2.214998	1.696459	15.34037
Log of home country manufacturing value added	1,008	24.95317	0.067682	24.80569	25.05169
Log of partner country manufacturing value added	910	24.38126	1.500103	20.63938	28.21191
Log of home country GDP per capita	1,278	10.32618	0.151598	10.08691	10.53187
Log of home country GDP per capita squared	1,278	106.653	3.126177	101.7458	110.9203
Log of communication infrastructure - internet users per 100 people	1,089	2.999099	1.674237	-0.53598	4.437461
Log of total patent applications by residents	957	7.744845	0.172557	7.473069	8.026497
Standard deviation of inflation rate.	959	1.118582	0.049854	0.735337	1.126728
Log of real exchange rate	1,238	-2.15759	2.54414	-9.45623	1.125997
Log of logistic performance indicator	1,329	1.332357	0.005822	1.316408	1.345472
Institutions variable based on political stability	958	1.020011	0.156793	0.826966	1.333422
Regional trade agreements	1,317	0.04404	0.205261	0	1
Colony	1,329	0.020316	0.141132	0	1
Log of distance	1,329	9.379516	0.406854	7.914384	9.77709
Contiguity of border	1,329	0	0	0	0
Common ethnic language	1,329	0.264108	0.441023	0	1

Table 5 Determinants of Manufacturing Exports[1]

Variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
Ln Real SBV, reporter[2]	1.24*** (0.03)	1.39*** (0.03)	1.82*** (0.06)	1.03*** (0.03)
Ln Real SDB, partner[3]	1.38*** (0.03)	1.10*** (0.03)	2.14*** (0.06)	1.19*** (0.03)
Ln Distance (DST)	-0.86*** (0.06)	-0.80*** (0.10)	-1.07*** (0.10)	-0.95*** (0.05)
Ln Relative per capital GDP (RPGDP)	-0.00** (0.00)	-0.01*** (0.00)	0.01** (0.01)	-0.01*** (0.00)
Ln Bilateral real exchange rate (RER)	0.01*** (0.00)	-0.00 (0.00)	-0.01* (0.01)	0.01*** (0.00)
Ln Technology base, reporter (TECH)	0.07*** (0.01)	0.22*** (0.01)	0.05*** (0.02)	0.09*** (0.01)
FTA membership dummy (FTA)	0.34*** (0.02)	0.47*** (0.04)	0.69*** (0.05)	0.22*** (0.02)
Institutional quality (INST), reporter	-0.06*** (0.01)	0.04** (0.02)	-0.05** (0.02)	-0.05*** (0.01)
Ln Logistic quality (LPI), reporter	0.93*** (0.12)	1.02*** (0.18)	1.16*** (0.24)	0.79*** (0.13)
Contiguity dummy (ADJ)	-0.03 (0.21)	-0.44 (0.35)	-0.60* (0.36)	0.11 (0.18)
Common language dummy (CML)	0.38*** (0.13)	0.70*** (0.23)	0.15 (0.22)	0.48*** (0.11)
Colony dummy (CLK)	-0.32 (0.22)	0.12 (0.37)	-0.93** (0.39)	0.01 (0.20)
European Union dummy (EU)	0.22 (0.15)	0.88*** (0.24)	0.42 (0.27)	0.05 (0.14)
East Asia dummy (EAS)	1.69*** (0.18)	1.97*** (0.30)	1.79*** (0.32)	1.37*** (0.16)
Constant	-51.52*** (1.18)	-47.14*** (1.31)	-87.95*** (2.23)	-40.75*** (1.17)
Australia dummy (AD) variables				
AD*SBV, Australia	-0.03 (0.32)	1.09 (1.48)	-1.22** (0.62)	0.13 (0.33)
AD*DBV, partner	-0.21 (0.24)	-0.23 (0.21)	-1.24*** (0.47)	0.09 (0.25)
AD*DST	-2.66*** (0.73)	-1.14 (1.17)	-0.98 (1.29)	-3.35 (0.66)
AD*RPGDP	-0.00 (0.01)	0.04*** (0.01)	0.00 (0.02)	-0.01 (0.01)
AD*RER	0.05* (0.03)	0.08** (0.04)	0.06 (0.05)	0.07*** (0.03)
AD*TECH	0.17 (0.26)	0.69 (0.50)	1.27** (0.50)	0.40 (0.27)
AD*FTA	-0.58*** (0.15)	-0.56*** (0.20)	-1.03*** (0.29)	-0.52*** (0.15)
AD**INST*	0.27 (0.18)	0.94*** (0.28)	0.32 (0.35)	0.14 (0.19)
AD*LPI	1.27 (3.23)	-2.74 (5.12)	7.36 (6.36)	3.45 (3.40)
AD*CML	0.26 (0.60)	0.41 (1.03)	0.88 (1.05)	0.08 (0.53)

Variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
AD*CLK	0.70 (1.74)	0.90 (2.72)	1.41 (3.06)	0.36 (1.56)
AD	27.10*** (10.42)	-13.09 (33.24)	54.24*** (19.62)	16.96* (10.30)
Observations	30,570	24,546	30,100	30,060
Number of country pairs	1,845	1,672	1,843	1,838

Notes:

1. Heteroscedasticity corrected standard errors are given in brackets. The statistical significance of regression coefficients denoted as: *** p<0.01, ** p<0.05, * p<0.1
2. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *i.*
3. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *j.*

Table 6 Determinants of Manufacturing Exports: Australia Specific Results[1]

Variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
Ln Real SBV, Australia	1.20*** (0.32)	2.43 (1.48)	0.60*** (0.22)	1.16*** (0.33)
Ln Real DBV, partner	1.17*** (0.24)	0.86*** (0.21)	0.90* (0.46)	1.28*** (0.24)
Ln Distance (*DST*)	-3.52*** (0.73)	-1.94 (1.17)	-2.05* (1.29)	-4.30*** (0.66)
Ln Relative per capital GDP (*RPGDP*)	-0.01 (0.01)	0.03*** (0.01)	0.01 (0.02)	-0.02 (0.01)
Ln Bilateral real exchange rate (*RER*)	0.06*** (0.02)	0.07** (0.04)	0.04 (0.05)	0.08*** (0.03)
Ln Technology base, reporter (*TECH*)	0.14*** (0.02)	0.43*** (0.03)	0.10*** (0.04)	0.18*** (0.01)
FTA membership dummy (*FTA*)	-0.22 (0.15)	-0.06 (0.20)	-0.28 (0.29)	-0.30* (0.15)
Institutional quality (*INST*), Australia	0.22 (0.18)	0.98*** (0.28)	0.27 (0.35)	0.09 (0.19)
Ln Logistic quality (*LPI*), reporter	2.22 (3.22)	-1.76 (5.11)	8.52 (6.35)	4.23 (3.39)
Common language dummy (*CML*)	0.64 (0.59)	1.12 (1.01)	1.02 (1.03)	0.56 (0.52)
Colony dummy (*CLK*)	0.38 (1.73)	1.03 (2.70)	0.48 (3.04)	0.37 (1.55)

Notes:

1.The results reported in this table are derived from the overall regressions reported in Table 6. The coefficients are the linear combinations of each of the base coefficients and the coefficient of the Australia dummy. The standards errors (derived from the covariance of the two coefficients) are given in brackets. The statistical significance of the regression coefficients is denoted as *** p<0.01, ** p<0.05, * p<0.10.

2. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *i.*

3. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *j.*

Appendix

Australian Aircraft Industry

The recent expansion of the Australian aircraft industry through integration into the value chain of the world aircraft industry is based on manufacturing talents and technological capabilities developed over hundred years. It has also been aided by a successful collaborative initiative by the Australian government and private sector partners in developing domestic technology for the production of carbon fibre composite materials (composites, for short).

The history of aircraft production in Australia dates back to 1914-18 when the Australian government experimented with local production of military aircraft (Butlin 1955). Based on the lessons learned from this initial ineffectual effort, during the inter-war years the government adopted a policy of encouragement of private enterprise. A number of aircraft companies, mainly catering for the needs of the Royal Australian Air Force (RAAF), emerged during the next two decades. Of these, the only company which managed to survive the Great Depression was De Havilland Aircraft Proprietary Ltd (established in 1929).

In October 1936, the Commonwealth Aircraft Corporation (CAC), a syndicate of private companies, was established for the manufacture of aircraft and engines. CAC joined hands with the RAAF to produce small military aircraft by modifying models from the US and the UK to permit the use of material readily obtainable in Australia. The aim was to archive self-sufficiency in the production of aircraft and to upgrade the RAAF's strike capacity. The US and UK governments supported the Australian initiatives because the location of light aircraft construction in Australia, with service and repair facilities, helped achieve a degree of regional specialisation and conserve shipping space during the war years. A total of 3,486 aircraft were produced during 1939-1945. In the peak year of 1944, the industry employed over 44,000 workers. The expansion of aircraft production spawned a large network of subcontractors involved in producing components and providing specialist services (Butlin and Schedvin 1977).

The lofty notion of self-sufficiency for the RAAF came to very little. Even during the war years the RAAF had to rely on American suppliers to meet Australian operational requirements. In the post-war era Australia could not compete in price or quality with the large international civil aircraft manufacturers. However, a number of aircraft manufacturing firms continued to survive by providing repair and ancillary services to the RAAF, producing small passenger aircraft, and (from about the early 1970s) by undertaking component production for large overseas producers. Over the past decade or so, some of these companies have gained a new lease of life, having benefited from the expansion of production sharing arrangements in the world aircraft industry.

The recent expansion of the Australian aircraft industry has been significantly aided by a successful public-private collaborative effort to gain a global niche in the production of composites. Composites are important in aerospace and automotive industries because they have a similar strength to metals, but are lighter weight with the consequent reduction in energy consumption, and also have fewer corrosion problems. The recent rapid growth of aircraft parts and component exports from Australia is an important success from this investment.

Over the past 20 years Australia has developed a considerable research capability in the design, manufacture and performance of composites, primarily through the Corporate Research Centre for Advanced Composite Structures (CRC-ACS). This centre is funded by industry partners and the Australian government under the Cooperative Research Centre Program. CSIRO, The Australian Future Fibre Research and Innovation Centre and a number of Australian universities, including Deakin and RMIT Universities, are active partners of the program (ACTSE 1988, Bremer Company 2015).

The following company case summaries and helps to understand the ongoing changes in the aircraft industry against the backdrop of the globalisation of aircraft manufacturing.

Boeing Aerostructures Australia

Boeing Aerostructures Australia (BAA) was formed in 1996 by Boeing USA by acquiring Aerospace Technologies Australia (formerly Commonwealth Aircraft Corporation (CAC), set up in 1936). In 2000 it expanded operations by acquiring Hawker de Havilland (established in 1929).

BAA is Boeing's largest manufacturing operation outside North America. It is a Tier 1 partner of the Boeing 787 Dreamliner program, the sole supplier of its movable trailing edges. The Boeing 787 Dreamliner contract with BAA is Australia's largest aerospace contract ever (20 years), and is valued at $5 billion. BAA is also the sole source of B737 ailerons, moveable leading edges of B747, and cove lip doors, elevators and rudders of B777. BAA works with a large number of small Australian companies.

Airbus Group Australia Pacific

Australian Aerospace Engineering (AAE), a Brisbane-based company specialising in airframe, tail boom and composite structures, has been a supplier of components to Airbus Helicopters (formerly Eurocopter), the helicopter manufacturing division of Airbus Group, for over two decades. Airbus Helicopters is the world's largest producer of turbine for helicopters. It has four major plants in Europe and two subsidiaries and partners around the world.

In 2014, Airbus Helicopters obtained full ownership of AAE and renamed it Airbus Group Australia Pacific (ABAP). ABAP now represents Airbus Group, Airbus Helicopters and Airbus Defence and Space in Australia and the Pacific region.

Mahindra & Mahindra

The Indian car company, Mahindra & Mahindra (M&M) entered the Australian aircraft industry in 2009 by acquiring majority ownership in two Australian companies: Aerostaff Australia and GippsAero (formerly Gippsland Aeronautics), both of which have an operational history dating back to the early 1970s. M&M aims to expand the component production capacity of the two companies to meet the growing needs of the world's civil and defence aircraft production - this is an attempt to further increase its presence in the global aerospace supply chain.

Aerostaff Australia is a manufacturer of precision close-tolerance aircraft components and assemblies for large original equipment manufacturers (OEMs) in the global aircraft industry. GippsAero is a manufacturer of single-engine utility aircraft. The company started operations in the 1970s at Latrobe Valley Airport as an aircraft maintenance and modification business. The Airvan 8 produced by GippsAero is one of the most rugged and versatile aircraft in that class. It is certified in 38 countries, more than 200 Airvan 8s are in service in Australia, Africa, North America, Europe and many other countries. The Airvan 8 will soon be joined by Airvan 10, a 10-seater turboprop aircraft.

Following the acquisition of the two Australian companies, Mahindra Aerospace has begun developing a 25,000 sq. m. facility in Gengaluru in India to produce airframe parts and assemblies. The facility was inaugurated in 2013 and is now delivering aerospace sheet metal parts and assemblies for global aircraft manufacturers, including Airbus.

Lovitt Technologies Australia

This company was founded in 1954 as George Levitt Manufacturing Pty to produce cutting tools components for the automotive industry. Located in Montmorency (Victoria), today it is a provider of precision machine tools, components, parts and assemblies to the aerospace and defence industries. It is a supplier to Boeing Australia, Airbus and many other aircraft producers.

Table A-1: Determinants of Manufacturing Exports: Random Effects Estimates[1]

Explanatory variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
Ln Real SBV, reporter[2]	0.88***	1.06***	0.99***	0.81***
	(0.02)	(0.02)	(0.03)	(0.02)
Ln Real SDB, partner[3]	1.00***	0.96***	1.11***	0.94***
	(0.02)	(0.02)	(0.02)	(0.02)
Ln Distance (DST)	-0.71***	-0.70***	-0.69***	-0.83***
	(0.04)	(0.05)	(0.05)	(0.04)
Ln Relative per capital GDP (RPGDP)	-0.01***	-0.00***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Ln Bilateral real exchange rate (RER)	0.01***	0.00	-0.00	0.01***
	(0.00)	(0.00)	(0.01)	(0.00)
Ln Technology base, reporter (TECH)	0.11***	0.17***	0.18***	0.11***
	(0.01)	(0.01)	(0.02)	(0.01)
FTA membership dummy (FTA)	0.33***	0.48***	0.74***	0.19***
	(0.02)	(0.04)	(0.05)	(0.03)
Institutional quality (INST), reporter	-0.04***	0.13***	0.04**	-0.05***
	(0.01)	(0.02)	(0.02)	(0.01)
Ln Logistic quality (LPI), reporter	1.45***	2.30***	3.14***	1.18***
	(0.11)	(0.16)	(0.20)	(0.12)
Contiguity dummy (ADJ)	0.32**	-0.03	0.26	0.38***
	(0.14)	(0.18)	(0.19)	(0.14)
Common language dummy (CML)	0.52***	0.72***	0.44***	0.56***
	(0.09)	(0.12)	(0.12)	(0.09)
Colony dummy (CLK)	0.05	0.36*	-0.02	0.24
	(0.15)	(0.19)	(0.20)	(0.15)
European Union dummy (EU)	0.50***	0.91***	1.03***	0.28***
	(0.10)	(0.13)	(0.14)	(0.10)
East Asia dummy (EAS)d_EAS	1.72***	2.09***	1.86***	1.42***
	(0.13)	(0.16)	(0.17)	(0.13)
Constant	-34.11***	-37.75***	- 44.77***	-30.01***
	(0.75)	(0.84)	(1.10)	(0.76)
Australia dummy (AD) variables				
AD*SBV, Australia	-0.10	0.52	-1.98***	0.25
	(0.27)	(1.51)	(0.52)	(0.28)
AD*SDB, partner	-0.07	-0.17	-0.22	0.04
	(0.12)	(0.13)	(0.17)	(0.12)
AD*DST	-2.70***	-1.75***	-1.80**	-3.21***
	(0.51)	(0.64)	(0.71)	(0.52)
AD*RER	0.05**	0.09**	0.07	0.07***
	(0.03)	(0.03)	(0.05)	(0.03)
AD*RPGDP	-0.00	0.02**	0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)
AD*LPI	-0.08	-4.82	2.49	2.69
	(3.27)	(5.29)	(6.47)	(3.43)
AD*TECH	0.06	0.45	0.90*	0.34
	(0.26)	(0.51)	(0.51)	(0.27)
AD*FTA	-0.53***	-0.52**	-0.97***	-0.48***
	(0.15)	(0.21)	(0.29)	(0.15)

Explanatory variables	Total manufacturing	Parts & components	Final assembly	Conventional (horizontal) exports
AD*IST	0.24	0.83***	0.17	0.14
	(0.18)	(0.29)	(0.36)	(0.19)
AD*CLK	0.63	0.73	0.50	0.53
	(1.18)	(1.44)	(1.58)	(1.19)
AD*CML	0.22	0.36	0.55	0.12
	(0.41)	(0.54)	(0.55)	(0.41)
AD	28.12***	8.87	64.95***	15.01
	(9.13)	(32.74)	(16.50)	(9.46)
Observations	30,570	24,546	30,100	30,060
Number of country pairs	1,845	1,672	1,843	1,838

Notes:

1. Heteroscedasticity corrected standard errors are given in brackets. The statistical significance of regression coefficients denoted as: *** p<0.01, ** p<0.05, * p<0.1
2. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *i.*
3. Real manufacturing output (RMF) for parts and components and GDP for final assembly and total exports of country *j.*

Table A-2 Determinants of Manufacturing Exports Using Correlated Random Effects

VARIABLES	PC RCE	MNF RCE
	(1)	(2)
Lh_Real manufacturing output	1.58***	1.48***
	(11.19)	(12.65)
Lp_Real manufacturing output	1.16***	1.00***
	(14.37)	(17.70)
lh_gdppc_real	1.89***	1.34***
	(2.63)	(2.76)
lh_gdppc_sq	-0.16***	-0.13***
	(-3.92)	(-4.66)
lh_internetusersper100people	0.07**	0.05**
	(2.53)	(2.48)
ltotalpa_res	0.16***	0.02
	(4.50)	(0.98)
sdinfrate	-0.03***	-0.02***
	(-4.33)	(-2.64)
lrer	-0.01	0.01
	(-1.35)	(0.77)
llpi_overall	0.34	0.21
	(1.06)	(0.92)
politicalstabilityandabsence	0.09**	0.05*
	(2.30)	(1.95)
rta	0.49***	0.49***
	(4.94)	(6.86)
colony	0.39**	0.32**
	(2.21)	(1.97)
ldistw	-1.03***	-0.99***
	(-27.40)	(-32.38)
contig	-0.11	0.14
	(-0.61)	(0.94)
comlang_ethno	0.75***	0.71***
	(5.05)	(6.00)
mlh_Real manufacturing output	-0.41***	-0.60***
	(-2.60)	(-4.51)
mlp_Real manufacturing output	-0.30***	-0.20***
	(-3.63)	(-3.34)
mlh_gdppc_real	-0.02	-2.01***

VARIABLES	PC RCE	MNF RCE
	(-0.02)	(-3.25)
mlh_gdppc_sq	-0.00	0.14***
	(-0.06)	(4.08)
mlh_internetusersper100people	0.72***	0.24**
	(5.40)	(2.15)
mltotalpa_res	-0.20***	0.02
	(-3.44)	(0.43)
mlrer	0.09***	0.06***
	(6.17)	(5.34)
mllpi_overall	6.68***	4.81***
	(10.22)	(8.84)
mpoliticalstabilityandabsence	0.17	-0.16*
	(1.37)	(-1.82)
mrta	-0.29*	-0.49***
	(-1.96)	(-4.28)
md_aus	-1,091.92***	-1,283.62***
	(-4.18)	(-5.20)
md_aus_Real manufacturing output	44.45***	52.28***
	(4.25)	(5.29)
md_aus_ Real manufacturing output	-0.02	-0.04
	(-0.14)	(-0.43)
md_aus_lrer	0.05	0.10
	(0.74)	(1.50)
md_aus_rta	0.69	0.26
	(0.99)	(0.34)
md_aus_colony	0.67*	0.60*
	(1.72)	(1.76)
md_aus_ldistw	-1.94***	-2.22***
	(-4.37)	(-5.53)
md_aus_comlang_ethno	0.19	0.19
	(0.53)	(0.64)
Constant	-44.31***	-22.72***
	(-16.41)	(-11.58)
Observations	24,629	24,849
Number of pairid	1,673	1,675

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

Chapter 5
Inequality or Poverty: Which is Bad for Growth?

1 Introduction

Recent research has re-focused attention on the impact of income inequality on economic growth. In this paper, we expand upon this by asking whether inequality and poverty, either separately or jointly, impact economic growth. We focus on extreme, absolute poverty as measured by two or three dollars per day income and we measure inequality using the Gini coefficient.

Inequality has been hypothesised to negatively affect growth through several channels. Inequality may result in under-investment in education, health and physical capital leading to lower growth. We argue that such under-investments could equally, or perhaps even more likely, be the result of poverty[60] rather than inequality, per se.

Poverty and inequality can also interact to have a negative impact on growth. This interaction between poverty and inequality may relate to mobility, or the quality of institutions, or other factors, which could impact negatively on growth.

Economic growth regressions which control for average incomes and inequality, but not for poverty, may fail to capture the disadvantage of poverty that harms growth. By including the percentage of people below the poverty line, we are additionally controlling for the concentration of disadvantage in the population. The effect of poverty might be distinct from and in addition to effects from low average incomes and inequality.

Empirically, we ask two simple questions: is the negative relationship between income inequality and economic growth robust to the inclusion of poverty? And, is the relationship between inequality and economic growth related to the level of poverty?

[60] We use absolute measures of poverty based on the World Bank's definition of headcount poverty rates. Details of how we measure poverty is explained in the data section.

We find that including poverty does matter. Specifically, we find that the negative impact of inequality on economic growth is related to the level of poverty. When the poverty level is low (less than about 25%), we find a statistically insignificant relationship between inequality and economic growth. For higher levels of poverty, we find that inequality negatively impacts economic growth. The negative effect of inequality on economic growth increases as poverty rises.

The policy implication is clear: promote growth by attacking poverty rather than by redistributing incomes.

We provide background and briefly review some relevant literature in the next section. The standard growth regression approach that we use is reviewed in Section 3. Detail of our data is provided in Section 4. We then present regression results and focus on the marginal effect of inequality on economic growth at different levels of poverty in section 5. We conclude in the final section.

2 Background

There has been a renewed focus on the relationship between inequality and economic growth spurred by two recent papers Cingano (2014) and Ostry, Berg and Tsangarides (2014). Ostry et al. (2014) use newly compiled data by Solt (2009) to find that lower net inequality is correlated with faster and more durable growth. They also find that more unequal societies tend to redistribute more, but that redistribution does not have a major effect on economic growth. In their baseline regressions, they include initial income, inequality and redistribution. They add standard growth determinants such as investment, population growth and education to verify if their results hold with a wider set of control variables. The final specification of Ostry et al. (2014) is a full set of growth determinants including terms of trade shocks, political institutions, openness, debt liabilities as well as the covariates mentioned before.

Cingano (2014) also finds that increases in inequality have a negative impact on economic growth. The growth regressions in Cingano (2014) only control for initial income, education and investment. His paper further finds that inequality interacts with human capital to impede growth. While Ostry et al. (2014) focus on a sample of countries from around the world, Cingano (2014) focuses only on the OECD countries.

The relationship between inequality and economic growth has been well-studied over the past 25 years with papers reporting a range of results including claims that inequality harms growth, that inequality is irrelevant for growth and that inequality aids in growth. Theory is ambiguous as to the expected effects. Inequality can affect economic growth in a number of complex ways and through various channels (Cingano (2014), Halter, Oechslin and Zweimu¨ller (2014), Lazear and Rosen (1979), Rosenzweig and Binswanger (1992) and Foellmi and Zweimuller (2006). The empirical literature on economic growth and inequality partly reflects this; where some papers find that inequality has a negative impact on economic growth, others find a positive relationship between the two variables. Simple intuition also leads us to no obvious conclusion. It is clear that excessive inequality leading to social conflict and exclusion should harm growth. On the other hand, 'perfect' equality achieved by redistribution away from the successful to the less successful must certainly produce incentives that also harm growth.

Some previous papers support the claim that inequality reduces economic growth. Galor and Moav (2004) and Galor and Zeira (1993) emphasise that inequality affects economic growth by depriving the poor the opportunity to maintain their health and accumulating human capital. Perotti (1996) shows that more equal societies have lower fertility rates and higher investment in education. Both of these factors help to improve economic growth. Perotti (1996) also shows that inequality is linked to socio-political instability. Alesina and Perotti (1996) add to this literature by finding that increases in inequality in land and income ownership have a negative impact on economic growth.

Halter et al. (2014) find that higher inequality fosters performance and growth in the short run, nevertheless, inequality tends to have a negative effect on economic growth in the long run. Forbes (2000) finds that inequality can lead to increased economic growth in the short run. Increased inequality can also cause better incentives for innovation, entrepreneurship and higher profits, see Lazear and Rosen (1979), Rosenzweig and Binswanger (1992) and Foellmi and Zweimüller (2006).

Establishing a relationship between inequality and economic growth is further obstructed by lack of data and, until recently, inadequate econometric techniques. Solt (2009) attempts to overcome the first problem by creating an extensive dataset on inequality. We make use of this dataset to aid in comparability of our results with others.

The application of Generalised Methods of Moments (GMM) (Durlauf, Johnson and Temple (2005) and Roodman (2009)), specifically system GMM, improves the ability to handle endogeneity and reverse causality typically found in economic growth regressions.

The literature on economic convergence asks whether low average incomes are associated with higher growth rates. A separate question, less well studied, is the impact of the concentration of poverty on economic growth. Theoretically, some authors have tried to establish a link between poverty and economic development, by hypothesising that low income can confine people to a poverty trap as in Sachs (2005). When people are poor, they need their income for subsistence. Due to this, they are unable to invest in human capital, physical capital and their own health. As a result, investments in the economy are reduced and makes the workforce less productive. Further, often poor people do not have access to a pension scheme, so they use children as a means of insurance, see Perkins, Radelet, Lindauer and Block (2012). However, higher population growth can be bad for economic growth as, for a given income level, higher population growth will mean less capital per person resulting in lower growth according to a simple Solow-Swan model (Ravallion, 2016).

The literature has shown that poverty can have a negative impact on investment and GDP growth, particularly when financial markets are not well developed; (Perry, 2006, chapter 1). Azariadis and Stachurski (2005) survey models of poverty traps and find a common theme that poverty impedes the acquisition of physical and human capital and also curtails the adoption of modern technology. Lo´pez (2006) endorses the hypothesis that poverty retards growth through various channels including education, institutions, health and physical capital accumulation. Bowels, Durlauf and Hoff (2006) discuss the large role that institutions play in perpetuating poverty traps. Lo´pez and Serv´en (2009) empirically show that higher levels of initial poverty reduces economic growth.

Our contribution in this paper is empirical. The empirical and theoretical literature cited above provide the rationale for our consideration of the effect on economic growth of poverty and inequality and their interaction.

3 Model and Estimation

We estimate the impact of inequality and poverty on economic growth as

$$y_{it} - y_{it-1} = \emptyset\, y_{i,t-1} + \emptyset_1 g_{i,t} + \emptyset_2 p_{i,t} + \emptyset_3 g_{i,t} \times p_{i,t} + \beta \boldsymbol{X}_{it} + \rho_t + \mu_i + \varepsilon_{it} \qquad (1)$$

where *i* indexes country and *t* indexes 5-year time periods. *y* denotes the natural log of real gross domestic product (GDP) per capita. In our empirical specification, we use the 5-year compound average growth rate of GDP as the dependent variable. g is the Gini coefficient and *p* is the poverty headcount ratio. In our results section, we first impose $\emptyset_2 = \emptyset_3 = 0$ to reproduce the standard literature which looks at the effect of inequality on economic growth. We then estimate the full model to examine the effect of poverty and its interaction with inequality on economic growth.

X is a vector of growth determinants. In our empirical specification, we use a variety of different sets of variables for the growth determinants as summarised in Table 1.

Table 1 : Different combinations of determinants of growth (X) used in empirical specification

Variables	Set 1	Set 2	Set 3	Set 4
Investment to GDP ratio	x	x	x	x
Years of Schooling	x	x	x	x
Log Population Growth		x	x	x
Price of Investment			x	x
Trade Share of GDP			x	x
Relative Redistribution				x

There are well-established problems of estimating growth equation like (1). The control variables suffer from endogeneity and measurement errors, see Roodman (2009), Arellano and Bond (1991) and Cingano (2014). One of the main problems in estimating Equation (1) is that applying within transformations or taking first differences creates a correlation between the lagged income variable and country fixed effects. Such approaches thus yield biased and inconsistent estimates.

First difference and system GMM techniques overcome these problems (Blundell and Bond, 1998). First difference GMM remedies these problems by taking the first difference of equation (1) to remove country fixed effects and using appropriately lagged values of y and X as internal instruments. However, the first difference transformation suffers from the drawback of weak instruments if the right-hand side variables are highly persistent, which is likely to be a case for inequality, poverty and education variables are also persistent, as recognised by Halter et al. (2014). System GMM overcomes this problem by building a system of level and first difference equations and using appropriately lagged variables as instruments from both the levels and the first difference equations. Further, the first difference methodology has the problems of magnifying the problems of unbalanced panels, so instead we use orthogonal deviations, constructed as in Roodman (2009). System GMM is also better than difference GMM in exploiting cross-country variation–Halter et al. (2014). Both one-step and two-step methodologies may be used in estimating system GMM equations. However, the two-step methodology is more efficient, see Bond, Hoeffler and Temple (2001). All the estimates we report, use the two-step GMM procedure. Our results do not change significantly when we use the one-step methodology.[61]

We use one lag of the internal instruments in all the estimates we report. Our substantive results do not change if we use two lags. However, this results in a larger number of instruments, which can be problematic. We treat all our right-hand side variable as endogenous. Changing persistent variables, including redistribution and education, to predetermined does not change our results.

GMM estimates can suffer from instrument proliferation problems, as discussed by Roodman (2009). The Hansen (1982) test can be used to check for the exogoneity of instruments and also for the problem of too many instruments, or instrument proliferation. The null hypothesis of the test is that instruments are exogenous. When the p-value is small, we reject the null hypothesis and conclude that the instruments are invalid, as exogeneity does not hold. On the other hand, Roodman (2009) shows that as the number of instruments becomes too large, the p-value of the Hansen test converges to one. For each model we estimate, we report the number of instruments. A rule of thumb is that when the p-value of the Hansen test is above 0.8, there may be a problem of instrument proliferation. In the two-step estimator we use, the Windmeijer correction Windmeijer (2005) as well as the small-sample correction Roodman (2009).

We turn next to a detailed description of our data.

4 Data

For our data, we focus on five-year periods from 1956 to 2011.[62] We draw the data from a variety of sources. Our full sample of countries for which we have GDP and other basic economic data consists of 152 countries. For some countries, we have observations on

[61] Results available from authors.

[62] Gini data only starts from 1960 onwards; however, by using GDP values of 1956 we can increase our sample size as we use lagged GDP in the growth regressions.

all 12 time periods and for some countries we have as few as two observations. (We drop countries for which we have valid data for only one five-year period.)

Our income variable is taken from the Penn World Tables 8.1 (PWT) and is based on real gross domestic product (GDP) at 2005 constant national prices. To get the dependent variable, we divide GDP by population to create Gross Domestic Product per capita (GDPPC) and take a compound average growth rate over 5 years. This variable is different from Ostry et al. (2014) in two ways. First, we use compound average growth rates, more typically used in studies of economic growth. Secondly, we use real GDP in national constant prices as opposed to GDP calculated by using purchasing power parity (PPP) conversion to US dollars. PWT recommends using real GDP in national constant prices as it is not distorted by measurement errors in the PPP calculations.

We use an inequality dataset from Solt (2009) using version 5 of the Standardized World Income Inequality Database (SWIIDv5).[63] This data covers, to the best of our knowledge, the largest number of countries and spans the longest period for available inequality data. To capture inequality, we use the Gini coefficient based on net inequality, which is calculated by taking into account taxes and transfers.

'Relative redistribution' is also taken from Solt (2009). Relative redistribution is the difference between the market-income and net-income Gini indices divided by the market income Gini and then multiplied by 100. Relative redistribution is positive if redistribution lowers inequality. It is negative if inequality increases after government redistribution. Most countries have positive relative redistribution but a few have negative values.

To capture human capital, we use total years of schooling for ages 15-64 of the population, Barro and Lee (2013). Investment (gross fixed capital formation) as a percentage of GDP, trade shares and fertility rates are taken from the World Development Indicators (WDI). The price level of investment data is taken from Heston,

[63] We obtained the data at the standardized world income inequality database website (http://myweb.uiowa.edu/fsolt/swiid/FAQ/FAQ.html) That dataset provides 100 multiple imputations for the value of the Gini for each country at each point in time. We use the STATA code provided on the website to create point estimates for each country at each point in time. We construct the 5-year averages for the Gini and 'relative redistribution' (see below) from these point estimates. We also create standard errors for each Gini observation to measure the precision with which the Gini is estimated. We use this standard error to eliminate imprecisely measured values of the Gini coefficient in our robustness checks.

Summers and Aten (2011). As there are some gaps in these datasets, and in line with the literature on economic growth, 5-year averages are taken for these variables.

The poverty headcount ratio (2 dollars a day at purchasing price parity) is also taken from the WDI. As there are some missing values for the poverty variable and given that the poverty rates show a high degree of persistence, 2005 values were carried forward to 2011 for the missing observations. WDI has discontinued poverty data for high-income economies. As a result, data for high-income economies is taken from the CEIC database (http://www.ceicdata.com/en) where the data is available.

Our data and key definitions are summarised in Table 2.

Table 2 : Variable definitions and sources

Variables	Definition and Source	Obs.	Mean	St. Dev.
ln(Income [GDP])	Real Gross Domestic Product per capita (GDPPC) at 2005 national prices; Penn World Tables 8.1	1,452	8.41	1.18
Growth rate	5 year compound average growth rate based on real GDPPC	1,367	2.11	3.41
Relative redistribution	Market inequality[a] less net inequality (Gini), divided by market inequality and then multiplied by 100	424	21.54	15.82
Investment	Gross fixed capital formation as a percentage of GDP; World Development Indicators	1,233	21.78	7.11
ln(Years of Schooling)	Average for ages 15-64 of the population, Barro and Lee (2013)	1,506	1.31	0.99
ln(Population Growth)	Log of population growth; World Development Indicators	1,579	0.34	1.33
Price of Investment	Price level of investment[b]; Heston et al. (2011)	1,519	85.38	169.71
Trade Share of GDP	Trade as a percentage of GDP	1,343	72.96	49.01
Gini coefficient	Gini based on income after taxes and transfers; Solt (2009) SWIIDv5	1,041	37.25	9.9
Poverty	Headcount ratio based on $2 ($3.10) a day on purchasing power parity; World Development Indicators	556	29.32	31.74

a Inequality (Gini) calculated before taxes and transfers is called market inequality.

b Calculated over country sample of column 3 of Table B.1, which avoids countries like Zimbabwe that experienced hyperinflation.

In section 5.1, we undertake several robustness checks with respect to our definition of poverty. We replace poverty with zero for high-income OECD economies.[64] These rich countries have very few individuals living on less than $2 a day, so zero is a reasonable estimate. Recently, the World Bank changed its definition of poverty to $3.10 a day at purchasing price parity. As this variable is missing for the high-income economies and there are no historical records to fill this gap, we prefer the poverty headcount ratio at $2 dollars a day to maximise the sample sizes in our regressions. We use this alternate version of poverty to check the robustness of our results in Section 5.1. The correlation between the poverty headcount ratio measured using $3.10 a day and that using $2 a day is above 97 percent.

4.1 Estimation sample

The panel is unbalanced. There are 16 countries for which we have inequality and gross domestic product data for all 12 years from 1956 - 2011. In the simplest growth regression, these countries each contribute 11 observations to the estimation (dropping one year for the lagged gross domestic product variable). 12 countries only contribute one observation as these countries only have two consecutive observations where gross domestic product and inequality data are available. In the simplest regression where we only include inequality and gross domestic product, we have 950 observations from these 152 countries. On average, each country contributes just over 6 observations.

Appendix B provides more information on which countries are included in our sample and how that changes with different sets of control variables. As we add more control variables to the regression, sample sizes decrease because of missing values in some of the explanatory variables. We estimate all models on the largest possible set of observations. We also provide estimates on a smaller set of countries/observations for which we have complete data on all required variables. We do this to help disentangle the different effects of changing the explanatory variable set from those caused by changing the sample composition. These estimates are discussed in Section 5.1.

As data on poverty is limited, our sample size drops to 128 countries once the poverty variables are included in the regressions. As we add the various independent variables to the regression, the number of countries drops to 109 (Set 1), 99 (Set 2), 98 (Set 3) and

[64] OECD countries with Gross National Income above USD20,000.

50 (Set 4). Table B.1 shows the countries that are included in each of the regressions that include both poverty and inequality.

We next turn to a discussion of our results.

5 Results

In Table 3 we present the generalised method of moments estimates from cross-country regressions on our full sample of data using the approach of Arellano and Bond (1991). In the second column, we include only lagged gross domestic product per capita (GDPPC) and the Gini coefficient. In columns three through six, we progressively add those control variables which are typically used in the literature. (See the definition of Set 1 through set 4 in Table 1.)

We find a negative effect of inequality on growth, but it seems fairly fragile. As we add additional control variables, its absolute size and statistical significance decreases. Based upon the regression with no controls, we can see that a one percentage point increase in the Gini coefficient results in a 0.183 percentage point decrease in the five-year average compound growth rate. When we add the investment to GDP ratio and years of schooling, this falls to -0.144. When we further add log population growth, this drops to -0.05. When we add the price of investment and the trade share of GDP, the coefficient falls to -0.03 and becomes insignificant. In the last column, when we add relative redistribution, there is a dramatic drop in sample size and inequality is again statistically significant.

We find a positive and significant effect of investment on growth. Years of schooling is not statistically significant in these regressions. Log population growth is negative, as expected, but the t-value is only around 1.25.

In the model with no controls, the p-value of the Hansen test is very small, indicating that we reject the null hypothesis of the exogeneity of the instruments. In the last two columns, the p-value for the Hansen test for exogeneity of the instruments approaches or equals one which is generally a sign of instrument proliferation, as discussed above. Only the models which control for the investment to GDP ratio, years of schooling and population growth (with or without population growth) generate suitable values for the

Hansen test. These two columns (Set 1 and Set 2) are thus our preferred models for this specification.

We also present the tests of Arellano and Bond (1991) for serial correlation in the first-differenced errors. There is no significant evidence of serial correlation at order two and three in the first-differenced errors for our preferred specifications.

Note that the number of instruments actually decreases when we add relative redistribution. The reason for this is that the number of years that we use in the data reduces as relative redistribution data is not available for the 1960s and early 1970s. As the number of years we use decreases, so does the instrument set.

In Appendix Table A.1 we present estimates of the simple model with no controls, but using the same sample composition from the five columns of Table 3. Recall that sample size changes due to missing values in the explanatory variables. The estimates of the effect of inequality on economic growth are fairly consistent across all of the sample compositions, except for the last column that includes relative redistribution.

The decreasing effect of inequality as we add additional control variables is caused by the additional explanatory variables picking up some of the explanatory power of inequality, not the changing sample composition. If anything, when we look at Appendix Table A.1, the effect of inequality seems stronger with the smaller sample sizes. We also conclude that the restricted sample which we are forced to use when we include relative redistribution is very different than the other samples. In this case, the sample restriction seems to be contributing substantially to changed parameter estimates.

In Table 4 we present similar results except that we now add a control for poverty (measured as the percentage of people below the poverty line) and we interact poverty and inequality. Some care needs to be exercised in interpreting the coefficients in Table 4 as the coefficient on lagged GDP can no longer be viewed as a pure 'convergence' parameter since the correlation between poverty and GDP is quite high - around 84%. The correlation between poverty and inequality is 43%, so the inclusion of poverty does provide additional information.

We have fewer observations because poverty data is missing for some countries. Looking at Table 4, we again prefer the models that control for investment to GDP ratio and years of schooling (with or without population growth, investment price and trade share of GDP) based upon the Hansen test. Looking at the columns labeled Set 1, Set 2 and Set 3, for example, we see strong evidence of convergence; lagged GDP is negative and poverty is positive. Inequality is statistically insignificant on its own, but the interaction between poverty and inequality is negative and statistically significant. Population growth is negative, but not quite statistically significant in these regressions. Investment and years of schooling both contribute positively to economic growth and are statistically significant.

Table 3 : The Effect of Inequality on Growth

Variables	No controls	Set 1	Set 2	Set 3	Set 4
$ln(GDPPC)_t{-}1$	−0.0204 (0.446)	-0.348 (0.339)	-0.588* (0.318)	−0.654*** (0.249)	0.175 (0.555)
Gini coefficient	−0.183*** (0.0615)	−0.144** (0.0568)	⁻0.0501* (0.0281)	−0.0309 (0.0332)	−0.0842 (0.101)
Investment to GDP ratio		0.190*** (0.053)	0.197 *** (0.0420)	0.168 *** (0.0459)	0.251 *** (0.0620)
Years of Schooling		-0.508 (0.673)	−0.0509 (0.521)	0.231 (0.401)	0.970 (1.59)
Log Population Growth			-0.341 (0.286)	-0.320 (0.225)	-0.295 (0.321)
Price of Investment				−0.00013 (0.00059)	−0.00767 (0.0232)
Trade share of GDP				0.0114 *** (0.00290)	0.00093 (0.0046)
Relative redistribution					-0.123* (0.0707)
Sample size	950	823	760	755	347
Hansen test (p-value)	0.00	0.28	0.32	0.98	1.00
Number of instruments	36	72	89	125	105
Serial correlation tests (p-values) for AR(p) in first differences:					
AR(1)	0.00***	0.00***	0.00***	0.00***	0.03**
AR(2)	0.11	0.25	0.76	0.81	0.22
AR(3)	0.76	0.76	0.93	0.97	0.12

Dependent variable: 5-year average growth rate of GDP
GMM estimation with robust standard errors in parentheses
***, **, * indicates significance at one, five and ten per cent respectively
All regressions include time dummies
Set 1: Investment to GDP ratio and log years of schooling
Set 2: Set 1 and log population growth
Set 3: Set 2 and price of investment and trade share of GDP
Set 4: Set 3 and relative redistribution

Table 4 : The Effect of Inequality and Poverty on Growth

Variables	No controls	Set 1	Set 2	Set 3	Set 4
$ln(GDPPC)_t{-}1$	−1.99*** (0.742)	−1.26*** (0.431)	−1.18** (0.568)	−1.14* (0.616)	−0.679 (0.662)
Gini coefficient	−0.136* (0.0760)	−0.0359 (0.0521)	0.00865 (0.0408)	0.00196 (0.0566)	0.0308 (0.129)
Poverty headcount	−0.0773 (0.132)	0.0238 (0.0519)	0.0605 (0.0497)	0.0764 (0.0614)	0.129 (0.0928)
Gini × Poverty	−0.00023 (0.0030)	−0.00123 (0.001116)	−0.00191** (0.00097)	−0.00231* (0.00130)	−0.00309 (0.00251)
Investment to GDP ratio		0.175 *** (0.0496)	0.181 *** (0.0476)	0.171 *** (0.0421)	0.259 *** (0.0592)
Years of Schooling		1.07 * (0.606)	0.997* (0.604)	1.13 ** (0.555)	2.11 (1.67)
Log Population Growth			−0.323 (0.214)	−0.361 (0.266)	−0.614* (0.310)
Price of Investment				−0.0148 (0.0110)	−0.0104 (0.0152)
Trade share of GDP				0.00507 (0.00572)	−0.00315 (0.0103)
Relative redistribution					−0.0437 (0.0597)
Sample size	530	465	410	407	236
Hansen test (p-value)	0.02	0.20	0.44	0.41	1.00
Number of instruments	37	61	73	94	104
Serial correlation tests (p-values) for AR(p) in first differences:					
AR(1)	0.32	0.01**	0.00***	0.00***	0.00***
AR(2)	0.01***	0.02**	0.63	0.95	0.78
AR(3)	0.57	0.85	0.32	0.55	0.65

Notes: Dependent variable: 5-year average growth rate of GDP
GMM estimation with robust standard errors in parentheses
***, **, * indicates significance at one, five and ten per cent respectively
All regressions include time dummies
Set 1: Investment to GDP ratio and log years of schooling
Set 2: Set 1 and log population growth
Set 3: Set 2 and price of investment and trade share of GDP
Set 4: Set 3 and relative redistribution

In Figure 1[65], we plot the marginal effect of inequality on economic growth from the estimated coefficients of the column labeled 'Set 2' in Table 4. (This is our preferred model.) The graph of marginal effects from the columns labeled Set 1 and Set 3 are quite similar.[66]

[65] At the End of the chapter.
[66] Results available from the authors.

We can see that at low levels of poverty, inequality has an insignificant effect on economic growth. When poverty is higher, the negative effect of inequality becomes statistically significant. The effect is statistically significant at the 10 per cent level at a poverty rate of 29% and significant at the 5 per cent level at poverty rates above 33%.

Countries such as South Africa, Bhutan and Guatemala have poverty rates around 29 per cent in 2011 and countries such as Tajikistan and Georgia have poverty rates around 33 per cent.

In Appendix Table A.2, we explore whether or not our results about inequality and poverty are driven by the smaller sample sizes. This doesn't appear to be the case. If we estimate the simple model from Table 3 without controls, we find that the effect of inequality on economic growth is statistically significant and roughly stable across all the sample compositions that we consider. Results from Table 4 do not seem to be driven by the restricted sample of countries with available data on poverty.

Appendix Table A.3 examines the effect on the simple regression without controls of the varying sample sizes in Table 4 as we add more variables (and lose observations where data is missing). Looking at Table A.3, the coefficients for the simplest model from Table 4 are very stable across all sample compositions. The basic picture we get across the various sample sizes is consistent and the marginal effects are quite similar to those shown in Figure 1.

In the next sub-section, we expand the sample size by treating poverty as negligible in rich OECD countries to see whether this alters the results. We also re-estimate our model, removing values for the Gini coefficient that have a high degree of uncertainty associated with them. The results do not change much.

5.1 Robustness checks

There are 136 country/year observations for wealthy OECD countries where poverty data is missing. In all of these countries, for years when we can observe the poverty rate, it is below 2 per cent. As a robustness check, we replace these missing poverty values with a value of zero, which will be approximately correct given the observed values of poverty in the data.

Table C.1 presents the results from re-estimating Table 4 using this 'imputed' poverty data. The results are broadly similar although the statistical significance of the individual coefficients decreases. Figure 2 provides the marginal effects from Table C.1. We find that the pattern of marginal effects is extremely similar. Inequality begins to have a statistically significant and negative impact on economic growth at slightly lower poverty rates – the marginal effects are statistically significant at the 10 per cent level at poverty rates of about 24 per cent and significant at the 5 per cent level for poverty rates about 28 per cent.

Some countries have inequality data which is poorly measured. We remove from the data any countries whose standard error of the Gini coefficient estimate is more than two standard deviations larger than the mean standard error of the Gini coefficient, as measured across all of the country observations.

We re-estimate Table 4 without these suspect observations (and without the missing poverty values that had been replaced with zero in the previous robustness check) and report the results in Table C.2 and Figure 3. Inequality begins to have a statistically significant, negative effect on economic growth at a poverty rate of 36 per cent at the 10 per cent significance level.

The World Bank recently changed its definition of poverty, raising the daily income cut-off to $3.10. We re-estimate our models using this definition of poverty. Our sample size changes slightly because there are fewer countries for which this new definition of poverty is available and the set of countries for which it is available is slightly different. The results of this investigation are presented in Figure 4.

The overall results are similar, though we now find that inequality has a positive and statistically significant effect on economic growth for poverty rates below about 10 per cent. Russia and Turkey have poverty rates about 10 per cent using the $3.10 per day measure. Inequality has a negative effect on economic growth at high poverty rates, above 60 per cent. This would be similar to the poverty rate in Honduras.

Note that in the sample which generates Figure 4, 98% of the countries have a gross national income less than USD20,000 per day. It would appear that middle-income countries with low poverty may benefit slightly from inequality using this definition.

Given the smaller sample sizes, our preference is to exercise caution in pushing the interpretation of these results too far.

If we impute zero poverty values to wealthy OECD countries, we find that significance levels drop (as we did before) and the overall pattern is similar to the first 3 figures. These results are summarised in Figure 5.

Both Figure 4 and Figure 5 are based upon the model where we control for investment to GDP ratio, Years of Schooling and Log Population Growth.

Our results do not seem to be driven by the choice of sample size, by missing poverty data in rich countries, by poor quality inequality measurement or by the choice of cut-off in defining poverty.

6 Conclusions

This paper offers new insights into the important relationship between inequality, poverty and economic growth. The central findings of this paper suggest that the proposition that inequality is harmful to economic growth on its own may be too strong. The results in this paper demonstrate that inequality interacts with high levels of poverty to negatively and significantly impact economic growth.

We find that when poverty is low (less than 25%), the relationship between inequality and economic growth is statistically insignificant. For higher levels of poverty, inequality negatively affects economic growth. This negative impact increases as poverty increases.

Our results, for the most part, do not suggest that inequality has a positive role to play in economic growth. There are a variety of reasons why countries might want to reduce inequality (and poverty) even if that has no impact on economic growth. These reasons may include inequality’s impact on social cohesion and long-term institutions.

The policy implication of this paper is that reducing inequality on its own may not improve economic growth prospects. Instead, poor countries may find that reducing poverty would be more beneficial for economic growth, rather than redistribution that does not reduce poverty.

A Appendix: Effect of changing sample sizes

Table A.1: The effect of inequality on growth

Simple model with no controls
Effect of restricting sample size to sub-samples considered in Table 3

$ln(GDPPC)_{t-1}$	−0.0204 (0.446)	−0.342 (0.476)	−0.748 (0.523)	−0.562 (0.493)	−0.551 (0.520)
Gini coefficient	−0.183*** (0.0615)	−0.275*** (0.0745)	−0.269*** (0.0941)	−0.246*** (0.0926)	−0.0639 (0.0595)
Sample size	950	823	760	755	347
Hansen test (p-value)	0.00	0.02	0.02	0.02	0.00
Number of instruments	36	36	36	36	24
Serial correlation tests (p-values) for AR(p) in first differences:					
AR(1)	0.00***	0.00***	0.00***	0.00***	0.00***
AR(2)	0.11	0.23	0.86	0.84	0.94
AR(3)	0.76	0.99	0.90	0.91	0.90

Dependent variable: 5-year average growth rate of GDP

GMM estimation with robust standard errors in parentheses

***, **, * indicates significance at one, five and ten per cent respectively

Regressions include time dummies

Table A.2: The Effect of Inequality on Growth

Simple model with no controls
Effect of restricting sample size to sub-samples considered in Table 4

ln(*GDPPC*)$_t$−1	−0.0204 (0.446)	−0.612 (0.412)	−0.648 (0.483)	−0.570 (0.507)	−1.24** (0.564)
Gini coefficient	−0.183*** (0.0615)	−0.146** (0.0632)	−0.138* (0.0757)	−0.130* (0.0797)	−0.165** (0.0674)
Sample size	950	465	410	407	236
Hansen test (p-value)	0.00	0.00	0.00	0.00	0.02
Number of instruments	36	19	19	19	19
Serial correlation tests (p-values) for AR(p) in first differences:					
AR(1)	0.00***	0.17	0.12	0.10	0.00***
AR(2)	0.11	0.49	0.91	0.92	0.65
AR(3)	0.76	0.35	0.80	0.83	0.60

Dependent variable: 5-year average growth rate of GDP
GMM estimation with robust standard errors in parentheses
***, **, * indicates significance at one, five and ten per cent respectively Regressions include time dummies

Table A.3: The Effect of Inequality and Poverty on Growth

Simple model with no controls
Effect of restricting sample size to sub-samples considered in Table 4

ln(*GDPPC*)$_t$−1	−1.99*** (0.742)	−1.56* (0.835)	−1.78* (0.935)	−1.83* (0.928)	−1.24 (0.823)
Gini coefficient	−0.136* (0.0760)	−0.113 (0.0704)	−0.121* (0.0715)	−0.124* (0.0724)	−0.130** (0.059)
Poverty headcount	−0.0773 (0.132)	0.0484 (0.104)	0.0405 (0.102)	0.0464 (0.104)	0.0347 (0.0736)
Gini × Poverty	−0.00023 (0.0030)	−0.00261 (0.00233)	−0.00235 (0.00207)	−0.00261 (0.00212)	−0.00032 (0.0020)
Sample size	530	465	410	407	236
Hansen test (p-value)	0.02	0.01	0.02	0.03	0.13
Number of instruments	37	37	37	37	37
Serial correlation tests (p-values) for AR(p) in first differences:					
AR(1)	0.32	0.02**	0.00***	0.00***	0.00***
AR(2)	0.01***	0.03**	0.97	0.98	0.79
AR(3)	0.57	0.54	0.62	0.65	0.50

Dependent variable: 5-year average growth rate of GDP
GMM estimation with robust standard errors in parentheses
***, **, * indicates significance at one, five and ten per cent respectively
Regressions include time dummies.

B Appendix: Sample composition

Table B.1: Country list of sample composition for regression models

Baseline	**Baseline & poverty variable**	**Baseline & poverty variable & Set 1**	**Baseline & poverty variable & Set 2***	**Baseline & poverty variable & Set 4**
Albania	Albania	Albania	Argentina	Argentina
Angola	Angola	Argentina	Australia	Australia
Argentina	Argentina	Armenia	Austria	Austria
Armenia	Armenia	Australia	Bangladesh	Belgium
Australia	Australia	Austria	Belgium	Brazil
Austria	Austria	Bangladesh	Belize	Canada
Azerbaijan	Azerbaijan	Belgium	Benin	Chile
The Bahamas	Bangladesh	Belize	Bolivia	China
Bangladesh	Belarus	Benin	Botswana	Colombia
Barbados	Belgium	Bolivia	Brazil	Costa Rica
Belarus	Belize	Botswana	Burundi	Czech Republic
Belgium	Benin	Brazil	Cambodia	Denmark
Belize	Bhutan	Bulgaria	Cameroon	Dominican Republic
Benin	Bolivia	Burundi	Canada	El Salvador
Bhutan	Bosnia and Herzegovina	Cambodia	Central African Republic	Finland
Bolivia	Botswana	Cameroon	Chile	France
Bosnia and Herzegovina	Brazil	Canada	China	Germany
Botswana	Bulgaria	Central African Republic	Colombia	Greece
Brazil	Burkina Faso	Chile	Republic of Congo	Guatemala
Bulgaria	Burundi	China	Costa Rica	Honduras
Burkina Faso	Cambodia	Colombia	Cote d'Ivoire	Iceland
Burundi	Cameroon	Republic of Congo	Croatia	India
Cambodia	Canada	Costa Rica	Czech Republic	Ireland

Table B.1: Country list of sample composition for regression models (continued)

Baseline	**Baseline & poverty variable**	**Baseline & poverty variable & set 1**	**Baseline & poverty variable & set 2***	**Baseline & poverty variable & set 4**
Cameroon	Central African Republic	Cote d'Ivoire	Denmark	Israel
Canada	Chad	Croatia	Dominican Republic	Italy
Central African Republic	Chile	Czech Republic	Ecuador	Kazakhstan
Chad	China	Denmark	"Egypt, Arab Rep."	Kenya
Chile	Colombia	Dominican Republic	El Salvador	Kyrgyz Republic
China	Comoros	Ecuador	Fiji	Mexico
Colombia	Republic of Congo	Egypt	Finland	Netherlands
Comoros	Costa Rica	El Salvador	France	Norway
Republic of Congo	Cote d'Ivoire	Estonia	Gabon	Panama
Costa Rica	Croatia	Fiji	Gambia	Paraguay
Cote d'Ivoire	Czech Republic	Finland	Germany	Philippines
Croatia	Denmark	France	Ghana	Poland
Cyprus	Djibouti	Gabon	Greece	Romania
Czech Republic	Dominican Republic	Gambia	Guatemala	Slovak Republic
Denmark	Ecuador	Germany	Honduras	Slovenia
Djibouti	Egypt	Ghana	Iceland	South Africa
Dominica	El Salvador	Greece	India	Spain
Dominican Republic	Estonia	Guatemala	Indonesia	Sri Lanka
Ecuador	Ethiopia	Honduras	Iran	Sweden
Egypt	Fiji	Hungary	Ireland	Switzerland
El Salvador	Finland	Iceland	Israel	Tajikistan
Estonia	France	India	Italy	Thailand
Ethiopia	Gabon	Indonesia	Jamaica	United Kingdom
Fiji	Gambia	Iran	Jordan	United States
Finland	Georgia	Ireland	Kazakhstan	Uruguay
France	Germany	Israel	Kenya	Venezuela, RB
Gabon	Ghana	Italy	Kyrgyz Republic	Vietnam
Gambia	Greece	Jamaica	Lao PDR	
Georgia	Guatemala	Japan	Lesotho	
Germany	Guinea	Jordan	Liberia	

Table B.1: Country list of sample composition for regression models (continued)

Baseline	Baseline & poverty variable	Baseline & poverty variable & set 1	Baseline & poverty variable & set 2*	Baseline & poverty variable & set 4
Ghana	Guinea-Bissau	Kazakhstan	Malawi	
Greece	Honduras	Kenya	Malaysia	
Grenada	Hungary	Kyrgyz Republic	Maldives	
Guatemala	Iceland	Lao PDR	Mali	
Guinea	India	Latvia	Mauritania	
Guinea-Bissau	Indonesia	Lesotho	Mauritius	
Honduras	Iran	Liberia	Mexico	
Hong Kong	Ireland	Lithuania	Morocco	
Hungary	Israel	Malawi	Mozambique	
Iceland	Italy	Malaysia	Namibia	
India	Jamaica	Maldives	Nepal	
Indonesia	Japan	Mali	Netherlands	
Iran	Jordan	Mauritania	Niger	
Ireland	Kazakhstan	Mauritius	Norway	
Israel	Kenya	Mexico	Pakistan	
Italy	Kyrgyz Republic	Morocco	Panama	
Jamaica	Lao PDR	Mozambique	Paraguay	
Japan	Latvia	Namibia	Peru	
Jordan	Lesotho	Nepal	Philippines	
Kazakhstan	Liberia	Netherlands	Poland	
Kenya	Lithuania	Niger	Romania	
Republic of Korea	Macedonia, FYR	Norway	Rwanda	
Kyrgyz Republic	Madagascar	Pakistan	Senegal	
Lao PDR	Malawi	Panama	Sierra Leone	
Latvia	Malaysia	Paraguay	Slovak Republic	
Lebanon	Maldives	Peru	Slovenia	
Lesotho	Mali	Philippines	South Africa	
Liberia	Mauritania	Poland	Spain	
Lithuania	Mauritius	Romania	Sri Lanka	
Luxembourg	Mexico	Russian Federation	Sudan	
Macedonia, FYR	Moldova	Rwanda	Swaziland	
Madagascar	Montenegro	Senegal	Sweden	
Malawi	Morocco	Sierra Leone	Switzerland	
Malaysia	Mozambique	Slovak Republic	Syrian Arab Republic	

Table B.1: Country list of sample composition for regression models (continued)

Baseline	Baseline & poverty variable	Baseline & poverty variable & set 1	Baseline & poverty variable & set 2*	Baseline & poverty variable & set 4
Maldives	Namibia	Slovenia	Tajikistan	
Mali	Nepal	South Africa	Tanzania	
Malta	Netherlands	Spain	Thailand	
Mauritania	Niger	Sri Lanka	Togo	
Mauritius	Nigeria	Sudan	Trinidad and Tobago	
Mexico	Norway	Swaziland	Tunisia	
Moldova	Pakistan	Sweden	Turkey	
Mongolia	Panama	Switzerland	Uganda	
Montenegro	Paraguay	Syrian Arab Republic	United Kingdom	
Morocco	Peru	Tajikistan	United States	
Mozambique	Philippines	Tanzania	Uruguay	
Namibia	Poland	Thailand	”Venezuela, RB”	
Nepal	Romania	Togo	Vietnam	
Netherlands	Russian Federation	Trinidad and Tobago	”Yemen, Rep.”	
New Zealand	Rwanda	Tunisia	Zambia	
Niger	Sao Tome and Principe	Turkey		
Nigeria	Senegal	Uganda		
Norway	Serbia	Ukraine		
Pakistan	Sierra Leone	United Kingdom		
Panama	Slovak Republic	United States		
Paraguay	Slovenia	Uruguay		
Peru	South Africa	”Venezuela, RB”		
Philippines	Spain	Vietnam		
Poland	Sri Lanka	”Yemen, Rep.”		
Portugal	St. Lucia	Zambia		
Romania	Sudan			
Russian Federation	Suriname			
Rwanda	Swaziland			
Sao Tome and Principe	Sweden			
Senegal	Switzerland			
Serbia	Syrian Arab Republic			
Sierra Leone	Tajikistan			

Table B.1: Country list of sample composition for regression models (continued)

Baseline	Baseline & poverty variable	Baseline & poverty variable & set 1	Baseline & poverty variable & set 2*	Baseline & poverty variable & set 4
Singapore	Tanzania			
Slovak Republic	Thailand			
Slovenia	Togo			
South Africa	Trinidad and Tobago			
Spain	Tunisia			
Sri Lanka	Turkey			
St. Lucia	Turkmenistan			
St. Vincent and the Grenadines	Uganda			
Sudan	Ukraine			
Suriname	United Kingdom			
Swaziland	United States			
Sweden	Uruguay			
Switzerland	Venezuela			
Syrian Arab Republic	Vietnam			
Tajikistan	Republic of Yemen			
Tanzania				
Thailand				
Togo				
Trinidad and Tobago				
Tunisia				
Turkey				
Turkmenistan				
Uganda				
Ukraine	Zambia			
United Kingdom				
United States				
Uruguay				
Uzbekistan				
Venezuela				
Vietnam				
Republic of Yemen				
Zambia				
Zimbabwe				

*Set two and three are the same except for Namibia which gets dropped in set 3

C Appendix: Robustness checks

Table C.1: The Effect of Inequality and Poverty on Growth Rich countries set to zero poverty

Variables	No controls	Set 1	Set 2	Set 3	Set 4
$ln(GDPPC)_t-1$	−2.17*** (0.530)	−1.57*** (0.478)	−1.86*** (0.674)	−1.76*** (0.586)	−0.681 (0.768)
Gini coefficient	−0.0768 (0.0568)	−0.0448 (0.0458)	−0.0305 (0.0478)	−0.0513 (0.0445)	−0.0595 (0.0928)
Poverty headcount	−0.0326 (0.112)	0.0153 (0.0522)	0.0208 (0.0587)	0.0319 (0.0528)	0.0916 (0.101)
Gini × Poverty	−0.00158 (0.00267)	−0.00133 (0.00118)	−0.00148 (0.00114)	−0.00176 (0.00116)	−0.00235 (0.00260)
Investment to GDP ratio		0.204 *** (0.0509)	0.219 *** (0.0516)	0.194 *** (0.0418)	0.254 *** (0.0600)
Years of Schooling		1.10 ** (0.455)	1.07 ** (0.537)	1.07 * (0.616)	0.960 (1.59)
Log Population Growth			−0.403 (0.265)	−0.308 (0.221)	−0.190 (0.363)
Price of Investment				−0.0132 (0.00964)	−0.0132 (0.0152)
Trade share of GDP				0.00379 (0.00488)	−0.00080 (0.00855)
Relative redistribution					−0.0589 (0.0438)
Sample size	666	590	532	529	313
Hansen test (p-value)	0.07	0.60	0.91	1.00	1.00
Instruments	56	92	109	145	125
Serial correlation tests (p-values) for AR(p) in first differences:					
AR(1)	0.04**	0.00***	0.00***	0.00***	0.00***
AR(2)	0.02**	0.02**	0.58	0.98	0.59
AR(3)	0.48	0.51	0.45	0.79	0.50

See footnotes in Table C.2

Table C.2: The Effect of Inequality and Poverty on Growth Removing Gini Coefficients with High Standard Errors

Variables	No controls	Set 1	Set 2	Set 3	Set 4
$ln(GDPPC)_{t-1}$	−1.11 (0.790)	−1.16* (0.456)	−1.14* (0.665)	−0.605 (0.542)	−0.518 (0.660)
Gini coefficient	−0.0440 (0.0965)	0.0159 (0.0615)	0.0213 (0.0501)	0.0642 (0.0577)	0.172 (0.177)
Poverty headcount	0.00348 (0.112)	0.106 (0.0722)	0.0712 (0.0576)	0.130 ** (0.0618)	0.243* (0.126)
Gini × Poverty	−0.00174 (0.00266)	−0.00326* (0.00175)	−0.00229* (0.00118)	−0.00335** (0.00132)	−0.00592* 0.00349
Investment to GDP ratio		0.192 *** (0.0535)	0.205 *** (0.0468)	0.182 *** (0.0441)	0.274 *** (0.0693)
Years of Schooling		1.33 * (0.683)	0.716 (0.737)	0.831 (0.596)	2.11 (1.43)
Log Population Growth			−0.363 (0.286)	−0.410 (0.261)	−0.689** (0.297)
Price of Investment				−0.0154 (0.0122)	−0.0121 (0.0146)
Trade share of GDP				0.00003 (0.00582)	0.00745 (0.00902)
Relative redistribution					0.0172 (0.0971)
Sample size	472	423	371	370	229
Hansen test (p-value)	0.02	0.16	0.53	0.72	1.00
Number of instruments	37	61	72	92	102
Serial correlation tests (p-values) for AR(p) in first differences:					
AR(1)	0.21	0.05**	0.00***	0.00***	0.00***
AR(2)	0.01**	0.02**	0.35	0.90	0.69
AR(3)	0.28	0.58	0.15	0.27	0.50

Dependent variable: 5-year average growth rate of GDP

GMM estimation with robust standard errors in parentheses

***, **, * indicates significance at one, five and ten per cent respectively

All regressions include time dummies

Set 1: Investment to GDP ratio and log years of schooling

Set 2: Set 1 and log population growth

Set 3: Set 2 and price of investment and trade share of GDP

Set 4: Set 3 and relative redistribution

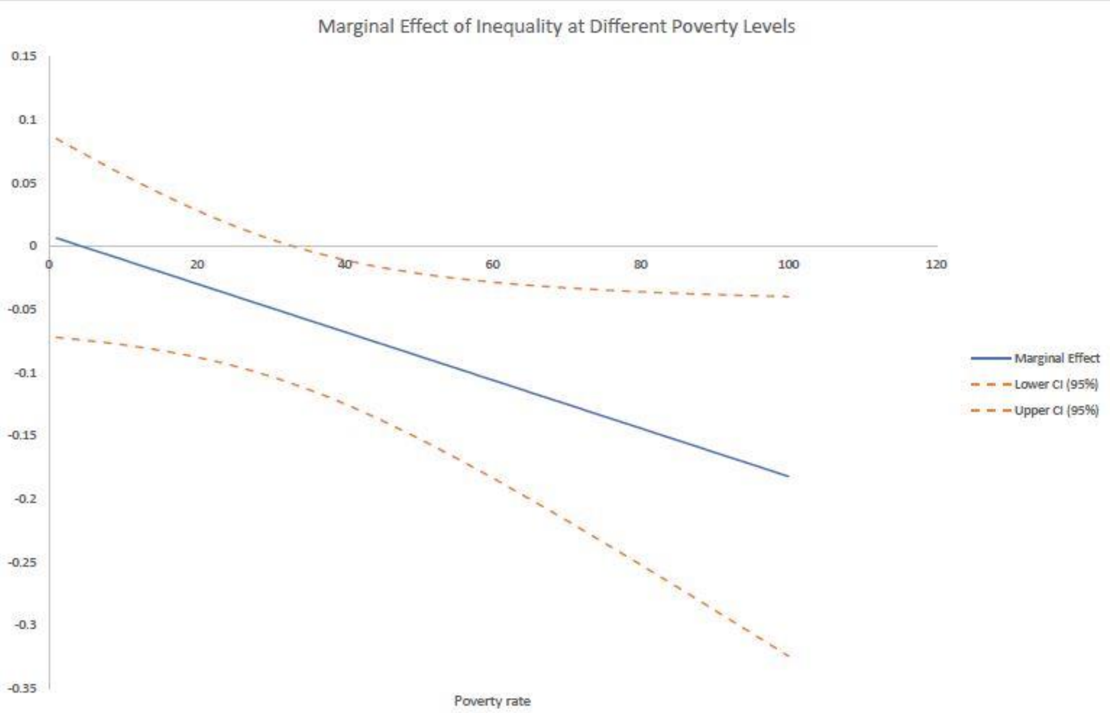

Figure 1 : Marginal Effect of Inequality on Economic Growth at Different Levels of Poverty Based upon Parameter Estimates of Column 3 of Table 4.

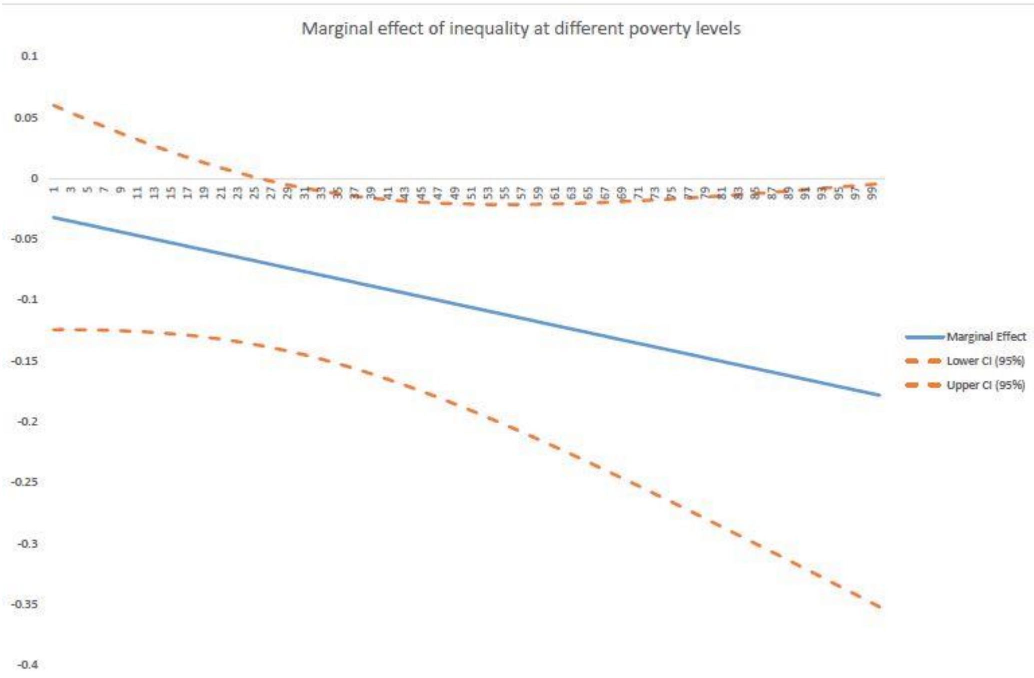

Figure 2 : Marginal Effect of Inequality on Economic Growth at Different Levels of Poverty Based upon Parameter Estimates of Column 3 of Table C.1.

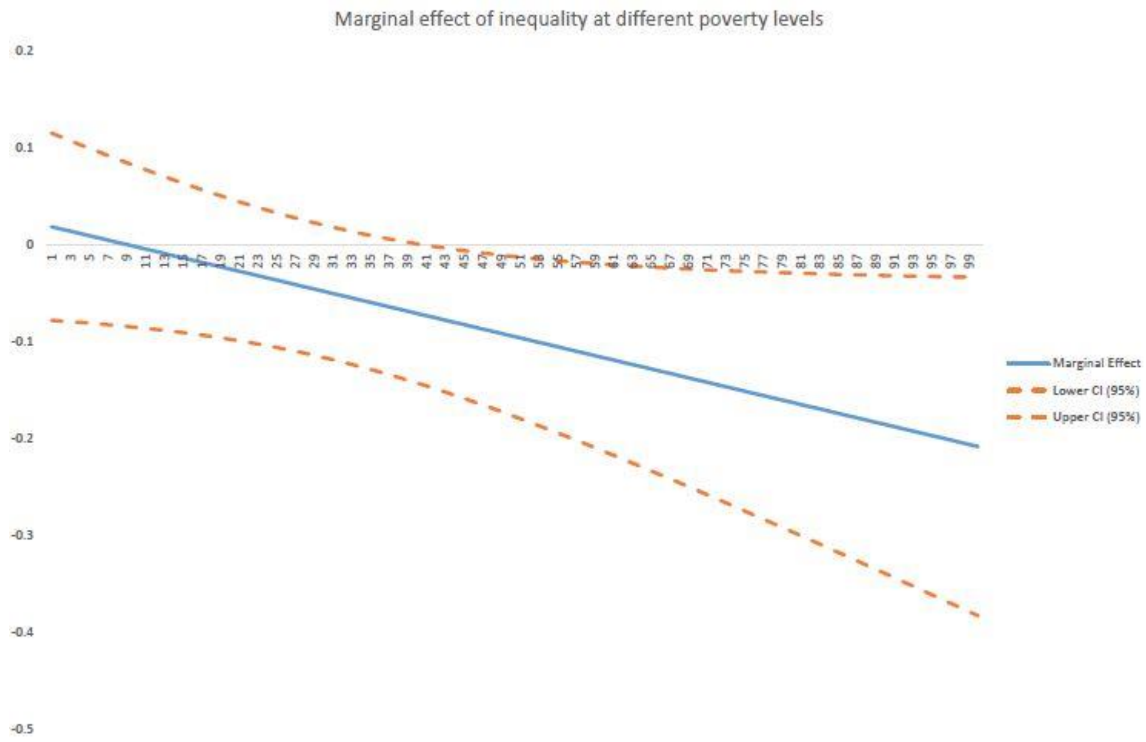

Figure 3: Marginal Effect of Inequality on Economic Growth at Different Levels of Poverty Based upon Parameter Estimates of Column 3 of Table C.2.

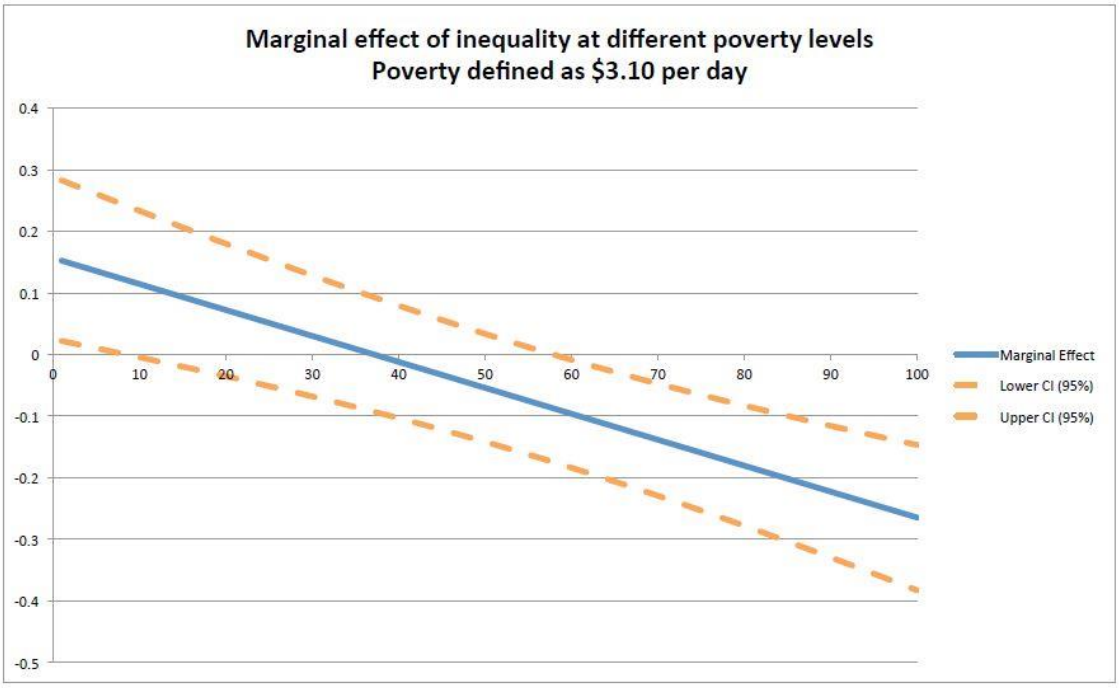

Figure 4 : Marginal Effect of Inequality on Economic Growth at Different Levels of Poverty Based upon $3.10 Per Day Definition of Poverty Controls for Investment, Years of Schooling and Population Growth

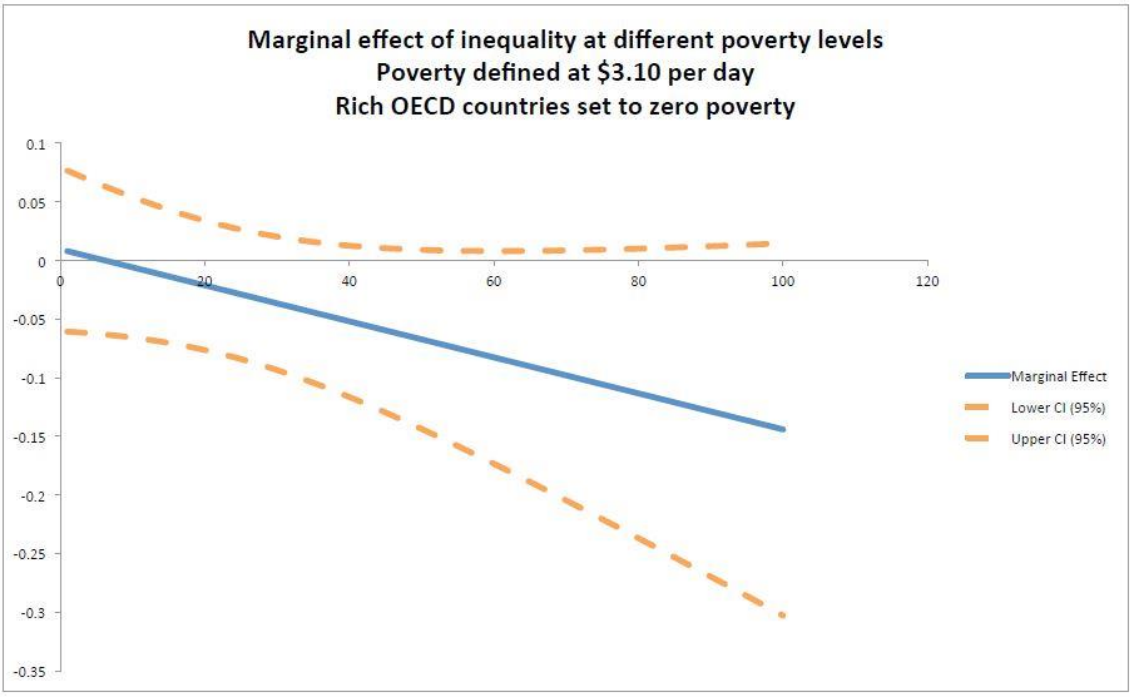

Figure 5 : Marginal Effect of Inequality on Economic Growth at Different Levels of Poverty Based upon $3.10 Per Day Definition of Poverty (Rich Country Poverty Set to 0). Controls for Investment, Years of Schooling and Population Growth

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