ESSAYS ON INTERNATIONAL TRADE AND PRODUCTIVITY:

A MICRO-LEVEL EMPIRICAL INVESTIGATION ON THE IMPLICATIONS AND DRIVERS OF GLOBAL VALUE CHAINS, SERVICE EXPORTS AND SERVICE TRADE BARRIERS FOR ADVANCED ECONOMIES.

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Doctor of Philosophy

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THESIS ABSTRACT

This thesis contains three chapters that contribute to our understanding of the relationship between international trade and productivity for advanced economies within the context of Global Value Chains (GVCs), the increasing importance of services in world trade and the deglobalisation trend leading to increased service trade barriers. The first empirical chapter investigates the interrelationship between participation in GVCS, productivity and robot adoption using a panel of OECD countries between 1995 and 2016. The chapter stresses that a bidirectional relationship exists between GVCs and productivity, GVCs and robot adoption, and robot adoption and productivity. The findings show evidence for this bidirectional relationship as we find a positive effect of GVCs on robot adoption and a positive effect of robot adoption on participation in GVCs. We also find a positive effect of GVCs on productivity and a positive effect of productivity on GVCs. However, we fail to find a significant effect of robot adoption on productivity. The second empirical chapter addresses the blurring line between manufacturing and services, focusing on what factors enable manufacturing firms successfully export services. Using a panel of UK manufacturing firms between 2011 and 2018, we find that in addition to productivity and Firm Specific Advantages (FSAs), selling services domestically is an avenue of learning which helps manufacturing firms successfully export services. The third empirical chapter focuses on the effect of service trade barriers on firm productivity and export performance, and also investigates the role of firm heterogeneity and trade policy uncertainty. Using a panel of UK firms between 2014 and 2019, we find a negative effect of service trade barriers on productivity and export performance. We also find that this effect is more pronounced for the firms in the lowest size quartile, and it is also stronger for the period after the Brexit referendum.

Keywords: Global Value Chains, Service Trade, Productivity, Industrial Robots, Service Exports, Non-Tariff Barriers, Trade Policy Uncertainty, International Trade.

DEDICATION

I dedicate this thesis to my parents, Prof. and Prof. (Mrs) Nduka, whose thirst for knowledge led to the start of this journey and whose constant support ensured that I saw it through to the finish.

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1.1 INTRODUCTION

1.1.1 Background of Research

International trade and productivity are related, and this relationship has been explored extensively in international economics. It has been argued that participating in international trade leads to productivity gains. Studies have identified several channels through which trade can affect productivity. One of these channels is through increasing the variety and quality of intermediate inputs available to a firm which reduces the firm's inputs costs and raises its productivity. Grossman and Helpman (1991) highlight this effect by arguing that imported intermediate inputs might be more technologically superior or productive than domestic inputs, hence its role in improving productivity. Furthermore, as a result of trade, the availability of high quality intermediate goods and inputs allows firms to adopt new production methods (Muendler, 1986). Also, there is the learning by exporting channel, where firms can learn directly through foreign buyer-seller relationships and access information and technology (Gereffi and Tam, 1998; Grossman and Helpman, 1991). Firms can also benefit from technological spillovers or learn of superior or more efficient production methods through their interaction with foreign trade partners.

However, the very nature of international trade is changing. With increasing globalisation, trade agreements between countries and improvements in technology, modern day international trade is quite different from the trade during the classical and neo-classical eras. This thesis is motivated by the observation of the changes in international trade, specifically the rise of Global Value Chains (GVCs), the increasing importance of services in international trade and the reversal of trade integration due to deglobalisation. These are all observed aspects of international trade in today's world that are focused on in this thesis to provide a better understanding of their drivers and implications.

This introductory chapter will focus on these three changing aspects of international trade where my thesis aims to fit in, highlighting the trends driving the motivations and research questions of this work. Then it would also provide a motivation for each empirical chapter that makes up the thesis, a summary of the findings and the contributions of each empirical chapter. Lastly, it would identify the position of the thesis in the literature and the gaps which the thesis aims to fill.

1.1.2 Global Value Chains Trends

Traditionally, international trade involved the movement of final goods across borders with production undertaken primarily in one country. However, with improvement in communication costs driven by the ICT revolution, it became possible for production to be split and carried out in different countries. Therefore, Global Value Chains (GVCs) refer to this international production sharing, where different stages of production are carried out in different countries with value added at each stage. The possibility of fragmenting production across different countries leads to more gains from specialisation and allows resources to flow to their most productive use. Although the concept of GVCs is not new, it has increased rapidly in both advanced and developing economies in recent decades, beginning in the early 1990s. According to the World Bank report in 2020, between 1990 and 2015, worldwide GVC participation increased by about 7% due to increased fragmentation of production in some countries and industries, and an increase in the share of world trade by countries that were already GVC-intensive. This expansion was mostly fuelled by lower transport costs, trade liberalisation such as the integration of China into the world economy, trade agreements such as NAFTA and the European single market, improvement in ICT technologies and innovation in logistics such as containerisation (Baldwin, 2018). Currently, about 80% of trade is now carried out within GVCs with countries now trading in value rather than in final goods.

Almost all countries participate in GVCs but not in the same way or to the same degree. While some countries export raw materials for further processing, others import inputs for processing, assembling and exports, while some others focus on the production of complex goods and services. This leads to specialisation in different tasks and stages of production by countries, leading to gains from GVC trade. Also, integration into GVCs occurs in two ways i.e. backward linkages or forward linkages. Backward linkages occur when a country imports intermediate inputs that are used in producing goods for export, while forward linkages are when a country exports intermediate inputs that are used by other countries in producing goods for export. Both backward and forward linkages are argued to have some benefits.

By using foreign inputs for production, backward linkages give countries access to a variety of intermediate inputs which might be of better quality and also have more favourable prices. On the other hand, supplying inputs used for production by other countries provide avenues for learning i.e. learning to export or learning by exporting, which improves the benefits of GVCs participation for these countries (Cheng et al., 2015). Aside from the gains from forward and backward linkages, it is argued that by increasing participation in GVCs, countries can experience productivity increase through knowledge spillovers and technology transfer, income growth, economic development and employment (Banga, 2016; Blalock and Veloso, 2007; Kummritz, 2016; Smarzynska Javorcik, 2004). As a result of this new nature of trade, there has also been a change in the measurement of international trade statistics. Measures such as domestic and foreign value added used to measure forward and backward linkages respectively, have been devised to better capture this new aspect of trade (Daudin et al., 2011; Hummels et al., 1998) as they are better indicators of where value is created and of a country's competitiveness compared to final export and import statistics which might not be accurate.

With the proliferation of GVCs and the wider availability of data on GVC participation, a recent strand of literature has emerged, focusing on what drives GVC participation and what impacts it could have. Due to comparative advantage, some countries obtain higher overall gains from integration into GVCs by specialising in higher value tasks within the chain. So, determining what segment of the GVC to will be profitable to specialise in is a function of the countries' productivity, technological endowment, skills and resources (De Backer et al., 2018). At the same time, participating in GVCs is meant to yield economic and social upgrading, where countries experience an efficiency increase in production either through the adoption of new technology or improvement in current production techniques, and gain the expertise required to produce more sophisticated products which boost their productivity. So, productivity and technology advances have been highlighted as potential drivers and outcomes of participation in GVCs.

Since the late 1990s, there has been a slowdown in the growth of productivity and trade in advanced economies, and this decline intensified after the global financial crisis. Productivity growth went from around 2% before the crisis to less than 1% after the crisis while the growth rate of OECD imports fell to about 3% from 7% (Constantinescu et al., 2016). A crucial characteristic of this slowdown in global trade is the stalling in the expansion of GVCs. In advanced economies, the share of GVC-related trade has remained at pre-crisis levels while emerging economies have witnessed a decline in this share. To combat this productivity slow-down, most advanced countries turned to robots in order to safeguard competitiveness and boost productivity.

However, aside from its productivity benefits, robotic technology has implications for international trade and organisation of production in GVCs due to its capacity to adapt and learn (De Backer et al., 2018; De Backer and DeStefano, 2021). Improved production efficiency and higher quality of products obtained through the use of robots can make it easier to integrate into GVCs and also upgrade in them by carrying out higher value activities within the value chain. In addition, the use of robots can reduce production costs while increasing the optimal scale and the demand for intermediate inputs. At the same time, the degree of integration into GVCs can also drive the adoption of robots as there is an incentive to upgrade, stay productive and competitive in GVCs.

So, a relationship might exist between robot adoption and GVC integration, however, the direction of that relationship is still undetermined and keenly debated. This is still an under-researched area where this thesis aims to make a contribution. What implications does increased participation in GVCs hold for productivity and robot adoption? How do robot adoption and productivity affect participation in GVCs? These are some of the questions the first empirical chapter aims to answer, and it aims to contribute to this emerging strand of literature by investigating the relationship between productivity and trade in GVCs, explicitly accounting for the role played by technology adoption.

Specifically, the first empirical chapter focuses on the adoption of industrial robots and aims to disentangle the relationship between trade in GVCs, robot adoption and productivity. The average cost of industrial robots has been on a decline, while their performance is continuously improving. This has led to a sharp increase in the adoption of industrial robots worldwide, with varying rates of adoption among countries. The sharp increase in robot adoption has prompted studies focused mostly on its labour market implications, although it is bound to benefit industries up and down the value chain, albeit unequally. Therefore, it is important to understand the interrelationship between robot adoption and productivity within a trade in the GVCs framework. This is one of the gaps this thesis aims to fill and the main contribution of this chapter.

1.1.3 The Importance of Services in International Trade for Developed Economies

Typically, when we speak of international trade, it mostly involved goods crossing borders. However, due to globalisation and improvements in ICT technology and use, services are more tradable than ever and play a critical role in the development and growth of a country (Hoekman and Shepherd, 2017). For many advanced countries, BOP statistics show that the growth in trade in services has surpassed the growth in goods trade for the last decade (Mattoo et al., 2007). Services have now become the backbone of most developed economies with a share of

70% of total employment and GDP and are the most dynamic component of international trade. Developed countries like the UK and even emerging economies like India have witnessed a growth in the percentage of service exports in the current account from about 16% to 38% between 1990 and 2020. This growth is attributed to not only the improvement in ICT technology but also the liberalisation and reform in service industries (Copeland and Mattoo, 2008). Even when it concerns trade in GVCs, most developed countries have joined the GVCs mostly through services (Baldwin, 2018), with services representing an important source of value-added for other sectors, especially manufacturing, in total trade.

Just like trade in goods, trade in services also generates welfare gains, economies of scale and efficient allocation of resources (Wolfmayr, 2008). It also enhances competitiveness for firms and increases the variety of services available to consumers, therefore promoting productivity. Also, given that many services are important inputs for other goods, they can have a significant effect on the productivity and growth of other sectors. Aside from the use of services as intermediate inputs in manufacturing, services and manufacturing have become intertwined for many reasons such as increased fragmentation in production, expansion of GVCs and the increased complexity in the organisation of production that increases the demand for services. This has led to the blurring of the line between the manufacturing and service sectors. Concepts such as servitisation – manufacturing firm offering services, productization – services marketed as products, and product-service systems (PSS) – integrated product and service offering, have been coined to demonstrate different ways in which manufacturing and service sectors have become intertwined (Baines et al., 2007), with manufacturing becoming more directly involved in services. Manufacturing firms selling services has become more common over the years with studies showing at least 20% of manufacturing firms also sell services across different countries (Neely, 2013; Neely et al., 2011). The motivation for this has been tied to increasing competitive advantages, economic and financial reasons, and also increasing the chances of the firm's survival. Empirical studies have found that by also selling services, manufacturing firms can improve their profitability, productivity and innovation (Bascavusoglu-Moreau and Tether, 2010; Dachs et al., 2014).

With regards to international trade, manufacturing firms are not only increasingly depending on service inputs, either sourced domestically or imported, but in some cases, are also actively engaged in service exports. Studies show that the manufacturing sector account for 19% of service exports in Germany and 16% of service exports in the UK, while 5% of Austrian manufacturing firms export services (Breinlich and Criscuolo, 2011; Kelle and Kleinert, 2010; Wolfmayr et al., 2013). Again, it is evident that not all manufacturing firms export services, making it imperative to carry out an investigation into what factors enable manufacturing firms to export services. In line with the literature, it is expected that already identified factors such as productivity, firm size, innovation, skills, etc. would play a role in aiding manufacturing firms to export services. In addition to this, this thesis highlights another factor that might be an additional avenue of learning for manufacturing firms that could enable them successfully export services, which is selling services domestically. Studies have highlighted that by offering services, manufacturing firms improve their competitive advantages, productivity and innovation. However, the role that selling services domestically by manufacturing firms might play in helping them successfully export services has been largely overlooked and this chapter makes a contribution by focusing on this factor. By selling services domestically, these manufacturing firms are uniquely positioned to learn in order to export.

So, the second empirical chapter of this thesis investigates the factors enabling manufacturing firms to successfully export services, focusing on already identified factors such as productivity and FSAs, but most importantly, it identifies selling services domestically as an additional source of firm heterogeneity for manufacturing firms' service exports. The study also highlights its importance for service export participation, and intensive and extensive margins. This is another contribution this thesis aims to make.

1.1.4 Deglobalisation and Trade Disintegration

The rapid growth in service trade has also been accompanied by increased interest in discussions about service trade policy. Proponents of trade advocate for free trade and the reduction of barriers to trade between countries in order to enable countries to reap the productivity and welfare benefits of trade, however, trade integration in services is much more difficult than for goods. Trade costs for services are traditionally higher than that of goods mostly due to the proximity burden required when trading services as opposed to goods, and due to complicated policy regimes applied to services trade. However, according to the World Bank report of 2020, trade costs in services have fallen by 9% between 2000 and 2019, and this is mostly due to technological improvements and service policy reforms. With regards to trade restrictions, service trade barriers are typically regulatory as opposed to restrictions in goods trade which are mostly tariffs. This is mostly due to the differences between services and goods trade. First, cross-border trade in services is usually in an intangible form, as opposed to goods trade. Also, the mode of delivery for services differs as it can involve the movement of labour or commercial presence in the form of FDI. Furthermore, many services are regulated or provided by the public sector. Due to these differences between services and goods trade, most trade barriers that exist for services are Non-Tariff Barriers (NTBs).

NTBs are any government policies that raise the cost of access to domestic markets for foreigners, mostly with the effect of favouring local producers (Copeland and Mattoo, 2008). This kind of barrier, compared to the tariff barriers that are more applicable to goods trade, is more complex, more difficult to measure and less transparent. With trade in goods, free trade equates to zero tariffs but due to the nature of the barriers that exist for service trade, trade liberalisation for this sector is much more complex. For instance, while licensing and certification requirements limit trade in professional services, it can be justified by the need to ensure quality and safety standards in the domestic market. Given the benefits associated with trade in services, trade policies have to adjust to accommodate the unique nature of service trade and work to reduce the NTBs to service trade.

In addition to the NTBs affecting service trade, the global economy is facing a new challenge of growing deglobalisation. This is the process of reducing global interdependence and integration, exacerbated by trade imbalance, political pressure and trade tensions between countries. The 2008 financial crisis caused a halt to the process of globalisation and in some ways, it rekindled nationalistic sentiments in advanced countries due to the economic depression that followed. In Europe, the Brexit vote led to an unravelling of decades of trade integration, introducing trade policy uncertainty, particularly with regard to services trade. As found by (Douch et al., 2020), the trade uncertainty as a result of Brexit saw the diversion of UK exports away from the EU to non-EU destinations. In the USA, Trump's trade war with China saw the introduction of tariff increases on products traded between the two countries. Import tariffs increased from 2.6% to 16.6% of annual US imports (Antràs, 2020b). And for the rest of the world, the Covid-19 pandemic in 2020 caused a decline in global economic activity due to mandated lockdowns and social distancing practices. Trade flows collapsed as a result of the pandemic with world trade declining by up to 17% in May of 2020. Although world trade has recovered, there are still travel restrictions in place as a result of the pandemic which still has a negative effect on service trade. Evidently, accompanying the deglobalisation is an increase in the barriers to trade, especially service trade.

Although the economic consequences of trade barriers have been studied for a long time, the impact of uncertainty about potential trade barriers has not been studied in depth. Also, the existing studies on the impact of uncertainty about future barriers have mostly focused on goods trade while services have been marginalised. With increased uncertainty in trade relations in some advanced economies and the proliferation of deep trade agreements, the impact of future trade barriers on firm productivity and export performance is an area of research that is imperative to understand. The UK Brexit vote and the uncertainty that followed provide a unique opportunity to study the impact of trade policy uncertainty, especially for services. This thesis contributes to this strand of literature by examining not only the impact of service trade barriers on firm performance but going a step further to investigate how the trade policy uncertainty following the Brexit vote affected the productivity and performance of UK firms. We also examine the effect of firm heterogeneity, paying particular attention to how the impact of service trade barriers varies by firm size and age. This is the focus of the third empirical chapter.

1.1.5 Research Aims and Objectives

The motivation of this thesis is primarily driven by important empirical observations that have shaped and continue to shape international trade and productivity. The first observation is the increase in the fragmentation of the production process across borders, leading to a growth in trade in intermediate goods, trade in GVCs and trade in services. The second observation is the global slowdown in productivity and trade growth for advanced countries, exacerbated by the global financial crisis. This is closely linked to a slowdown in the expansion of GVC-related trade for both advanced and developing countries. The third observation is the growing importance of service trade in advanced economies, increased implementation of NTBs and increased trade policy uncertainty. Service trade barriers limit the free movement of services which might prove harmful to the productivity and welfare gains of the country.

Driven by these observations, this thesis explores the intricate and dynamic relationship between productivity and trade, exploring emerging trade phenomena such as GVCs and service trade barriers. When considering international trade, this thesis focuses on trade in services and particularly on service exports, due to the growing importance of services in many advanced economies. It focuses on several aspects of service trade such as the probability of exporting services, and intensive and extensive margins of trade in services. Another factor this thesis pays attention to is productivity. In international economics, productivity has taken centre stage, either when focusing on the causes of trade or the effect of trade. This thesis is no different as productivity (both labour productivity and TFP) is a common thread that runs through each empirical chapter. I explore what role productivity plays in the trade in GVCs and manufacturing firms exporting services. I also investigate how trade in GVCs and the presence of NTBs affect productivity. I also explore other factors such as robot adoption, services sold domestically by manufacturing firms and innovation, all within the context of the changing aspects of international trade and productivity.

This thesis aims to contribute to our understanding of international trade and productivity, exploring this relationship within the context of GVCs, service exports and service trade barriers. Consequently, this thesis aims to answer the following questions.

1. What is the relationship between integration into global value chains, productivity and the adoption of industrial robots? Is this relationship unidirectional or bidirectional?
2. What factors enable manufacturing firms to successfully export services? What role do domestic services provided by manufacturing firms play in enabling manufacturing firms successfully export services?
3. What is the effect of service trade barriers on productivity and service export performance?

In the next section, I present a summary of the three empirical chapters, highlighting the research questions, objectives, methodology and contributions of each empirical chapter.

1.1.6 Chapter Summaries

1.1.6.1 Chapter 2 - Industrial Robots, Global Value Chains and Productivity

The second chapter of this thesis is directed toward answering research question one stated above. International trade, productivity and technology adoption have all been linked with one another by previous studies. It has been found that productivity and technological differences drive international trade (P. R. Krugman and Obstfeld, 2009), international trade yields productivity and technological benefits (Caselli and Coleman, 2001) and international trade and productivity drive technology adoption (Piermartini and Rubínová, 2021). This chapter strives to contribute to the international trade and technology adoption literature. It is motivated by the rising GVCs and robot adoption trends, combined with a slowing productivity growth observed in advanced economies. In this chapter, I develop hypotheses about the relationship between trade, productivity and technology adoption, utilising multi-country panel data and adopting a Panel Vector Autoregressive model (PVAR). The hypotheses argues that trade, productivity and technology adoption are interrelated and interdependent, and that a bidirectional relationship exists between them.

The chapter examines international trade from the lens of trade in GVCs and trade in value added, thereby addressing one aspect of change in international trade identified earlier, while the adoption of industrial robots is the focus for technology adoption. I distinguish between backward and forward linkages in GVCs, and examine how this is *affected* by the adoption of industrial robots, and how it also *affects* the adoption of industrial robots utilising a panel of 20 OECD countries for the period 1995 to 2016. I find that changes in GVC integration through forward and backward linkages affect the adoption of industrial robots, and that the adoption of industrial robots also simultaneously affects the integration into GVCs through forward and backward linkages. I also find that while changes in productivity affect robot adoption, robot adoption does not have a significant effect on productivity. Lastly, I find evidence for a bidirectional relationship between productivity and integration into GVCs.

1.1.6.1.2 ***Contributions***

To the best of my knowledge, studies analysing the relationship between trade, technology adoption and productivity have done so by assuming a one-way causality between the variables – an approach that is bound to suffer from endogeneity issues. In this chapter, I analysis this relationship within a system of equations, directly accounting for the dynamic behaviour and cross-dependence of these variables, thereby mitigating endogeneity concerns. This is the main contribution of this chapter. I argue that a dynamic bidirectional relationship exists between trade in GVCs and productivity, productivity and robot adoption, and robot adoption and trade in GVCs. I also argue that to understand the factors driving the increasing trade in GVCs across the world, then the dynamic effects of productivity and robot adoption must be accounted for. Therefore, this chapter contributes to the broad literature on how new technologies affect trade. It also contributes to the literature on the impact of GVCs on productivity. Lastly, by utilising a PVAR model, it makes a methodological contribution, providing the building blocks to explain the intertwined relationship between trade, technology and productivity.

1.1.6.2 Chapter 3 - Learning by Serving (At Home)

International trade is considered an important avenue of growth and development (Eaton and Kortum, 2001; Frankel and Romer, 1999). Given the growing importance of services, more studies are now focusing on the drivers of service trade and its impacts (Breinlich et al., 2018; Malchow-Møller et al., 2015). Chapter three focuses on the factors that enable manufacturing firms successfully export services. It addresses the blurring lines between manufacturing and services, thereby exploring another aspect in which trade is changing in advanced economies. Studies have explored the factors affecting the export behaviour or manufacturing firms; however, they do not distinguish between their goods and services exports, which this chapter does. I focus on this area of overlap between manufacturing and services, exploring specifically the relationship between services sold domestically by UK manufacturing firms and their service exports behaviour. Therefore, chapter three seeks to answer research question two stated in the previous section. Specifically, I investigate what factors affect the service export participation, intensity and external margins of UK manufacturing firms.

To achieve this, I utilise a firm level panel of UK manufacturers containing service trade and firm specific information between 2011 and 2018. The UK is the second largest service exporter in the world with services contributing about 80% to its GDP, and manufacturing making up about 16% of its service exports according to the Office of National Statistics (ONS). This makes it a good context within which this research can be carried out. I estimate a logit model with random effects, Tobit model and Poisson models in the empirical investigation and I find that productivity, firm specific advantages (FSAs) such as innovation and employees' skills are factors enabling manufacturing firms to successfully export services. We also find a strong and statistically significant effect of services sold domestically by manufacturing firms on their service export behaviour. Lastly, we find that selling services domestically by manufacturing firms is the only factor that affects the probability of exporting services, the intensity of services export and the extensive margins; other factors such as productivity of FSAs affect either participation or intensity or extensive margins, but not all three.

1.1.6.2.1 Contributions

This chapter contributes to the selection into exporting literature (Melitz, 2003; Roper et al., 2006) and by focusing on the service exports of manufacturing firms, it also contributes to the understanding of services trade and the factors driving it. Also, this chapter contributes to the learning to export and internationalisation process literature by investigating both the probability, intensive and extensive margins of services exports by manufacturing firms. The major contribution of this chapter is it identifies an important link between the services sold domestically by manufacturing firms and their service export behaviour which helps to explain why manufacturing firms export services. It argues that manufacturing firms offering services not only affect their profitability and productivity, but that it is a major avenue of learning that enables them to successfully enter service export markets.

1.1.6.3 Chapter 4 - Service Trade Barriers and Firm Performance: A UK Perspective

This chapter is aimed at answering research question three stated in the previous section and explores the changing nature of international trade with regard to deglobalisation which gives rise to service trade barriers and uncertainty in trade policy. Several studies have investigated the impact of trade barriers on firm performance and most find evidence for a negative relationship between the two (Ahmad et al., 2020; Amiti and Konings, 2007; Shepotylo and Vakhitov, 2015). However, most studies on the effects of trade barriers on firm performance have focused on goods trade as opposed to services. In this chapter, I focus on the impact of service trade barriers on firm productivity and service export performance.

Utilising a panel of UK firms and estimating fixed effects models, I find that service trade barriers have a negative impact on firm productivity and services export performance which is in line with theoretical expectations and empirical findings. Focusing on the sub-periods to investigate the effect of trade policy uncertainty i.e. before and after the Brexit referendum, I also find that this effect is stronger for the period after the Brexit referendum. Turning attention to the heterogeneous effect with regard to firm size, I find that firms in the smallest size quartile are the most affected by service trade barriers for both productivity and services export performance. However, in the period after the Brexit referendum, I find that only firms in the smallest size quartile are negatively impacted by service trade barriers. The findings of this chapter contribute to the debate on service trade policy and the literature on the impact of service trade barriers on firm performance. The results also provide key insight for policymakers with regard to the effect of the Brexit referendum and also highlights the potential impact on small businesses.

1.1.6.3.1 Contributions

Although this study is complementary to the studies investigating the impact of trade barriers on firm performance, it deviates from them in three ways. First, while most studies examine trade barriers in terms of tariffs and mostly for the manufacturing sector, this study focuses more on services and non-tariff barriers (NTBs). By focusing on service trade barriers, this study contributes to the emerging literature that focuses on services and the impact of NTBs on firm performance.

Second, the study investigates the impact of trade policy uncertainty by examining the effect of NTBs on firm performance in two sub-periods i.e. before and after the Brexit referendum. Although some studies have investigated the potential impact of the Brexit referendum on the trading patterns of UK firms (Delis et al., 2018; Douch et al., 2020; Du and Shepotylo, 2021a), these studies have mostly relied on simulations of the counterfactual in their analysis. However, in this chapter, I utilise actual data to investigate how the effect of service trade barriers differs in the periods before and after the Brexit referendum.

Lastly, this chapter also investigates the source of heterogenous effects of service trade barriers on firm performance, focusing on firm size and age. With regards to firm size, there have been mixed findings in the literature with some studies finding that the smallest firms are the most affected by trade barriers (Nataraj, 2011; Shepotylo and Vakhitov, 2015), others finding either that larger firms are more affected (Bustos, 2011; Fernandes, 2007) and some finding no evidence that firm size is a source of heterogeneity in the impact of trade barriers on firm performance (Topalova and Khandelwal, 2011). In this chapter, I also examine the effect of service trade barriers on firm performance by firm size and go a step further by focusing on this effect in the period after the Brexit referendum. To the best of my knowledge, this is the only study that combines both the firm size and the Brexit referendum heterogeneity effects in examining the impact of service trade barriers on firm performance.

1.1.7 Position of the Thesis in the Literature

This thesis lies within the literature on international trade and productivity. Although the thesis contributes to the broad literature on international trade and productivity, it also contributes to the literature on service exports, GVC participation, trade and automation, trade barriers and trade uncertainties. Specifically, the first empirical chapter contributes to the literature on the impact of GVC participation on productivity. It also explores the interrelationship between GVCs, automation and productivity. The second empirical chapter contributes broadly to the literature on service trade. Specifically, it looks at the factors that drive manufacturing firms to export services and in doing so, it also contributes to the literature on learning to export and selection into exporting. Lastly, the third empirical chapter also contributes broadly to the service trade literature. This paper also contributes to the literature on the effects of trade barriers on productivity and the economic effects of trade policy uncertainties.

1.1.8 Structure of the Thesis

This thesis is made up of five chapters which consist of the introduction, three empirical chapters and the conclusion. Each empirical chapter contains its own specific literature review, data and methodology sections.

Chapter two focuses on the interrelationship between productivity, robot adoption and global value chains (GVCs), making an argument and showing evidence for the existence of a bidirectional relationship between these variables. Chapter three focuses on the service exports of UK manufacturing firms, identifying the factors that increase the probability, intensity and extensive margins of service exports for manufacturers. This chapter emphasises the important role selling services domestically plays in enabling manufacturing firms to export services successfully. Chapter four examines the impact of service trade barriers on the productivity and services export performance of UK firms. This chapter investigates how the effect varies in the periods before and after the Brexit referendum, exploring the heterogenous effects by firm size and age. Lastly, chapter five concludes the thesis by presenting a summary of the findings, highlighting the contributions of the thesis, acknowledging its limitations and suggesting the areas for future research.

CHAPTER 2 INDUSTRIAL ROBOTS, GLOBAL VALUE CHAINS AND PRODUCTIVITY

ABSTRACT

This study investigates the interrelationship between GVC integration, robot adoption and productivity using a panel of industries from 20 OECD countries spanning a period of 20 years. We argue that a bidirectional relationship exists between these factors and we investigate this using a Panel Vector Autoregressive (PVAR) model which accounts for the endogeneity between these variables. Analysing the relationship between GVC integration and robot adoption, we find that backward linkages in GVCs positively affect robot adoption while robot adoption affects both backward and forward linkages. Also, for the relationship between robot adoption and productivity, we find evidence that productivity increases robot adoption while robot adoption has no significant effect on productivity. Lastly, we examine the relationship between GVC integration and productivity, and we find a positive effect of productivity on both backward and forward linkages, while neither backward linkages nor forward linkages have a significant effect on productivity.

2.1 INTRODUCTION

Technology, trade and productivity are three phenomena that have been extensively studied and discussed for centuries. Right from the era of classical to neo-classical theories, economists have linked trade, technology and productivity. For each of these phenomena, one or both of the other two have been identified as a cause and/or an effect. In examining the factors affecting international trade, productivity and technological differences between countries have been highlighted as key drivers (P. R. Krugman and Obstfeld, 2009; Rivera-Batiz and Romer, 1991). Also, in investigating the benefits of international trade, productivity and technological gains have been highlighted (Caselli and Coleman, 2001; Keller, 2002). The same can be said for studies that have identified international trade and technology adoption as both a driver for productivity and a consequence of productivity (Koch et al., 2021; Kummritz, 2016; Pahl and Timmer, 2020). Lastly, some studies have focused on technology adoption and found productivity and trade to be both drivers and consequences of technology adoption (Kromann and Skaksen, 2007; Piermartini and Rubínová, 2021). Therefore, there exists an interrelationship between these three phenomena.

However, with globalisation and improvements in technology, the concept of international trade is changing and the possibilities that come from technological progress keep expanding. International trade is now conducted in so-called Global value Chains (GVCs) where different stages of the production process are now located in different countries, with value added at each stage (De Backer and Yamano, 2011; Del Prete et al., 2018). According to a 2018 report by the OECD, about 70% of international trade today involves GVCs and there is a budding interest in what impacts participating in GVCs could have on countries, industries and firms. Countries can integrate into GVCs by using intermediate inputs sourced from abroad in producing goods for export (backward linkages) or supplying intermediate goods used by other industries to produce goods for export (forward linkages), with most countries having both forward and backward linkages (Abrenica, 2017; Kummritz, 2016). On the other hand, there has been a productivity slowdown in most advanced countries, which started before the financial crisis. Recovery after the financial crisis has been slow for productivity and studies have also shown that the growth of GVCs since the crisis has also slowed (Bank, 2015; Gal and Witheridge, 2019). While productivity growth has declined to 1% per year after the crisis as opposed to 2% before the crisis, GVC expansion has slowed to 3% as opposed to 7% before the crisis.

Furthermore, the fourth industrial revolution which refers to the creation and adoption of a broad range of new digital industrial technologies such as 3D printing, IoT or robotics is disrupting the production processes of manufacturing. Although these technologies have been available for some time, however, the improvement in their quality coupled with a reduction in the cost has led to an increase in their uptake (Strange and Zucchella, 2017). From the variety of automation technologies that exist, this study focuses specifically on industrial robots. The average costs of industrial robots have fallen by 23% in the past decade, while their performance has increased by 5% according to the IFR. Also, the adoption of industrial robots around the world is accelerating at a high rate. According to the International Federation of Robotics (IFR), the global average for industrial robots per 10,000 manufacturing workers grew from 66 in 2015 to 126 in 2021 in the manufacturing industries, nearly doubling in a short period of seven years. While the wave of automation promises enhanced productivity and prosperity (Graetz and Michaels, 2018), it is anticipated to benefit industries up and down the value chains and global economy, but perhaps quite unevenly. A key reason for the uneven distribution of benefits comes from the uneven adoption of robotic technologies, which we know little of so far.

There is a large heterogeneity among countries in the landscape of adopting industrial robots. The top 5 most automated countries in the world lead the way up - South Korea, Singapore, Japan, Germany, and Sweden – far ahead of other industrialised countries (IFR, 2021). Even within Europe, the rate of adoption varies considerably. While the most automated country Germany is ranked 4th worldwide with 371 units per 10,000 employees, Spain, the Netherlands and France use 203, 209 and 194 units, well above the world average of 126 units. The UK by contrast is the only G7 country with a robot density below the world average. Manufacturing economies are expected to use more industrial robots than service economies. But there should be more explanations for the unequal adoption than just the economic structure. For example, the UK and France have similar weights of services in the economy, but France has adopted much more.

Therefore, we are witnessing a decline in GVC expansion and productivity, while there is immense growth in the adoption of industrial robots. Although a number of studies have focused on the relationship between these three phenomena, however, what remains unclear is the directionality of the relationship between productivity, globalisation and the adoption of robots. Automation increases productivity, while productive industries are more equipped to adopt automation, given they usually enjoy economies of scale, accumulated capital and skills and superior management ability. The degree of integration with the GVCs drives the adoption of automation because producers can upgrade their technology, as they have the incentive to stay productive and competitive. On the other hand, embedding into global value chains with a certain value proposition may lead to rigidity in moving up the value chains and impact productivity. Also, the degree of integration into GVCs can enhance productivity through the use of superior intermediate inputs in production, while productivity is a driver of GVC integration given that only productive countries can participate in trade. The upshot of all these theories and evidence is that the relationships between robots, productivity and global value chains are less than obvious. Yet, their entwined connections have deep implications for their industrial strategy and growth trajectory. Therefore, careful investigation is needed.

This study investigates this entwined relationship between these three observed patterns. Why do some countries adopt robots more than others? Does integration in GVCs and productivity affect robot adoption patterns? How does the rate of adoption affect their participation in the global value chains and productivity? How does productivity affect integration into GVCs, and what effect does this integration have on productivity? Needless to say, there is a large number of factors that drive productivity, integration into GVCs and the decisions to automate, which we cannot capture in full. Rather we aim, from a global value chains perspective, to provide novel insights on the evolutionary dynamics of technology adoption, productivity and integration into the global value chains.

We analyse the causes behind the observed patterns in robot adoption, productivity and GVC integration by considering a two-way causal relationship between GVCs and productivity, productivity and robot adoption, and robot adoption and GVCs. To achieve this, we utilise a Panel Vector Autoregressive (PVAR) model which accounts for both the dynamic behaviour and cross-dependence of these three phenomena specified as endogenous in the system of equations. Using this method addresses the endogeneity that may bias the impact of these factors on the other if we were looking at a unidirectional relationship. While most studies consider endogeneity when modelling the relationship between GVCs and productivity, productivity and robot adoption, or robot adoption and GVCs (Acemoglu and Restrepo, 2020; Graetz and Michaels, 2018; Stapleton and Webb, 2020), they do not analyse the interactive effects between these factors, and this is the main contribution of this paper.

This study uses panel data at the industry level for 20 OECD countries covering the period of 1995 - 2016. The results from our estimation are varied. First, we find a positive effect of productivity on both forward and backward linkages in GVCs. However, we fail to find a significant effect of GVCs, measured as both backward and forward linkages, on productivity. This shows some evidence for the selection argument in international trade where productivity is a prerequisite for entry into global markets (Melitz, 2003; Roper et al., 2006). Therefore, productive industries are more likely to participate in GVCs. Secondly, we find a positive effect of productivity on robot adoption, but we fail to find an effect of robot adoption on productivity. This might have to do with the absorptive capacity of the industries, where only productive industries can successfully integrate industrial robots into their production process (Koch et al., 2021). Lastly, the results show a positive effect of robot adoption on both forward and backward linkages, while we only find a positive effect of backward linkages on robot adoption and no evidence for the effect of forward linkages on robot adoption. We attribute this finding to the robot adoption improving the precision and quality of production, and making production more cost effective, therefore enabling these industries participate in GVCs. The results validate our initiative of using a PVAR estimation and investigating the interrelationships between these three phenomena as estimating a unidirectional relationship would omit the two-way relationship between these factors and would produce biased estimates.

The rest of this study is as follows. Section 2 looks at the review of the literature and formulates the hypotheses. Section 3 presents the data and methodology. Section 4 presents the findings, section 5 contains the robustness checks for the findings while section 6 presents the discussion and conclusion.

2.2 LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.2.1 Theoretical Framework

The theoretical framework underpinning this study is from the endogenous growth literature. These theories have typically considered the relationship between new technology and productivity (Romer, 1990) and have been extended to accommodate other factors such as international trade (Rivera-Batiz and Romer, 1991), human capital (Romer, 1990) and wage inequality (Lloyd-Ellis, 1999). Endogenous growth theories seek to establish a relationship between growth, factors affecting technology, and human and physical capital. One of its arguments is that investment in physical capital increases productivity, which leads to sustained growth for countries. Another argument made by the endogenous growth theories is that an increase in the quality of machines or an increase in the variety of inputs will also yield productivity gains which would lead to economic growth (Grossman and Helpman, 1991; Romer, 1990). Also, as opposed to neoclassical theories that assume that technological change is exogenous, endogenous growth theories attempt to explain the factors that drive technological change, be it profit maximising behaviour of firms (Romer, 1990), increase in human capital (Lucas Jr, 1988; Nelson and Phelps, 1966) or international trade (Grossman and Helpman, 1991).

These theoretical considerations provide an overall framework in which we conceptualise the two-way relationships between productivity, adoption of robots and integration of global value chains in this study. The adoption of industrial robots can be seen as an increase in the quality of machines, while through integration into GVCs which is a form of international trade, industries have access to a wider variety and higher quality of inputs. We consider all three factors i.e. robot adoption, productivity and integration into GVCs as endogenous factors that are interrelated and have interactive effects on one another. Although the endogenous growth theory does not encompass all aspects of our study, it provides a good theoretical foundation to motivate this study.

2.2.2 Productivity and Global Value Chains

International trade and productivity are interconnected. Theoretically, differences in labour productivity between countries were the main determinant of international trade. Countries produced and sold goods they had a comparative advantage in. In turn, trade affects productivity through multiple channels: international technology spillovers (Coe and Helpman, 1995; Keller, 2002), GDP growth (Frankel and Romer, 1999; Lewer and Berg, 2003), learning from international trade (Grossman and Helpman, 1991), market size effect (Aghion and Howitt, 2008) and the competition effect (Bloom et al., 2016).

Empirically, the evidence of productivity selection effect to trade is strong and consistent, while a large body of literature is more mixed on how trade affects productivity. While Dowrick and Golley (2004) find a positive relationship between trade openness and productivity, Abeliansky and Prettner (2017) find no effect between trade openness and productivity. The varied findings have been attributed to the possibility of the presence of reverse causality between productivity and trade. It has always been a concern to conclude that trade leads to productivity, while it could well be that highly productive industries or countries can participate in international trade due to comparative advantage.

To make the matter more complicated, fast globalisation in the last thirty years has altered the traditional concept of international trade from a final good crossing from one country to another, to trading intermediate goods crossing several national borders, adding value at each stage, before being sold as final goods (De Backer and Yamano, 2011; Del Prete et al., 2018). The fragmentation of production processes known as the Global Value Chains (GVC) implies the uneven distribution of value adding along the chains, and so are the gains from trading. With about 70% of today's international trade involving GVCs, measures such as trade openness, and gross values of exports and imports are insufficient in measuring the true nature of trade. A country or industry with high gross exports might have contributed very little in terms of value added to its gross exports (Koopman et al., 2014; Timmer et al., 2019). Gross exports can consist of domestic value added in exports and foreign value added in exports, reflecting where value is created in GVCs. Hence, trade in value added is what we will focus on in this study, instead of trade openness and values.

Countries can integrate into GVCs by using intermediate inputs sourced from abroad in producing goods for export (backward linkages) or supplying intermediate goods used by other industries to produce goods for export (forward linkages), with most countries having both forward and backward linkages (Kummritz, 2016). Forward and backward linkages bring opportunities to improve productivity using channels of technology spillovers, learning externalities and diversity in input varieties (Constantinescu et al., 2019; Kummritz, 2016; Pahl and Timmer, 2020). Through backward linkages, industries can import and use inputs embodying superior technology while through forward linkages, industries can acquire information about technology and management know-how from their export partners (Urata and Baek, 2019).

Learning externalities occur when industries access information and technology through interaction with foreign suppliers and buyers when participating in the GVCs. Gereffi (1999) argues that participating in GVCs is a necessary step for industrial upgrading as it puts firms and economies on potentially dynamic learning curves. With backward linkages, imports can affect technology transfer as quality imported goods might embody foreign technology (Keller, 2002). Not all imported inputs are more technologically advanced and more productive than domestic ones, but one can reasonably assume that if they are imported, they have some type of advantage over domestic inputs (Grossman and

Helpman, 1991). Empirically, studies have found evidence of a positive relationship between GVCs and productivity. Using patents as a measure of innovation, Piermartini and Rubínová (2021) find that knowledge spillovers occur when a country is fully integrated into the GVCs through forward and backward linkages. In addition, they find that GVC integration not only encourages innovation in countries, but also increases the flow of foreign R&D absorbed by these economies, further increasing productivity. However, Kummritz (2016) fails to find any evidence for the positive impact of backward linkages on productivity. Using both forward and backward linkages, he only finds that a 1% increase in forward linkages increases labour productivity by 0.33%. This leads to his conclusion that forward linkages are more important for labour productivity gains compared to backward linkages.

Although not directly investigated in this study, offshoring also affects the productivity of firms and enables them successfully to participate in GVCs. Offshoring has become a prevalent strategy for firms looking to remain competitive in an increasingly globalised economy. One of the arguments in favor of offshoring is that it enables firms to access cheaper inputs, which can lead to cost savings and increased efficiency. Amiti and Wei (2005) found that firms that offshored intermediate inputs experienced productivity gains due to lower input costs. Similarly, a study by Hijzen and Swaim (2010) found that offshoring can lead to productivity gains in the manufacturing sector. However, the impact of offshoring on productivity can be dependent on several factors such as industry type, technological capacity and absorptive capacity. In addition to this, the imports also have a considerable impact on productivity especially the importation of intermediate goods. Goldberg et al. (2010) find that firms that imported intermediates experienced productivity gains due to the higher quality of imported inputs. This is similar to the findings of Blalock and Veloso (2007) who find that importing intermediates can facilitate supply chain learning, leading to productivity improvements. Also, Arnold and Javorcik (2009) find that the positive impact of importing intermediates on productivity was greater for firms in industries that were more technologically advanced while Amiti and Konings (2007) argue that although there is a positive effect of importing intermediates on productivity, this effect is only evident in the short run as reduced incentives for firms to innovate can cause this effect to become negative in the long run.

Although several studies have found evidence for a positive impact of GVC integration and productivity, the issue of the possibility of reverse causality still exists as more productive industries are more likely to increase their GVC participation. In examining the factors that determine GVC integration, Taglioni and Winkler (2016) identified labour productivity as a crucial factor for participation in GVCs as a measure of competitiveness. They argue that there is a two-way relationship between labour productivity and participation in GVCs, with labour productivity facilitating integration in GVCs and at the same time, integration in GVCs enhancing labour productivity. This is similar to the argument of Melitz (2003) who shows that more productive firms self-select into the export market and a reallocation of resources causes the least productive firms to exit, thereby increasing the average productivity. So, although economic theory argues for a direct relationship between trade and productivity, there is still an empirical debate on the true nature of this relationship. Specifically, empirical studies argue that the presence of reverse causality may introduce bias in the results and they try to mitigate this by using instruments (Badinger and Breuss, 2008; Frankel and Romer, 1999; Lewer and Berg, 2003). All taken together, we hypothesise an interrelationship or two-way relationship between productivity and GVCs. So, we lean on the theoretical predictions of the positive relationship between GVCs and productivity, while also allowing for the existence of the reverse causality where productivity determines participation in GVCs. Based on that, we propose the following hypotheses.

H1ai: Integration into GVCs through backward linkages is positively associated with productivity.

H1aii: Integration into GVCs through forward linkages is positively associated with productivity.

H1bi: Productivity is positively associated with integration into GVCs through backward linkages.

H1bii: Productivity is positively associated with integration into GVCs through forward linkages.

2.2.3 Productivity and Robot Adoption

With the rising rates of robot adoption across the world, there has been an increasing interest in what effect it could have on productivity. Theoretically, robot adoption may reduce the cost of production and labour input, thereby improving labour productivity. This effect is aptly named the "productivity effect" by Acemoglu and Restrepo (2020) who argue that the adoption of industrial robots will lead to a positive price-productivity and scale-productivity effect which occurs through the reduction of the cost of production and expansion in total output, respectively.

The empirical support for the productive effect of robots is strong but not uniform. Graetz and Michaels (2018) find that increased adoption of robots has a positive effect on both labour productivity and TFP, Dauth et al. (2017) find that robots raise labour productivity and similar to Stapleton and Webb (2020), thus providing evidence of the existence of this productivity effect. Jäger et al. (2015) contend that intensive users of industrial robots are more productive than non-users of industrial robots due to the competitive economies of scale, efficient production and high process qualities that emanate from using robots. Using a multi-country dataset, they also find a positive and significant relationship between industrial robot adoption and productivity measured as TFP and labour productivity.

Further, Arntz et al. (2016) argue that industrial robots are complementary to a skilled workforce, identifying another channel through which the adoption of industrial robots can improve productivity. Studies have shown that industrial robots are most likely to replace routine tasks and they argue that by replacing routine workers, robots free up skilled workers and enable them to focus their efforts on higher-value tasks, therefore, boosting productivity. In addition to country and sectoral studies, firm level studies also show that the incorporation of robots is a clear mechanism for improving firm productivity (Acemoglu et al., 2020; Dinlersoz and Wolf, 2018; Dixon et al., 2020; Stapleton and Webb, 2020).

Not all studies confirm the positive effect of robots on productive. Chiacchio et al. (2018) fail to find evidence for the productivity effect of robot adoption in EU countries after controlling for the exposure to ICT capital. A potential limitation of these studies is the assumption of a relationship between the adoption of robots and productivity. In fact, most of these studies that focused on the impact of robot adoption on productivity acknowledge that there could be the presence of reverse causality, where more productive industries are adopting industrial robots. Therefore, inadequately addressing the reverse causality could lead to an overestimation of the productive effect of robot adoption.

The existing evidence suggests that the landscape of robot adoption is uneven and this may lead to divergence in productivity outcomes. Kromann et al. (2020) show that the uneven adoption of industrial robots across countries and industries could be due to the productivity differences that exist between them. Consequently, higher exposure to robots rises significantly productivity and markups in those firms with high starting levels, while having a non-relevant impact on firms with initially low productivity and markups in the same industry. This leads to an increasing productivity divergence reinforcing the superstar phenomenon (Stiebale et al., 2020). Similarly, Koch et al. (2021) argue that more productive firms are more likely to adopt industrial robots and the higher the exposure to robots in an industry, the higher the industry's productivity will be due to the reallocation effect. As more productive firms increase their market shares due to reduced marginal costs from robot adoption, the productivity cut-off is raised, causing the least productive firms to exit the market. Therefore, aggregate industry productivity increases. Empirically, they find that ex-ante, more productive firms adopt robots and that the use of robots impacts the future productivity of these firms. Also, they find that productivity gains are more evident for exporting firms than for non-exporting firms.

There is yet a synthesis of what pre-conditions are required for robot adoption. Arguably, adopting industrial robots comes with an initial cost and requires an absorptive capacity to enable the integration of these robots into production processes. However, not all industries possess the absorptive capacity required to benefit from the use of robots. In this study, we focus on the interrelationship between robot adoption and productivity, therefore allowing for a two-way relationship to exist between them. In line with previous literature, we argue that productivity is a driver of robot adoption and also, robot adoption improves the productivity of the industries. Therefore, we test the following hypotheses.

H2a: Productivity is positively associated with robot adoption.

H2b: Robot adoption is positively associated with productivity.

2.2.4 Robot Adoption and Global Value Chains

Technologies and global value chains are also interconnected. The international economic literature has long theorised the impact of trade openness on technology adoption. Trade opens up an industry to both domestic and foreign competition. Although there is no consensus on the effect of competition on innovation, many studies find that stronger import competition leads to innovation (Aghion, Bloom, et al., 2005; Bloom et al., 2016).

One of the channels of this effect that the new growth theory describes is direct and indirect technology transfer from trading partners. This is also known as the push effect of trade on technology adoption. Grossman and Helpman (1991) argue that trade provides access for a country to the advances of technological knowledge of its trade partners and countries are more likely to adopt the technology they are exposed to. Further, Parente and Prescott (1994) highlight that trade openness helps to reduce the barriers to technology adoption, which leads to a positive relationship between trade openness and technology adoption. Empirically, Keller (2002) finds that technology is transferred between countries through trade in intermediates that embody new technologies created in other countries. Studies focused mainly on R&D spillovers have found evidence supporting this hypothesis (Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997).

Trade openness also exerts pressure on domestic firms to improve their productivity, which can be achieved by adopting more productive technologies. This is known as the pull effect of trade on technology adoption. Empirical evidence shows that domestic producers adopt technologies to sustain their international competitiveness following trade liberalisation policies (Bayar et al., 2001; Bustos, 2011). In addition, Caselli and Coleman (2001) find that openness to manufacturing trade by countries increased their adoption of computers. Specifically, they highlighted the importance of trade partners to technology adoption as they find that manufacturing imports and exports from and to OECD countries are a significant predictor of computer adoption. Thus, both the origin and nature of trade flows matter for the magnitude of computer adoption. Comin and Hobijn (2004) who use historical data spanning 200 years to examine the cross-country adoption of 25 different technologies also support this finding. They find that openness to trade accounted for a 12% variation in the adoption of the different technologies across countries. Interestingly, Abeliansky and Prettner (2017) fail to find a significant relationship between trade openness and the adoption of automation technologies using a sample of 60 countries. This implies that the existing patterns the literature has found so far on technology adoptions may not apply to automation.

Further, trade value and volume are not the same as the value added from trade. The different levels of value added and the nature of trade embody varied learning opportunities and different levels of competitive pressure. A country or industry with high gross exports might have contributed very little in terms of value added to its gross exports (Koopman et al., 2014; Timmer et al., 2019). Hence, there are strong rationales to presume that the integration with the global value chains and the value added along these chains may have varied impacts on technology adoption.

So far though, the impact of integration in GVCs on robot adoption has not been explored. We argue that channels through which integrating into GVCs impacts technology adoption resemble that of trade opening but with more nuances. First, the learning effect of integrating into GVCs can occur through interaction with foreign suppliers and buyers, which allows industries to access information and technology. The most obvious channel is from suppliers from backward linkages through imports. Gereffi and Tam (1998) explain that participating in GVCs provides the opportunity to import technology and learn from it, making participating in GVCs an important aspect of technology adoption. This is particularly the case when countries import inputs that are more technologically advanced, specialise in the production of certain goods or even learn by imitation.

With backward linkages, imports can affect technology transfer as quality imported goods might embody foreign technology (Keller, 2002). Although not all imported inputs are more technologically advanced and more productive than domestic ones, one can reasonably assume that if they are imported, they have some type of advantage over domestic inputs (Grossman and Helpman, 1991). As industries successfully integrate these inputs into their production, they learn; so do they learn by imitating the production of these goods and improving their technological capacity. Moreover, Apergis et al. (2008) find that import flows are important for knowledge transmission as well as improving the chances of invention.

Second, participation in GVCs can affect technology adoption due to the competition effect. Taglioni and Winkler (2016) posit that in order to expand and strengthen their GVC participation, countries have to promote technology upgrading. This is because globalisation brings pressure on domestic industries to innovate and improve their competitive position. A country with more rapid technological progress is well placed to capture an ever-growing share of the world market for innovative products (Grossman and Helpman, 1991). With forward linkages, industries need to offer competitive prices to maintain their position in GVCs, and this might force them to reduce the cost of production through automation. In order to capture more value added in the value chain or maintain their positions in the value chain, these industries must continuously upgrade to withstand the competition and achieve efficiency gains. In line with this, Pahl and Timmer (2020) argue that producing for global markets demands higher levels of precision and standards of quality which might necessitate the adoption of automation technology such as industrial robots. Adopting industrial robots may make it more cost-effective for domestic production while also satisfying consumer demand by improving the quality of goods. Expanding exports to more export markets through forward linkages may encourage the adoption of productivity enhancing technologies or enable firms/industries to bear the cost of investing in technology (Cilekoglu et al., 2021).

In addition to GVC participation encouraging technology adoption, we expect a reverse relationship that the adoption of industrial robots affects the degree by which industries integrate into GVCs. The new technological developments, with the integration of artificial intelligence and the rapid diffusion of industrial robots adoption, have led to important changes in the world distribution of economic activities and the organisation of global value chains (GVCs) (Atkinson, 2019). Many studies have shown that advanced technologies such as ICT and robotics are important drivers of GVC integration (Antràs, 2020; Fort, 2017; Hummels et al., 1998; Rodrik, 2018). In an integrated global economy, the implementation of new technologies can have important implications for relative production costs, international specialization and trade (Eaton and Kortum, 2012). Specifically, increased use of industrial robots can alter factor endowments and factor costs in countries, and also enhance the flexibility of the production process (De Backer et al., 2018; De Backer and DeStefano, 2021). The use of industrial robots can improve the productivity of these industries, therefore enabling them to successfully integrate into GVCs.

Automation affects backwardly connected firms in the global value chains through exporting. Automation could play a prominent role in promoting firms' competitiveness in the international markets and their GVC participation through exports (Zeng, 2017). Stapleton and Webb (2020) find that robot adoption has a positive effect on the extensive margins of trade and the value of intermediate imports. Robot adoption not only helps Spanish firms to start exporting and moves their specialisation towards intermediate products, but also favours export survival and export sales of exporting firms (Alguacil et al., 2021). Cilekoglu et al. (2021) find that robot adoption increased the backward linkages of Spanish manufacturers.

Automation could also impact forwardly connected firms and industries to the global value chains through imports. Artuc et al. (2019) use a task-based Ricardian two-stage production and trade model to examine the implications of robotization for North-South trade. Although robots can reshape comparative advantages and substitute imports from less developed countries, the efficiency gains promoted by robots foster an increase both in North-South exports and imports. Empirically, in fact, they obtain a significant positive effect of the use of robots on imports from less developed economies and an even greater impact on exports to these economies. Similarly, De Backer et al. (2018) find a positive effect of robot adoption on forward linkages for developed countries, but no evidence for emerging economies. This could be attributed to the fact that emerging economies only recently started investing heavily in robots or that the effects of robot adoption might take some time to materialise (De Backer and DeStefano, 2021). Using firm level data, Stapleton and Webb (2020) show that the use of robots for Spanish firms had a positive impact on their imports from less developed countries and on the number of affiliates located there.

In addition, robot adoption has been linked to reshoring. Reshoring refers to the process of bringing back manufacturing jobs and operations to the domestic market from foreign countries. This trend gained momentum after the 2008 global financial crisis, which highlighted the risks and challenges associated with offshoring. Reshoring not only benefits the local economy but also provides companies with greater control over their supply chain, quality assurance, and intellectual property rights. In recent years, the adoption of robots and automation has been considered a key enabler of reshoring, as it can increase productivity, reduce costs, and improve quality control. Several studies have explored the relationship between reshoring and robot adoption. According to a report by the Reshoring Initiative, the total number of reshored jobs in the US from 2010 to 2020 was around 1 million, and the use of automation and robotics was a significant factor in this trend (De Backer et al., 2016). Similarly, a study by the Boston Consulting Group found that the adoption of advanced robotics could result in a 20-30% cost advantage for US manufacturers compared to their Asian counterparts (Boston Consulting Group, 2015).

However, other studies have highlighted the challenges and limitations of robot adoption for reshoring. Frey and Osborne (2017) found that the use of robots in the US would not necessarily lead to significant job creation, as the automation of manufacturing processes could also lead to job displacement. Similarly, Manova and Yu (2016) found that the cost savings from automation were often offset by the costs of reorganizing production processes and retraining workers. In conclusion, the relationship between reshoring and robot adoption is complex and multifaceted, and this can have implications for the relationship between robot adoption and integration into GVCs. Reshoring can affect the distribution of value within GVCs, as companies may seek to capture a greater share of value by bringing manufacturing operations back to the domestic market. This can have implications for the role of robots in GVCs, as companies may need to reconfigure their production processes and supply chains to take advantage of new opportunities. While robot adoption can help companies improve their competitiveness and participate more fully in GVCs, the impact of reshoring on the distribution of value within GVCs and the need for companies to reconfigure their production processes and supply chains requires careful consideration. However, the empirical analysis in this chapter is unable to identify reshoring and explore this mechanism.

Given the documented evidence for both integration in GVCs affecting robot adoption, and robot adoption affecting integration into GVCs, this study allows for a two-way relationship between both of them. We argue that robot adoption affects integration in GVCs while integration into GVCs also affects robot adoption. This gives rise to the following hypotheses.

H3ai: Integration into GVCs through backward linkages is positively associated with robot adoption.

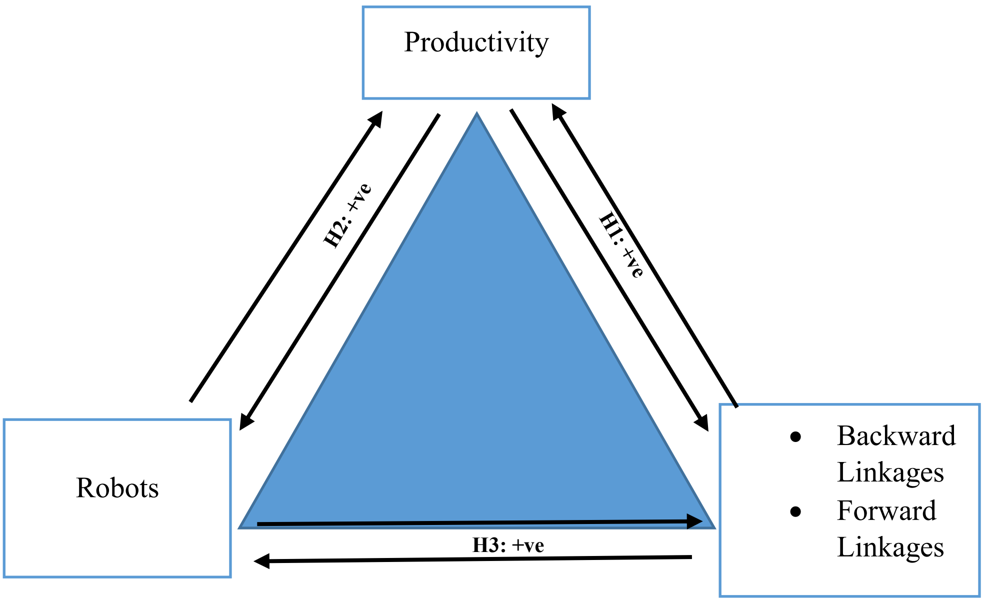
H3aii: Integration into GVCs through forward linkages is positively associated with robot adoption.

H3bi: Robot adoption is positively associated with integration into GVCs through backward linkages.

H3bii: Robot adoption is positively associated with integration into GVCs through forward linkages.

In conclusion, there are several mechanisms through which robot adoption, GVCs and productivity affect one another. These mechanisms include increased efficiency, technology and knowledge transfer, and adaptability to changing market conditions. Taken together, we postulate a triangular relationship between the adoption of robots, productivity and global value chains, as illustrated below in Figure 2.1. The following sections will construct empirical tests to seek evidence.

Figure 2.1 Theoretical Model: Robot Adoption, Productivity and GVCs



2.2.5 Conceptual Framework

This study focuses on the interrelationship between the adoption of industrial robots, integration into GVCs and productivity. In this section, we outline the definition of these three key variables as used in this study. According to the IFR, an industrial robot is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications. In the GVC literature, backward linkages refer to the use of imported inputs in manufacturing goods for export. Foreign value added (FVA) is a good measure of the backward linkages of a country's GVC participation (Banga, 2016; Hummels et al., 1998; Tijaja, 2017). In this study, we use the *Foreign value added share of gross exports* (FVASH) to capture backward linkages. This is defined as the foreign value added in the gross exports of industry *i* in country *c* as a percentage of total gross exports of the same industry from the same country (OECD, 2016).

Forward linkages refer to the supply of intermediates that are used in another country's exports. They show how domestic industries export value added both through direct final exports and via indirect exports of intermediates through other countries to foreign final consumers. First proposed by Hummels et al. (1998) and computed by Daudin et al. (2011), forward linkages reflect how industries are connected to consumers in other countries even where no direct trade relationship exists. Banga (2016) captures it using domestic value added in exports of intermediate goods while Tijaja (2017) captures it using the domestic value added embodied in foreign final demand. In this study, *domestic value added share in gross exports of intermediate products* (INTDVASH) is used to measure forward linkages. It is measured as the domestic value added in the gross exports of intermediate products by industry *i* in country *c,* as a percentage of the total gross exports of the same industry in the same country (OECD, 2016). Lastly, labour productivity is traditionally measured as output per worker or as output per hours worked. In this study, we measured labour productivity as output per worker.

2.3 DATA AND METHODOLOGY

2.3.1 Data

The data for this study is obtained from several sources. The data on the stock of industrial robots is obtained from the International Federation of Robotics (IFR) database. The IFR provides data on the demand and stock of robots by industry, country and year from 1993, with industry classification for some countries starting at varying dates. This study focuses on a three-dimensional panel of country, industry and year; for 20 OECD countries and covers the time period from 1995 to 2016; a total time period of 21 years.[1] Aside from the manufacturing industry, the IFR has data for the stock of industrial robots in six broad industries roughly at the two-digit level, which are mining, construction, education, forestry and fishing, agriculture, utilities, research and development, and other non-manufacturing industries (e.g. services). For the manufacturing industry, the data available covers a more detailed set of 13 industries, roughly at the three-digit level.[2] Initially, the sample consists of about 26,000 observations across the specified time period. About 5% of the robots in our sample are not classified into one of these industries and in line with Acemoglu and Restrepo (2020), the unclassified robots are allocated to industries in the same proportions, while the years with missing robot stock data are

[1] The list of countries is presented in Table A1 of the appendix. Some countries like the USA and Canada are excluded from the sample as the detailed industry classification of robots for these countries do not start from 1993. Countries like China and South Korea who have high robot adoption numbers are excluded due to not being OECD countries.

[2] These industries are food and beverages, textiles, wood and furniture, paper, plastic and chemicals, glass and ceramics, basic metals, metal products, metal machinery, electronics, automotive, other vehicles, and other manufacturing industries.

estimated by deflating the earliest available data of the robot stock of the industry by the total growth rate of robot stock in the country.[3]

Data for GVCs participation through forward and backward linkages is obtained from the OECD Trade in Value Added (TiVA) database. The data covers roughly 20 years i.e. 1995 to 2016, for the selected countries in the sample. Also, data for industry characteristics are gotten from EUKLEMS. These variables include labour productivity, R&D stock, wages and employment. We use labour productivity as a measure of productivity due to data limitations in constructing country level TFP for each of the countries in our sample. The monetary values from EUKLEMS are reported in the home currency, and this is converted to USD using the exchange rate from the Penn World Table. Furthermore, country level data on the average years of schooling are gotten from the Penn World Tables. Combining the data from the IFR, EUKLEMS and TiVA database leads to data attrition as the data is not available for some of the detailed industries identified in the IFR database. After the combination, we are left with about 3,500 observations in the sample.

[3] Excluding these unclassified robots from the sample does not alter the findings.

Table 2.1: Descriptive Statistics

Variables	Variable Definition	Mean	Std. dev.	Skewness	Kurtosis	Min	Max
Endogenous Variables:							
* Robots	The existing stock of robots	0.235	0.444	2.24	9.71	-2.0	2.0
* Forward Linkages	Domestic value added in intermediate exports	-0.03	2.44	0.238	7.84	-20	20
* Backward Linkages	Foreign value added in exports	0.14	2.51	-3.99	7.84	-17.43	16.2
* Productivity	Output per employee	0.006	0.027	9.37	226.10	-0.15	0.699
Exogenous Variables:							
Employment	Number of employees	335.95	808.98	5.95	47.65	1	8,317.6
Education	Average years of schooling	11.54	1.55	2.411	-1.05	6.63	13.58
* Wage	Wages paid to employees	0.02	0.089	0.074	56.04	-1.339	1.595
* R&D	R&D Expenditure	0.069	0.41	1.677	34.264	-3.025	5.94

Variables (*) are in first difference with asinh transformations while the other variables are in levels. The first difference is taken to achieve stationarity in these variables while variables in levels are already stationary and therefore do not need to be first-differenced. Variables have also been winsorised at the 99% and 1% threshold.

Table 2.2 Correlation Matrix

	Robots	Forward Linkages	Backward Linkages	R&D	Productivity	Employment	Wage	Education
Robots	1							
Forward Linkages	-0.014	1						
Backward Linkages	0.010	-0.598	1					
R&D	0.040	0.014	-0.034	1				
Productivity	0.039	-0.152	0.239	0.022	1			
Employment	-0.039	-0.016	0.011	0.002	-0.002	1		
Wage	0.056	0.068	-0.140	0.021	-0.120	0.009	1	
Education	-0.074	0.045	-0.032	-0.023	0.028	0.024	0.075	1

2.3.2 Methodology

The Panel Vector Autoregressive (PVAR) model (Gilchrist and Himmelberg, 1995; Holtz-Eakin et al., 1988) has been designed to account both for dynamic behaviour and cross-dependence of the variables specified as endogenous in its system of equations. Consequently, it is a particularly suitable tool to capture the dynamics of the interrelationship between industrial robots, GVCs and productivity. Therefore, the remainder of this section focuses on discussing the PVAR model and how it is utilised in this study.

Schematically, and following the notation of Abrigo and Love (2016) and Love and Zicchino (2006), a k-variate PVAR model of order p with panel-specific fixed effects can be described by the following system of equations:

$$Y_{it} = \sum_{k=1}^{p} Y_{it-k} A_k + X_{it} B + u_i + e_{it} \tag{1.1}$$

where $i \in \{1, 2, \ldots, N\}$, $t \in \{1,2, \ldots, Ti\}$, Y_{it} is a (1xk) vector of dependent variables; X_{it} is a (1xl) vector of exogenous covariates; and u_i and e_{it} are respectively (1xk) vectors of dependent variable-specific fixed-effects and idiosyncratic errors which are assumed to be uncorrelated over time and distributed around zero with constant variance-covariance matrix. The (kxk) A matrices and the (lxk) matrix B contain the parameters to be estimated. In our case, we make use of the trivariate variant (k=3) with growth levels of industrial robots, GVC variables and productivity as the endogenous variables.[4] Each equation contains (a) the lagged values of the corresponding endogenous variable, (b) the lagged values of the remaining two endogenous variables and (c) a set of control variables exogenous to the system.

The estimation of such a PVAR model is not straightforward. The standard mean-differencing methods to control for individual fixed effects induce bias in the typical OLS estimation procedure because of the presence of lags of the dependent variables as regressors, which means that the fixed effects are inevitably correlated with the regressors (Nickell, 1981). To address this, we adopt the solution of Abrigo and Love (2015), the first step is to apply the Helmert transformation and the second step is to estimate the parameters simultaneously with the General Method of Moments (GMM). The Helmert transformation is effectively about removing the mean of all future observations available for each pair of i and t and it is used because it preserves the orthogonality between the variables and their lags allowing the use of the lags as instruments in a system GMM estimation (Arellano and Bover, 1995).

[4] It is worth noting here that apart from winsorisation of the variables, due to the presence of some extreme value irregularities that they exhibited, due to the presence of the so-called 'true zeroes', we have also used the difference of the inverse hyperbolic sine transformation of the values instead of the natural log-differences to capture the growth rates following the suggestion of Hansen (1982).

A crucial aspect of fully specifying a PVAR model is the selection of the number of lags (*p* in the above model). Following the standard practice, we have selected this number by considering the moment and model selection criteria indicated by Andrews and Lu (2001). However, it is worth noting that we did so only for those specifications that satisfy Hansen's (1982) *J* statistic of over-identifying restrictions and eigenvalue stability conditions. These are reported in the Appendix, Table A2. Finally, it is worth noting that we also time-demean all series to control for time effects.

Once the estimation results are obtained, the next step is to derive our inference. A peculiarity of the PVAR framework stems from the fact that the model is not only dynamic but also the dynamics of each endogenous variable affect the dynamics of every other variable i.e. they are intertwined, making it very difficult to discern how the values of a variable evolve over time simply based on the coefficient estimates. To address this issue, the econometric literature has established that inference based on PVAR models should be drawn primarily upon the so-called impulse-response functions (IRFs).

The IRFs method to draw inference was initially introduced in signal processing. It facilitates inference of dynamic systems by determining the response over time of each of the endogenous variables to a one period exogenous impulse (shock), typically stemming from the stochastic term of each of the equations. This response is commonly graphed over time, providing a clear demonstration of how the values of the endogenous variables will be affected over time. In other words, the IRFs allow us to follow the evolution in the whole system of a one-period change of the innovation term or shock of each endogenous variable. By consequence, we can describe visually in a unified way not only the possible time-dependence (a form of inertia) that industrial robots, GVCs and productivity may exhibit but also their possible interdependence.

At this point, it is worth noting that the estimation of the model does not necessitate that errors across the endogenous variables will be contemporaneously uncorrelated. This is an important point when computing the IRFs because if they are correlated contemporaneously, then the shocks from each variable are linear combinations of those of all the endogenous variables and therefore we cannot attribute them exclusively to a specific variable. This is problematic because it becomes difficult to identify the response of the system to a shock in one specific variable. Consequently, inference becomes convoluted if at all possible.

Following the traditional econometric literature, we address this issue by applying the Cholesky decomposition method to obtain contemporaneously uncorrelated errors across the variables. In this way, we make sure that our inference will not be drawn upon composites of the innovation terms of the three variables. Instead, the shock of each endogenous variable is explicitly identified. The corresponding IRFs are denoted 'orthogonalized IRFs'.

Overall, and in anticipation of the empirical results that follow, the best-fit model for the region *i* at time period *t* proved to be given by:

$$\begin{pmatrix} Robots_{it} \\ GVCs_{it} \\ Productivity_{it} \end{pmatrix} = \begin{pmatrix} Robots_{it-1} \\ GVCs_{it-1} \\ Productivity_{it-1} \end{pmatrix} A_1 + \begin{pmatrix} Employment_{it} \\ Education_{it} \\ Wage_{it} \\ Innovation_{it} \end{pmatrix} B + u_i + e_{it} \quad (1.2)$$

where the vector of the dependent variables includes the standardised values of industrial robots, GVCs and productivity. Robots are measured as the growth in the stock of industrial robots, GVCs are measured using both the forward and backward linkages and productivity is measured as labour productivity i.e. output per employee. Also, as can be seen from this model, apart from the modelled dynamics of the endogenous variables and the included fixed effects (which should suffice to control for unobserved heterogeneity), we include a vector of control variables B_{it} to provide further robustness. For the controls, Employment is defined as the number of employees in the industry, Education is measured as the average years of schooling in the country, wage measures the industry wage expenditure and Innovation is measured as the R&D expenditure of the industry.

2.4 RESULTS

2.4.1 Global Value Chains and Productivity

In estimating the relationship between GVCs and industrial robots, we measure GVCs as backward and forward linkages consecutively. In figure 2.2, panel C2, we see a positive and significant effect of a shock in productivity on backward linkages in GVCs. Specifically, the results show that a one standard deviation impulse shock in productivity increases backward linkages by about 0.4% instantly and this effect declines to zero after about 2 years. Between the second and the third year, this effect becomes negative before slowly increasing and returning to a steady state around the fourth year. This result shows some evidence for *Hypothesis 1bi* as an increase in industry productivity increases the backward linkages of that industry. This is also in line with the argument that backward linkages are more assembly/low-level activities and so as the productivity of the industries increases, then they may start to move away from lower value activities, causing a temporary negative effect in the backward linkages. On the other hand, when examining the effect of an impulse shock in backward linkages on productivity as seen in figure 2, panel B3, the results show an initial negative effect which is reversed after about 2 years, and this is statistically significant. Specifically, a one standard deviation impulse shock in backward linkages first reduces productivity by about 0.15% and this persists for roughly 2 years. By the third year, the effect becomes positive with the one standard deviation impulse shock on backward linkages in the initial period leading to an increase in productivity of about 0.2%. By the 5th year, this effect declines to zero, thereby indicating a higher persistence on the effect of backward linkages on productivity. Therefore, we also find some evidence for *Hypothesis 1ai.* The lag in the positive effect of backward linkages on productivity could be due to the learning/adjustment period where industries have to introduce the imported inputs into their production process. After this learning period, industries then experience a positive impact on productivity.

Next, we measure GVCs using the industry's forward linkages. As can be seen in figure 2.3, panel B3, although an impulse change in forward linkages leads to an increase in productivity lasting about 3 years, this response is not statistically significant at any interval. Therefore, we fail to find support for *Hypothesis 1aii*. On the other hand, we find a negative but increasing effect of productivity on forward linkages as can be seen in figure 2.3, panel C2. However, this negative effect is reversed after one year and we then see a positive effect on productivity. The results show that an impulse shock to productivity immediately reduces forward linkages by 0.2% with this effect diminishing after one year. Between the second and third years, forward linkages become positive, peaking at 0.1% before returning to a steady state in the fourth year. Therefore, we find some evidence for *Hypothesis 1bii.* This lag in the positive effect of productivity on forward linkages could be due to the time needed to establish forward/selling linkages after the industry becomes productive enough to enter export markets (Kummritz, 2016).

2.4.2 Productivity and Industrial Robots

Next, we consider the relationship between productivity and the adoption of industrial robots. A potential issue of using labour productivity instead of TFP is that if automation displaces workers in an industry, labour productivity will automatically increase. However, by using the PVAR methodology which accounts for contemporaneous relationships between our endogenous variables, then we mitigate the issues that using labour productivity could introduce in the analysis. In figures 2.2&2.3, panels C1, we see a positive effect of productivity on the adoption of robots. Specifically, the results show that a one standard deviation impulse shock in productivity results in an increase in the adoption of industrial robots by about 0.5%, with this effect persisting for about 3 years. This shows evidence for *Hypothesis 2a* and can be attributed to the absorptive capacity of the industry. In order to be able to integrate industrial robots successfully into the production process, these industries might possess a high level of human capital or ICT capital, which speaks to their absorptive capacity (Koch et al., 2021). On the other hand, although the effect of a robot shock on productivity is negative, this is not significant as can be seen in figures 2.2&2.3, panels A3. So, we fail to find a significant effect of a robot shock on productivity, therefore not finding evidence for *Hypothesis 2b*. This could be due to the argument that the effect of the adoption of industrial robots is not immediate as it takes some time to materialise due to learning effects, necessary rearrangements of production or factor complementarities (De Backer et al., 2018). Also, Muendler (1986) identifies an implementation cost that comes with the adoption of foreign technologies as workers might need to be retrained in order to carry out adjustments to the production process, thereby leading to a reduction in productivity initially. This could also be attributed to the displacement effect as identified by Acemoglu and Restrepo, (2020) where the adoption of industrial robots replaces the workers previously performing these tasks thereby reducing labour productivity. Therefore, there might be a stronger displacement effect compared to the productivity effect, hence the negative effect of robot adoption on productivity.

Figure 2.2: Trivariate Impulse Response Function With Robots, Backward Linkages and Productivity

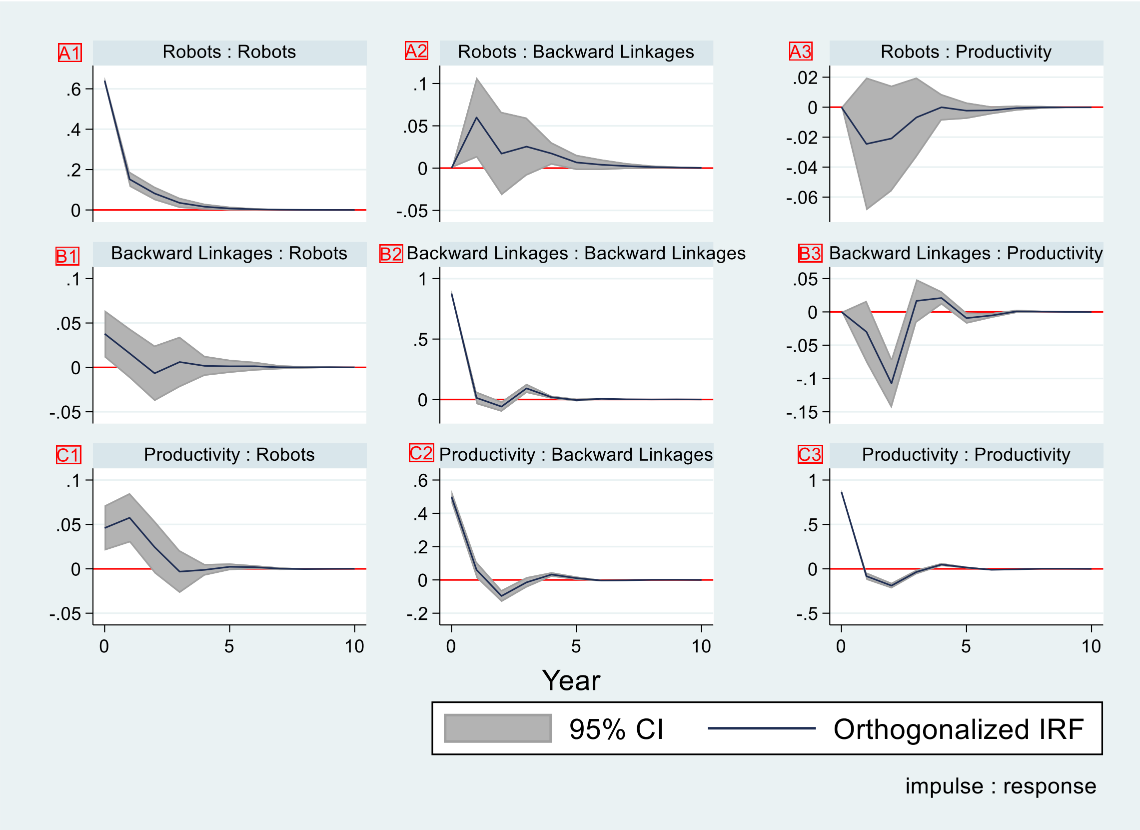
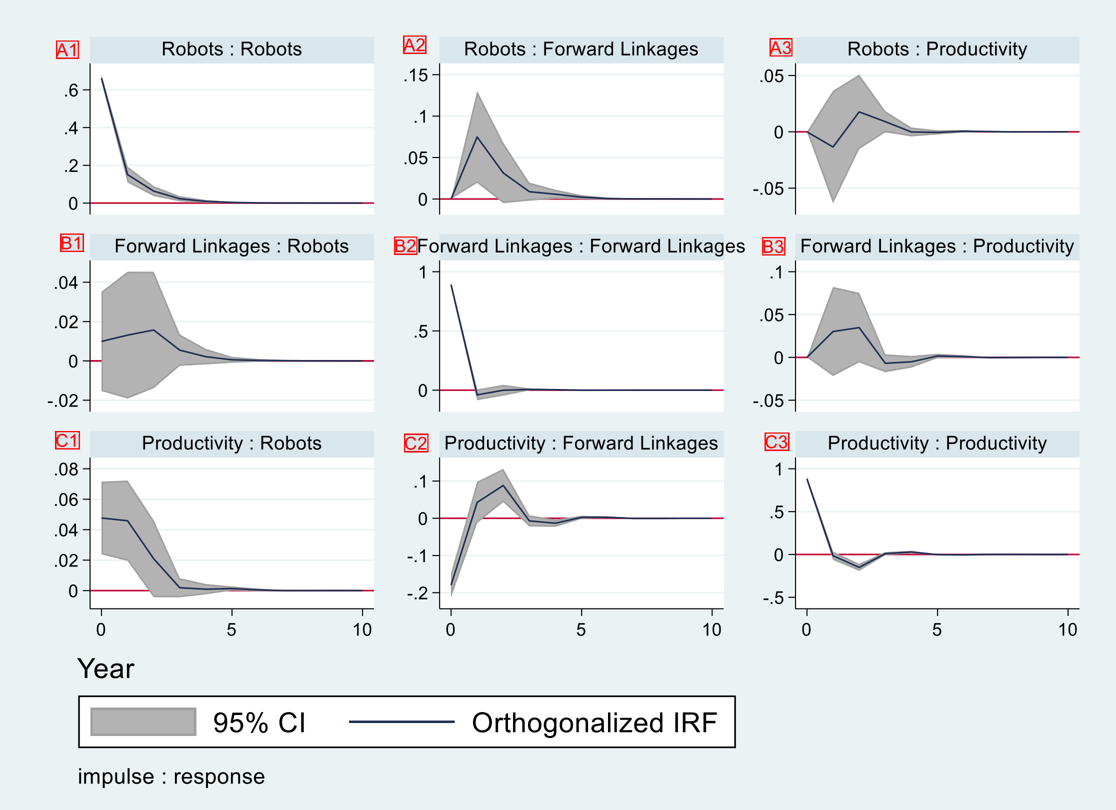


Figure 2.3: Trivariate Impulse Response Function With Robots, Forward Linkages and Productivity



2.4.3 Industrial Robots and Global Value Chains.

Lastly, we consider the relationship between robot adoption and integration into GVCs. We begin by looking at the effect of an impulse shock of backward linkages on industrial robots, and the result shows a positive but declining effect. Specifically in figure 2.2, panel B1, we see that a shock in backward linkages increases robot adoption by about 0.05%, however, this effect is not persistent as it diminishes after one year. This positive effect shows evidence for *Hypothesis 3ai* and can be attributed to backward linkages embodying more assembly tasks that would benefit from automation. Therefore, the more backward linkages an industry has, the more it might adopt industrial robots. Turning our focus to forward linkages in figure 2.3, panel B1, we fail to find a significant effect of a forward linkage shock on robot adoption. This could be due to forward linkages consisting of more high-value tasks that are not easily replaceable by industrial robots. Therefore, we fail to find evidence for *Hypothesis 3aii*. Furthermore, we look at the effect of an impulse shock of robot adoption on both backward and forward linkages. Starting with backward linkages in figure 2.2, panel A2, we see that a one standard deviation impulse shock in robot adoption has a marginally positive effect of about 0.05% on backward linkages, although this effect is not persistent i.e. the effect diminishes after a year. This result shows evidence for *Hypothesis 3bi*. Given that backward linkages incorporate more routine, assembly-type, adopting industrial robots can make the industry specialised in these tasks, thereby increasing their backward linkages (Kummritz, 2016). Lastly, we look at the effect of a shock in robot adoption on forward linkages in figure 2.3, panel A2. The results show a positive and significant effect of a one standard deviation increase in robot adoption on forward linkages. Specifically, a one standard deviation impulse shock to robot adoption leads to an increase of 0.05% in forward linkages, and this effect persists for roughly 3 years. This lends support to the competition effect highlighted in *Hypothesis 3bii* where the adoption of industrial robots improves quality, and reduces production cost, thereby enabling industries to withstand foreign competition.[5]

2.4.4 Exogenous Drivers

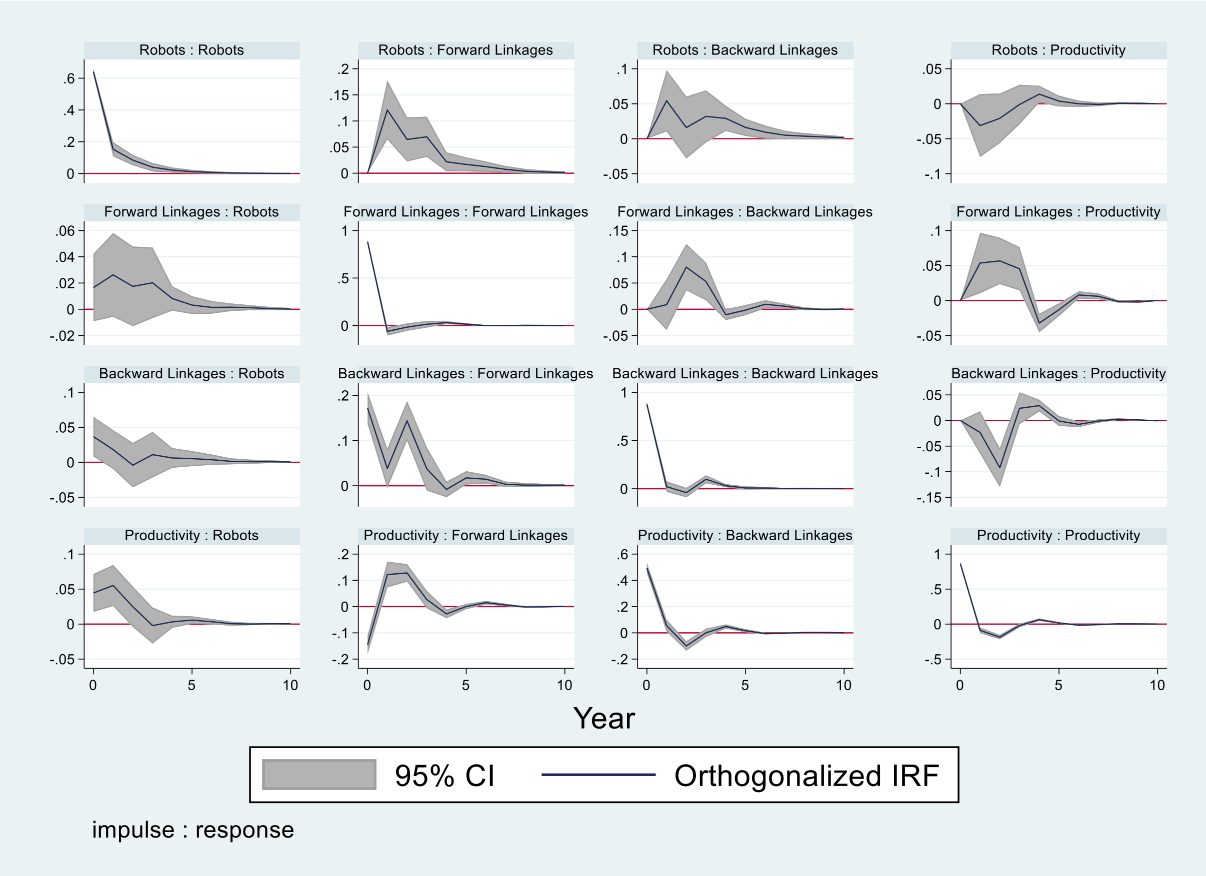
Focusing on the exogenous independent variables, the results show a positive effect between industry size, proxied by the number of employees and R&D expenditure on robot adoption. This is expected as bigger industries enjoy the benefits of economies of scale, which would enable them to overcome the costs that come with robot adoption. R&D expenditure indicates the innovative capability of the industries and their absorptive capacity, which enables the successful adoption of industrial robots. Also, there is a negative relationship between human capital, proxied by the years of schooling in the country, and robot adoption. This is expected as the capabilities of robots are still limited in terms of the tasks they can perform. It is reasonable to assume that a more educated workforce will perform more complex tasks that cannot be easily performed by industrial robots (Taglioni and Winkler, 2016). For forward linkages, we find a positive impact of wages and schooling while for backward linkages, R&D expenditure and the average years of schooling is significant. Again, this speaks to the absorptive capacity of the industries which enables them to participate in GVCs. Lastly, we see a positive relationship between R&D and productivity, which is in line with theoretical predictions. The results for the exogenous variables are reported in Table A3 - A5 of the appendix.

2.4.5 Robustness Checks

In most econometric estimations, endogeneity is a major source of concern in the models. However, by utilising the PVAR methodology and allowing for the main variables of interest to be endogenous, we account for the endogeneity bias and boost the reliability of our results. In the previous section, forward and backward linkages are used to measure GVCs consecutively. However, most industries have both forward and backward linkages and some studies have argued that backward and forward linkages are interrelated (Antràs, 2020a; Rodrik, 2018). We account for this including forward and backward linkages simultaneously in the model. By making both variables endogenous, we allow for backward and forward linkages to affect each other contemporaneously.

[5] We also analyse the results using the Cumulative Impulse Response Function, and the results are still the same as using just the IRF.

Figure 2.4: Quadravariate Impulse Response Function With Robots, Forward Linkages, Backward Linkages and Productivity



From figure 2.4, we see that the results remain the same as in the previous section. We still find a positive but not persistent relationship between robot adoption and backward linkages, a positive effect between productivity shock and robot adoption and a positive effect of a shock in robot adoption and forward linkages. Looking at the two GVC variables, we find a positive and significant effect of a shock in backward linkages on forward linkages, which is persistent for about 4 years. This could be because industries that are fully integrated into GVCs through both backward and forward linkages utilise imported foreign inputs in their exported domestic production. However, there is no effect of forward linkages on backward linkages.

2.5 DISCUSSION AND CONCLUSION.

The study is based on a multi-country industry level panel covering roughly 20 OECD countries for the years 1995-2016, and it investigates the interrelationship between integration in GVCs, adoption of industrial robots and productivity. The study argues that a bidirectional relationship exists between these three phenomena and that imposing a unidirectional relationship between them will cause bias in the results. By utilising a PVAR model to account for the endogeneity between the three variables, this study accounts for the dynamic behaviour and cross-dependence that exists between these variables. So, we investigate the relationship between integration into GVCs and productivity, productivity and robot adoption, and robot adoption and integration into GVCs. Specifically, we study how an impulse shock in one variable creates a response in the other variable and how long this effect will persist.

The results show a positive effect of productivity on both backward and forward linkages which lasts for about 2 years. We attribute this positive effect to more productive industries being more competitive and therefore able to successfully import inputs which are then utilised in their exports, and also successfully export intermediate inputs to other industries. This is similar to the findings of (Antràs, 2020a; Taglioni and Winkler, 2016) and in line with our expectations. Considering the other side of the relationship i.e. the effect of integration into GVCs on productivity, we fail to find any significant effect of forward linkages on productivity. This is contrary to the findings of Kummritz (2016) and although the effect is positive, which is in line with our expectations, it is not statistically significant. On the effect of backward linkages on productivity, we have mixed findings. We find that a shock to backward linkages has a negative effect on productivity in the first 2 years, but after the third year, this effect becomes positive. An explanation for this finding could be due to the composition of countries in the sample i.e. mostly developed countries with supposedly high productivity levels, who might have more forward linkages than backward linkages. So, an increase in their backward linkages may not have an immediate positive effect on their productivity but the productivity gains are delayed. The positive effect is in line with previous studies and also our proposed hypothesis (Blalock and Veloso, 2007; Smarzynska Javorcik, 2004).

Next, we considered the relationship between robots and productivity and in line with the literature, we find that more productive industries adopt more industrial robots (Koch et al., 2021). However, we fail to find a significant effect of robot adoption on productivity, contrary to the findings of (Graetz and Michaels, 2018; Stapleton and Webb, 2020). However, in line with Chiacchio et al. (2018) who fail to find a significant effect on robot adoption and productivity after controlling for ICT capital, we argue the absence of a productivity effect on robot adoption could be due to controlling for R&D investment which might be concurrent with automation.

Also, the results for the relationship between robot adoption and GVCs show a positive but non-persistent effect of backward linkages on robot adoption. This shows evidence for the learning effect through knowledge and technological spillovers, and this is in line with the literature and our predictions (Grossman and Helpman, 1991; Pahl and Timmer, 2020; Taglioni and Winkler, 2016). Also, an increase in backward linkages could be a sign that the industry is mainly focused on assembling tasks that would benefit from the use of robots (Kordalska et al., 2016). The results do not show a significant effect of forward linkages on robot adoption. Again, we attribute this to the sample composition as the OECD countries may already be performing high value tasks in GVCs and so an increase in their forward linkages might not necessarily drive them to adopt more robots in their production process. Lastly, the results show a positive effect of robot adoption on both forward and backward linkages, indicating that adopting robots helps industries integrate into GVCs. This is largely in line with the findings from the literature and the arguments that advanced technologies are important drivers for GVC integration (Antràs, 2020a; Rodrik, 2018) and the use of industrial robots can improve the quality and precision of production while reducing the cost of production, thereby making it easier for industries to participate in GVCs (Cilekoglu et al., 2021; De Backer and DeStefano, 2021; Stapleton and Webb, 2020).

This study contributes to the existing literature by exploring the interrelationship between trade, technology adoption and productivity; three phenomena that have been extensively researched in the field of international economics albeit separately. Endogenous growth theories suggest that there is a positive relationship between technology, trade and productivity, and while many empirical studies have tested this relationship while accounting for potential reverse causality, the interactive effects between these variables have not been explored and that is what we do in this study. The theoretical predictions are largely in line with the main findings of this paper as we find a positive effect between productivity and GVCs, robot adoption and productivity, and GVCs and robot adoption.

By considering the persistence of the effects of a shock in these variables on one another, these findings have some policy implications. First, policymakers should be wary of laws that focus exclusively on one of these factors without accounting for the other, as the findings have shown that they are interrelated. Therefore, policy regarding promoting (discouraging) the adoption of robots due to fears of their effect on the labour market should also take into account the positive (negative) effect it would have on GVC integration and productivity in the industry. Also, the results show the effect of an impulse shock on the variables on the other lasting an average of 3 years. This indicates that there is some persistence in the effect, which would be important when making policies as the impact could be long lasting. Lastly, given the adverse effects of the COVID-19 pandemic on country productivity and output, the results show that for OECD countries, introducing more robots to the production line might not necessarily boost productivity but will promote GVC integration. So other options can be explored by policymakers to enhance productivity.

The main limitation of this study is that although the study is a multi-country study, it is focused on just OECD countries and this is due to the paucity of industry level data for most developing countries with regards to their GVC and robot adoption information. Future research can look at this interrelationship between robot adoption, GVC participation and productivity for developing and developed countries as there might be some heterogeneity in the findings. Also, the study is carried out on an industry level but might benefit from investigating the interrelationship from a firm or micro-level given that firms make up industries and firms are the ones trading in GVCs. Also, by conducting the analysis on the firm level, information on the type of tasks (routine, abstract or manual) can be included, and other sources of firm heterogeneity can be accounted for. Lastly, future research can explore the role reshoring plays in this interrelationship between robot adoption, GVCs and productivity.

APPENDICES OF CHAPTER 2

Table 2.3: List of Countries in Sample.

Countries			
Australia	Estonia	Israel	Poland
Austria	Finland	Italy	Portugal
Belgium	France	Lithuania	Slovakia
Czech Republic	Germany	Netherlands	Spain
Denmark	Hungary	Norway	United Kingdom

Table 2.4: PVAR Model Selection Criteria

Lags	CD	J Statistic	J Statistic p-value	MBIC	MAIC	MQIC
Model 1: Endogenous Variables: Productivity, Robots and Backward Linkages						
1	0.365	123.865	<0.01	-78.470	69.865	15.104
2	-1.569	30.503	0.033	-104.386	-5.497	-42.004
***3	-7.826	15.550	0.077	-51.895	-2.450	-20.703
Model 2: Endogenous Variables: Productivity, Robots and Forward Linkages						
1	0.321	64.966	<0.01	-135.260	10.966	-43.229
***2	-1.633	22.009	0.232	-111.476	-13.991	-50.121
3	-13.770	5.690	0.771	-61.052	-12.310	-30.375
Model 3: Endogenous Variables: Productivity, Robots, Backward and Forward Linkages						
1	-0.11219	99.72537	<0.01	-256.203	3.725373	-92.6134
2	-2.94313	46.27646	0.049175	-191.009	-17.7235	-81.9494
***3	-106.84	8.254388	0.94093	-110.388	-23.7456	-55.8585

***: indicates the optimal number of lags to be used in the model.
CD: Confidence Distribution, MBIC: Modified Bayesian Information Criterion
MAIC: Modified Akaike Information Criterion; MQIC: Hannan-Quinn information criteria

Table 2.5: Coefficients for Exogenous Variables in Trivariate Impulse Response Function With Robots, Backward Linkages and Productivity

	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Robots Equation						
Employment	0.001***	0.000	2.050	0.041	0.000	0.001
Wage	-0.073	0.187	-0.390	0.698	-0.440	0.295
Schooling	-0.190*	0.101	-1.890	0.059	-0.387	0.007
R&D	0.039***	0.016	2.500	0.012	0.009	0.070
Backward Linkages Equation						
Employment	0.0001	0.001	-0.250	0.802	-0.001	0.001
Wage	0.003	0.340	0.010	0.993	-0.663	0.669
Schooling	0.583***	0.142	4.100	0.000	0.304	0.862
R&D	0.151***	0.027	5.550	0.000	0.097	0.204
Productivity Equation						
Employment	0.001	0.001	0.920	0.356	-0.001	0.002
Wage	-1.352***	0.294	-4.610	0.000	-1.928	-0.777
Schooling	-0.617***	0.119	-5.170	0.000	-0.851	-0.383
R&D	0.071***	0.023	3.070	0.002	0.026	0.116

Table 2.6: Coefficients for Exogenous Variables Trivariate Impulse Response Function With Robots, Backward Linkages and Productivity

	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Robots Equation						
Employment	0.001***	0.000	2.910	0.004	0.000	0.001
Wage	0.092	0.186	0.490	0.623	-0.274	0.457
Schooling	-0.262***	0.083	-3.140	0.002	-0.425	-0.098
R&D	0.047***	0.015	3.020	0.002	0.016	0.077
Forward Linkages Equation						
Employment	0.0001	0.001	0.220	0.824	-0.001	0.001
Wage	2.010*	1.041	1.930	0.053	-0.030	4.050
Schooling	1.250***	0.158	7.930	0.000	0.941	1.558
R&D	-0.022	0.028	-0.770	0.440	-0.076	0.033
Productivity Equation						
Employment	0.0001	0.001	0.260	0.797	-0.001	0.001
Wage	-2.577***	0.905	-2.850	0.004	-4.351	-0.802
Schooling	-0.593***	0.134	-4.440	0.000	-0.855	-0.331
R&D	0.084***	0.026	3.300	0.001	0.034	0.134

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

Table 2.7: Coefficients for Exogenous Variables in Quadravariate Impulse Response Function With Robots, Backward Linkages and Productivity

Variable	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Robots equation						
Employment	0.001***	0.000	2.030	0.042	0.000	0.001
Wage	-0.048	0.189	-0.250	0.801	-0.418	0.323
Schooling	-0.209***	0.102	-2.040	0.041	-0.409	-0.009
R&D	0.039***	0.016	2.420	0.016	0.007	0.070
Forward linkages equation						
Employment	-0.001	0.001	-1.240	0.214	-0.002	0.000
Wage	0.424	0.302	1.400	0.160	-0.168	1.016
Schooling	1.526***	0.139	10.970	0.000	1.254	1.799
R&D	0.001	0.023	0.020	0.980	-0.045	0.047
Backward linkages equation						
Employment	0.0001	0.001	-0.190	0.847	-0.001	0.001
Wage	-0.004	0.349	-0.010	0.990	-0.688	0.679
Schooling	0.504***	0.142	3.550	0.000	0.226	0.782
R&D	0.146***	0.027	5.440	0.000	0.093	0.198
Productivity equation						
Employment	0.001	0.001	1.060	0.291	-0.001	0.002
Wage	-1.336***	0.295	-4.520	0.000	-1.915	-0.757
Schooling	-0.724***	0.121	-6.000	0.000	-0.961	-0.488
R&D	0.069***	0.023	3.000	0.003	0.024	0.114

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

CHAPTER 3: LEARNING BY SERVING (AT HOME)

ABSTRACT

The increasing participation of manufacturing firms in providing services has prompted studies aimed at understanding why manufacturing firms do this and what benefits providing services might have for these firms. Our paper focuses on the export of services by manufacturing firms and investigates the factors that drive manufacturing firms to export services abroad, focusing on the role played by productivity, Firm Specific Advantages (FSAs) and the selling of services domestically. We consider the participation in service exports, and intensive and extensive margins of trade. We argue that in addition to productivity and FSAs, selling services domestically serves as a channel of learning for manufacturing firms, and this learning at home enables them to successfully export services. The results show that productivity and FSAs help manufacturing firms enter service export markets, however, only the provision of services domestically is positively related to service export participation, and intensive and extensive margins.

3.1 INTRODUCTION

There is an increasing blur between the manufacturing and service sectors, as their activities continue to intertwine and overlap. While some service firms market services as products, a term commonly referred to as productisation, some manufacturing firms are also gradually shifting away from pure manufacturing activities and provision of goods, to including more services in their offerings. This phenomenon has been documented both theoretically and empirically and has been argued to be driven by the introduction of new information and communication technologies (Cui and Liu, 2018; Luz Martín-Peña et al., 2018). The degree to which manufacturing firms offer services has been on an upward trajectory over the years with Neely (2013) finding that 25% of German manufacturing firms offered services and that the USA has the highest level of manufacturing firms offering services with about 30%. However, the National Board of Trade Sweden finds that EU manufacturing firms are even more inclined to offer services compared to the USA. Also, using a multi-country sample, Neely et al. (2011) finds that on average, 30% of manufacturing firms in the sample also provided services.

Given the prevalence of this phenomenon, there is an interest in why manufacturing firms might choose to offer services and if there are any benefits from doing this. Economic, financial and strategic gains have been identified as potential reasons manufacturing firms might choose to offer services, as it could help them compete favourably in the domestic market and improve their chances of survival (Lightfoot et al., 2013; Neely, 2013). For its benefits for firm performance, improvement in productivity, profitability and innovation have all been highlighted as gains from offering services (Bascavusoglu-Moreau and Tether, 2010; Dachs et al., 2014).

However, manufacturing firms are not only selling services domestically, but they are also increasingly exporting services abroad. According to the ONS International Trade in Services (ITIS) report of 2018, there has been a steady increase in the contribution of the UK manufacturing sector to service exports - this has increased from 12% in 2015 to 16% in 2018. Wolfmayr et al. (2013) find that 5% of the manufacturing firms in Austria export services, which is smaller than the 15% observed by Breinlich and Criscuolo (2011) for the UK. Also, Kelle and Kleinert (2010) find that manufacturing firms accounted for 19% of service exports in Germany in 2005. So, although previous studies show that a high proportion of manufacturing firms also offer services, it is also apparent that a small percentage of manufacturing firms successfully export services. Naturally, this begs the question - what factors enable manufacturing firms to successfully export services? What role does selling services domestically play in enabling manufacturing firms successfully export services? These are the questions this study seeks to answer.

Addressing these questions is pertinent, especially for the UK due to the changing global environment following the double impact of Brexit and the Covid-19 pandemic. The UK is the second-largest service exporter in the world, with service exports making up 44% of the UK's total exports in 2019 (ONS, 2020). Compared to Q2 of 2019, UK service exports fell by 18.5% in Q2 of 2020 as a result of the restrictions from the pandemic. Post-Brexit and post-Covid19 era will see the UK try to attain the pre-pandemic levels of service trade through targeted government policy. Given that manufacturing firms make up a sizeable percentage of service exports, it is important to determine what factors enable these manufacturing firms to participate in service exports as this can guide the targeted efforts from the policies.

Also, firm exports have been traditionally linked to firm performance and survival, and although there are a lot of studies that focus on the firm level determinants of exports, services have remained under-researched as most of these studies are focused on the manufacturing sector. In most of the literature, firm size, innovation, productivity, skills, and ownership, among others have been highlighted as positive determinants of exports for manufacturing firms (Bernard and Jensen, 1999; Gourlay et al., 2005; Love and Mansury, 2009; Roper et al., 2006). However, most of these studies do not distinguish between the goods and service exports of these firms. This distinction is important because the nature of service trade differs between manufacturing and service sector firms. Wolfmayr et al. (2013) argue that the service export of manufacturing firms is most likely linked to the internationalisation of production and goods export. Also, Ariu (2012) compares goods and service exporters and finds that there are differences between both types of exporters. They find that compared to goods trade, fewer firms participate in service trade and this could be due to a higher fixed cost associated with exporting services. Additionally, they find that service traders are more sluggish in increasing their extensive margins of trade i.e. the number of service products exported and the number of service export destinations. These differences reinforce the importance of differentiating between the goods and service exports of manufacturing firms.

This study contributes to the literature by focusing on this niche where manufacturing and services intersect, and by considering the link between selling services domestically and exporting services for manufacturing firms. We differentiate between the goods and service exports of manufacturing firms, and we argue that the selling of services domestically is an important factor that facilitates exporting of services by these manufacturing firms. Offering services in addition to goods has been found to improve productivity, profitability, survival, innovation and competitive advantage of manufacturing firms (Bascavusoglu-Moreau and Tether, 2010; Dachs et al., 2014). Going from this, we argue that selling services domestically is an additional avenue through which manufacturing firms learn, thereby facilitating their entry into service export markets.

Our results show evidence for this. We find that selling services domestically is positively related to services export participation, intensity and extensive margins. In addition to selling services domestically, we also find evidence for a positive relationship between productivity, Firm Specific

Advantages (FSAs) such as size, employee skills and technological resources. The results also reinforce our argument concerning the crucial role of selling services domestically as we find that productivity and FSAs affect entry into service exports but not the intensity of exporting for manufacturing firms. However, selling services domestically is positively related to both the entry to service exports and the intensity of service exports for manufacturing firms.

The rest of the study is organised as follows. Section 2 reviews the relevant literature, section 3 covers the theoretical and conceptual frameworks, and the hypotheses development, section 4 looks at the data and stylised facts, section 5 included the empirical model and estimation, section 6 discusses the findings and the implications, and section 7 concludes the study.

3.2 LITERATURE REVIEW

This study is related to the literature concerned with the determinants of exports. Economists have long been fascinated with international trade, with early international trade theories focusing on why countries trade. This interest led to classical theories such as Ricardo's Comparative advantage and the Hescher-Olin framework, where they argued that the reasons why countries trade were because of differences in labour productivity and differences in resource endowment (Krugman and Obstfeld, 2009)**.** Over time, economists have acknowledged that countries or industries do not trade with one another, but it is the firms within these countries and industries that trade. So, the attention has shifted from the concept of a representative firm which was present in early theoretical models (Krugman and Obstfeld, 2009) to the concept of heterogeneous firms with different production capacities and productivity levels (Melitz, 2003; Penrose, 2009).

Productivity has continuously played a central role in explaining international trade. From the theory of Comparative Advantage to the endogenous growth models, and current theories of heterogeneous firms in trade, differences in productivity have been identified as a main driver of exports (Krugman and Obstfeld, 2009; Melitz, 2003). Studies have also shown that not all firms export and so this has led to investigations into how productivity differences affect selection into exporting (Ariu et al., 2019; Bernard and Wagner, 1997; Breinlich and Criscuolo, 2011).

Melitz (2003) develops a dynamic industry model which shows that only the most productive firms export while the least productive firms exit the export market. He refers to a productivity cut-off firms must attain in order to successfully export. This points to a selection criterion based on the firm's productivity, where only the most productive firms successfully export. This argument is also echoed by (Bernard and Jensen, 1999; Helpman et al., 2004) who posit that the least productive firms only operate in the domestic market, while the more productive firms export as higher productivity predates entry into the export markets. Several empirical studies have validated the theoretical predictions of the Melitz model (Bernard and Jensen, 2004; Bernard and Wagner, 1997; Love and Mansury, 2009).

There is a cost associated with exporting which acts as a barrier for firms to select into exporting. Love and Mansury (2009) argue that there is a fixed cost hurdle to becoming exporters and once firms overcome this hurdle, productivity does not play a role in how much they export. They find evidence for this as their results show that more productive firms select into exporting but once a firm is already exporting, productivity does not affect the intensity of exports as there is no difference in the export volume of more productive and less productive firms. In the same vein, Bernard and Wagner (1997) argue that firms need to be productive before exporting as exporting does not improve firm performance. Using a sample of German firms, they find that more productive firms select into exporting and that in the short run, exporting does not improve productivity. They attributed this to the entry and exit from exporting markets that firms experience in the short run. Alvarez (2007) shows support for this argument by examining the factors that explain export success for Chilean manufacturers, where export success is defined in terms of how long a firm carries on exporting without exiting the export market. The findings show that although high productivity enables firms to enter the export market, it had little effect on the probability of them remaining permanent exporters. So, productivity alone could not explain the differences in export behaviour between permanent exporters and sporadic exporters. However, Bernini et al. (2016) find that more productive firms are less likely to exit the export market after entry.

Also, Melitz (2003) goes further to argue that the exit of the least productive firms from the export market and the additional export sales enjoyed by the more productive firms reallocate market shares towards the more productive firms, causing their productivity to further increase. This indicates a learning effect that accrues to firms from exporting, better known as learning by exporting. Some studies have argued that there is a learning from exporting mechanism where firms become more productive as a result of participating in the export market (Love and Mansury, 2009; Wolfmayr et al., 2013). Aside from exploring the selection into exporting argument, Love and Mansury (2009) also consider the effect of exporting on firm productivity. After correcting for selection into exports, they find that being an exporter increases the productivity of the firms. So, they find evidence for both the selection into exporting and learning from exporting arguments. This is similar to the findings of Wolfmayr et al. (2013) where they find that not only do more productive firms select into exporting but that these firms experience productivity growth as a result of exporting.

Although international economics has focused extensively on productivity and trade, the International Business (IB) field has taken a much more encompassing approach by focusing on other factors aside from productivity, using the so-called Firm Specific Advantages (FSA) (Barney, 1991; Bernini et al., 2016; Dunning, 1980). Both strands of literature are similar as they focus on the preconditions firms need to meet in order to successfully overcome the high costs of entry into foreign markets. A contribution to the FSA studied from the IB literature is Dunning's Eclectic Paradigm, which identified

Ownership, Location and Internalization advantages as key determinants of a firm's choice of entry mode to a foreign market (Dunning, 1980). The paradigm argues that a firm needed ownership advantages in order to overcome the barriers it will face from operating in a different country. Ownership advantages are superior assets or resources that a firm owns which gives it a competitive advantage compared to foreign rivals and allows it to overcome the high entry costs of servicing foreign markets (Agarwal and Ramaswami, 1992). The theory argues that in the absence of Location and Internalization advantages, a firm with only ownership advantages should choose exports as its mode of entry into a foreign market.

The concept of FSA is closely related to the Resource Based Theory of the Firm (RBV). In the RBV, the source of a firm's competitive advantages are the unique resources that are at the core of the firm and it assumes that there is heterogeneity in the resources that firms own and control (Dhanaraj and Beamish, 2003). Penrose (2009) defines the firm as a pool of resources that are both tangible and intangible, which they can take advantage of to improve their performance. Based on the RBV and the OLI paradigm, several studies have identified other factors aside from productivity that can predict successful entry into export markets.

A factor that has received a lot of attention in the literature is firm size. It has been established that bigger firms are more likely to be exporters compared to smaller firms (Bernard and Jensen, 1999; Breinlich and Criscuolo, 2011; Javalgi et al., 1998). This is attributed to the economies of scale enjoyed by bigger firms and access to more resources which would enable them to overcome the costly barriers of exporting. Empirically, a number of studies have found a positive relationship between firm size and exporting probability (Agarwal and Ramaswami, 1992; Dhanaraj and Beamish, 2003; Javalgi et al., 1998; J. H. Love and Mansury, 2009).

Also, studies have analysed the relationship between exports and technological innovation. On one hand, the product cycle theories of international trade posit that innovation is the driving force behind exports as developed countries undertake innovative activities and develop new goods which are exported to developing countries, and in order to maintain their exports, they must continue to innovate (Krugman, 1979; Vernon, 1966). On the other hand, endogenous growth models postulate that innovation is a result of exposure to international trade and that this occurs through two channels. First, firms involved in international trade face additional competition from both foreign and domestic firms and this spurs them to innovate in order to stay in the foreign market (Aghion and Howitt, 1990; Grossman and Helpman, 1991). The other channel is through learning by exporting. Firms that engage in international trade can learn about new technologies and adopt them in their production processes, thereby improving their innovation (Grossman and Helpman, 1991).

Empirically, some studies have investigated the relationship between exporting and innovation. The consensus seems to be that innovation increases the probability of exports as a number of studies have found a strong positive relationship between a firm's R&D, which is a typical measure of innovation, and a firm's exports (Gourlay et al., 2005; Love and Mansury, 2009; Roper et al., 2006). However, Alvarez (2007) finds that technological innovation is not a good predictor of export success as R&D was insignificant in his analysis. Also, Barrios et al. (2003) find that a firm's R&D is more important in determining whether a firm exports or not, as R&D spillovers are not a strong predictor of exports.

Another internal firm resource that has been analysed with regard to exports is the human capital of the firm or the quality of its workforce. Penrose (2009) stated that the human resources available to a firm in the form of skilled or unskilled labour, and technical or managerial staff, are as valuable to a firm as its physical capital and assets. Theoretically, endogenous technological trade theories argue that human capital is a critical input that determines R&D levels, thereby spurring innovation and promoting trade (Rivera-Batiz and Romer, 1991). Also, Engelbrecht (1997) argues that R&D capital is a specific form of human capital that is related to innovation. Therefore, an increase in human capital improves productivity, thereby improving the probability of participating in international trade. Empirically, Gourlay et al. (2005) find that UK firms with highly skilled directors are better able to penetrate international markets. Also, Roper et al. (2006) find that the education level of employees matters for export intensity. They find that the proportion of the firms' workforce with degrees is positively and significantly related to the firms' export intensity.

Lastly, ownership and age are other factors that have been posited to play a role in determining a firm's entry into international trade. With regard to firm age, there are two opposing theoretical arguments on how it can affect participation in international markets. On one hand, older firms might have had more time to build their resource base, be more experienced and have the first-mover advantage, enabling them to navigate the entry barriers to foreign markets more easily, compared to younger firms (Contractor et al., 2007). On the other hand, older firms might be set in their ways, exhibiting inertia in adapting to changing external factors. Autio et al. (2000) specifically argue that younger firms can easily unlearn old routines, learn and absorb new knowledge from international markets, and absorb an international identity, compared to older firms at the point of entry to international markets. Therefore, they argue that younger firms possess learning advantages in terms of assimilating and adapting new foreign knowledge, which propel their international growth. Empirically, the findings on the relationship between age and exporting have varied to reflect these two theoretical positions. While Javalgi et al. (1998) find that older firms have a higher propensity for exports, Roper et al. (2006) finds that younger firms in their sample have a higher export intensity.

For firm ownership, foreign owned firms are theorised to have greater learning and international experience and access to foreign inputs which can boost their performance and reduce the cost of entry into exporting. Hobdari et al. (2011) posit that foreign firms are more dynamic, possess the resources that enable them to restructure easily, and are more likely to identify new market opportunities compared to domestically owned firms. The evidence for this is also varied in the literature. Some studies have found a positive relationship between foreign ownership and exporting propensity (Bernard and Jensen, 2004; Manez et al., 2004; Roper et al., 2006). However, Brakman et al. (2020) find that for high productive firms, ownership does not affect the propensity of export.

On the effects of manufacturing firms offering services, some studies have looked at its impact on firm profitability and survival. With this, there exists a paradox with evidence showing that manufacturing firms that offer services do not necessarily experience higher levels of profitability compared to firms engaged in pure manufacturing activities (Kharlamov and Parry, 2020; Neely et al., 2011). However, Crozet and Milet (2017) and Neely (2008) find that offering services increases the profitability of smaller firms but not that of larger firms. Its impact on productivity has also been examined and the consensus is that although manufacturing firms that offer services might not experience an increase in their profits, they are more productive than the manufacturing firms that do not offer services (Crozet and Milet, 2017; Kharlamov and Parry, 2020). Also, Dachs et al. (2014) find that manufacturing firms that also offer services are more innovative as they are more likely to introduce new products and processes in their domestic operations.

With regards to linking manufacturing firms selling services domestically and their exporting activities, the evidence is still scant and geared more towards goods exports rather than service exports. Cui and Liu (2018) find that selling services domestically by manufacturing firms increases firm competitiveness, therefore allowing them to successfully export goods. They also find that these manufacturing firms are less likely to exit the goods export market compared to the pure manufacturing firms. Lodefalk (2014) toe the same line as he looked at the importance of service inputs for manufacturing goods exports. He finds that higher levels of service inputs reduce trade costs, raise a firm's productivity and facilitate goods exports. Although both studies focus on the importance of domestic services for exports, they are focused on the goods exports of these manufacturing firms and not the service exports. This study aims to fill this gap by establishing a link between selling services domestically and service exports of manufacturing firms.

3.3 THEORETICAL FRAMEWORK AND HYPOTHESES FORMULATION.

3.3.1 Theoretical Framework

This study is motivated by the Resource Based View of the firm (RBV) which defines a firm's resource as anything that can be seen as a weakness or strength tied semi-permanently to the firm (Wernerfelt, 1984). The RBV was developed to answer the question of why some firms performed better than others, and this was attributed to the heterogeneous resources controlled by the firm. One of the early contributors to the RBV theory is Penrose (1959), who argued that the resources controlled by firms vary by firms even if these firms belong to the same industry i.e. firms are heterogeneous. This was an important contribution to the literature as earlier theories mostly assumed that aside from firm size, firms within the same industry were homogeneous in terms of the resources they controlled (Porter, 1989). Going from this, Wernerfelt (1984) argued that the resources a firm controls could be a source of competitive advantage in implementing product market strategies. Also, Barney and Clark (2007) contributed to the RBV theory by attributing the persistent superiority of a firm's performance to the resources that firms control.

Therefore, RBV makes two important assumptions which are that firms within an industry are heterogeneous in terms of the resources they control, and that these resources may not be perfectly mobile across firms, thereby causing the heterogeneity to persist. Resources can include skilled workforce, in-house technology, physical capital and even intangible assets, such as brand names. Specifically, the RBV identifies four categories of resources a firm might control to gain a competitive advantage. They are human capital resources, physical capital resources, financial capital resources and organisational capital resources. The RBV theory is suited for the empirical analysis carried out in this study as the motivation of this study is to understand what factors enable some manufacturing firms to successfully export services.

3.3.2 Manufacturing Services Exports and Productivity

Several studies have investigated the link between productivity and exports. It has been generally observed that exporters are more productive than non-exporters. However, there is an argument on what the source of the productivity difference is. Is it because firms increase their productivity in order to participate in the export market or because firms become more productive from participating in the export market? The former alludes to a self-selection mechanism where more productive firms self-select into the export market, while the latter alludes to a learning by exporting mechanism (Melitz, 2003).

The self-selection argument is rooted in the premise that participating in the export market comes with additional costs such as information gathering, economies of production or marketing costs, and not all firms can overcome these costs (Roper et al., 2006). Therefore, these costs act as entry barriers to less successful firms, allowing only the most productive firms to participate in exporting. Theoretical studies such as Melitz (2003) refer to a productivity cut-off firms must attain in order to successfully export and participate in the export market. Exposure to the export market forces the least productive firms to exist, while the more productive firms continue to export. Resources are therefore reallocated to these productive firms, thereby increasing their productivity. This argument is also echoed by Bernard and Jensen (1999) and Helpman et al. (2004) who argue that the least productive firms only operate in the domestic market, while the more productive firms export as higher productivity predates entry into the export markets.

Empirically, several studies have found evidence for the self-selection argument. Love and Mansury (2009) examine the relationship between productivity exporting for US business services firms. They find that more productive firms select into exporting. Also, Bernard and Wagner (1997) find similar evidence for German manufacturing firms. However, Greenaway et al. (2007) investigate the factors influencing exports for UK manufacturing firms and find that productivity was not a significant determinant for a firm's decision to export.

Next, we look at the learning by exporting mechanism. This argument is rooted in export-led growth models which argue that firms become more productive from participating in international markets through innovation spurred by increased competition or through economies of scale brought about by export growth (Kunst and Marin, 1989). The evidence for this argument is somewhat mixed in the literature with differing conclusions among different studies. Love and Mansury (2009) look at the relationship between exporting and productivity both from the self-selection argument and from the learning by exporting angles. They find clear evidence for both arguments. They also find that among US knowledge-intensive business firms, being an exporter has a strong positive association with firm productivity while once selection into exporting is accounted for, productivity does not affect the intensity of exporting. On the other hand, Bernard and Wagner (1997) only find evidence for the self-selection argument as exporting did not improve firm performance in their sample of German firms. They attributed this poor performance to the repeated entry and exit from export markets that exporting firms experience and conclude that in the short run, exporting does not improve firm performance.

Going from this, Alvarez (2007) looked at the factors that determine whether a firm is a successful exporter, defining successful exporting as a firm being a permanent as opposed to being a sporadic exporter. The study also fails to find any evidence for productivity increasing exporting success as it finds that productivity is important to enter export markets but does not increase the probability of a firm being a successful exporter. Interestingly, Wolfmayr et al. (2013) find evidence for both arguments, analysing the relationship between productivity and exporting for Austrian service firms. They find that more productive firms select into exporting and correcting for that selection bias, being an exporter increases productivity. However, Wagner (2007) surveys 54 studies on firm level productivity on average and concludes that based on the findings of these studies, exporting does not improve productivity.

Other studies have approached both arguments from the aspect of export intensity, typically measured as the share of export in sales, rather than the participation in exports indicator. In fact, Gourlay et al. (2005) argue that the decision to export and the export intensity of a firm are distinct and they might have different drivers or determinants. They find evidence that there are indeed different determinants for the decision to export and the firm's export intensity. Also, Love and Mansury (2009) find that although productivity is important for a firm's decision to begin exporting, once a firm starts to export, then productivity does not affect the intensity of exports. However, Lodefalk (2014) finds evidence that productivity increases the export intensity of Swedish manufacturing firms. This is similar to the conclusion reached by Wolfmayr et al. (2013) who find that not only does productivity increase the probability of being an exporter, but it also increases the firms' export intensity to a particular destination.

A key point of note is that except for some studies (Gourlay et al., 2005; La et al., 2005; Love and Mansury, 2009; Wolfmayr et al., 2013), most studies on the relationship between productivity and exports have been focused on the manufacturing sector with no distinction between their exports of goods and services. While Gourlay et al. (2005) model the determinants of the decision to export and export intensity for service firms, the productivity of the firm is not included as a determinant, and so they could not show evidence for either the self-selection or learning by exports argument. Also, Love and Mansury (2009) focused on business service firms but do not differentiate between their exports of goods and services.

Although this study is also focused on manufacturing firms, we are mainly interested in manufacturing firms exporting services. We argue that not all the findings that apply to goods exporting manufacturing firms will apply to service exporting manufacturing firms. In the same vein, we also argue that not all findings that apply to service exporting service firms will apply to this niche of service exporting manufacturing firms. Following the theoretical and empirical literature outlined above, this study is focused on the drivers of exporting services by manufacturing firms. Its impact on firm performance is outside the scope of the study. Therefore, we test the self-selection mechanism and not the learning by export mechanism, and this gives rise to the following hypotheses.

H1a: Productivity is positively related to the manufacturing firms' services export participation.

H1b: Productivity is positively related to the manufacturing firms' services export intensity.

3.3.3 Manufacturing Services Exports and Firm Specific Advantages

Although productivity has been centred in the international economics literature as the main determinant of export participation, the IB literature has taken a more encompassing approach by including the so-called Firm Specific Advantages (FSAs) which is embedded within the context of the Resource-Based View (RBV) of firms. The RBV sees the firm as a pool of resources that are tied to the firm, where resources can be tangible or intangible (Wernerfelt, 1984). Barney (1991) identifies a firm's resources as "all assets, capabilities, organisational processes, firm attributes, information, knowledge, etc. controlled by the firm that enables it to conceive and implement strategies that improve its efficiency". Also, just like the theories of heterogeneous firms, the RBV assumes that firms maybe heterogeneous with regard to the resources they possess and that these resources may not be mobile across firms (Barney, 1991). Therefore, from the perspective of the RBV, productivity is not the only source of competitive advantage for a firm as its physical, human and organisational capital resources are also sources of competitive advantage (Barney, 1991).

In their study, Brakman et al. (2020) examine high productivity Dutch firms and they observe that some high productivity firms in their sample do not export, which is contrary to the predictions of the Melitz model. Therefore, they conclude that controlling for high productivity, there are other factors that raise the entry costs to export markets and certain factors need to be present in order for highly productive firms to enter the export market. So, even though high productivity is important, it is not sufficient for entry into export markets. As different firms might face different entry costs, a firm overcoming the barriers to export markets indicates domestic success borne out of leveraging all its resources and capabilities. Dhanaraj and Beamish (2003) identify firm size, R&D and manager's capabilities as factors influencing export strategy. They develop a causal model of the relationship between resources and export strategy, and they find that organisational resources (proxied by firm size), entrepreneurial resources and technological resources (proxied by R&D expenditure) of a firm are good predictors of its export strategies.

In the RBV literature, firm size is regarded as an indicator of the firm's organisational resources and it is argued that bigger firms have access to more resources which then facilitates their expansion into international markets (Barney, 1991; Dhanaraj and Beamish, 2003; Wernerfelt, 1984). Empirically, many studies have found it to be a positive predictor of exports (Brakman et al., 2020; Dhanaraj and Beamish, 2003; Gourlay et al., 2005; Roper et al., 2006). However, there have been a few studies that find that firm size plays little or no role in exporting propensity (Pla-Barber and Alegre, 2007; Wolff and Pett, 2000).

The technological resources of the firm is another resource identified in the RBV theory as a source of competitive advantage for the firm (Dhanaraj and Beamish, 2003; Wernerfelt, 1984). This encompasses the firms’ innovation capabilities typically measured as R&D expenditure or patenting propensity. These capabilities speak to the firm’s absorptive capacity to implement new technologies or develop new products and processes. Theoretically, innovation has been argued to be the main driving force behind exports (Bleaney and Wakelin, 2002; P. Krugman, 1979; Vernon, 1966) and empirically, there is supporting evidence for this. Some studies have found that innovation, measured as the R&D or patenting propensity of the firm increases the probability of the firm being an exporter (Barrios et al., 2003; Gourlay et al., 2005; Roper et al., 2006). However, Alvarez (2007) finds that for Chilean manufacturers, firm R&D expenditure was not significant for export entry or success, and Brakman et al. (2020) find that after controlling for high productivity, the technological intensity does not matter for propensity to export.

Lastly, RBV theory argues identifies the human resources of the firm, in the form of skilled and unskilled labour, training and experience of workers and managers, as important to the firm’s competitive advantage as its physical resources such as plant or equipment (Penrose, 2009; Wernerfelt, 1984). Developing an export strategy is dependent on the knowledge and experience of the individual workers and managers, who can gather information about foreign markets and implement strategies to facilitate entry into these markets (Beleska-Spasova et al., 2012; Gourlay et al., 2005). This suggests that the quality of the human resources available to a firm should be positively associated with export propensity. However, there have been mixed findings on the importance of human capital for the propensity to export empirically. Using the director’s wage as a measure of human capital, Gourlay et al. (2005) find a positive and significant relationship between human capital and exports. This is similar to the findings of Love and Mansury (2009) who find that firms with a higher proportion of workers with degrees had a higher tendency of becoming exporters. However, Brakman et al. (2020) fail to find any evidence for employees' skills after controlling for high productivity.

Although not explored empirically in this study due to data limitations, the FDI activities of manufacturing firms can also affect their service exports. FDI facilitates technology transfer which can lead to increased competitiveness of the firm and enable it successfully export services. Helpman et al., (2004) find that FDI increases the productivity of manufacturing firms and enables them to produce more goods with the same amount of labour. This can lead to a greater demand for services such as transportation, logistics, and marketing, which can be exported to other countries. Also, Smarzynska and Javorcik (2004) find that FDI can increase service exports for manufacturing firms by improving their access to foreign markets and providing information about regulatory requirements, consumer preferences and supply chain complexities. This can help firms tailor their services to the specific needs of foreign customers and partners and facilitate the export of these services to foreign markets. On the other hand, Barba Navaretti et al. (2016) found that the impact of FDI on service exports for manufacturing firms depends on a range of factors, including the nature of the services being exported, the quality of domestic infrastructure and institutions, and the degree of competition in foreign markets.

The arguments presented above emphasise the importance of FSAs and the firm's internal resources to improving the firm's competitive advantages and enabling them to overcome the high cost of entry into export markets. Although there have been conflicting findings regarding the impact of these resources on export propensity, it has been shown that these resources can be leveraged to improve firm effectiveness and efficiency (Barney, 1991; Wernerfelt, 1984). Therefore, we propose the following hypotheses.

H2: Firm Specific advantages are positively related to the manufacturing firms' services export participation.

H2a: Firm size is positively related to the manufacturing firms' services export participation.

H2ai: Firm size is positively related to the manufacturing firms' services export intensity.

H2b: Technological resources are positively related to the manufacturing firms' services export participation.

H2bi: Technological resources are positively related to the manufacturing firms' services export intensity.

H2c: Human resources are positively related to the manufacturing firms' services export participation.

H2ci: Human resources are positively related to the manufacturing firms' services export.

3.3.4 Manufacturing Services Exports and Selling Services Domestically

The phenomenon of manufacturing firms also selling services has been well documented in the literature. Vandermerwe and Rada (1988) highlighted that manufacturing firms were adding services to their core products or integrating services as part of their core products as a result of globalisation, technology innovation and competition. Since this seminal paper, there have been several studies looking at what drives manufacturing firms to provide services and what effects this could have on the firms. Some studies argue that manufacturing firms switch to services as a result of trade liberalisation (Breinlich et al., 2018), as a strategy for survival (Bascavusoglu-Moreau and Tether, 2010) and for economic reasons such as cost competition and revenue stability (Neely et al., 2011).

On the impact of manufacturing firms selling services, most studies have focused on the financial impacts of profitability or survival. The consensus is that there exists a paradox where manufacturing firms that venture into services do not become more profitable than the firms who remain purely manufacturing firms, but they have a higher chance of survival compared to firms who remain pure manufacturing firms (Kharlamov and Parry, 2020; Neely et al., 2011). The research on its impact on firms' export is still scant and given the increasing share of manufacturing firms in service exports, it has become imperative to examine the effects selling services domestically has on manufacturing firms' service exports.

One study that looks at the impact of offering services on manufacturing exports is Cui and Liu (2018) who examine the effect on the export of goods and survival in the export market for Chinese manufacturing firms. They argue that selling services domestically increases the competitiveness of manufacturing firms, thereby enabling them to overcome the entry costs of exporting. Also, they find a positive relationship between selling services domestically and goods exporting success, and they attribute this to the fact that offering services increases the differentiation of manufacturing products in the export market, thereby ensuring a level of exporting success. This argument is reiterated by Luz Martín-Peña et al. (2018) who emphasise the symbiosis between traditional manufacturing and services, where offering services increases the firm's competitive advantage and enables them to capture more market share. However, these studies neglect the potential effect selling services domestically might have on exporting services for these manufacturing firms.

Some studies have argued that the service activities of manufacturing firms should also include the services that are purchased, produced in-house and utilised by manufacturing firms. With this approach, Lodefalk (2014) focuses on how service inputs of manufacturing firms affect their manufacturing exports. He argues that manufacturing firms can prepare for exports and sustain exporting activity by increasing the service content in their products, as this would most likely increase their productivity. He finds that the service input increases the export intensity of the firms. However, two things are not captured in this study. Firstly, the focus is on the share of purchased services and the share of services in in-house production, and not on the services produced and sold domestically by these manufacturing firms. Secondly, like the other studies, the focus is on the goods exports of the manufacturing firms and not on their service exports due to the lack of service trade data. Also, Ariu et al. (2016) argue that for manufacturing firms, goods and services are complements and that by offering services, manufacturing firms can differentiate their products, thereby boosting their manufacturing exports. This study focuses on the drivers of bi-exporting i.e. exporting both goods and services, and does not consider just service exports for manufacturing firms.

One thing these studies agree on is that manufacturing firms offering services improves their competitiveness and productivity and promotes their goods exports. So, we argue that concerning exporting services, the additional competitive advantage gained from selling services domestically enables manufacturing firms to successfully overcome the barriers to service exports and enter the service export market. Through selling services domestically, we argue that manufacturing firms learn from this process, enabling them to leverage their experience in domestic services sales to propel their provision of services internationally. In fact, Lodefalk (2017) states that aside from improving their productivity, manufacturing firms might offer services to overcome entry barriers to foreign markets, sustain foreign market sales and participate in global value chains. Also, if we consider manufacturing firms offering services as a form of product diversification, then the above argument ties in with Batsakis and Mohr (2017) who argued that product diversification precedes expansion into foreign markets. In the same vein, Salomon and Shaver (2005) find a positive relationship between domestic sales and export decisions, whereby firms focus on the domestic market and their success domestically drives them to export to foreign markets. Therefore, they conclude that domestic sales and exports are complements, where an increase in domestic sales also increases exports. This argument is similar to the self-selection into exporting argument where firms export from a position of domestic strength and leverage their domestic capabilities in international markets (Bernard and Jensen, 1999).

Regardless of the few studies centred on the relationship between manufacturing firms selling services domestically and exporting, they do not address this relationship within the specific context of service exports. The focus has been exclusively on how services inputs foster goods exports (Cui and Liu, 2018; Lodefalk, 2014). We argue that aside from the services used as inputs by manufacturing firms, the services sold by manufacturing firms domestically should not be overlooked as it could be an avenue through which the firms learn in order to facilitate their entry into service export markets. Several studies have found that offering services improves productivity, innovation, profitability and competitiveness for manufacturing firms (Crozet and Milet, 2017; Dachs et al., 2014; Opazo-Basáez et al., 2018). It has been documented that selling services domestically plays a role in promoting goods exporting success and we argue that it also plays a role in promoting service exporting success. The above arguments lead to the next set of hypotheses.

H3a: Selling services domestically is positively related to the participation in services export by manufacturing firms.

H3b: Selling services domestically is positively related to the intensity of services exported by manufacturing firms.

3.3.5 Service Export Strategy: Extensive Margins of Manufacturing Services Export

Once firms enter the export market, then the next step is to select and implement their export strategy which involves deciding the rate of export market and product expansion, and how to allocate the marketing activities across different markets (Katsikeas and Leonidou, 1996). The firms' extensive margins typically refer to the number of products exported and the number of destination markets served by the firm. Firms can either keep exporting the same products to the same markets or enter more markets and ship more products (Katsikeas and Leonidou, 1996).

Theoretically, several firm specific factors have been identified as positive determinants of extensive margins of trade. Firm productivity has been identified as a key determinant affecting firms' extensive margins of trade. Some studies have examined the relationship between extensive margins of trade and firm productivity, with some studies finding that productivity enabled firms to export to more markets (Castellani et al., 2010; Muûls and Pisu, 2009; Wagner, 2007b), while other studies find that exporting to more markets increases firm productivity (De Loecker, 2007; Yashiro and Hirano, 2009). Specifically, Wagner (2012) argues that higher productivity for firms increases extensive margins of more destinations and more products because more productive firms are better able to withstand international competition and overcome barriers to entering new markets. He finds a positive and significant relationship between productivity and extensive margins of trade. On the other hand, Crinò and Epifani (2009) fail to find any relationship between productivity and extensive margins.

Organisational resources such as firm size and technological capabilities have been argued to have a relationship with increasing the number of destinations a firm serves. Firm size is an indicator of the firm's organisational resource base and some studies argue that the relationship between serving more international markets and firm size is positive based on the premise that bigger firms are less constrained by resources compared to smaller firms, and are more likely to successfully withstand the market competition that comes with market expansion (Cos et al., 2019; Eliasson et al., 2012; Katsikeas and Leonidou, 1996). Katsikeas and Leonidou (1996) find some evidence for this as they find that bigger firms are more likely to increase the number of destinations they export to, while smaller firms are more likely to export to a limited number of destinations. They argue that this might be due to smaller firms being more interested in exporting profitability instead of export volume. This result is similar to the findings of Cos et al. (2019), who find that medium-sized and larger firms are more likely to serve more international markets. However, Chang and Wang (2007) find contradicting evidence for this as they find that small to medium-sized firms are more likely to serve multiple international markets as they exhibit less inertia compared to large firms.

Technological resources of the firm in the form of innovation, patents and R&D expenditure also indicate the firm's organisational resources and have been identified as an influence on firms entering new markets and introducing new products. Jovanovic and Gilbert (1993) argue that internationally diversified firms require more complex technology and that firms that have high R&D expenditure or high patenting activity are more likely to benefit from technological spillovers, which will facilitate their market expansion. Also, Dass (2000) argues that innovation increases the product diversity of a firm, which provides more opportunities for market and product expansion, economies of scope and learning avenues for the firm. However, Elliott et al. (2020) point out that innovation may be a force of creative destruction in two ways. First, firms can introduce new products which may deepen their existing trade relationships or replace existing products, therefore creating an ambiguous effect on extensive margins. Secondly, the introduction of a new product aimed at a new foreign product will open up new markets but may also cause firms to exit existing markets. Empirically, some evidence has been found for the positive relationship between the technological resources of the firm such as R&D expenditure and patenting propensity, and the export market expansion (Cirera et al., 2015; Hauser et al., 2013). However, Elliott et al. (2020) find little evidence for the impact of innovation on a firm's extensive trade margins.

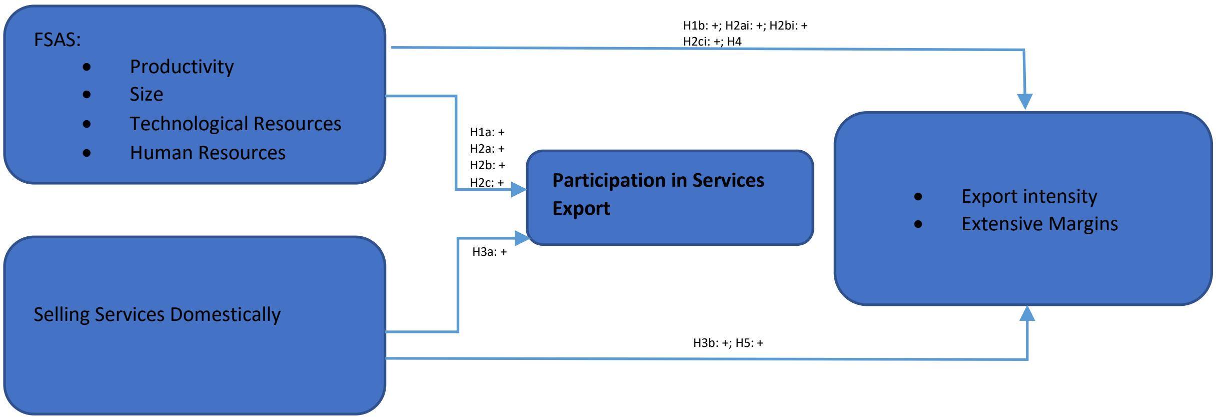
Given the importance of FSAs for overcoming the barriers of entry into export markets, we hypothesise that these FSAs will also be crucial to the extensive margins of the firms as this entails expanding export services to different markets. The foregoing leads to the following hypotheses.

H4: FSAs are positively related to the extensive margins of manufacturing service exports.

Lastly, we consider the relationship between selling services domestically and the extensive margins of trade of the firm. Manufacturing firms selling services can be considered as a form of product diversification, where aside from their core goods offering, manufacturing firms also include services in their core offerings (Bascavusoglu-Moreau and Tether, 2010). In this vein, selling services domestically is expected to improve the competitiveness and financial strength of the firm, and offer the firm an opportunity to generate economies of synergy by leveraging its resources (Teece, 1980). Studies have found that manufacturing firms that also offer services experience an increase in profit (Crozet and Milet, 2017), an increase in productivity (Opazo-Basáez et al., 2018) and encourage product innovation (Dachs et al., 2014). All these points to an improvement in the competitive advantage of the manufacturing firm as a result of offering services, which will enable them to expand into multiple markets and export more products. Cui and Liu (2018) argue that offering services can reduce trade costs, promote innovation and lead to the production of more heterogeneous products, all of which will enable manufacturing firms to survive longer in international markets and expand into more international markets. All these points to an improvement in the competitive advantage of a firm as a result of offering services, which will enable them to expand into multiple markets and offer multiple products. Therefore, we propose the following hypothesis.

H5: Selling Services Domestically is positively related to the extensive margins of manufacturing service exports.

Figure 3.1: Main Determinants of the Participation, Intensity and Strategy of Manufacturing Services Exports



3.4 DATA, STYLISED FACTS AND METHODOLOGY.

In this section, we present the data used in this study and some stylised facts characterising the data that will guide the empirical analysis.

3.4.1 Data and Variables

This analysis is based on data from two main sources: International trade in services data (ITIS) and the Annual Business Survey (ABS), both yearly surveys from the Office of National Statistics (ONS). The ITIS collects detailed information on different services imported and exported by UK firms to different destinations. We link the ITIS with the ABS which contains detailed financial information of UK businesses that have at least 100 employees. The linked sample of ITIS and ABS consists of an average of 45,000 firms per year, containing both service traders and non-service traders. The study focuses on the manufacturing sector between 2011-2018 and in the linked sample, there is an average of 7,000 manufacturing firms per year. The time period is chosen due to the availability of goods trade information from 2011. The data is cleaned following the standard procedure by dropping some missing observations and assuming that firms with missing service trade information do not undertake service trade in that year. After the cleaning process, we end up with a sample of 6,000 manufacturing firms a year. Of these firms, 2% are intermittent exporters who exit and re-enter the exporting market in the sample period while about 8% exit the export market and never re-enter. So, the data exhibits some dynamism in the entry and exit patterns of manufacturing firms from the services exports markets.

Lastly, this data is then linked to the Business Structural Database (BSD) to get information on the age of the firms. The ABS data is considered a representative sample as it covers businesses that represent approximately two-thirds of the UK economy by Gross Value Added (GVA). However, the survey focuses on large enterprises i.e. at least 100 employees, and this can introduce a selection bias in the models which we account for in the analysis.

In terms of the dependent variables, we measure manufacturing service export participation as a binary variable coded 1 or 0, indicating if the firm undertook service trade that year or not. This measure of export has been used widely in the literature (Gourlay et al., 2005; Javalgi et al., 1998; Roper et al., 2006). Also, we measure service export intensity as the ratio of service exports to turnover in the year while the extensive margins are measured as the number of destinations exported to and the number of services exported by the firm.

For the independent variables, productivity is measured as TFP using the Levinsohn-Petrin estimation with ACF correction. We use the log of the ratio of industrial and non-industrial services sold domestically to turnover to capture manufacturing firms' domestic services sales.[6] Firm size is measured as the log of employees, human capital of the firm is measured as the log of wages while technological capacity is measured as the firm's investment in patents and computer software. We also include dummies for service exporting experience (1 if the firm has ever exported services, 0 otherwise) and foreign ownership (1 if the firm is foreign owned, 0 otherwise). Lastly, data on goods trade is limited in the ABS database as they do not report the value of goods traded by firms and only report if the firm trades in goods or not in a particular year. This is a limitation in the data that prevents us from analysing the impact of goods trade on service exports in line with the literature. In order to overcome this limitation, we use a binary variable to capture goods exports (1 if the firm exports goods in the time period, 0 otherwise). Although this measure is not perfect, it mitigates against potential model bias e.g. omitted variable bias, if we do not include this variable at all.

[6] Industrial services include services such as repairs, maintenance and installation while non-industrial services are services such as computer processing, advertising, transport and delivery, management fees and technical research.

3.4.2 Stylised Facts

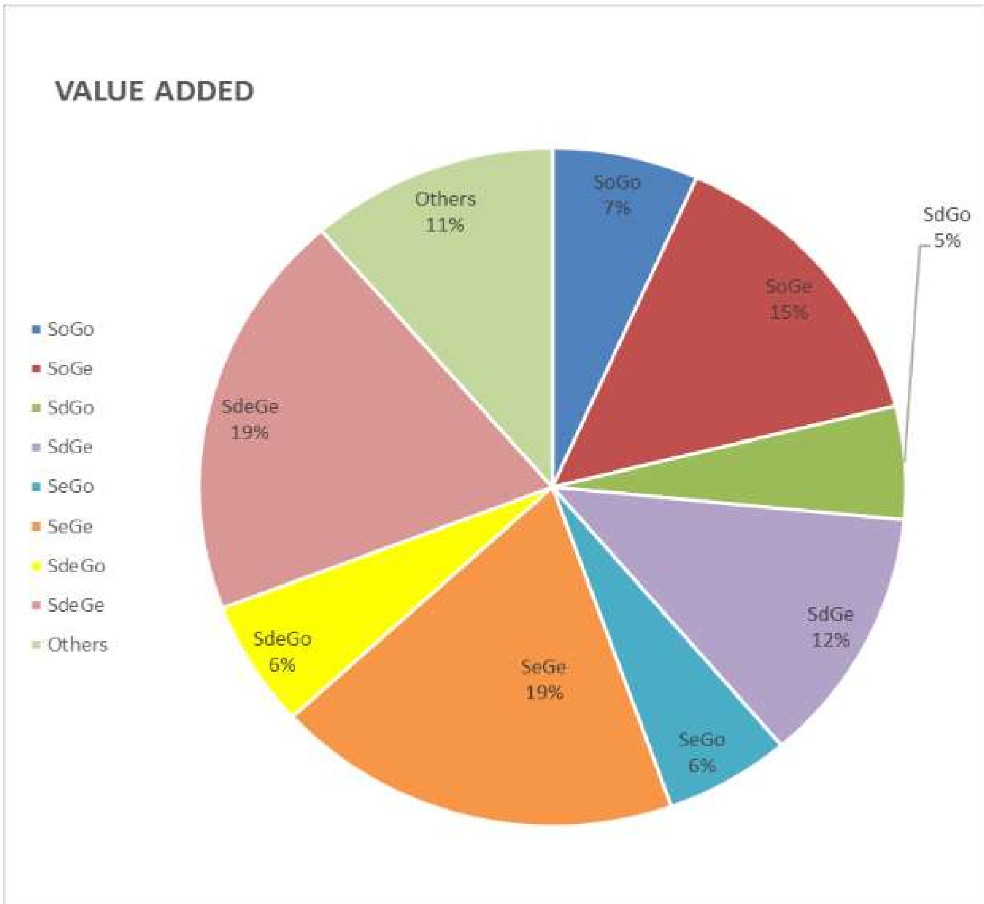
Table 3.1: Breakdown of Categories of Service and Goods Traders for the Manufacturing Sector

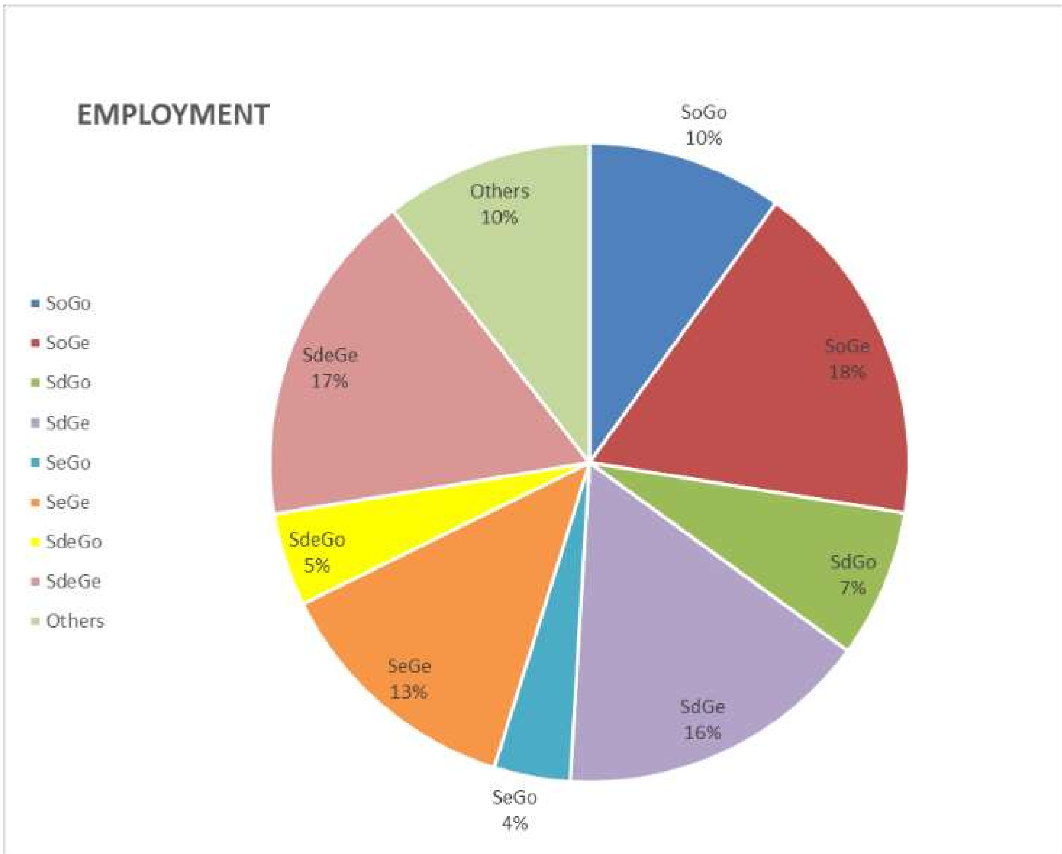
Service Trade Categories	**Service Trade categories and non-exporters of Goods**	**Service Trade categories and exporters of Goods**	**Total**
Service exporter and domestic provider Average Age	1,255 (3%) 25 years	5,306 (11%) 28 years	6,561 (14%) 28 years
Service Exporter Average Age	580 (1.3%) 29 years	1,901 (3.7%) 31 years	2,481 (5%) 30 years
Domestic Service provider Average Age	13,282 (29%) 21 years	12,030 (26%) 28 years	25,312 (55%) 25 years
Non-Service Provider Average Age	5,928 (13%) 21 years	5,872 (13%) 29 years	11,800 (26%) 25 years
Total	***21,045 (46%)***	***25,109 (54%)***	***46,154 (100%)***
	Non-Goods Trader	**Goods Exporter**	
	21,416 (45%) 22 years	**26,534 (55%)** 29 years	**47,950** 26 years

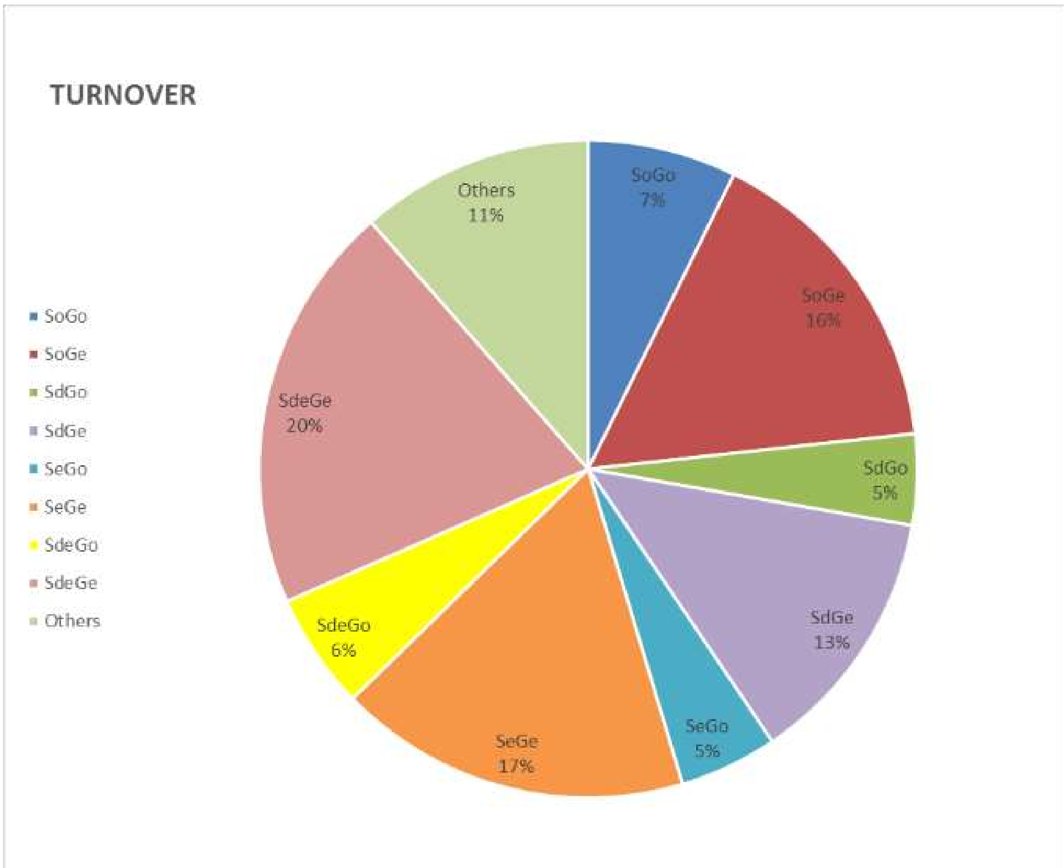
i) *Although 69% of the manufacturing firms sell services domestically, only 14% also export services.*

From table 3.1, we see a breakdown of the firms in the sample by their goods and services trading status. In the service trade category, we identify pure manufacturing firms, manufacturing firms that sell services domestically, manufacturing firms that export services, and manufacturing firms that sell services both at home and abroad. All the categories are mutually exclusive. The table shows that **19%** of manufacturing firms export services. This is comparable to Breinlich and Criscuolo (2011) who have about 22% of manufacturing firms exporting services. **4%** of these firms export only services and no goods, while only 26% of the firms do not sell services either domestically or internationally. Selling services domestically is more prevalent than exporting services with 55% of the firms offering services domestically with no service export, while 5% export services without selling services domestically. Only 14% of the firms sell services both domestically and internationally.

Figure 3.2: Contribution to GVA, Employment, Turnover and Service Exports for Manufacturing Firms




EMPLOYMENT
SoGo
SoGe
SdGo
SdGe
SeGo
SeGe
SdeGo
SdeGe
Others
SoGo 10%
SoGe 18%
SdGo 7%
SdGe 16%
SeGo 4%
SeGe 13%
SdeGo 5%
SdeGe 17%
Others 10%


TURNOVER
SoGo
SoGe
SdGo
SdGe
SeGo
SeGe
SdeGo
SdeGe
Others
SoGo 7%
SoGe 16%
SdGo 5%
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SeGe 17%
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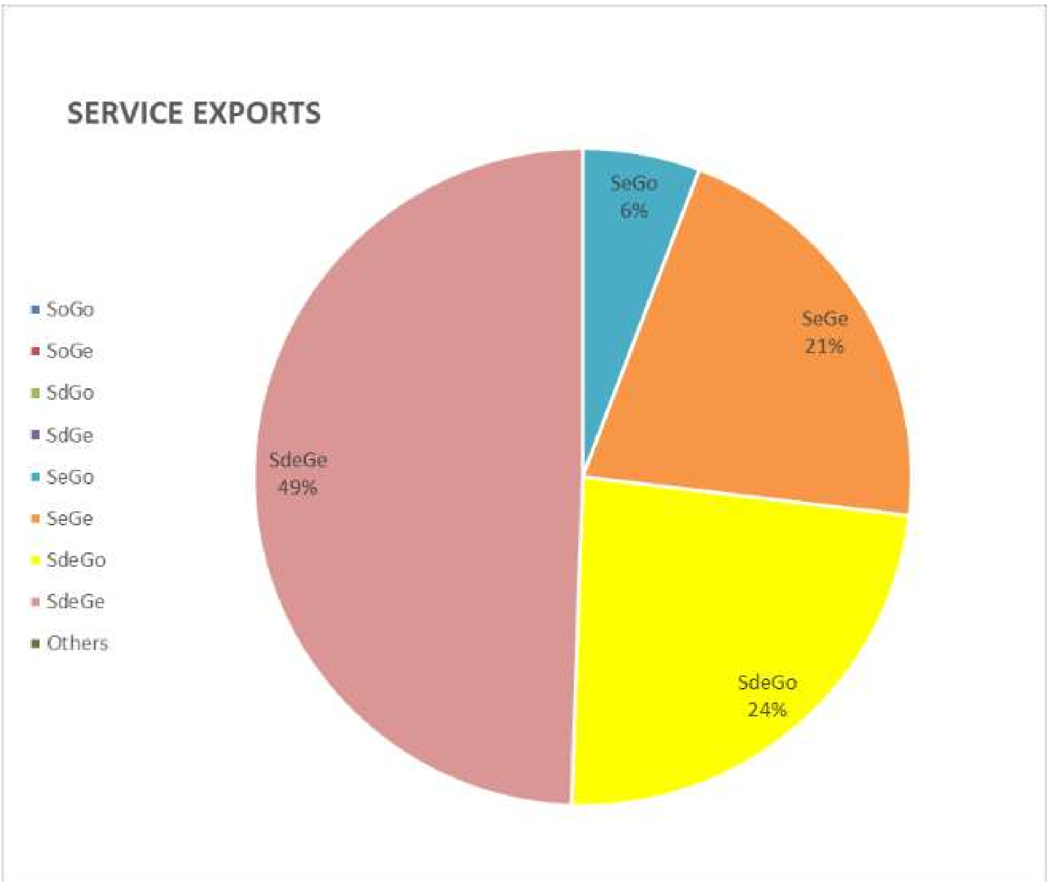
SdeGe 20%
Others 11%



Number of Observations: S_oG_o = 5,928. S_oG_e = 5,872. S_dG_o = 13,282. S_dG_e = 12,030. S_eG_o = 580. S_eG_e = 1,901. $S_{de}G_o$ = 1,255. $S_{de}G_e$ = 5,306. **Others** = 1,796
S_oG_o = Non-Service provider, Non-Goods Exporter. S_oG_e = Non-Service provider, Goods Exporter. S_dG_o = Sells Service domestically, Non-Goods exporter. S_dG_e = Sells Services domestically, Goods Exporter. S_eG_o = Service Exporter, Non-Goods exporter. S_eG_e = Service Exporter, Goods Exporter. $S_{de}G_o$ = Sells Services domestically and service exporter, Non-Goods exporter. $S_{de}G_e$ = Sells Services domestically and service exporter, Goods Exporter. **Others** = Other categories
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12

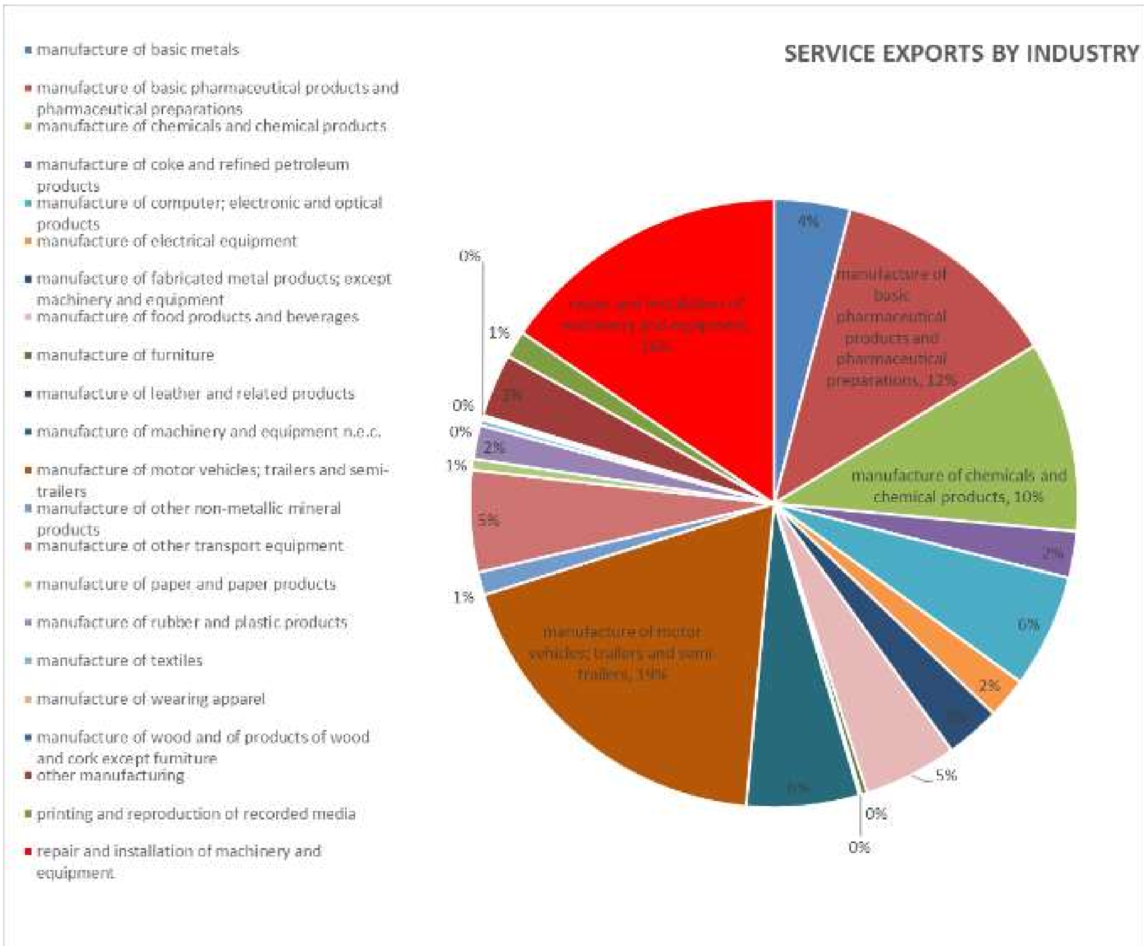
ii) Manufacturing firms that export services and goods contribute significantly to the economy in terms of Value added, Turnover and Employment, compared to the other categories of manufacturing firms.

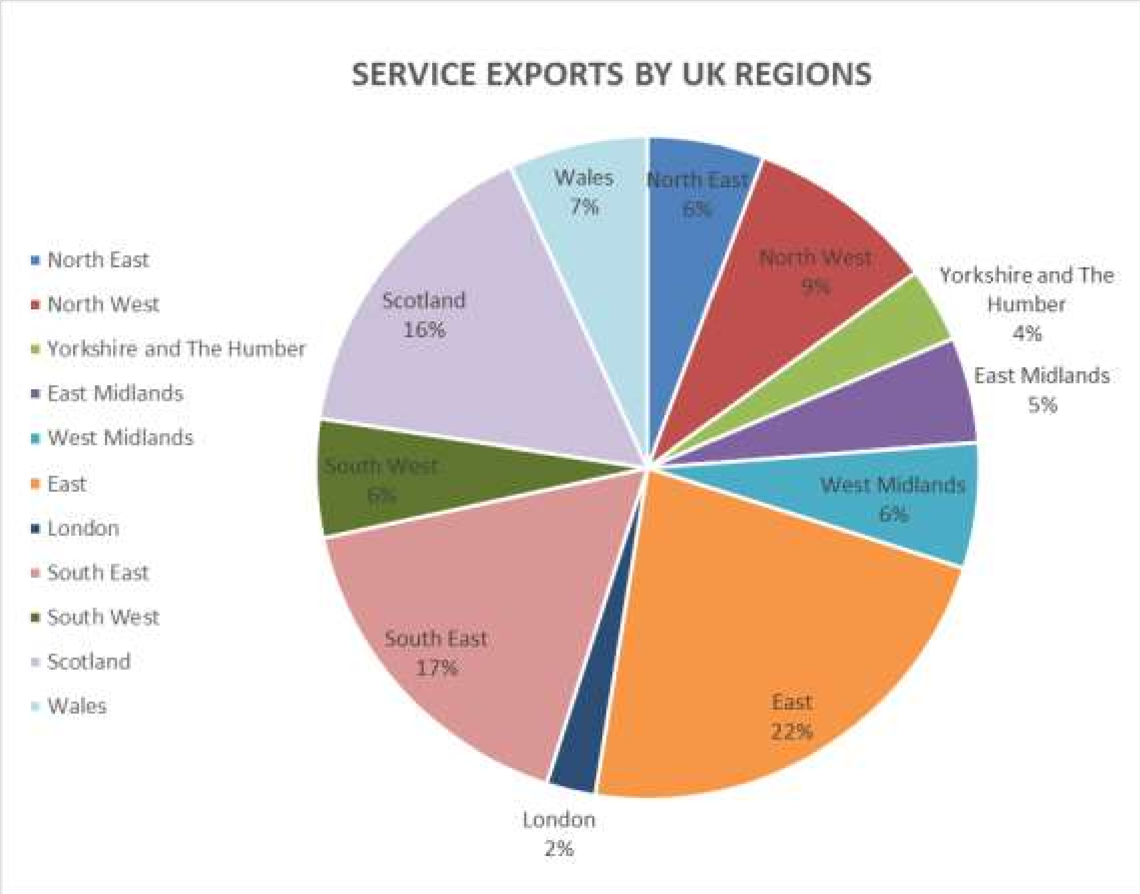
Although they only make up 3% of the sample, manufacturing firms that export both services and goods (S_eG_e) contribute significantly to the economy making up 19% of value added, 13% of employment and 17% of turnover. The other category with a high contribution to value added, employment and turnover is the manufacturing firms that sell services both domestically and internationally, in addition to exporting goods ($S_{de}G_e$). They contribute 19% contribution to value added, 17% to employment and 20% to turnover. Lastly, manufacturing firms who sell services either domestically or internationally, but with no goods exports have a smaller contribution to value added, employment and turnover, with only about 6%. This shows that firms who combine goods export with either selling services domestically or internationally are bigger in terms of value added, employment and turnover, compared to manufacturing firms that only sell services domestically or internationally with no goods export.

iii) *Manufacturing firms that sell services domestically and internationally, and also export goods account for the majority of service exports.*

Although these firms ($S_{de}G_e$) make up 11% of the sample, they account for 49% of the service exports. The category with the smallest contribution to the service exports is manufacturing firms that only export services and neither sell services domestically nor export goods (S_eG_0). This category only accounts for 6% of service exports. Lastly, manufacturing firms who do not export goods but sell services both domestically and internationally ($S_{de}G_0$) have the second largest contribution to service exports with 24%. This seems to reinforce the interrelation between goods and services exports (Ariu et al., 2019).

Figure 3.3: Industry and Region Breakdown of Service Exports by Manufacturing Firms





Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12

iv) Manufacturing industries and UK regions are heterogeneous with regard to their level of services export.

With regards to the value of service exports by manufacturing firms within UK regions, three regions (i.e. East, South East and Scotland) account for more than 50% of the total value of service exports by manufacturing firms. For the industries which are at the SIC 2007 2-digit level, four industries (Motor vehicles, Repair and Installation of Machinery and Equipment, Manufacture of Basic pharmaceutical products and Manufacture of Chemicals) account for almost 60% of the value of service exports by manufacturing firms.

Table 3.2: Conditional Test of Difference in Means between Categories of Manufacturing Firms

Variables	Service Exporters (mean) (Obs = 9,041)	Service Non-Exporters (Mean). (Obs = 38,908)
TFP	3.5*	3
Age (years)	29*	25
Size: Employees	304*	112
Size: Turnover (Log)	9.4*	7.7
Wages (Log)	7.8*	6*
Investment in Patents per employee (log)	0.02*	0.01
Investment in Purchased Software per employee (log)	0.2*	0.1
Industrial Domestic Services Provided/Turnover (Log)	0.07*	0.04
Non-Industrial Domestic Services Provided/Turnover (Log)	0.017*	0.012
Subsidy received (Log)	0.3*	0.1

** Difference significant at 5% or better on a two tailed t-test.* Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12

v) On average, manufacturing firms that export services are more productive, bigger in terms of employment and turnover, older, more innovative/invest in more intangible assets and have a higher level of selling services domestically compared to manufacturing firms that do not export services.

From Table 3.2, we see that manufacturing firms that export services have a higher average labour productivity (TFP) compared to non-service exporters, even though the non-service exporters outnumber the service exporters firms four times to one. This difference is also seen for wages, size, age, investment in intangible assets and selling services domestically, and these differences are statistically significant. So, on average, service-exporting manufacturing firms are more productive, bigger, older, sell more services domestically and invest more in intangible assets compared to non-service-exporting manufacturing firms. These preliminary observations are similar to patterns already identified in the literature (Ariu, 2012; Breinlich and Criscuolo, 2011; Love and Mansury, 2009). Given the debate in the literature on whether these differences between service exporters and non-exporters are a result of the selection mechanism or the learning by exporting mechanism, we argue that these observed differences between service-exporting manufacturing firms and non- service-exporting manufacturing firms are due to the selection mechanism.

3.4.2 Descriptive Statistics and Methodology

In this section, we outline the empirical strategy that will operationalise our hypothesis testing. To test the selection mechanism, a logit model with random effects will be estimated with the dependent variable being a binary outcome of 1 or 0 indicating if the firm exported services in that time period or not. To investigate the factors affecting the service export intensity for manufacturing firms, a Tobit regression will be estimated with the dependent variable being the export intensity which is measured as the ratio of service exports to turnover. A Tobit model is estimated because there could be censorship in the data as firms with less than £5,000 in service exports are not considered to have exported services i.e. reported as having zero service exports. This variable takes a value between 0 and 1. To test the extensive margins hypotheses, a Poisson estimation is utilised where the dependent variable is a count variable of the number of products and destinations a firm exports and exports to.

Table 3.3: Summary Statistics of Relevant Variables

Variable	Observations	Mean	Std. Dev.
Export intensity	56,372	0.11	0.20
Log TFP	56,374	4.81	1.6
Log employees	56,374	3.64	1.67
Log average wage	56,373	2.93	0.98
Age	54,953	26	13.11
Log Patent per employees	56,373	0.01	0.11
Log Average purchased software	56,373	0.11	0.33
Log Average computer service purchased	54,447	0.01	0.04
Log Average Telecom service purchased	54,447	0.01	0.04
Log Average Industrial service purchased	54,447	0.03	0.05
Log industrial services provided/Turnover	56,374	0.05	0.12
Log non-industrial services provided/Turnover	56,374	0.01	0.04
Log subsidy	56,374	0.15	0.74
Exchange rate	56,374	0.70	0.03
Extensive margins			
Number destination exports	4,467	8.97	11.53
Number products exports	4,467	1.76	1.39
Log Number destination exports	4,467	1.80	0.96
Log Number products exports	4,467	0.93	0.37

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In table 3.3, we present the summary statistics of the relevant variables used in this study. On average, for service-exporting manufacturing firms, service exports make up 12% of their total turnover. This is comparable to the 18% observed by Breinlich and Criscuolo (2011) for manufacturing firms in the UK.

Also, the manufacturing firms in the sample are older firms with the average age being 26 years. Lastly, manufacturing firms export to an average of 9 destinations and export an average of 1 service type. This is also comparable to the findings of Breinlich and Criscuolo (2011) who have the average number of destinations exported to as 6 and the average number of service types exported as 1.

3.5 MODEL AND ESTIMATION

3.5.1 Determinants of Participation and Intensity of Manufacturing Service Exports

We estimate both a logit model with random effects and a Tobit model to analyse the determinants of participation and intensity of manufacturing service exports respectively, incorporating the variables that have been identified in the theoretical arguments and empirical studies.

$$SE_{it} = \alpha_i + \beta_1 Productivity_{it} + \beta_2 FSA_{it} + \beta_3 DS_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (1.1)$$

Where SE_{it} is the service exports of manufacturing firms defined in two ways. For the participation in service exports, it is specified as a binary variable taking a value of 1 if the firm exports services in time t and 0 otherwise. In this instance, a logit model with random effects is estimated. When analysing the intensity of service exports, it is specified as the ratio of service exports to turnover. In this instance, a Tobit model with a lower limit of 0 and an upper limit of 1 is estimated. Productivity is the firm's TFP calculated using the Levinsohn-Petrin estimation with ACF correction. FSA_{it} is a vector containing firm size which is measured as the log of the number of employees, and the level of employees' skills which is measured as the log of employee wages and technological resources measured as the log of the average investment in patents and expenditure on computer software. DS_{it} is the domestic services i.e. services sold domestically by manufacturing firms, which is measured as the log of the ratio of industrial and non-industrial services sold at home to turnover, while X_{it} is a vector of controls including ownership, service exporting experience, goods export status, subsidy received by the firm and the yearly exchange rate. In this study, DS_{it} is the main variable of interest.

3.5.2 Determinants of Extensive Margins of Manufacturing Services Exports

After a manufacturing firm enters the service exports market, the firm can export just one service type or multiple services and can also export to just one destination or multiple destinations. In this section, we model the factors that affect the extensive margins of services exports of the firm.

$$EM_{it} = \alpha_i + \beta_1 Productivity_{it} + \beta_2 FSA_{it} + \beta_3 DS_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (1.2)$$

Where EM_{it} is the extensive margins of the firm and it is measured in four ways: a binary variable taking the value of 1 if the firm exports to more than one destination and 0 otherwise, another binary variable taking the value of 1 if the firm exports more than one service type and 0 otherwise, count variables for the number of destinations a firm exports to and the number of products it exports. A logit model with random effects is used to estimate the binary choice models while a Poisson model is used to estimate the count models. For both models, the Inverse Mills Ratio (IMR) calculated from model (1) is included to correct for selection bias. Other variables remain the same as defined above.

3.6 RESULTS

3.6.1 Determinants of Manufacturing Services Export Participation and Intensity

In table 3.4, we estimate the model for the determinants of manufacturing services export participation. In model (1), we estimate a probit model with random effects and in model (2), a logit model with random effects is estimated. The results from both estimations are similar and show evidence for hypotheses 1a, 2a and 3a. Specifically, the findings show support for the selection mechanism as productivity proxied by TFP is positive and significant for service export participation of manufacturing firms. This indicates that the more productive a manufacturing firm is, the higher its probability of exporting services. The coefficient from model (2) in table 3.4 shows that an increase in TFP by 1% increases the probability of exporting services by about 0.12%.

We also find evidence for other FSAs enabling manufacturing services export participation. The results show a positive effect for size, employees' skills measured by the log of wages and the technological resources of the firm measured by the average investment in patents and computer software. These results are expected based on the evidence from previous studies (Bernard and Wagner, 1997; Gourlay et al., 2005; Love and Mansury, 2009; Roper et al., 2006). A 1% increase in size, employees' skills and average patent expenditure increase the probability of exporting services by 0.27%, 0.2% and 0.2% respectively.

Table 3.4. Regression Results on the Determinants of Manufacturing Service Export Participation

VARIABLES	(1) participation (probit, RE)	(2) participation (logit, RE)	(3) participation (logit, RE) (non-high-tech)	(4) participation (logit, RE) (high-tech)
Firm Characteristics				
Log TFP	0.0711***	0.124***	0.119***	0.141*
	(0.0191)	(0.0342)	(0.0387)	(0.0732)
Log employee	0.278***	0.469***	0.442***	0.540***
	(0.0197)	(0.0346)	(0.0386)	(0.0769)
Log average wage	0.197***	0.362***	0.352***	0.383***
	(0.0256)	(0.0463)	(0.0532)	(0.0953)
Log age	-0.0810***	-0.145***	-0.120**	-0.209**
	(0.0244)	(0.0431)	(0.0485)	(0.0936)
Intangible Assets				
Log patent per employees	0.213***	0.376***	0.463***	0.166
	(0.0797)	(0.140)	(0.160)	(0.237)
Log purchased software per employee	0.197***	0.338***	0.327***	0.396***
	(0.0346)	(0.0611)	(0.0716)	(0.120)
Domestic Services Provided				
Log Industrial services provided/Turnover	0.735***	1.329***	1.340***	1.303***
	(0.131)	(0.232)	(0.332)	(0.340)
Log Non-Industrial services provided/Turnover	2.441***	4.289***	5.343***	2.484**
	(0.329)	(0.581)	(0.715)	(1.002)
External Factors				
Log subsidy	0.147***	0.261***	0.267***	0.222***
	(0.0160)	(0.0285)	(0.0307)	(0.0716)
Exchange rate	0.909	1.077	0.132	2.804
	(0.741)	(1.309)	(1.464)	(2.885)
Dummies				
Goods export	0.637***	1.149***	1.144***	1.197***
	(0.0376)	(0.0688)	(0.0776)	(0.149)
Ever exported services	0.421***	0.832***	0.847***	0.918***
	(0.0449)	(0.0772)	(0.0872)	(0.167)
Foreign owned	0.444***	0.784***	0.809***	0.676***
	(0.0410)	(0.0719)	(0.0805)	(0.159)
Constant	-4.389***	-7.370***	-6.556***	-9.580***
	(0.548)	(0.963)	(1.068)	(3.077)
Observations	50,130	50,130	41,145	8,970
Number of entref	23,989	23,989	19,698	4,474

Robust standard errors are in parentheses. Standard errors clustered by industry. Region, year and industry dummies included. *** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.

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Next, we turn out attention to the services sold domestically by the manufacturing firms. This is measured as the log of the ratio of industrial and non-industrial services sold by the firm to its turnover. The results show a positive and statistically significant relationship between selling services domestically and manufacturing services export participation. This confirms our hypotheses 3a and 3b as we argue that not only does selling services domestically improve the competitive advantage of manufacturing firms as shown by (Crozet and Milet, 2017; Dachs et al., 2014), but it is also an avenue of learning which facilitates successful export of services by these firms. For the controls, the results show a negative relationship for age, indicating that younger manufacturing firms are more likely to export services. This is in line with the finding by Roper et al. (2006) who finds a negative relationship between age and exporting for Irish firms. Also, the results show that foreign ownership, previous service exporting experience and goods exporting status are positively related to manufacturing services export participation.

In (3) and (4), we divide the sample into high-tech and low-tech manufacturing firms.[7] The results from model (2) are largely unchanged for both the high-tech and low-tech manufacturing firms, showing that the variables explain manufacturing services export participation for both high-tech and low-tech manufacturing firms.

[7] The definition of High-Tech and Low-Tech manufacturing industries the Eurostat and OECD definition, which is based on the R&D and knowledge intensity of the industries.

Table 3.5. Regression Results on the Determinants of Manufacturing Services Export Intensity

VARIABLES	(1) export_intensity (Tobit, RE)	(2) export_intensity (Tobit, RE) (non-high-tech)	(3) export_intensity (Tobit, RE) (high-tech)
Firm Characteristics			
Log TFP	0.0136***	0.0122***	0.0175***
	(0.00256)	(0.00276)	(0.00583)
Log employee	0.0469***	0.0423***	0.0580***
	(0.00262)	(0.00285)	(0.00595)
Log average wage	0.0304***	0.0291***	0.0334***
	(0.00331)	(0.00369)	(0.00705)
Log age	-0.0166***	-0.0144***	-0.0217**
	(0.00421)	(0.00452)	(0.00987)
Intangible Assets			
Log patent per employees	0.00947	0.00469	0.0250
	(0.00952)	(0.0108)	(0.0194)
Log purchased software per employee	0.0101**	0.0160***	0.00335
	(0.00445)	(0.00505)	(0.00907)
Domestic Services Provided			
Log Industrial services provided/Turnover	0.0909***	0.0897***	0.0996***
	(0.0179)	(0.0247)	(0.0289)
Log Non-Industrial services provided/Turnover	0.361***	0.376***	0.318***
	(0.0453)	(0.0524)	(0.0898)
External Factors			
Log subsidy	0.0106***	0.0116***	0.00514
	(0.00175)	(0.00183)	(0.00426)
Exchange rate	0.698***	0.643***	0.849***
	(0.103)	(0.109)	(0.248)
Dummies			
Ever exported services	0.00195	-0.00393	0.0162
	(0.00447)	(0.00478)	(0.0103)
Foreign owned	0.0609***	0.0589***	0.0584***
	(0.00569)	(0.00617)	(0.0129)
Constant	-1.027***	-0.945***	-1.369***
	(0.0748)	(0.0788)	(0.293)
Observations	50,128	41,144	8,984
Number of entref	23,988	19,697	4,483

Robust standard errors are in parentheses. Standard errors clustered by industry. Region, year and industry dummies included. *** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
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In table 3.5, we analyse the determinants of manufacturing services export intensity. From the results, we see a smaller impact of productivity on the intensity. Specifically, an increase in TFP by 1% will increase the manufacturing services export intensity by 0.013%. Also, there is a positive and significant result for size and wages, with a 10% increase leading to a 0.4% and 0.3% increase in manufacturing services export intensity, respectively. In this specification, the firm's investments in patents do not seem to affect the intensity, while investment in purchased software does. Lastly, we consider the variables for selling services domestically, and the results show that they are positively and significantly related to export intensity. A 1% increase in either the ratio of industrial or non-industrial services provided to turnover will increase the manufacturing services export intensity by about 0.1% - 0.4%, and this holds for both the high-tech and non-high-tech firms.

3.6.2 Determinants of the Extensive Margins of Manufacturing Services Export

In table 3.6, we estimate the model examining the determinants of manufacturing services export extensive margins. In these estimations, we correct for selection bias by adding the IMR calculated from model (2) in table 3.4 as an additional independent variable. The exclusion restriction is the goods export variable as this could affect the selection into exporting services by manufacturing firms but should not affect the extensive margins of services export. The IMR is negative and significant in most specifications, validating our inclusion of it. In models (1) to (4), the results show that TFP is insignificant in determining the extensive margins. It has a negative sign for the probability of a firm exporting multiple service products or to multiple destinations. However, this is not significant. The results also show that bigger firms export more service types and also export to more destinations. This is expected as bigger firms enjoy economies of scale and may have more internal resources, enabling them to enter multiple export markets and export multiple products. Lastly, we consider the impact of selling services domestically on manufacturing services export extensive margins. While industrial services (repairs, maintenance, etc.) are positively related to the number of destinations exported to, non-industrial services (computer processing, advertising, etc.) are positively related to the number of products exported. This alludes to the existence of a heterogeneous effect between the types of services sold domestically on the different measures of the extensive margins. However, investigating the nature and extent of this heterogeneous effect is beyond the scope of this paper.

Table 3.6. Regression Results on the Determinants of the Extensive Margins of Manufacturing Services Exports

VARIABLES	(1) Multiple Products Export (Logit, RE, margins)	(2) Number of Products exported (Poisson)	(3) Multiple destinations export (Logit, RE, margins)	(4) Number of destinations exports (Poisson)
Firm Characteristics				
Log TFP	-0.00680	0.00614	-0.00256	0.0257
	(0.00800)	(0.0177)	(0.00950)	(0.0218)
Log employee	0.0155*	0.0525***	-0.00699	0.0584***
	(0.00930)	(0.00926)	(0.0111)	(0.0190)
Log average wage	0.0405***	-0.0127	0.0367	0.0525
	(0.0139)	(0.0432)	(0.0326)	(0.0409)
Log age	0.0366**	0.0464*	0.0395*	0.112***
	(0.0154)	(0.0237)	(0.0240)	(0.0354)
Intangible Assets				
Log patent per employees	0.0268	-0.00438	0.0123	-0.00659
	(0.0241)	(0.0196)	(0.0146)	(0.0354)
Log purchased software per employee	0.0113	0.0129	0.00683	0.0627**
	(0.00798)	(0.0276)	(0.0175)	(0.0267)
Domestic Services Provided				
Log Industrial services provided/Turnover	0.0457	-0.0432	0.0716	0.361***
	(0.0612)	(0.111)	(0.0803)	(0.0335)
Log Non-Industrial services provided/Turnover	0.182	0.875***	0.142	0.428
	(0.127)	(0.249)	(0.199)	(0.276)
External Factors				
Log subsidy	0.00453	0.0172**	0.00425	0.0102
	(0.00432)	(0.00702)	(0.00478)	(0.00896)
Exchange rate	-0.836**	-0.378	-1.094***	-1.672**
	(0.334)	(0.378)	(0.360)	(0.824)
IMR	-0.413	-0.00638	-0.401	-0.0703***
	(0.294)	(0.0252)	(0.301)	(0.0262)
Dummies				
Ever exported services	0.0850***	0.0437***	0.115***	0.0969***
	(0.0171)	(0.0150)	(0.0147)	(0.0258)
Foreign owned	0.00626	0.0359*	-0.0498**	-0.0893***
	(0.0147)	(0.0185)	(0.0215)	(0.0288)
Constant	-1.759	-0.310	4.435	0.610
	(3.930)	(0.339)	(4.019)	(0.646)
Observations	6,088	4,342	6,088	4,342

Robust standard errors are in parentheses. Standard errors clustered by industry. Region, year and industry dummies included. Multiple products exported is a dummy = 1 if the firm exports more than one service type and 0 otherwise. Also, multiple destinations exported is a dummy = 1 if the firm exports services to more than one destination and 0 otherwise.
*** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
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3.7 ROBUSTNESS CHECKS

3.7.1 Instrumental Variables Estimation

A source of concern for the validity of our results is potential endogeneity and/or reverse causality that might exist in the model. There might be omitted variables that are not captured in the model, therefore introducing bias to the results. To address this concern, we use the ratio of *domestic services purchased* as instruments for the *service sold domestically*. We argue that *domestic services purchased* are complementary to *services sold domestically* as firms would ultimately source for services they cannot provide. Specifically, we use the ratio of the domestic services purchased to turnover (industrial, computer, telecommunications, advertisement and other services purchased) as instruments for the ratio of industrial and non-industrial services provided to turnover. We estimate a two- stage probit and Tobit regression to test the validity of our results.

Table 3.7. Instrumental Variable Regression: Instrumenting Services Sold Domestically.

VARIABLES	(1) Log Industrial services provided/Turnover (IV First stage)	(2) Log Non-Industrial services provided/Turnover (IV First stage)	(3) Export Services (IV Probit second stage)	(4) Export Intensity (IV Tobit second stage)
Firm Characteristics				
Log TFP	0.00746***	0.00267***	0.0320***	0.0112***
	(0.000602)	(0.000251)	(0.0114)	(0.00273)
Log employee	0.00271***	0.000005	0.0800***	0.0182***
	(0.000510)	(0.000205)	(0.00906)	(0.00214)
Log average wage	-0.000667	-0.00290***	0.138***	0.0386***
	(0.000797)	(0.000355)	(0.0145)	(0.00335)
Log age	-0.000489	-0.000007	-0.0523***	-0.0127***
	(0.000737)	(0.000294)	(0.0135)	(0.00333)
Intangible Assets				
Log patent per employees	-0.0128***	-0.00262**	0.201***	0.0237*
	(0.00214)	(0.00122)	(0.0572)	(0.0133)
Log purchased software per employee	-0.00361***	0.00214***	0.128***	-0.00413
	(0.00124)	(0.000609)	(0.0242)	(0.00548)
Domestic Services Provided (Endogenous variables)				
Log Industrial services provided/Turnover			2.517**	-0.234
			(1.174)	(0.265)
Log Non-Industrial services provided/Turnover			4.594**	3.845***
			(2.255)	(0.513)
Instruments (Services purchased				

domestically)				
Log Industrial services purchased/Turnover	-0.108***	0.111***		
	(0.0374)	(0.0164)		
Log Computer services purchased/Turnover	0.499***	0.355***		
	(0.141)	(0.0659)		
Log Telecom services purchased/Turnover	3.529***	1.111***		
	(0.251)	(0.111)		
Log Advert services purchased/Turnover	-0.172***	0.0173		
	(0.0309)	(0.0153)		
Log Other services purchased/Turnover	0.0669***	0.0500***		
	(0.0144)	(0.00663)		
External Factors				
Log subsidy	-0.000127	-0.000196	0.0940***	0.0135***
	(0.000453)	(0.000205)	(0.00876)	(0.00213)
Exchange rate	-0.0628**	0.0159*	-5.274***	-0.988***
	(0.0258)	(0.00904)	(0.484)	(0.122)
Dummies				
Goods export	-0.0183***	-0.00197***	0.512***	
	(0.00100)	(0.000365)	(0.0260)	
Ever exported services	0.00957***	0.00241***	1.326***	0.252***
	(0.00127)	(0.000446)	(0.0205)	(0.00521)
Foreign owned	-0.00186*	0.000374	0.249***	0.0463***
	(0.00112)	(0.000411)	(0.0190)	(0.00476)
Constant	0.0550***	0.000494	1.300***	0.173**
	(0.0178)	(0.00625)	(0.334)	(0.0843)
Observations	50,130	50,130	50,130	50,128
R-squared	0.452	0.086		
F- Statistic	**783.18**	**89.59**		
Wald Test of Exogeneity			**31.46*** **	**113.76*** **

Robust standard errors are in parentheses. Standard errors clustered by industry. Region, year and industry dummies included. *** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.

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In line with standard practice, the first-stage F-statistic is used for testing the hypothesis that the instruments are not weak and are unrelated to the endogenous regressor (selling services domestically in this case). Typically, the first stage F-statistic should be greater than 10 in order to rule out weak instruments. From table 3.7, we have an F-statistic that exceeds this threshold. Also, the Wald test for exogeneity is statistically significant, indicating that endogeneity was present in the estimated models and previous results might be misleading. However, the results from the instrumental variables estimation still show a positive relationship between selling services domestically and manufacturing services export participation, with a larger magnitude compared to the baseline model. For export intensity, we also find a positive and significant relationship between non-industrial services and manufacturing services export intensity utilising the instrumental variable approach. Overall, addressing potential endogeneity concerns in our baseline model by adopting an instrumental variable approach does not alter our results, as we still find a positive and significant association between selling services domestically and manufacturing services export participation and intensity.

Endogeneity in a model can arise from different sources such as sample selection, measurement errors, simultaneity, etc. In the case of simultaneity, the endogenous explanatory variables and the explanatory variable are determined through a system of equations such that they are correlated with the error term through feedback from the dependent to the endogenous explanatory variables (Blundell and Powell, 2001). Given that our model is a non-linear model with continuous endogenous regressors, we also utilise a Generalised Structural Equation Model (GSEM) approach to address the endogeneity/simultaneity in the model. The results from table 3.8 are in line with the results from our baseline model as we still see a positive and statistically significant relationship between selling services domestically and manufacturing services export participation. This rules out the possibility of endogeneity through the presence of simultaneity in the model.

Table 3.8. Generalised Structural Equation Regression: Instrumenting Services Sold Domestically

VARIABLES	(1) Export services	(2) Log Industrial services provided/Turnover	(3) Log Non-Industrial services provided/Turnover
Firm Characteristics			
Log TFP	0.0834***	0.00999***	0.00265***
	(0.0201)	(0.000635)	(0.000188)
l_employee	0.141***	0.00313***	-1.45e-05
	(0.0161)	(0.000529)	(0.000156)
l_avg_wage	0.290***	0.00212***	-0.00269***
	(0.0269)	(0.000780)	(0.000231)
l_age	-0.106***	-0.00975***	-0.000476**
	(0.0247)	(0.000815)	(0.000241)
Intangible Assets			
l_patent_employees	0.285***		
	(0.0954)		
l_avg_purchased_software	0.219***		
	(0.0389)		
Domestic Services Provided (Endogenous variables)			
Log Industrial services provided/Turnover	1.301***		
	(0.137)		
Log Non-Industrial services provided/Turnover	3.578***		
	(0.351)		
Instruments (Services purchased domestically)			
Log Industrial services purchased/Turnover		-0.478***	0.0997***
		(0.0340)	(0.0101)
Log Computer services purchased/Turnover		1.937***	0.464***
		(0.124)	(0.0368)
Log Telecom services purchased/Turnover		5.539***	1.354***
		(0.171)	(0.0505)
Log Advert services purchased/Turnover		-0.944***	-0.0299***
		(0.0375)	(0.0111)
Log Other services purchased/Turnover		0.0297**	0.0531***
		(0.0122)	(0.00362)
External Factors			
l_subsidy	0.162***	-0.00151**	-0.000194
	(0.0152)	(0.000682)	(0.000202)
exchange_rate	-10.28***		
	(0.834)		
Dummies			
1.export_goods	0.838***		
	(0.0338)		

1.ever_export_serv	2.285***		
	(0.0329)		
1.foreign_owned	0.429***		
	(0.0327)		
Constant	3.043***	0.0544***	0.0141***
	(0.578)	(0.00270)	(0.000797)
Observations	54,952	54,952	54,952

Robust standard errors are in parentheses. Standard errors clustered by industry. Region, year and industry dummies included. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Entref is the unique company identifier.
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
Office of National Statistics. (2019). *International Trade in Services, 1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

Lastly, we introduce a lag structure to all the models to check for dynamic effects. The results remain roughly the same. For the manufacturing services export participation, the results indicate that the previous period's productivity, size and employees' skills are positively related to manufacturing services export participation, while technological resources of the previous period are not significant. Also, we see that the services sold domestically in the previous period are also a positive predictor of manufacturing services' export participation. For export intensity, only the previous period's employees' skills are significant for the firm's FSA. Also, the previous period's services sold domestically are positive and significant for export intensity. Generally, the findings for selling services domestically remain consistent as the previous period's domestic services sales are also positively related to the extensive margins of services export. The results are presented in Table 3.9 of the appendix.

3.8 DISCUSSION AND IMPLICATIONS

This study aims to investigate the factors that affect the different aspects of service exports of manufacturing firms. Specifically, the study looks at the factors affecting the services export participation, intensity and strategy of manufacturing firms. We develop and test models examining the relationship between productivity, FSAs and services sold domestically on these different aspects of manufacturing services export. We find that manufacturing firms that are more productive, innovative and bigger, and who have high levels of employee skills and sell services domestically are more likely to enter service exports markets, have a higher service export intensity, and have more extensive margins in terms of the number of products sold and number of export destinations. These findings are in line with the selection argument that only certain firms can participate in export markets due to the competitive advantages they possess (Bernard and Jensen, 1999; Melitz, 2003).

A key finding from this study is the importance of selling services domestically to service the export behaviour of manufacturing firms. Not only does it facilitate entry into service exports for manufacturing firms, but it also determines their exporting intensity and market. This finding complements previous empirical findings which have mostly identified the importance of productivity and FSAs in determining firms' export behaviour. By accounting for the role played by domestic services sales, this study identifies an additional factor that is important for explaining the service export behaviour of manufacturing firms.

Carrying out robustness checks reinforces our findings. The instrumental variable estimation and GSEM produces the same results, reiterating the importance of domestic services sales to service export participation, intensity and strategy for manufacturing firms. Introducing a lag structure to the model, we still find that domestic services sales from the previous period are positively related to manufacturing services export participation, intensity and extensive margins. This also seems to tie into the selection argument because it can be seen as firms increasing their domestic activities in preparation for future entry into the export market (Lodefalk, 2014).

3.8.1 Contributions

In some aspects, the results from this study are similar to those documented in the studies for exporting for manufacturing firms and goods export. Like (Bernard and Jensen, 2004; Love and Mansury, 2009), we find evidence for a strong selection effect into service exports by manufacturing firms based on firm productivity. Also, we account for the FSAs by examining the effect of firm size, employee skills and technological resources on the firms. We find a positive relationship between these FSAs and manufacturing services export participation, which are in line with some studies (Bernard and Jensen, 2004; Gourlay et al., 2005; Roper et al., 2006). However, our main contribution to the literature is the importance of domestic services sales of these manufacturing firms to their service exports participation, intensity and strategy. This additional mechanism has been overlooked in the literature.

Few studies like Cui and Liu (2018) look at the importance of offering services on goods export but fail to account for its importance for service exports, and Lodefalk (2014) looks at the importance of service inputs to goods exports but does not consider the importance of services sold domestically on service exports. This study focuses on the services provided domestically as a key determinant of service exports of manufacturing firms. We find a positive, significant and consistent relationship between services provided domestically and manufacturing services export participation, intensity and strategy. These findings indicate that the domestic service activities of firms cannot be ignored when exploring the service exporting behaviour of manufacturing firms. We argue that selling services domestically is a critical avenue through which firms learn at home in order to successfully enter the service export market. These findings provide an additional building block to the literature in understanding the drivers of service exports. Manufacturing firms that sell services domestically are more likely to enter export service markets, export more service types and export to more destinations.

3.9 CONCLUSION

Compared to the number of studies focused on manufacturing firms and goods export, the service sector has remained relatively under-researched. However, the service sector contributes about 80% to the UK GDP and its importance cannot be overlooked. Also, given the increasing blurring of the lines between manufacturing and services, and in this case, the overlap between the two sectors, it is important to not just look at the exporting activity of manufacturing firms but to differentiate between the goods and service exports of these firms. The ONS 2018 report shows that 16% of service exports for the UK were by the manufacturing sector, buttressing the fact that the lines between both sectors are blurring. This study homes in on this to understand what factors enable manufacturing firms to successfully export services. This is quite important as not all findings regarding goods exporting and performance for manufacturing firms will apply to manufacturing firms exporting services given the difference in the nature of goods and services. Also, not all finding about performance and exports for service firms will apply to these manufacturing firms exporting services as the nature of service trade can differ between manufacturing and service firms. So, this niche of manufacturing firms had to be studied to further the understanding of the factors driving their service export behaviour.

The findings from this study identify domestic services sales as an important channel, in addition to productivity and FSAs, that facilitates manufacturing firms' services export participation, intensity and strategy. This is a crucial finding as the proportion of manufacturing firms offering services has been steadily increasing around the world and its impact goes beyond its effect on the firm's performance, but also affects the firm's exporting behaviour as this study has shown. As with all studies, this study suffers from some limitations. Firstly, we do not explore the exporting premia angle as the scope of this project was to analyse the drivers of manufacturing services export and not its impact. This provides an avenue for future research where the impact of manufacturing services export on firm performance can be investigated, also accounting for domestic services sales. Additionally, the study does not differentiate between the different kinds of services exported or services exported to different destinations due to data limitations. Future research can delve into this nuanced approach, exploring the relationship between selling services domestically and service of exports of specific service types and to specific destinations.

APPENDICES FOR CHAPTER 3.

Table 3.9. Regression Results on the Determinants of International Servitisation Including Lags

VARIABLES	(1) Participation (logit, FE)	(5) Export intensity	(7) Multiple Products Export (Logit, FE, margins)	(9) Multiple destinations export (Logit, FE, margins)	(11) Number of Products exported (Poisson)	(12) Number of destinations exports (Poisson)
Firm Characteristics						
L.Log TFP	0.134***	0.000719	0.116	-0.209	0.00690	0.0413*
	(0.0507)	(0.00336)	(0.157)	(0.200)	(0.0219)	(0.0234)
L.l_employee	0.280***	-0.00795**	0.365*	-0.224	0.0493***	0.0538***
	(0.0408)	(0.00394)	(0.191)	(0.170)	(0.0142)	(0.0186)
L.l_avg_wage	0.358***	0.0112**	0.360	0.715	-0.0238	0.0417
	(0.0816)	(0.00527)	(0.360)	(0.435)	(0.0567)	(0.0472)
l_age	-0.0784	-0.00470	1.017***	0.841***	0.0652**	0.137***
	(0.0648)	(0.00545)	(0.295)	(0.304)	(0.0306)	(0.0495)
Intangible Assets						
L.l_patent_employees	0.0196	-0.0123	-0.434	-0.653	-0.0435**	0.00478
	(0.162)	(0.0104)	(0.516)	(0.596)	(0.0172)	(0.0728)
L.l_avg_purchased_software	0.0119	-0.00192	0.267	0.147	0.0203	0.0201
	(0.0895)	(0.00547)	(0.251)	(0.280)	(0.0337)	(0.0459)
Domestic Services Provided						
L.Log Industrial services provided/Turnover	1.257***	0.119***	-0.781	0.402	-0.106	0.362***
	(0.320)	(0.0219)	(1.224)	(1.307)	(0.123)	(0.0506)
L.Log Non-Industrial services provided/Turnover	5.298***	0.224***	9.751***	6.460**	1.040***	0.497
	(0.838)	(0.0580)	(2.999)	(2.715)	(0.274)	(0.308)
External Factors						
L.l_subsidy	0.0312	-0.00226	0.0181	-0.00664	0.0235***	0.00607
	(0.0297)	(0.00198)	(0.0577)	(0.0895)	(0.00805)	(0.0107)
exchange_rate	-9.214***	-0.325***	-0.845	-7.521**	0.107	-0.441
	(1.424)	(0.0958)	(3.562)	(3.582)	(0.410)	(0.594)
IMR		-0.0494***	-0.623	-0.460	-0.0149	-0.115***
		(0.00631)	(0.423)	(0.350)	(0.0290)	(0.0340)
Dummies						
1.export_goods	0.154**	-0.0317***				
	(0.0783)	(0.00737)				
1.ever_export_serv	3.391***	0.164***	4.287***	6.130***	0.109***	0.182***
	(0.0800)	(0.00682)	(0.991)	(1.029)	(0.0260)	(0.0439)
1.foreign_owned	0.414***	-0.00248	-0.0961	-1.053***	0.0345	-0.127***
	(0.0754)	(0.00676)	(0.281)	(0.366)	(0.0240)	(0.0303)
Constant	0.639	0.126	-12.05***	-4.757	-0.717*	-0.204
	(1.033)	(0.0811)	(4.520)	(4.071)	(0.424)	(0.407)
Observations	21,734	21,734	3,528	3,546	3,083	3,083
Number of entref	9,696	9,696	1,138	1,146		

Robust standard errors are in parentheses. Standard errors clustered by industry. Region, year and industry dummies included. *** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.

Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12. Office of National Statistics. (2019). *International Trade in Services*, *1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

CHAPTER 4: SERVICE TRADE BARRIERS AND FIRM PERFORMANCE: A UK PERSPECTIVE

ABSTRACT

This study focuses on the effect of service trade barriers on the productivity and export performance of UK firms between the period of 2014 – 2019. The results show evidence of a negative effect of an increase in service trade barriers on firm productivity and service export performance. We focus on different aspects of firm heterogeneity, and we find that this effect is more pronounced for smaller and older firms, highlighting the importance of service trade policy to small businesses. Also, focus on the period after the Brexit Referendum and we find that generally, negative effects are stronger for this period. After the Brexit referendum, the results show that only firms in the smallest size quartile are negatively impacted by service trade barriers.

4.1 INTRODUCTION

There is a consensus among trade economists that productivity and trade are intertwined. A strand of literature argues that productivity is a driver of trade as there is a cost to exporting and only the most productive firms can meet the minimum productivity level required to successfully enter export markets (Melitz, 2003; Roper et al., 2006; Wagner, 2007b). On the other hand, economic theory also identifies different channels through which trade can affect productivity. There is a competition channel, where increased import competition due to trade induces firms to innovate and upgrade their technology (Bustos, 2011; Kasahara and Rodrigue, 2008). Also, trade provides firms with access to a wider variety of inputs that might be of higher quality and embody technology, thereby increasing the firms' productivity (Amiti and Konings, 2007; Schor, 2004). Lastly, trade provides the opportunity to expand into larger markets, thereby providing an incentive for firms to improve their production efficiency and quality and boost productivity (Kim et al., 2020). This points to a form of learning by exporting or importing.

Traditionally, the most emphasis has been placed on the manufacturing sector and understanding the relationship between trade in goods and productivity. The service sector had been largely overlooked. However, the share of the services in world GDP and employment has been steadily increasing. In addition to this, rapid globalisation, advances in ICT technologies and more inclusive trade policies have expanded the tradability of services, leading to an increase in the volume of service trade across many countries. Trade in services is quite different from trade in goods as it often requires the movement of providers, either firms or people (Hoekman and Shepherd, 2021). This implies that compared to goods trade, trade in services often requires a broader range of policy instruments. Also, services are important inputs for a large number of industries such as downstream manufacturing industries, and so service imports can be an important channel for productivity growth (Beverelli et al., 2017; Shepotylo and Vakhitov, 2015). So, as with trade in goods, services trade can also be inhibited by policy barriers but unlike goods which are mostly affected by tariffs, service sectors are affected more by non-tariff measures such as restrictions to foreign entry, movement of people and other discriminatory measures. The OECD (2020) argues that the trade cost equivalent of service trade barriers exceeds the average tariffs on goods and these barriers affect both service imports and exports.

This paper focuses on the impact of service trade restrictions on the productivity and export performance of UK firms, focusing on the heterogeneous effect by firm size and the period after the Brexit referendum. This focus on the UK is for a number of reasons. First, the service sector is quite important to the UK economy as it has contributed about 80% to the UK's GDP and accounts for about 80% of employment since 2013 (ONS). Also, since the economic downturn following the global financial crisis, the service sector has driven economic recovery, being the first sector to recover from the crisis. In addition to being the second largest service exporter in the world, the UK's economy is more dependent on the service sector compared to any other G7 country. However, despite a favourable business environment and good policy frameworks, the UK's productivity growth has been slow compared to the US and other European countries, especially after the 2008 global financial crisis. Before the crisis, UK productivity growth was on the same level as Germany but in the period after the crisis, the UK growth is well below that of the G7 countries (Du and Shepotylo, 2021b). Solving this productivity puzzle has been at the centre of most studies focused on UK firms.

In addition, the 2016 Brexit referendum which saw the vote for the UK to leave the EU has created a quasi-natural experiment, with studies focused on what effects this could have on the productivity growth and export performance of UK firms. As of 2016, EU countries collectively made up almost half of the UK's exports at 43% and accounted for more than half of the UK's imports at 54%, according to ONS statistics. Given the UK's dependence on the EU with regard to trade, research is needed to understand what effect the country's exit from the EU single market and the likely increase in trade barriers between the UK and the EU would have on export performance and firms' productivity. Du and Shepotylo (2021) examine the impact of the referendum on UK service exports and they find that UK's service exports declined by 5.7% on average between 2016 and 2019, while Ireland experienced an increase of 14.8% for the same period. This is similar to Douch et al. (2020) who find that the UK's trade policy uncertainty as a result of the Brexit referendum has a negative impact on UK-EU trade with smaller firms being more impacted. However, with the introduction of the EU-UK Trade and Cooperation Agreement (TCA) in 2020, much of the uncertainty regarding tariffs and quotas has been resolved. However, EU-UK trade is now subject to non-tariff barriers such as sanitary, technical and licensing standards. These restrictions are bound to reduce UK-EU trade at the intensive and extensive margins, leading to welfare loss (Delis et al., 2018). Moreso, the TCA does little in facilitating service trade, exposing the trade in services to more difficulties and restrictions, which are bound to adversely affect the productivity and export performance of UK firms.

In light of the potential Brexit impact on UK firms, more research is required to further understand the impact service trade barriers could have on firm productivity and export performance, paying particular attention to the period after the Brexit referendum. Douch et al. (2020) already provide evidence showing that smaller firms were more affected by the Brexit uncertainty, diverting their trade to farther non-EU locations and being more exposed to adverse productivity effects as a result. Generally, smaller firms are more vulnerable to increased trade costs and risks, and therefore could be more adversely impacted by service trade barriers. Therefore, research into the effect of service trade barriers needs to account for firm heterogeneity given that firms might respond differently to these barriers.

This study seeks to contribute to the existing literature in the following ways. First, a rich dataset of UK firms across sectors was used to analyse the impact of service trade barriers on firm productivity and export performance. Given that the research on trade in services and service trade barriers is minimal, this study will provide evidence to augment our knowledge of these phenomena. Also, the structure of our data allows us to decompose the effect by sectors, analysing manufacturing and service sectors separately. Lastly and most importantly, we include the heterogenous effects of service trade barriers along different dimensions such as different time periods, firm size and age. Specifically, we consider the heterogenous effect of service trade barriers for firms in different size quartiles, and we also investigate the impact of the Brexit referendum by looking at sub-periods before and after 2016. This study further analysed the heterogenous effect by firm size over the entire period and narrow it down by considering the effect of firm size specifically after 2016 as smaller firms might be more vulnerable to increased trade costs and risks. This makes an important contribution to trade policy and how it might affect small businesses.

The findings show that a 10% increase in the measure of service trade barriers reduces productivity by 2.7%, which is similar in magnitude to the finding of Amiti and Konings (2007), and reduces export intensity for firms reliant on imported inputs by about 1.1%. Considering the heterogenous effect, this negative impact is observed to be stronger for smaller firms and more pronounced after the Brexit referendum. Specifically, the results show that the smallest firms have a reduction in productivity of about 19%, which is three times as large as the negative effect experienced by the largest firms i.e., 6%. For the period after the Brexit referendum, the negative effect on productivity is only observed for the smallest firms, with a magnitude of almost 50%. When we consider export intensity on the other hand, the results also show that only the smallest firms are negatively affected by an increase in service trade barriers with a magnitude of about 3.3%. This is unchanged when we examine the period after the Brexit referendum i.e., only the smallest firms are still negatively impacted and the magnitude of the impact remains roughly the same. This negative effect of an increase in service trade barriers, especially for smaller firms after the Brexit referendum provides an important insight for policymakers concerned about promoting the performance of small enterprises. We account for the use of service inputs by the manufacturing firms, but we find that firms in the service sector are more affected by service trade barriers compared to firms in the manufacturing sector. Lastly, we consider firm age as a source of heterogeneity because younger firms might be more dynamic than older firms in terms of adapting to changing external factors. We find that older firms are more adversely affected than younger firms.

The rest of this paper is organised as follows. Section 2 reviews the relevant literature, section 3 presents the data and empirical strategy, section 4 details the model and estimation methods, section 5 presents the results and findings, and section 6 concludes the study.

4.2 LITERATURE REVIEW

This study is related to the strands of literature that look at the impact of reducing trade barriers on productivity and export performance. Trade theories have argued that promoting free trade is an avenue to increase productivity. Theoretically, several channels have been identified through which trade can affect productivity. Some studies argue that a reduction in trade barriers can affect productivity by inducing tougher import competition or competition in the export markets (Beverelli et al., 2017; Kasahara and Rodrigue, 2008). Specifically, due to the increased import competition, firms are inclined to focus their product scope on their best performing products thereby increasing their productivity (Damijan et al., 2014), upgrading their technology in order to improve their production efficiency (Bustos, 2011) or forced to exit if they cannot withstand the competition due to the reallocation of resources towards more productive firms (Melitz, 2003; Nataraj, 2011). With regards to competition in the export market, a reduction in trade barriers increases the possibility for firms to enter into export markets and this provides an incentive for these firms to improve their quality or efficiency of production, thereby increasing their productivity and enabling them to bear the cost that comes with exporting and self-select into export markets (Kim et al., 2020; Melitz, 2003).

Also, some other studies have argued that the increase in productivity as a reduction of trade barriers is through the increase in the variety and quality of intermediate inputs that becomes available to domestic firms (Amiti and Konings, 2007; Schor, 2004). Reducing trade barriers may boost productivity through increasing access to a larger variety of inputs, increasing the quality of inputs available to domestic firms in addition to providing access to more specialised and technologically sophisticated intermediate inputs, which yields productivity gains (Amiti and Konings, 2007; Bøler et al., 2015; Goldberg et al., 2010). Closely related to the variety channel is the price channel. A reduction in trade barriers reduces the prices of foreign intermediate inputs, compared to the domestic inputs. The reduction in price will lead to an increase in the firms' profitability, efficiency and competitiveness (Bas, 2012). This increase in efficiency and competitiveness ultimately results in an increase in the productivity of the firm. Going from this argument, Bøler et al. (2015) argue that the reduced input cost as a result of lower trade barriers fosters firm innovation. They posit that the increases in firm profit as a result of lower marginal cost provide additional resources to firms which can be directed towards R&D investment, boosting innovation and ultimately boosting productivity. This argument is similar to the argument of firms upgrading their technology or improving process and product innovation in order to withstand the competition that occurs as a result of reduced trade barriers.

Lastly, an innovation or technology channel for productivity increase through a reduction in trade barriers has also been identified in the literature. Aghion et al. (2005) posit that firms close to the technological frontier will invest more in technology and innovate more in order to withstand the competitive pressure due to the removal of entry barriers which will improve the performance of these firms compared to firms who are far from the technological frontier. This argument is also echoed by Aghion et al. (2004) as they also posit that while firms closer to the technological frontier will invest in technology and innovation, firms far from the technological frontier are disincentivised to do the same, causing them to exit from the market. However, Bustos (2011) takes a slightly different stance by arguing that the increase in revenues as a result of a reduction in trade barriers will induce exporters and the most productive firms to upgrade their technology.

Empirically, studies have investigated the relationship between reduction in trade barriers and productivity and the consensus appears to be that the presence of trade barriers is harmful to firm productivity. Amiti and Konings (2007) investigate the effects of tariffs on the productivity of Indonesian manufacturing firms. They differentiate between tariffs on intermediate and final goods, and they find a negative relationship between tariffs and productivity, with a more adverse effect for the tariffs on intermediate goods. This is similar to the findings of (Goldberg et al., 2010; Topalova and Khandelwal, 2011) who focus on Indian manufacturers and also find a negative relationship between tariffs and productivity. These findings indicate that increasing barriers to trade have a negative impact on firm productivity.

While it has been well established that there is a negative relationship between trade barriers and productivity, the channel through which this productivity gain occurs is still open to debate. Bustos (2011) focuses on the technology adoption mechanism for Argentinian manufacturers. Specifically, she finds that a reduction in tariffs leads to an increase in revenue which induces exporters to invest in technology adoption. Also, Lileeva and Trefler (2010) find that Canadian firms who start exporting as a result of tariff cuts due to the trade agreement with the US adopted more advanced manufacturing technologies which increased their productivity. Another channel that has been investigated in the literature is access to varieties. Amiti and Konings (2007) argue that by using more foreign inputs, firms can increase their productivity through a learning effect from the technology embodied in the imported inputs and also through the availability of more input varieties. They find that firms that import their inputs experience a larger productivity gain compared to non-importing firms and they attribute this to the benefits of access to a variety of inputs. Bas and Strauss-Kahn (2014) also support the argument of learning effects through increased varieties as they find a positive relationship between importing technologically advanced inputs and productivity. This is similar to Schor (2004) who finds that reduction in trade barriers improves firm productivity due to embodied technology in intermediate inputs imported from more advanced countries.

Some studies have distinguished between input and output tariffs, with the former relating to the access to varieties channel while the latter concerns itself with the increased competition channel. Utilising a multi-country approach, Ahn et al. (2019) investigate the impact of input and output tariffs on sectoral productivity. They find that a 1% reduction in input tariffs increases productivity by about 2% and they fail to find any strong evidence for the effect of output tariffs on productivity. This led them to conclude that the input variety channel is more important for productivity gains than the competition channel. On the other hand, Amiti and Konings (2007) also differentiate between input and output tariffs and they find that a fall in output tariffs by 10% increases productivity by 0.7% while a fall in input tariffs by the same 10% increases productivity by 4%. They conclude that while both channels play a role in enhancing firm productivity following a reduction in trade barriers, the input tariff (access to variety channel) dominates the output tariff (competition channel). However, Muendler (1986) finds that the competition channel is more important than the variety channel for Brazilian manufacturers. Specifically, he finds that an increase in the output tariff by 1% increases productivity by 3.5% and he finds no evidence for input tariffs. He argues that this might be due to the time required for the firms to adjust to using the imported inputs.

Furthermore, the innovation channel has also been explored by researchers. Bøler et al. (2015) argue that productivity gains after a reduction in trade barriers occur through the interaction between investment in R&D by firms and access to foreign inputs. They find that the productivity gains as a result of a reduction in input barriers are greater for firms that invest in R&D compared to firms that do not, and that access to more foreign inputs reduces R&D costs, thereby promoting R&D investments and productivity. Also, Lileeva and Trefler (2010) find that firms induced to begin exporting due to tariff cuts also increased their product innovation, which increased their productivity.

In addition, some studies have argued that the gains from a reduction in trade barriers are heterogeneous across firms depending on different firm characteristics. New trade theories suggest that reduced trade barriers will affect the smallest and least productive firms, causing them to exit. Investigating this source of heterogeneity, Nataraj (2011) finds that the smaller and least productive firms are more adversely affected as a result of trade barriers compared to bigger and more productive firms. However, Topalova and Khandelwal (2011) fail to find any evidence for firms of different sizes reacting differently to a reduction in trade barriers. Bustos (2011) however finds that firms in the third quartile of the firm size distribution were induced to upgrade their technology and improve their productivity as a response to reduced trade barriers while Fernandes (2007) finds that larger plants are more affected by trade barriers than smaller plants. Also, Nataraj (2011) considers the difference in response to trade barriers between firms in the formal sector against firms in the informal sector, and she finds that a 10% reduction in trade barriers increases the productivity of all firms in the informal sector by 3.3% while on average, there was no effect on firms in the formal sector. Also, some studies have considered the trading status of the firm as another source of this heterogeneity. Both Amiti and Konings (2007) and Kasahara and Lapham (2013) show that importers benefit more from a fall in trade barriers while Shepotylo and Vakhitov (2015) fail to find any evidence of exporters benefitting more from a fall in trade barriers. So, with regard to the heterogeneous effect of trade restrictions on firms, the debate is still inconclusive as to what specific firm characteristics can explain the source of the heterogeneity.

Although most studies have focused on the impact of trade barriers on goods trade and manufacturing firms, the debate is easily extended to service trade and the service sector. Advances in ICT technologies and rapid globalisation have increased the tradability of services across borders. For services, non-tariff measures such as restrictions on foreign entry, discriminatory measures, regulatory transparency, etc, are the main policy instruments affecting trade rather than tariffs and they can be difficult to quantify (Ahmad et al., 2020). With the rapid growth of the service sector particularly after the financial crisis, more research has been focused on the effect of service trade barriers on firms. Ahn et al. (2019) include both the manufacturing and service sectors in their analysis and they find that while there is a negative effect of trade barriers on productivity, there is no significant difference between the service and manufacturing sectors. However, Kim et al. (2020) find that the magnitude of the effect of barriers to trade was greater for service sectors compared to the manufacturing sector.

Also, some studies have investigated the impact of service trade barriers on downstream manufacturing firms, given the dependence of some manufacturing sectors on service inputs. Reducing service trade barriers will encourage new firms, both foreign and domestic, to enter the market and this will increase the availability of service providers for downstream users of service inputs. Beverelli et al. (2017) find that reducing service trade barriers improves the productivity of manufacturing firms that use services as intermediate inputs in production. Akin to this, Shepotylo and Vakhitov (2015) find that a standard deviation increase in service trade barriers reduces the productivity of Ukrainian manufacturing firms by 9%. This finding is similar to Arnold et al. (2016) who find that a one standard deviation increase in service liberalisation increases the productivity of Indian manufacturers by 9.1% on average. However, Arnold et al. (2011) argue that there are specific channels through which service trade liberalisation affects manufacturing and they find that the presence of foreign providers of services is the key channel through which downstream manufacturing sectors enjoy productivity gains following reduction in service trade barriers. This could be due to greater access to service inputs or improvement in the quality of inputs due to the entrance of foreign firms leading to productivity enhancing changes for manufacturing sectors.

The other strand of literature focuses on the relationship between the reduction of trade barriers and the exporting performance of the firm. Compared to studies looking at the impact of trade barriers on productivity, studies focusing on the impact on export performance are few. These studies primarily make two arguments. First, they argue that the reduction of trade barriers reduces the cost associated with exporting, thereby making exporting accessible to more firms (Bas, 2012). The second argument is that given that there is an increase in firm productivity due to increased competition or availability of a variety of inputs following a reduction in input trade barriers, this increase in productivity increases the firms' chances of participating in exports (Feng et al., 2016; Shepotylo and Vakhitov, 2015). Kasahara and Lapham (2013) argue that importing and exporting are complementary and so policies that affect the importation of foreign intermediates would have a negative impact on exports. In addition, Aristei et al. (2013) argue that both importing and exporting have sunk costs and firms might either self-select into both in order to spread their costs or an increase in productivity through importing inputs might spur exporting. Several studies have found a positive relationship between importing inputs and exporting. Bas and Strauss-Kahn (2014) find that following a reduction in input trade barriers, importing an additional variety of input increase export volumes and extensive margins by 0.7%. Also, Feng et al. (2016) find that Chinese firms that use more imported intermediates increased their exports, while Shepotylo and Vakhitov (2015) also find that a reduction in import tariffs in industries firms source their intermediate inputs will lead to a higher productivity for the firms, therefore improving their chances of becoming an exporter.

Aristei et al. (2013) identify an innovation channel and they argue that importing intermediate inputs increases product innovation and productivity, therefore paving the way for future exporting. They find that while importing intermediate inputs increases the probability of exporting in the future, this is not the case for exporting influencing the probability of becoming an importer. So they conclude that access to imported inputs is a predictor of future exporting activity. Kasahara and Lapham (2013) establish a more direct link between import trade barriers and exporting. They utilise counterfactual experiments and they find that when there is an increase in the restriction of the trade of intermediates, the fraction of exporters of final goods falls. This led them to conclude that trade barriers that affect the importation of intermediate inputs can lead to the destruction of exports. However, Chevassus-Lozza et al. (2013) find that lower input trade barriers increase the export sales of the most productive firms at the expense of the least productive firms who end up exiting the market. Although the number of studies in this strand of literature is still minimal, the consensus seems to be that there is a link between importing and exporting, and import trade barriers ultimately have a negative effect on export performance.

4.3 DATA AND EMPIRICAL STRATEGY

The study uses several data sources at different levels of aggregation. First, we use the OECD Service Trade Restrictive Index (STRI) which measures service trade barriers at the sector level. We also utilise the ONS International Trade in Services (ITIS), Annual Business Survey (ABS), and the Business Structural Database (BSD). These datasets provide detailed firm level information for service trade, firm characteristics, etc. We discuss these datasets in more detail below.

4.3.1 OECD STRI

We use the STRI from the OECD database to measure the service sector trade barriers. This database provides service sector trade barriers for 48 countries, including both OECD and non-OECD countries, and it is available from 2014, which informs our selection of the time period of this study i.e., 2014 to 2019. Specifically, the STRI database provides information on regulations affecting services trade at the country-sector level, covering aspects such as importer and exporter restrictive index, restrictions on foreign entry and movement of people, other discriminatory measures, barriers to competition and regulatory transparency. The data covers 19 major service sectors.[8] We match these sectors to the Extended Balance of Payments Services Classification (EBOPS) and then match them to the corresponding NACE 2 classification. The OECD STRI measures are weighted to reflect their importance in hindering service trade, and the measure ranges between 0 and 1, where 1 is a completely closed market and 0 is a completely unrestricted market to foreign service providers.[9] It is a useful tool for analysing how service trade barriers negatively impact productivity. However, the OECD STRI does not account for preferential trade agreements between countries and given that the UK's major trading partner is the EU, we substitute the OECD STRI with the OECD Intra-EEA STRI for EU trading partners of the UK. Figure 1 shows the average Intra-EEA STRI and the average OECD STRI from 2014 to 2019. As seen in the figure, the average intra-EEA STRI is consistently lower than the OECD STRI for all time periods. By substituting the OECD STRI with the intra-EEA STRI for UK's EU trading partners, we correct for any upward bias in the magnitude of the impact of NTMs on the UK's exports to the EU and account for economic integration in Europe. This methodology is also utilised by Ahmad et al. (2020) who show that the Intra-EEA STRI tends to be lower than the main OECD STRI.

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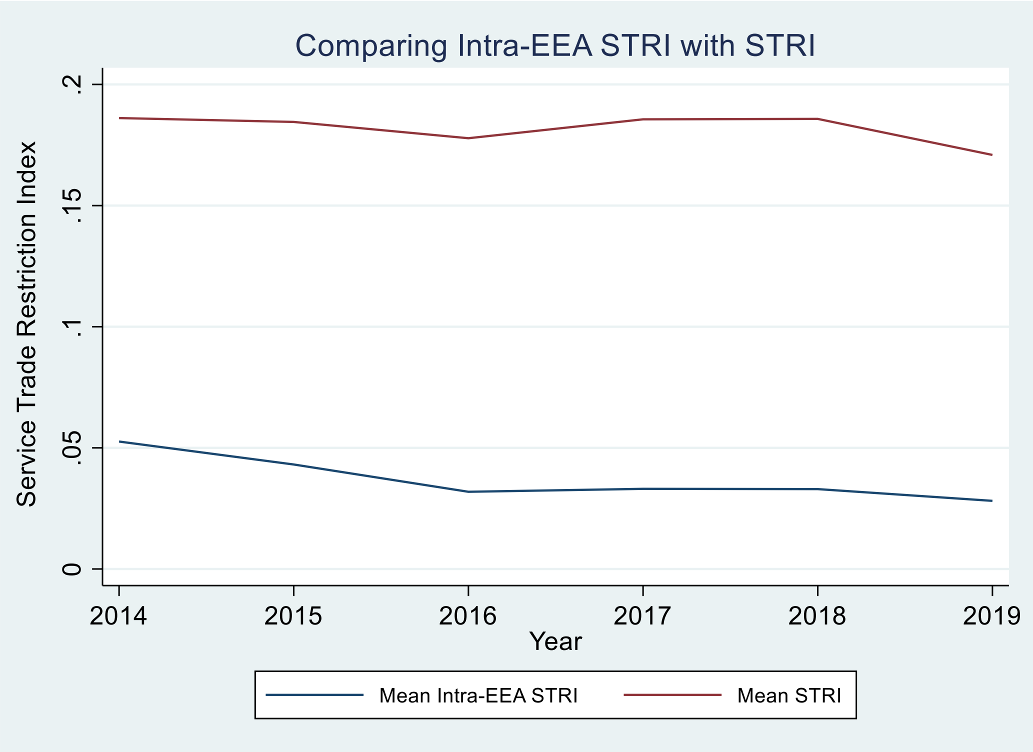
[8]The sectors are Computer and related services, construction, architecture and engineering services, telecommunication services, distribution services, audio-visual services, financial services, transport and courier services and logistics services.
[9]The weights used to calculate the STRI is subjective but the results are not sensitive to the choice of the weights (Grosso et al., 2015).

Figure 4.1: Average Intra-EEA STRI and Average OECD STRI Average Intra-EEA STRI and Average OECD STRI



4.3.2 Firm Level Data

The Office of National Statistics (ONS) International Trade in Services (ITIS) data contains a detailed breakdown of service imports and exports of UK plants by value, destinations and products, across all sectors and regions. It includes service trade information for 51 service types and reports UK service trade with more than 100 trade partners. For the period of 2014 – 2019, we have about 37,000 service importers and 45,000 service exporters. We merge this data with the Annual Business Survey (ABS), which contains detailed firm level information on a sample of UK businesses. It contains data on labour, capital, intermediate inputs, ownership, etc. Additionally, we link this dataset to the Business Structural Database (BSD) which contains the population of UK firms and information on firm age. The final linked sample contains an average of 43,000 firms per year, including both service and non-service traders.[10] We include non-traders in the study as we argue that they would be affected by industry input barriers given the linkages between sectors. The study covers the period of 2014 – 2019, given that the earliest available STRI data is from 2014 and the ITIS and ABS datasets are up to 2019.

[10] This data is the same as data utilised in chapter 3 with the difference being in the time period studied. Therefore, comments on data limitation, representativeness, etc. discussed in chapter 3 also applies here.

4.3.3 Total Factor Productivity

There are several techniques used in estimating productivity with the basic method being obtaining the residuals from an OLS or fixed effects estimation. However, this method may suffer from some bias due to selection and simultaneity problems. To solve this issue, Olley and Pakes (1996) (OP) introduce a two-stage semi-parametric approach using investment levels as a proxy for productivity to control for the correlation between input levels and the unobserved productivity shock. However, to use the investment proxy, then firms must have a positive investment expenditure, which is a limitation of this approach. To solve this, Levinsohn and Petrin (2003) (LP) propose using intermediate inputs as a proxy instead of investment as most firms would report inputs such as energy, water or materials. Also, Ackerberg et al. (2015) argued that the OP and LP methods of production function estimation can suffer from a functional correlation problem where the labour input is a function of other variables. To address this issue, they introduce labour input into the function of investment (OP method) or intermediate inputs (LP method) in order to improve the estimation of the production function. This is known as the ACF correction. Given that 25% of the firms in our sample report zero investment, we adopt the Levinsohn and Petrin method with ACF correction to estimate the production function. Specifically, we estimate the equation below for each firm.

$$Y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_t + \beta_e e_{it} + \omega_{it} + \varepsilon_{it} \qquad (4.1)$$

Where Y_{it} is the log of value added for firm i in year t, $k_t$is the log of industry capital stock at a two-digit level, l_{it} us the log of labour input measured as the number of employees, e_{it} is the log of energy used in production i.e. intermediate input, ω_{it} is the productivity shocks potentially observable by the firm before making input decisions and ε_{it} represents productivity shocks that are not observable by the firms before making input decisions.

4.3.4 Empirical Strategy

The objective of the empirical analysis is to estimate the impact of service trade input barriers on the productivity and export intensity of UK firms. First, we measure productivity as Total Factor productivity (TFP) using the Levinsohn-Petrin estimation with ACF correction as described in the previous section, while export intensity is measured as the ratio of the value of exports to turnover. Our main explanatory variable of interest is the industry specific input barrier. We use the industry level barrier due to data on firm specific barriers being unavailable. We construct this variable to account for intersectoral linkages by weighting the sector STRI by the reliance on inputs from other sectors. To achieve this, we use information from the UK 2014 national input-output tables to evaluate the interdependence between sectors. Specifically, we interact the sector STRI with the 2014 input-output coefficient of services input reliance for each sector and derive the weighted average of service trade restrictiveness by sector and year in line with Arnold et al. (2011). This measure of service trade restrictiveness is argued to be a more accurate approach to measuring the effect of service trade barriers on productivity compared to an unweighted measure. Also, by using the coefficient of service input use from the initial period as weights, we mitigate some potential endogeneity concerns in the model, making it a more reliable measure. Specifically, we define this weighted average of service trade restrictiveness as follows:

$$WSTRI_{cjt} = \sum_j STRI_{cjt} \times w_{cjp} \tag{4.2}$$

Where $STRI_{cjt}$ is the service trade restrictiveness index for country c (i.e. the UK), sector j and time t, and w_{cjp} measures the use of imported input p by sector j in country c utilising the 2014 input-output shares.

Also, we include the firm's exposure to imports which is calculated as the ratio of the value of imports to the total purchases of energy and materials. This measure is meant to capture the dependence of firms on imported inputs. Capital intensity is the ratio of capital expenditure to turnover. Lastly, we control for firm size which is measured as the log of employees, firm age and ownership which is a dummy variable with a value of 1 if the firm is foreign owned, and zero otherwise.

Table 4.1. Summary Statistics of Relevant Variables

Variable	Definition	Obs.	Mean	Std. Dev.
Log TFP	Total Factor Productivity (Levinsohn-Petrin)	78,315	-15.26	9.64
Export Intensity	Export/Turnover	78,315	0.06	0.18
Weighted Service Sector Import Barrier	Weighted OECD STRI	78,315	0.06	0.11
L.Weighted Service Sector Import Barrier	Lag Weighted OECD STRI	33,252	0.06	0.11
Exposure to Imports	Imports/Total Inputs Purchases	78,315	0.13	0.31
L. Exposure to Imports	Lag Imports/Total Inputs Purchases	33,252	0.09	0.23
Capital Intensity	Capital Expenditure/Turnover	78,315	0.04	0.11
Number of Employees	Number of Employees	78,315	422.49	3185.73
Log Employees	Log Number of Employees	78,315	3.95	2.06
Age	Age of firm	78,315	21.79	13.87
Foreign Owned	Foreign owned = 1, Domestic owned = 0	78,315	0.15	0.36

Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
Office of National Statistics. (2019). *International Trade in Services, 1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

From Table 4.1, we see that the average of the weighted service sector import barrier is 0.06, indicating that on average, the level of import restriction for the UK service sector is low. Although this is a weighted measure of the OECD STRI, this average is in line with the OECD 2020 report which had an average import STRI of 0.11 for the UK. [11] Also, the sample is made up of mostly older firms and bigger firms as the mean age is 21 years and the mean employee size is 422 employees. On average, firms import 13% of their inputs and the export intensity is 6% of turnover. Lastly, foreign owned firms make up 10% of the sample.

4.4 MODEL AND ESTIMATION

We estimate a fixed effects model to analyse the impact of sector level service trade restrictions on firm level productivity using the variables delineated in previous sections.

$$Productivity_{ijt} = \alpha_i + \beta_1 WSTRI_{jt-1} + \beta_2 ExposureImports_{ijt} + \beta_4 X_{ijt} + u_i + \varepsilon_{it} \quad (4.3)$$

Where $Productivity_{ist}$ is defined as the TFP of firm *i* in industry *s* at time *t,* estimated using the Levinsohn-Petrin method with ACF correction as described in the previous section.

We also estimate a Tobit model with random effects to analyse the impact of service trade import barriers on export intensity. The Tobit model is used in the export intensity model as export intensity lies between the interval of 0 and 1, and also due to the presence of censored data in the export variable. As mentioned in the previous chapter, firms with less than £5,000 in service exports are recorded as non-exporters. This makes the choice of Tobit preferable to the fractional logit model for instance.

$$ExportIntensity_{ijt} = \alpha_i + \beta_1 WSTRI_{jt-1} + \beta_2 ExposureImports_{ijt} + \beta_3 (WSTRI_{jt} \times ExposureImports_{ijt}) + u_{it} + \beta_4 X_{ijt} + \varepsilon_{it} \quad (4.4)$$

Where the export intensity of firm *i* in industry *s* at time *t* is calculated as the ratio of export values to turnover and takes values between 0 and 1.

In both models (4.3) and (4.4), $WSTRI_{jt-1}$ is the main variable of interest. Being a measure of trade policy, this variable is potentially endogenous. The service sector is a key sector for the UK economy and given its contribution to the economy, this creates an incentive for lobbying. So, more productive firms may influence the government's service trade policy decision, thereby introducing endogeneity in the model through reverse causality. To mitigate the potential endogeneity, we weight the OECD STRI by the input-output coefficients of the initial period of the study to construct $WSTRI_{jt}$. By using the information from the 2014 input-output tables, we further reduce the potential for endogeneity even

[11] https://www.oecd.org/trade/topics/services-trade/documents/oecd-stri-policy-trends-up-to-2020.pdf

at the level of the average firm in an industry. Also, we use the lag of $WSTRI_{jt}$ in each specification as we do not expect productivity to adjust instantaneously to a change in service trade policy. Utilising the lags also helps us mitigate some endogeneity concerns and capture any dynamic effects.

$ExposureImports_{ijt}$ is the import share in materials purchases for firm i in industry j at time t. One of the channels through which trade affects productivity is the access to foreign inputs used in production, and this is what this variable captures. In model (4.4), β_3 captures the effect of the interaction between exposure to imports and sector STRI on export intensity. We include this interaction as we argue that service trade import barriers might have a more adverse effect on importers that depend on imported inputs, compared to non-importers. Given that the effects of trade barriers might take time to materialise, the trade barrier variable is lagged for one period. X_{ijt} is a vector of controls including capital intensity, firm age and ownership which is a dummy variable measuring 1 if the firm is foreign owned and 0 otherwise. We do not include the imported services in these estimations so as not to introduce endogeneity in the model. Specifically, productivity is a predictor of imports as shown in the literature and having service imports as an additional variable in this model can lead to reverse causality. Lastly, u_i is the firm specific unobserved effect, which could be fixed effects as in model (4.3) or random effects as in model (4.4). Given the short period of this study, using a fixed effects model would eliminate all unobserved time invariant for heterogeneity, such as managerial influence, that could be biasing the estimates. These unobserved effects might affect firm productivity or be related to the error term. So, by eliminating them from the model, we improve the precision of our estimates of the effects. For all the models estimated, we also include year and industry fixed effects. The year fixed effects will absorb any macroeconomic shocks resulting from a macroeconomic policy that would affect these sectors over time while the industry effects will absorb industry specific effects that might influence our estimation.

4.5 RESULTS AND FINDINGS.

4.5.1 Service Sector Import Barriers and Productivity: Baseline Model

Table 4.2 presents the results of estimating equation (1) on an unbalanced panel with firm, industry and time fixed effects for the period 2014 – 2019. We use robust standard errors in all regressions. The result in table 4.2 is in line with theoretical and empirical expectations as we find a negative relationship between the service sector import barrier and productivity, measured as TFP. In column (1), TFP is regressed on the service import barrier and the coefficient of the import barrier is negative and significant. Specifically, the results show that a 10% increase in the industry import barrier reduces productivity by about 2.7%. This is similar to the findings of Amiti and Konings (2007) who had a corresponding decrease of about 2.1%. We include the export intensity of the firm to capture the fact that exporters are more productive than non-exporters. However, the export intensity is not significant.[12] Next, we include exposure to imported input variables as firms that have access to a wider variety of inputs might experience productivity gains through this channel (Ahn et al., 2019; Bøler et al., 2015; Halpern et al., 2015). This variable is positive and significant, further buttressing the importance of the variety of inputs channel to productivity and does not affect the magnitude or significance of the service trade barrier variable. Next, we control for capital intensity, firm age and ownership as these might also affect productivity. Adding these variables does not alter the results and the coefficients of these variables show that younger firms and domestic owned firms are more productive, while capital intensity has a positive relationship with productivity.

[12]We also included the interactions of the service input barrier and export intensity and export dummy alternatively to check if exporters might be more adversely affected by service input barriers as they might use services more intensively for their overseas activities compared to non-exporters. However, these interactions were insignificant.

Table 4.2. Effect of Service Sector Import Barrier on Productivity

VARIABLES	(1) Log TFP	(2) Log TFP	(3) Log TFP	(4) Log TFP	(5) Log TFP	(6) Log TFP	(7) Log TFP
L.$WSTRI_{kt}$	-0.27**	-0.27**	-0.27**	-0.27**	-0.27**	-0.27**	-0.27**
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
Export intensity		0.19	0.047	0.037	0.020	0.0036	0.0020
		(0.15)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Exposure imports			0.42***	0.45***	0.47***	0.47***	0.47***
			(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Capital intensity					0.40*	0.38*	0.38*
					(0.22)	(0.22)	(0.22)
Log age						-2.15***	-2.16***
						(0.35)	(0.35)
1.foreign_owned							-0.21**
							(0.086)
Constant	-23.2***	-23.2***	-23.2***	-23.2***	-23.2***	-16.5***	-16.4***
	(0.80)	(0.80)	(0.80)	(0.80)	(0.80)	(1.35)	(1.35)
Observations	33,531	33,525	33,525	33,524	33,518	33,516	33,516
R-squared	0.775	0.775	0.775	0.775	0.776	0.777	0.777
Number of entref	16,578	16,574	16,574	16,573	16,568	16,567	16,567

All models are estimated using a fixed effects model with industry and year dummies. Robust standard errors are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
Office of National Statistics. (2019). *International Trade in Services, 1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

4.5.2 Service Input Trade Barriers and Export Intensity: Baseline Model

Next, we examine the effect of service trade import barriers on export intensity as shown in Table 4.3. Like in Table 4.2, we include industry and time fixed effects for all regressions. In column (1), we estimate a logit model to capture selection into exporting. The logic is that some firm characteristics such as productivity, size, etc. are positively associated with a firm selecting into exporting services (Bernard and Wagner, 1997; Roper et al., 2006). From this model, we calculate the inverse mills ratio (IMR) which we include in subsequent regressions to correct for this selection bias. In column (2), we regress export intensity on the service sector import barrier and the results show a positive and significant effect, implying that higher service sector import barriers increase export intensity. This is contrary to theoretical expectations and we infer that this could be due to a selection bias. So, in column (3), we include the IMR and now, the impact of the service sector input barrier is negative, although insignificant. Also, the IMR is negative and significant, validating our correcting for selection. We include exposure to imported inputs variable and an interaction of these imported inputs with the service sector input barrier similar to Table 4.2. Imported inputs might have a higher quality and can embody superior technology which is required in export markets, and accessing imported inputs at lower costs can boost export revenue and increase export scope (Bas and Strauss-Kahn, 2014).

Table 4.3. Effect of Service Sector Import Barrier on Export Intensity

VARIABLES	(1) export_serv (logit)	(2) Export intensity (Tobit)	(3) Export intensity (Tobit)	(4) Export intensity (Tobit)	(5) Export intensity (Tobit)	(6) Export intensity (Tobit)	(7) Export intensity (Tobit)	(8) Export intensity (Tobit)	(9) Export intensity (Tobit)	(10) Export intensity (Tobit)	(11) Export intensity (Tobit)
L. $WSTRI_{kt}$	0.83***	0.050***	-0.0083	-0.00015	-0.0016	0.014	0.014	0.015	0.015	0.016	0.016
	(0.24)	(0.015)	(0.015)	(0.014)	(0.014)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Exposure imports	2.75***			0.14***	0.12***	0.12***	0.12***	0.11***	0.11***	0.11***	0.11***
	(0.17)			(0.0090)	(0.0092)	(0.0092)	(0.0091)	(0.0093)	(0.0094)	(0.0094)	(0.0098)
L.exposureimports	1.02***				0.092***	0.10***	0.10***	0.10***	0.10***	0.099***	0.099***
	(0.14)				(0.0085)	(0.0095)	(0.0095)	(0.0095)	(0.0095)	(0.0095)	(0.0095)
L. $WSTRI_{kt}$ #L.exposureimports	-2.67***					-0.11**	-0.11**	-0.11**	-0.11**	-0.11**	-0.11**
	(0.61)					(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
Capitalintensity	-0.84**						0.14***	0.14***	0.14***	0.14***	0.14***
	(0.35)						(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Log employee	2.25***							-0.0057***	-0.0039*	-0.0051**	-0.011
	(0.13)							(0.0021)	(0.0021)	(0.0021)	(0.0095)
Log age	0.41***								-0.020***	-0.020***	-0.020***
	(0.065)								(0.0054)	(0.0054)	(0.0055)
Foreignowned dummy	1.05***									0.030***	0.030***
	(0.097)									(0.0064)	(0.0064)
Log TFP	0.40***										-0.0010
	(0.026)										(0.0018)
IMR			-0.14***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***	-0.12***
			(0.0028)	(0.0031)	(0.0031)	(0.0031)	(0.0031)	(0.0031)	(0.0032)	(0.0033)	(0.0039)
Constant	-9.87***	-0.59***	0.33***	0.19***	0.19***	0.19***	0.19***	0.24***	0.30***	0.27***	0.28***
	(0.35)	(0.020)	(0.025)	(0.026)	(0.026)	(0.026)	(0.026)	(0.031)	(0.035)	(0.035)	(0.041)
Obs.	33,516	37,022	33,506	33,506	33,506	33,506	33,506	33,506	33,506	33,506	33,506
Number of entref	16,567	17,713	16,563	16,563	16,563	16,563	16,563	16,563	16,563	16,563	16,563

All models are estimated using a fixed effects model with industry and year dummies. Robust standard errors are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
Office of National Statistics. (2019). *International Trade in Services, 1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

From the results, we see a positive and significant coefficient of exposure to imported inputs on export intensity, showing that the use of imported intermediate inputs can increase export intensity. Turning our attention to the interaction term, the coefficient is negative and significant. This shows that the more a firm depends on imported intermediate inputs, the more adversely affected its export intensity will be by an increase in service sector input barriers. This is the key finding for the export intensity model. We go further to control for capital intensity, size, age and ownership. The results show that foreign owned firms, younger and smaller firms have a higher export intensity, and more capital intensive firms also have a higher export intensity.

4.5.3 Results for Sectors and Sub-samples

To check the robustness of our results, we explore some heterogeneous effects by looking at the effects of manufacturing vs service sectors, and estimating the effect of service sector import barriers on sub-samples of the data before and after the 2016 Brexit referendum, firm size dimensions and firm age.

4.5.3.1 Effect of Service Sector Input Barrier by Sector

First, we look at the effects of the service sector input barrier on both the manufacturing and the service sector separately. Not only do manufacturing sectors depend on service inputs for their production, but a small percentage of manufacturing firms also export services (Breinlich and Criscuolo, 2011). The results are not significant when we look at the manufacturing sector but they are significant and positive for the service sector. Although some studies have found evidence for a negative relationship between service trade barriers and productivity in the manufacturing sector (Arnold et al., 2011; Shepotylo and Vakhitov, 2015), these studies focus exclusively on downstream manufacturing firms that are dependent on the service sector. In this study, we do not make a distinction in the category of manufacturing firms and the sample is made up predominantly of firms in the service sector, so we expect the results to be driven by the service sector. The size of the coefficient is 2.3% for TFP and 1.1% for export intensity for a 10% increase in service sector input barriers, which is similar to the size of the coefficient from the baseline models in Tables 4.2 and 4.3.

4.5.3.2 Effect of Service Sector Input Barrier Before and After 2016

Next, we split the sample into two periods i.e. 2014 – 2016, and 2017 – 2019 to control for the possible effect of the 2016 Brexit referendum. Although the UK did not formally leave the EU until 2021, the period after the Brexit vote was fraught with a lot of uncertainty in terms of trade policy that could have affected firms' trading patterns and the subsequent effect on productivity and export intensity. The results show that the period after the Brexit referendum is driving the results from the baseline model. As can be seen from Table 4.4, the effect of service sector import barriers on productivity in the sub-period before the referendum is not statistically significant, while the effect in the sub-period after the referendum is negative and significant with a magnitude of 2.8% for a 10% increase in service sector input barriers, which is comparable to the baseline model. When we consider the export intensity model, the period after the Brexit referendum is also driving the results as we see a negative and significant coefficient of the interaction term between service sector input barriers and the exposure to imported inputs measure for the sub-period after 2016.

There could be several reasons why we observe a negative effect of service sector import barriers on productivity only in the sub-period after 2016 despite no changes being made to trade policy until 2020 following the Brexit vote. One possible explanation could be due to changes in the business environment, such as increased uncertainty about the future of the UK-EU relationship, which may have affected the investment decisions and overall economic activity of firms in the UK. This uncertainty could have intensified after the Brexit vote in 2016, leading to a negative impact observed only in the post-2016 period. However, identifying the underlying mechanisms driving this finding is beyond the scope of this study and therefore, further research is necessary to identify these mechanisms and to provide a more comprehensive understanding of them.

Table 4.4. Effect of Service Sector Import Barrier on Productivity: Breakdown of Firms by Sector, Sub-Period and Age.

VARIABLES	(1) Log TFP (manufacturing)	(2) Log TFP (services)	(3) Log TFP (pre-2016)	(4) Log TFP (Post-2016)	(5) TFP (<= 5 years)	(6) TFP (> 5 years)
L.$WSTRI_{kt}$	3.38	-0.23*	1.66	-0.28**	-0.81	-0.39**
	(2.88)	(0.13)	(2.96)	(0.13)	(0.80)	(0.16)
export_intensity	-0.11	0.027	-0.41	-0.19	-0.76	0.20
	(0.35)	(0.17)	(0.59)	(0.24)	(1.38)	(0.18)
exposure_imports	0.40	0.45***	0.28	0.53***	1.20**	0.39***
	(0.49)	(0.14)	(0.39)	(0.18)	(0.51)	(0.14)
capital_intensity	-0.080	0.39*	2.01	0.44	1.84	0.051
	(0.68)	(0.23)	(1.30)	(0.57)	(2.17)	(0.27)
l_age	-1.14	-2.31***	-3.06*	-6.31***		
	(1.06)	(0.33)	(1.80)	(1.63)		
1.foreign_owned	-0.18	-0.25**	-0.19	-0.31***	-0.39	-0.16*
	(0.13)	(0.10)	(0.28)	(0.12)	(1.20)	(0.082)
Constant	-19.1***	-15.8***	-15.0**	0.24	-18.3***	-23.6***
	(3.65)	(1.34)	(6.33)	(5.59)	(0.59)	(0.94)
Observations	3,917	29,597	11,443	22,073	1,456	32,062
R-squared	0.847	0.766	0.022	0.857	0.621	0.733
Number of entref	1,409	15,224	7,887	12,950	1,146	15,357

All models are estimated using a fixed effects model with industry and year dummies. Robust standard errors are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
Office of National Statistics. (2019). *International Trade in Services*, *1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

Table 4.5. Effect of Service Sector Import Barrier on Export Intensity: Breakdown of Firms by Sector, Sub-Period and Age

VARIABLES	(1) Export intensity (Tobit, Manufacturing)	(2) Export intensity (Tobit, Service)	(3) Export intensity (pre-2016)	(4) Export intensity (post-2016)	(5) Export intensity (<=5 years)	(6) Export intensity (> 5 years)
L.$WSTRI_{kt}$	0.67	0.0042	0.99***	0.0089	-0.075	0.017
	(0.48)	(0.017)	(0.12)	(0.018)	(0.14)	(0.016)
Exposure imports	0.41***	0.083***	0.24***	0.093***	-0.024	0.12***
	(0.024)	(0.011)	(0.019)	(0.012)	(0.12)	(0.0098)
L.exposure imports	-0.11	0.10***	0.19***	0.10***	-0.037	0.11***
	(0.28)	(0.010)	(0.029)	(0.012)	(0.062)	(0.0097)
L.$WSTRI_{kt}$#L.exposure imports	2.57	-0.11**	-0.39	-0.12**	-0.12	-0.11**
	(2.65)	(0.050)	(0.36)	(0.050)	(0.30)	(0.048)
Capital intensity	0.19***	0.13***	0.13***	0.063*	-0.12	0.14***
	(0.059)	(0.028)	(0.040)	(0.032)	(0.21)	(0.025)
Log employee	-0.054**	0.014	0.11***	-0.033***	0.065	-0.021**
	(0.023)	(0.011)	(0.018)	(0.011)	(0.10)	(0.0096)
Log age	-0.051***	-0.018***	-0.00025	-0.021***		
	(0.013)	(0.0061)	(0.0080)	(0.0064)		
Foreign owned dummy	-0.011	0.041***	0.063***	0.030***	0.17***	0.028***
	(0.011)	(0.0076)	(0.010)	(0.0078)	(0.057)	(0.0065)
Log TFP	-0.010**	0.0037*	0.021***	-0.0049**	0.016	-0.0032*
	(0.0046)	(0.0020)	(0.0032)	(0.0021)	(0.018)	(0.0018)
IMR	-0.039***	-0.13***	-0.053***	-0.13***	-0.12**	-0.12***
	(0.013)	(0.0044)	(0.0083)	(0.0046)	(0.048)	(0.0039)
Constant	0.14*	0.27***	-0.30***	0.39***	0.098	0.32***
	(0.072)	(0.046)	(0.078)	(0.048)	(0.45)	(0.043)
Observations	3,917	29,587	11,443	22,063	1,456	32,050
Number of entref	1,409	15,220	7,887	12,945	1,146	15,352

All models are estimated using a fixed effects model with industry and year dummies. Robust standard errors are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
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4.5.3.3 Effect of Service Sector Input Barrier By Firm Age

Lastly, we split the sample by firm age, looking at young firms i.e. 5 years old or younger, and older firms i.e. more than 5 years old. Younger firms might exhibit more dynamism compared to older firms in their response to service sector input barriers. Autio et al. (2000) argue that older firms might exhibit some form of inertia in adapting to changing external factors compared to younger firms. They argue that younger firms might learn more quickly and are more likely to unlearn old routines and explore new avenues in international firms, compared to older firms that might be set in their ways and invested heavily in existing trade patterns. In line with this, we expect that older firms would be more negatively impacted by service sector input barriers compared to younger firms. The results from Tables 4.4 and

4.5 are in line with this argument. For productivity, although both young and old firms experience a negative effect from sector barriers, only the coefficient for older firms is significant with a magnitude of 3.9% for a 10% increase in service sector input barriers. When we consider the export intensity model, the coefficient of the interaction term between the service sector barrier and exposure to imported inputs is negative and significant for only the old firms.

4.5.3.4 Effect of Service Sector Input Barrier By Firm Size

Promoters of free trade argue that reduced trade barriers and improved access to foreign markets will benefit some firms and not all firms. Therefore, there might be the presence of some heterogenous effects of reduced service sector input barriers on firms with different characteristics. Similar to Shepotylo and Vakhitov (2015), we expect smaller firms to be more affected by service sector input barriers as they might be more dependent on imported service inputs compared to bigger firms that can produce some services in-house. The argument is that the cost of dealing with the barriers and policy hurdles in every new market affects SMEs more than larger firms. The OECD estimates that an average level of services trade restrictions represents an additional 7% in trade costs and is equivalent to an additional 12% tariff for very small firms engaging in service exports compared to the larger firms.

Table 4.6. Effect of Service Sector Import Barrier on Productivity: Breakdown of Firms by Turnover Size

VARIABLES	(1) TFP (size = 1st quart)	(2) TFP (size = 2nd quart)	(3) TFP (size = 3rd quart)	(4) TFP (size = 4th quart)	(5) TFP (post-2016 size = 1st quart)	(6) TFP (post-2016 size = 2nd quart)	(7) TFP (post-2016 size = 3rd quart)	(8) TFP (post-2016 size = 4th quart)
L.$WSTRI_{kt}$	-1.91***	-0.38***	-0.44***	-0.62**	-5.10***	-0.18	-0.26	-0.55
	(0.61)	(0.12)	(0.16)	(0.26)	(0.60)	(0.13)	(0.13)	(0.36)
Exposure imports	0.44*	0.51*	0.058	0.93**	0.74***	0.67**	-0.33	0.34
	(0.24)	(0.27)	(0.24)	(0.43)	(0.27)	(0.26)	(0.34)	(0.42)
Export intensity	-0.087	0.63	-0.31	-1.09*	0.066	-0.37	0.50	-0.60
	(0.36)	(0.53)	(0.24)	(0.59)	(0.40)	(0.48)	(0.49)	(0.58)
Capital intensity	-0.38	1.61**	0.92	-1.06	0.40	0.77	1.64	-0.042
	(1.18)	(0.78)	(1.05)	(1.42)	(0.69)	(1.08)	(1.62)	(1.10)
Log age	-3.63**	-0.83	0.093	-1.63*	-6.71**	-2.02	-0.19	-14.7***
	(1.47)	(0.91)	(0.83)	(0.94)	(2.61)	(1.29)	(2.96)	(4.19)
Foreign owned dummy	-0.033	-0.035	-0.12	-0.14	0.021	-0.37*	0.048	-0.23
	(0.21)	(0.15)	(0.18)	(0.20)	(0.22)	(0.21)	(0.27)	(0.27)
Constant	-5.11	-20.9***	-24.9***	-24.5***	4.95	-14.2***	-23.8**	22.8
	(4.62)	(3.15)	(2.86)	(3.36)	(8.45)	(4.38)	(10.2)	(14.7)
Observations	8,591	8,483	8,166	8,276	5,585	5,670	5,407	5,411
R-squared	0.808	0.886	0.865	0.846	0.872	0.942	0.914	0.920
Number of entref	7,106	5,093	2,986	2,382	4,782	3,781	2,724	2,284

All models are estimated using a fixed effects model with industry and year dummies. Robust standard errors are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
Office of National Statistics. (2019). *International Trade in Services, 1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

Table 4.7. Effect of Service Sector Import Barriers on Export Intensity: Breakdown of Firms by Turnover Size

VARIABLES	(1) export intensity (size = 1st quart)	(2) export intensity (size = 2nd quart)	(3) export intensity (size = 3rd quart)	(4) export intensity (size = 4th quart)	(5) export intensity (post-2016 size = 1st quart)	(6) export intensity (post-2016 size = 2nd quart)	(7) export intensity (post-2016 size = 3rd quart)	(8) export intensity (post-2016 size = 4th quart)
L. $WSTRI_{kt}$	-0.028	-0.038	0.018	0.037	-0.058	-0.069	0.013	0.044
	(0.063)	(0.043)	(0.024)	(0.025)	(0.065)	(0.050)	(0.027)	(0.028)
Exposure imports	-0.16***	0.059**	0.16***	0.34***	-0.18***	0.020	0.14***	0.34***
	(0.043)	(0.023)	(0.018)	(0.015)	(0.050)	(0.028)	(0.022)	(0.019)
L.exposure imports	0.15***	0.11***	0.084***	0.10***	0.12***	0.099***	0.11***	0.14***
	(0.026)	(0.020)	(0.019)	(0.016)	(0.031)	(0.023)	(0.023)	(0.021)
L. $WSTRI_{kt}$ #L.exposure imports	-0.33**	-0.026	0.11	-0.023	-0.32**	-0.0017	0.011	-0.045
	(0.14)	(0.094)	(0.10)	(0.083)	(0.15)	(0.099)	(0.11)	(0.095)
Capital intensity	0.15**	0.044	0.085	0.16***	0.095	0.027	-0.076	0.12**
	(0.063)	(0.053)	(0.053)	(0.045)	(0.077)	(0.064)	(0.071)	(0.056)
Log employee	0.12**	-0.032	-0.077***	-0.074***	0.086	-0.068*	-0.11***	-0.097***
	(0.047)	(0.032)	(0.024)	(0.013)	(0.057)	(0.039)	(0.030)	(0.016)
Log age	-0.053***	-0.016	-0.0057	-0.023**	-0.043***	-0.031**	-0.013	-0.021*
	(0.013)	(0.010)	(0.010)	(0.011)	(0.016)	(0.013)	(0.012)	(0.013)
Foreign owned dummy	0.24***	0.071***	0.0018	-0.037***	0.22***	0.044**	0.000045	-0.038***
	(0.032)	(0.015)	(0.010)	(0.0088)	(0.039)	(0.018)	(0.012)	(0.011)
Log TFP	0.025***	0.00058	-0.0093**	-0.012***	0.019*	-0.0052	-0.015***	-0.016***
	(0.0086)	(0.0059)	(0.0042)	(0.0023)	(0.010)	(0.0072)	(0.0054)	(0.0028)
IMR	-0.11***	-0.11***	-0.14***	-0.13***	-0.12***	-0.13***	-0.15***	-0.15***
	(0.017)	(0.0092)	(0.0072)	(0.0064)	(0.019)	(0.011)	(0.0084)	(0.0077)
Constant	-0.00046	0.37***	0.60***	0.64***	0.14	0.51***	0.69***	0.76***
	(0.17)	(0.098)	(0.082)	(0.070)	(0.20)	(0.12)	(0.095)	(0.081)
Observations	7,982	8,367	8,598	8,559	5,274	5,536	5,675	5,578
Number of entref	6,883	4,941	3,470	2,675	4,593	3,718	2,956	2,490

All models are estimated using a fixed effects model with industry and year dummies. Robust standard errors are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1. Entref is the unique company identifier.
Office of National Statistics. (2020). *Annual Business Survey, 2008-2017*: Secure Access. [data collected]. *12th Edition*. UK Data Service. SN:7451, http://doi.org/10.5255/UKDA-SN-7451-12
Office of National Statistics. (2019). *International Trade in Services*, *1996-2017*: Secure Access. [data collected]. *8th Edition*. UK Data Service. SN:6711, http://doi.org/10.5255/UKDA-SN-6711-9

We divided the firms in the sample into quartiles.[13] From Table 4.6, we see that although there is a negative effect of the service trade import barrier on productivity for firms of all sizes, the magnitude of the effect is largest for the smallest firms (i.e. 1st quartile), followed by the largest firms (4th quartile). Specifically, the effect of service sector import barriers on productivity is twice as large for the smallest firms compared to the largest firms. We also have a similar finding when looking at the interaction term for export intensity i.e. the smallest firms are more negatively impacted by service import barriers. We go one step further and look at the effect of the service sector import barrier by firm size after the Brexit referendum. We also expect smaller firms to be more adversely affected after the Brexit referendum and the results in Table 4.6 supports this. The results indicate that not only are the smallest firms the only category to be negatively affected after 2016 in terms of productivity, but the magnitude of the impact is about five times larger than the magnitude when using the full sample. For export intensity as shown in Table 4.7, the smallest firms are still the only category affected after 2016 but the magnitude of the effect is comparable to when using the full sample.

Our finding that smaller firms are more affected by service trade barriers could be due to smaller firms lacking the necessary resources and expertise that it takes to navigate the complex regulations that are associated with non-tariff barriers. Compared to larger firms, this can lead to an increased cost, reducing their competitiveness, productivity and ability to expand into new markets. The post-Brexit period was fraught with increased uncertainty and this could have made it more difficult for smaller firms to plan and make strategic investments, hereby negatively impacting their productivity.[14]

4.6 CONCLUSION

Several studies have examined the impact of trade barriers on firm productivity and performance, and the consensus seems to be that the presence of trade barriers between countries has a negative effect on productivity and performance. Through trade, firms have access to a variety of imported inputs, are exposed to foreign competition which can cause them to innovate and upgrade their technology and are exposed to foreign technology and know-how from their trading partners, all of which are channels for productivity increase. This paper focuses on the effect of service sector input barriers on the productivity and export performance of UK firms. Empirical studies focused on goods trade for the manufacturing sector have identified a negative relationship between trade barriers and firm performance. The findings of this study are in line with this. Specifically, we find that a 10% increase in the service sector input barrier reduces productivity by 2.7% and export intensity by 1.1%. We explore heterogenous effects along the lines of firm size, sector, and sub-periods i.e. before and after 2016 to account for the effect

[13] The quartiles are 1-104 for the first quartile, 105-209 for the second quartile, 210-314 for the third quartile and 315 and above for the fourth quartile.
[14] Further analysis were carried out for the period before Brexit and there was no difference in the effect between larger and smaller firms, indicating that smaller firms are worse off as a result of Brexit.

of the Brexit vote and age. The results show that the smallest firms (firms in the first size quartile) are more adversely affected than larger firms, older firms are more impacted than younger firms and firms in the service sector are also more affected than firms in the manufacturing sector. With regards to the sub-periods, we find that the period after the Brexit vote is driving the results and considering the heterogeneity along firm size in the sub-periods, we find that after the Brexit vote, the smallest firms are the only ones affected.

While contributing to the growing literature on the impact of service trade barriers on firm performance, the findings of this study also have practical policy implications. In the wake of the combined effect of Brexit and Covid19 pandemic, and the ongoing UK productivity puzzle, policy will be geared towards promoting the performance of UK firms. The findings of this paper have identified the smallest firms as being more negatively impacted by service sector trade barriers compared to larger firms, and this provides the basis for a more targeted policy framework directed at these firms. Also, given the exit of the UK from the EU single market, policymakers should bear in mind the negative effect of trade barriers in the service sector when drafting and implementing new trade policies. This study also suffers from some limitations. The study only considers the effect of service sector barriers on productivity and export intensity and does not explore the effect on the extensive margins of trade. Future research can explore this, identifying what traded service products and export/import destinations are most affected by these barriers. Furthermore, the study focuses on the aggregated STRI index and is not separated by the mode of delivery. It might be worth investigating which mode of delivery is most affected by trade barriers, tying this to the breakdown of traded service products to analyse its impact on firms. Also, as more data becomes available since the formal exit of the UK from the EU at the end of 2020, future research can analyse the actual impact of trade barriers after Brexit.

CHAPTER 5: CONCLUSION

This thesis is motivated by the observation of the changes in international trade and it focuses on the expansion of GVCs, the growing importance of services in international trade and the reversal of trade integration due to deglobalisation. Focused primarily on advanced economies, this thesis has presented evidence to answer three key questions relating to the identified trends in the global economy with an emphasis on international trade. First, what is the relationship between trade in GVCs and productivity, and how do technological advances, especially in the use of robots affect both productivity and trade in GVCs. This question is motivated by the proliferation of trade in GVCs and the increase in the adoption of industrial robots across advanced economies. Over the past 30 years, production has become more fragmented across international borders through the increasing prevalence of GVCs which is driven by productivity growth and improvement in ICT technologies. Participating in GVCs yields some productivity benefits through increasing comparative advantage as countries specialise in certain tasks in the value chain, knowledge spillovers and technology transfers that serve to boost productivity in the participating countries. At the same time, productivity growth is a driver for the integration into GVCs. In addition to being a vehicle for knowledge transfer, participating in GVCs can promote the adoption of new production technologies in order for countries to improve their international competitiveness and capture more value within the GVCs. For advanced economies, this has provided an opportunity to specialise in specific high-value tasks within the value chain and to reap the benefits that come with it. In order to stay productive and competitive, advanced economies have turned to the adoption of automation technologies, such as industrial robots, to upgrade their positions in GVCs. In the same vein, robot adoption can also affect integration into GVCs by increasing the reshoring tendencies of industries in developed economies, and it is associated with productivity increase which could also promote integration into GVCs. So, it is unclear the direction of the relationship between GVCs participation, productivity and robot adoption, and this is one gap the thesis addresses.

The first empirical chapter focuses on this intertwining relationship between participation in GVCs, productivity and robot adoption. It focuses on a panel of industries from OECD countries spanning a period of 20 years and utilises a Panel Vector Autoregressive model (PVAR) to investigate this relationship. In this chapter, the findings show that most importantly, a bidirectional relationship exists between productivity and robot adoption, productivity and trade in GVCs, and trade in GVCs and robot adoption. Specifically, adopting industrial robots positively affects integration into GVCs for both forward and backward linkages, and at the same time, integration into GVCs positively affects robot adoption. Furthermore, productivity positively affects integration into GVCs and robot adoption, while only integration into GVCs affects productivity. These findings address the gap identified earlier, establishing that participating in GVCs, productivity and robot adoption positively affect one another contemporaneously.

This chapter makes several contributions. First, it contributes to the literature on the relationship between GVCs and productivity. Studies have shown that participating in GVCs leads to productivity growth (Blalock and Veloso, 2007; Kummritz, 2016) and also that productivity boosts GVC participation (Taglioni and Winkler, 2016). This chapter brings these two strands of literature together by providing evidence that there is a bi-directional relationship between productivity and GVC participation, thereby making a significant contribution to the literature. Second, this chapter also contributes to the broad literature on how the adoption of new technologies affects trade. By focusing on the adoption of industrial robots and GVCs, this chapter contributes to the literature on the effect of robot adoption. Most studies on the effect of robot adoption have focused on the labour market implications (Acemoglu and Restrepo, 2020; Dauth et al., 2017), however, this chapter provides evidence showing how robot adoption affects GVC participation. Additionally, studies have investigated the implications of GVC participation for robot adoption (De Backer and DeStefano, 2021). Similar to productivity, this chapter also provides evidence showing that there exists a bi-directional relationship between robot adoption and GVC participation. Third, it has been established that robot adoption has positive implications for productivity (Dixon et al., 2020; Graetz and Michaels, 2018) and at the same time, productive industries are more likely to adopt robots (Acemoglu and Restrepo, 2020; Koch et al., 2021). Again, this chapter ties together these two strands of literature and provides evidence to show that there is a bi-directional relationship between productivity and robot adoption. Therefore, this chapter also contributes to the literature on the relationship between robot adoption and productivity. Fourth, by utilising a PVAR model, this chapter makes a methodological contribution to the literature by explicitly accounting for the bidirectional relationship between GVC participation, robot adoption and productivity, and it provides a foundation that can be built upon in disentangling the relationship between these three phenomena.

However, there are some limitations and future avenues of research on this topic. First, the analysis in this chapter was done on an industry level due to the availability of data, and this is the main limitation of this chapter. Conducting this investigation on the firm level can provide meaningful insight and enable the research to take into account firm heterogeneity and its impact on the findings. It will also provide an avenue to investigate the reshoring tendencies of firms in advanced economies and focus on the specialisation in tasks within the value chain. Furthermore, given that the research is carried out on an industry level, it was unable to account for occupational composition which is an important aspect when looking at robot adoption. It is argued that robot adoption is more prevalent in the presence of routine tasks, and this can be investigated in a firm level analysis. Also, this chapter focuses exclusively on a panel of relatively advanced economies. As a result, it has not been able to investigate if the findings also hold for developing economies and this would be an interesting avenue for future research.

The second question this thesis set out to answer is, what factors enable manufacturing firms to export services and what role does selling services domestically play in this? This question is motivated by the increasing importance of services in advanced economies. Improvement in ICT technology has made services more tradable than ever, and this has led to a growth in service trade for most developed economies. Also, the importance of services to these economies has grown over the years with the sector contributing about 70% of employment and 80% to the GDP. Furthermore, given the nature of services, it is an important intermediate input for other industries, especially manufacturing, which can have important implications for their productivity. However, there is an increasing blurring of the line between manufacturing and services, with manufacturing firms not only increasing their use of services as intermediate inputs, but also getting directly involved in the provision of services. A significant number of manufacturing firms sell services domestically, and an even smaller number of manufacturing firms export services. With regards to service exports, just like goods exports, studies have identified productivity, FSAs, innovation and human capital as key factors promoting it (Bernard and Wagner, 1997; Roper et al., 2006; Wagner, 2012). However, most studies have been focused on service firms and the role of manufacturing firms in service exports has been largely ignored. So, this thesis addresses this gap by focusing on the unique intersection of manufacturing and services, providing evidence to answer the question of what factors enable manufacturing firms to export services.

This question is addressed in the second empirical chapter using a panel of UK manufacturing firms between 2011 and 2018. Utilising a logit model with random effects, Tobit and Poisson models, I explore the factors affecting the probability, intensive and extensive margins of service exports by manufacturing firms. The findings in this chapter show that productivity and Firm Specific Advantages (FSAs) such as innovation and employees' skills, are factors that increase the *probability* of manufacturing firms to successfully export services. It also shows a strong effect for services sold domestically on the *probability* of manufacturing firms to successfully export services. With regards to the intensive and extensive margins of trade, the results show that productivity and FSAs do not have an effect on these. However, selling services domestically positively and significantly affects the *intensive and extensive margins* of service exports for manufacturing. This is the most important finding of this chapter. Specifically, the results show that the services sold domestically are the only factor that positively affects the *probability, intensive and extensive margins of service exports* by manufacturing firms. Other factors such as productivity and FSAs affect either the probability, intensive or extensive margins, but not all three.

This chapter contributes to the literature on service trade exports and also improves our understanding of manufacturing service exports. Specifically, this chapter contributes to the literature on selection into exporting, learning to export and the internationalisation process literature, within the context of manufacturing service exports. Most importantly, the findings from this chapter make an important contribution by identifying an important additional factor to be considered when investigating the factors affecting the service exports of manufacturing firms, which is the services sold domestically by manufacturing firms. I show that this is an important avenue of learning that enables manufacturing firms successfully to not only participate in service exports but also increase their intensive and extensive margins of services export.

The findings of this chapter also have some policy implications for the UK. The UK is the second-largest service exporter in the world and services contribute about 80% to its GDP. Given the impact of Brexit and Covid-19 on service exports, UK policymakers are keen to boost exports back to pre-pandemic levels. This chapter reiterates the importance of UK manufacturing firms to service exports and so they must be included in policies targeted towards boosting service exports. Also, having identified services sold domestically as a key driver of manufacturing firms exporting services, to encourage manufacturing firms to export services, favourable policies targeted towards boosting domestic service sales can be explored.

This chapter also suffers from some limitations. First, we do not explore the learning by exporting angle by investigating the impact of exporting services on UK manufacturing firms' performance. This was beyond the scope of this study as it was primarily directed at analysing the drivers of manufacturing services exports and not their impact. Therefore, this is a viable avenue for future research to investigate the learning by exporting mechanism for manufacturing firms in service exports. Secondly, UK manufacturing firms export different types of services to a number of destinations. It will be worthwhile to investigate the service type and destination heterogeneity i.e. factors affecting the export of different types of services to different destinations. This thesis was unable to pursue this nuanced approach due to data limitations, but it will be a useful avenue for future research, especially since the exit of the UK from the EU.

The third question addressed by this thesis is, what is the effect of service trade barriers on productivity and export performance? This question is also motivated by the growth in service trade and the increasing presence of service trade barriers as a result of deglobalisation and trade disintegration. Typically, service trade costs are higher than that of goods, and this is due to the proximity burden required when trading services. Also, the barriers faced by services are more regulatory as opposed to the tariffs faced by goods. These Non-Tariff Barriers (NTBs) are more difficult to measure, more complex and less transparent, and they hinder the free flow of services, thereby affecting the benefits that can be reaped because of service trade. Following the 2008 financial crisis, there has been a decline in the process of globalisation with some advanced countries leaning more towards protectionism as opposed to trade liberalisation. A notable example is Trump's trade war with China and the 2016 Brexit referendum which saw the UK exit the EU and its single market, unravelling years of deep trade integration. This trend towards deglobalisation and trade disintegration has an effect on trade barriers, especially for services. Although several studies have focused on the effect of trade barriers on firm performance for manufacturing, the empirical evidence for services is still scant and this thesis addresses this gap. In addition to examining the impact of service trade barriers on firm productivity and export performance, the thesis also examines the impact of trade policy uncertainty, utilising the Brexit referendum as a case in point.

These questions are addressed in the third empirical chapter of this thesis. This chapter utilises a panel of UK firms between 2014 and 2019, and by estimating a fixed effects model, it provides some empirical findings to shed more light on the impact of service trade barriers on firm productivity and export performance. The first finding of this chapter shows a negative effect of service trade barriers on firm productivity and export performance, which is in line with the theoretical expectations following research on the effects of tariffs on manufacturing firms. However, in this chapter, I go a step further by also investigating the role of firm heterogeneity and the impact of service trade policy uncertainty on firm productivity and export performance. The first aspect of heterogeneity explored is firm size. This is because the effect of service trade barriers might vary across firms of different sizes, with smaller firms being more affected than larger firms. By looking at firms in different size quartiles, the findings show that firms in the smallest size quartile are more negatively impacted by service trade barriers compared to bigger firms. This finding makes an important contribution to the literature on small businesses and provides key insight for policymakers regarding SMEs' export behaviour and performance.

Also, this chapter explores the effect of trade policy uncertainty on productivity and export performance by utilising the Brexit referendum. We focus on the Brexit referendum as it introduced a threat UK's trade with the rest of the EU due to uncertainty surrounding what deal the UK would be able to negotiate with the EU. To investigate this effect, the analysis is carried out for two sub-periods i.e., before and after the referendum, to analysis if there has been a Brexit effect on the impact of service trade barriers on firm performance. By so doing, this chapter aims to capture the effects of the uncertainty surrounding trade policy and service trade barriers following the referendum. The findings show that the negative impact of service trade barriers on firm productivity and export performance is stronger in the period after the Brexit referendum. This is expected as there was uncertainty surrounding what barriers could exist between the UK and the rest of the EU. Lastly, I find that in the period after the Brexit referendum, only the firms in the smallest size quartile are negatively impacted by service trade barriers. So, this chapter contributes broadly to the literature on service trade, and specifically to the literature on service exports. It also makes a contribution to the literature on trade policy and the impact of trade uncertainty. Its findings also highlight the importance of firm heterogeneity in the impact of service trade barriers, and it also makes a contribution to the emerging literature on the impact of Brexit on UK and EU firms.

The findings from this chapter have a number of policy implications. Firstly, by investigating the impact of service trade barriers on firms of different sizes and finding a stronger effect for smaller firms, this chapter highlights the importance of service trade policy to UK small businesses. As of the start of 2020, the ONS estimates that small businesses accounted for 19% of the UK's service exports. This is a sizeable proportion and so these firms must be protected from the adverse effects of service trade barriers. Also, the negative effect of an increase in service trade barriers, especially for smaller firms after the Brexit referendum provides an important insight for policymakers concerned about promoting the performance of small enterprises following the aftermath of Brexit. Lastly, by investigating the periods before and after the Brexit referendum and finding a stronger negative effect in the period after the referendum, policymakers would have to bear this in mind when drafting and implementing new service trade policies as it provides the basis for a more targeted policy framework.

Like the other chapters, this chapter also suffers from some limitations. Firstly, when considering service export performance, this study focuses on just the intensity of service exports and does not consider the extensive margins of exports. In this vein, this study could not investigate changes in trade patterns of UK firms either through trade diversion or product switching as a result of the Brexit referendum specifically, or the presence of trade barriers generally. Neither could it investigate what service trade destinations or service products are most affected by trade barriers. Also, the chapter uses an aggregated STRI index to measure trade barriers, and this index does not allow for the investigation into the mode of delivery for services exports, which is quite important.

In conclusion, this thesis has provided a robust discussion and empirical evidence around international trade, especially service exports, productivity, trade policy and trade uncertainty. Using both industry and firm level analysis, it has provided deeper insights into the relationship between GVCs, productivity and robot adoption, manufacturing firms exporting services and the impact of service trade barriers on firm productivity and export performance. The empirical findings and methodologies used contribute to existing literature while providing a good foundation for future research. The thesis also has some policy implications which have been highlighted. Lastly, although this thesis suffers from some limitations, it provides a good starting point for future research to address these limitations highlighted in order to further enhance our understanding of the areas addressed in this thesis.

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