Technical Progress and Structural Change: The Roles of Demand and Supply in Economic Growth

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TECHNICAL PROGRESS AND STRUCTURAL CHANGE: THE ROLES OF DEMAND AND SUPPLY IN ECONOMIC GROWTH

This study is based on the doctoral dissertation titled “Technical Progress and Structural Change: The Roles of Demand and Supply in Economic Growth”, selected as the award winning entry for the Exim Bank of India BRICS Economic Research Award 2016. The dissertation was written by Dr. João Prates Romero, currently Adjunct Professor, Department of Economics, Universidade Federal de Minas Gerais (UFMG), Brazil, under the supervision of Professor John S. L. McCombie. Dr. Romero received his doctoral degree in 2015 from the University of Cambridge (UK).

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EXECUTIVE SUMMARY

The Kaldorian and the Schumpeterian approaches to economic growth present strong theoretical foundations, with important contributions to macroeconomic growth theory and considerable support from a large number of empirical works. On the one hand, Kaldorian works emphasise the importance of demand growth for long-term productivity growth (e.g. Kaldor, 1966; Dixon and Thirlwall, 1975; Thirlwall, 1979; McCombie and Thirlwall, 1994; Araújo and Lima, 2007). On the other hand, Schumpeterian works emphasise the importance of supply-side factors such as technological transfer and research and development for technical progress (e.g. Soete, 1981; Fagerberg, 1988; Romer, 1990; Aghion and Howitt, 1992; 1998; Verspagen, 1991; Amable and Verspagen, 1995; Griffith *et al.*, 2004).

The main objective of this study is to combine the Kaldorian and the Schumpeterian approaches in a consistent multi-sectoral growth model, in order to offer a more comprehensive explanation for long-term growth. In general terms, taking into account the contributions of Kaldorian and Schumpeterian theories, the thesis advocated in this study is that both demand and supply-side factors influence long-term growth. In addition, this study also seeks to show that different sectors are subject to different dynamics, so that structural change and inter-sectoral interactions affect long-term growth. The novelty of the thesis is threefold: (i) to integrate the Kaldorian and the Schumpeterian traditions in an unprecedented form; (ii) to provide more specific explanations for how demand and supply interact; and (iii) to provide more detailed information about how structural change and sectoral dynamics influence long-term growth.

This study provides seven contributions to understanding the process of economic growth, providing evidence that:

(i) increasing returns to scale are higher in high-tech industries than in low-tech industries, and that this difference has increased in the last decades;

(ii) the degree of returns to scale depends on the level of research intensity observed in each industry, so that the difference between the scale economies observed between high-tech and low-tech industries can be partially explained by differences in the level of research intensity verified in each group;

(iii) high-tech industries not only present higher returns to scale, but they also present higher income elasticities of demand for exports and imports, although the magnitude of this difference seems to have reduced in the last decades;

(iv) domestic and foreign productivity growth influence the growth rate of exports and imports, capturing intra-industry non-price competitiveness, while income elasticities of demand still differ between industries due to inter-industry non-price competitiveness;

(v) product sophistication influences subsequent productivity growth and impacts on export and import growth.

(vi) in a multi-sectoral framework with balance-of-payments constraint, changes in the performance of a given sector affect the performance of the rest of the economy via inter-sector demand externalities. More specifically, an increase in productivity in a given sector leads to an increase in this sector's exports, which eases the balance-of-payments constraint, allowing higher output growth in the other sectors of the economy.

(vii) an increase in the growth rate of foreign output can exert a negative impact on the domestic economy if the negative effect of this increase on the trade performance of the domestic economy (via the increased foreign non-price competitiveness) is larger than the positive demand effect.

To sum up, the model proposed in this study and the associated econometric evidence show that the Kaldorian and the Schumpeterian traditions can be combined without subverting their core ideas, as long as both demand and supply-side factors are allowed to play a role in long-term growth. According to the Multi-Sectoral Kaldor-Schumpeter growth model proposed and tested in this study, higher equilibrium growth rates can be achieved if:

(i) the growth rate of foreign income raises, and the negative effect of this increase on the trade performance of the domestic economy (through non-price competitiveness) is smaller than the positive demand effect;

(ii) the share of high-tech exports increases;

(iii) technology absorption increases;

(iv) research intensity increases in any given sector of the domestic economy, but especially in high-tech industries.

INTRODUCTION

Throughout the years, amongst different explanations for why output and productivity growth differ between countries, two alternative theories became particularly influential.

On the one hand, building on Keynes' (1936) short-term demand-led approach, Kaldorian works emphasise the importance of demand growth for long-term productivity growth. Influenced by Allyn Young (1928) and seminal findings of Verdoorn (1949), Kaldor (1966) stressed that the pace of demand growth influences the pace of technical progress. Similarly to Smith (1776), who argued that the size of the market determines the level of division of labour, Kaldor (1966) argued that the rate of growth of the market determines the rates of growth of division of labour and of technical progress. Consequently, this relationship, known as Kaldor-Verdoorn's Law, stresses the role of increasing returns to scale in productivity growth. Furthermore, Kaldor (1970) argued also that the rate of growth of aggregate demand depends on the rate of growth of exports, which is the main autonomous component of demand. Thirlwall (1979) expanded this approach by stressing that export growth is also crucial to allow other components of demand to grow without incurring in balance-of-payments disequilibria, which constrains the pace of growth of domestic demand. These two ideas form the core of the Kaldorian approach to economic growth, and a large number of studies have found evidence in support of these hypotheses (e.g. McCombie and De Ridder, 1983; 1984; Angeriz et al., 2008; 2009; Thirlwall, 1979; Hussain and Thirlwall, 1982; Bairam and Dempster, 1991; McCombie and Thirlwall, 1994; 1997; Perraton, 2003; Bagnai, 2010). Finally, combining these ideas with the assumption that productivity growth influences price movements gives rise to the Kaldor-Dixon-Thirlwall (KDT) model of cumulative growth developed by Dixon and Thirlwall (1975), in which output growth leads to productivity growth, which leads to better export performance, leading to further output growth.

On the other hand, in parallel to the Kaldorian demand-led approach, Schumpeterian works emphasise the importance of supply-side factors for technical progress. The importance of research intensity for technical progress and economic growth represents the main foundation of Schumpeterian models of economic growth (e.g. Romer, 1990; Aghion and Howitt, 1992; 1998; Ha and Howitt, 2007). According to Schumpeter (1943), innovations create temporary monopolies, providing strong incentives for firms to invest in research and development (R&D). Furthermore, other contributions from Schumpeter's (1934; 1943) works have been explored in the literature that investigates the determinants of economic growth (e.g. Aghion and Howitt, 1992; King and Levine, 1993; Nelson, 1993). Amongst these contributions, two stand out. Firstly, a number of Schumpeterian studies emphasise the importance of technological transfer for productivity growth (e.g. Posner, 1961; Abramovitz, 1986; Verspagen, 1991; Griffith *et al.*, 2004; Vanderbusche *et al.*, 2006). Transposing Schumpeter's (1934; 1943) microeconomic ideas on innovation and imitation to a macroeconomic setting, these works stress that follower economies can benefit from their backwardness and achieve higher productivity growth than leading economies through imitation, given that absorbing (imitating) foreign technology is easier (cheaper) than creating innovations. According to this approach, the existence of productivity gaps between countries opens up the opportunity for technological transfer from frontier countries to follower countries, providing a fruitful explanation for conditional convergence. Secondly, in Schumpeter's (1934; 1943) seminal works, technological competitiveness is crucial for economic growth. Consequently, Schumpeterian studies also stress the importance of technological competitiveness for trade performance (e.g. Fagerberg, 1988; Greenhalgh, 1990). Most importantly, these three central ideas have been investigated in a vast number of empirical works, and most of these studies found results that support the Schumpeterian insights (e.g. Soete, 1981; Verspagen, 1991; Amable and Verspagen, 1995; Griffith et al., 2004; Ha and Howitt, 2007; Madsen, 2008).

In sum, both the Kaldorian and the Schumpeterian approaches to economic growth present strong theoretical foundations, with important contributions to macroeconomic growth theory and considerable support from a large number of empirical works.

The two approaches show some important similarities. They emphasise the importance of endogenous technical progress and trade for economic growth, while recognizing the importance of non-price competitiveness for trade performance and stressing the role of structural change in economic growth (e.g. Kaldor, 1970; Fagerberg, 1988). Furthermore, both approaches emphasise the importance of cumulative mechanisms for long-term growth. In the Kaldorian tradition, cumulative causation is generated via the impact of output growth on productivity growth through Kaldor-Verdoorn's Law (e.g. Dixon and Thirlwall, 1975). In the Schumpeterian tradition, cumulative causation is generated through the impact of knowledge accumulation on productivity growth (e.g. Romer, 1990; Aghion and Howitt, 1992; 1998; Nelson and Winter, 2002). Finally, both approaches are compatible with conditional convergence, as shown by Verspagen (1991) inter alia regarding Schumpeterian theory, and as recently demonstrated by Roberts (2007) regarding Kaldorian theory.

Similarities notwithstanding, the two traditions present an important difference. While Kaldorian theory emphasises the importance of demand growth for long-term growth, putting less stress on the importance of supply-side factors, the opposite holds true for Schumpeterian theory. On the one hand, this difference generates a certain degree of complementarity between the two approaches, opening up the possibility of enriching the explanation of the process of long-term growth by combining the two. On the other hand, this difference creates an important difficulty, since combining these theories can subvert one of the two by attributing final role to either demand or to supply alone. Perhaps because of this issue, in spite of the large number of Kaldorian and Schumpeterian works that have investigated the determinants of productivity growth, there have been relatively few attempts of reconciling the two approaches (e.g. Amable, 1993; Targetii and Foti, 1997; Léon-Ledesma, 2002).

The main objective of this study is to combine the Kaldorian and the Schumpeterian approaches in a consistent multi-sectoral growth model, in order to offer a more comprehensive explanation for long-term growth. In general terms, taking into account the contributions of Kaldorian and Schumpeterian theories, the thesis advocated in this study is that both demand and supply-side factors influence long-term growth. In addition, this study also seeks to show that different sectors are subject to different dynamics, so that structural change and inter-sectoral interactions affect long-term growth. The novelty of the thesis is threefold: (i) to integrate the Kaldorian and the Schumpeterian traditions in an unprecedented form; (ii) to provide more specific explanations for how demand and supply interact; and (iii) to provide more detailed information about how structural change and sectoral dynamics influence long-term growth.

In order to achieve the main objective of the thesis, besides this introduction and the conclusion, the study presents eight chapters, which are divided in three parts:

(i) Part I of the study is composed of chapters 1 and 2, and aims to discuss the main theories explored in the thesis, providing the foundations for the discussion to be presented in the subsequent chapters. In chapter 1, the gaps in the Kaldorian theory to be addressed in this study are identified. In chapter 2, the main determinants of long-term growth emphasised in the Schumpeterian tradition are discussed, aiming to identify elements to be incorporated into the Kaldorian approach.

(ii) Part II of the study is composed of chapters 3 to 7, and aims to combine and test different parts of the Kaldorian and the Schumpeterian theories discussed in chapters 1 and 2. As discussed above, the Kaldorian approach to growth is composed of two core ideas: the importance of increasing returns to productivity growth, and the role of balance-of-payments constraint in output growth. In chapters 3 to 7, Schumpeterian insights are introduced into Kaldorian models and formally tested. Chapters 3 and 4 focus on the first topic, whereas chapters 5 to 7 focus on the second. The empirical results found in these chapters provide the evidence required to construct a multi-sectoral model that integrates the contributions of the Kaldorian and the Schumpeterian approaches.

(iii) Part III of the study is composed of chapter 8, and aims to propose a multi-sectoral model that combines the empirical contributions of chapters 3 to 7, while addressing important critiques directed to the canonical Kaldorian model of cumulative growth. Most importantly, this chapter not only integrates the previous contributions of the thesis, but it also shows how combining these findings in a formal model leads to results not observed when each relationship is analysed separately. This chapter, therefore, provides the main contribution of the study.

As mentioned above, chapters 1 and 2 discuss in detail the Kaldorian and the Schumpeterian theories, respectively. These chapters scrutinize the most important models elaborated based on the central ideas of each tradition, analysing the empirical evidence associated with each of the models. The Kaldorian approach to growth constitutes the main theoretical foundation of the thesis, while elements from Schumpeterian theory are incorporated into the Kaldorian framework to enrich its explanation of the process of economic growth.

The literature review carried out in chapter 1 shows that there are three important gaps in the Kaldorian literature. Firstly, there is still no clear explanation for what determines differences in the degree of returns to scale across countries, industries and through time, nor for what determines the magnitudes of income elasticities of demand for exports and imports. In both cases, exploring the effects of additional variables could help clarify what determines the magnitudes of these parameters. Secondly, sectoral differences have not yet been fully explored in Kaldorian theory. Although several works have investigated the validity of Kaldor-Verdoorn's Law in different sectors, to the best of my knowledge, no work has tried to carry out a careful assessment of the relationship between increasing returns and specific characteristics of the goods produced in each sector. Similarly, only recently has Thirlwall's Law been disaggregated to test for differences in income elasticities across sectors. Hence, further work is still necessary to properly assess the relationship between structural change and economic growth from a Kaldorian perspective. Thirdly, the original KDT model received two important critiques that have not been satisfactorily addressed, namely: (i) cumulative causation works through price competitiveness; and (ii) the degree of returns to scale is left unexplained.

This study addresses these three important gaps in the Kaldorian literature. First, following the review of the Schumpeterian approach carried out in chapter 2, the thesis incorporates the main insights from Schumpeterian theory into the Kaldorian framework, aiming to improve the explanatory power of the latter. Second, the thesis proposes and tests expanded versions of Thirlwall's Law, Kaldor-Verdoorn's Law and of the Kaldor-Dixon-Thirlwall model, disaggregating each relationship of the models to analyse the importance of sectoral dynamics for long-term growth.

Chapters 3 and 4 of the study address a central question in Kaldorian theory: provided the Kaldor-Verdoorn Law holds and there are increasing returns to scale in manufacturing, what determines the magnitude of such scale economies? Thus, taking into account the main objective of the thesis, these chapters investigate whether supply-side factors explain differences in returns to scale.

Chapter 3 investigates whether the degree of increasing returns to scale varies between technological sectors and through time. In the Schumpeterian literature, technological classifications of industries are normally used to stress differences in the dynamics of production and innovation across sectors (e.g. Pavit, 1984; Lall, 1992). Nonetheless, in spite of the interesting results found by the studies that follow this approach, only recently have Kaldorian studies started to carry out empirical investigations using technological classifications (e.g. Gouvêa and Lima, 2010). Still, Kaldor-Verdoorn's Law has never before been tested adopting a technological classification of industries. Chapter 3 reports estimates of Kaldor-Verdoorn's Law for low-tech and high-tech manufacturing industries using data from the EU KLEMS Database. Using such classification allows understanding whether the technological content of industries influences the degree of returns to scale. Furthermore, seeking to identify changes in the magnitude of returns to scale through time, this chapter reports estimates of the law for different time periods. Finally, the tests reported in this chapter provide a contribution in terms of the method used to estimate Kaldor-Verdoorn's Law. To the best of my knowledge, no study has ever used cross-country-industry panels to test the law, which is usually estimated in cross-country or cross-region regressions. Yet, using this estimation strategy considerably increases the number of observations available, improving the efficiency and consistency of the regressions. Moreover, the tests reported in this chapter employ modern panel data techniques not previously explored in this literature.

The evidence reported in chapter 3 provides the first empirical contribution of the thesis. This evidence suggests that increasing returns to scale are higher in high-tech industries than in low-tech industries, which indicates that supply-side characteristics of goods influence the degree of scale economies generated when demand grows. Furthermore, the empirical investigation presented in this chapter shows that the magnitude of the returns to scale in manufacturing as a whole has increased in the last decades, driven by a raise in the returns to scale observed in high-tech industries.

Chapter 4 complements and extends the investigation reported in chapter 3. Following the findings of chapter 3, chapter 4 investigates whether the level of research intensity determines the degree of returns to scale verified in each country and/or industry. The technological classification of industries used in the tests of chapter 3 follows the research intensity of each industry, assuming that industries with high research intensity are high-tech industries. Thus, chapter 3 provides initial evidence of the importance of research intensity for productivity growth. Chapter 4, in turn, investigates two hypotheses. Firstly, the chapter investigates whether research intensity and output growth have significant impacts on productivity growth when simultaneously considered, assessing if the basic Kaldorian and Schumpeterian models can be combined. Secondly, the chapter examines whether research intensity impacts on the degree of returns to scale, assessing if countries/industries with higher research intensity benefit from higher returns to scale. The intuition behind this hypothesis is that higher research intensity generates higher knowledge, which allows faster technical progress (or dynamic returns to scale) in response to output growth. The empirical investigation reported in this chapter is based on disaggregated data on patents and productivity not used elsewhere in the literature. The data used to calculate total factor productivity growth is from the EU KLEMS Database, and comprises 12 manufacturing industries in up to 15 OECD countries over the period 1976-2006. Data on patents for each country, industry and year is from the United States Patent and Trademark Office (USPTO), and was aggregated by industry using the methodology developed by Lybbert and Zolas (2014). Thus, the investigation presented in this chapter extends previous works carried out using EU KLEMS data by incorporating innovation indicators into the database, as suggested by O'Mahony and Timmer (2009: F396).

The exercises presented in chapter 4 provide the second empirical contribution of the thesis. The test results reported in this chapter support the claim that although productivity growth is determined by output growth, which indicates the existence of increasing returns to scale, research intensity influences the magnitude of such returns. This shows that countries with higher research intensity benefit from higher increasing returns in response to output growth. Still, without demand growth research intensity has no effect on productivity growth. Therefore, complementing the first contribution of the thesis, this second contribution provides a partial explanation for why returns to scale are higher in high-tech industries than in low-tech industries. Nonetheless, the investigation indicates that there are other unidentified supply-side characteristics that lead to the existence of higher autonomous (in relation to research intensity) returns to scale in high-tech industries, reinforcing the results of chapter 3. In addition, the tests also suggest that technological transfer influences productivity growth. Hence, this second empirical contribution provides additional support to the claim that both demand and supply-side factors influence productivity growth.

After exploring the determinants of productivity growth and increasing returns to scale in chapters 3 and 4, chapters 5 to 7 investigate the determinants of long-term output growth. Chapters 3 and 4 show that demand growth determines the pace of productivity growth. In the Kaldorian approach, demand growth is constrained by balance-of-payments disequilibria. Hence, it is crucial to examine what determines export and import growth to understand what determines the pace demand growth. This task is carried out in chapters 5 to 7.

Chapter 5 investigates the validity of the balance-of-payments constrained growth model. This model, proposed by Thirlwall (1979), builds on Kaldor's (1970) ideas about the dominant role of exports in income growth, and stresses that the balance-of-payments constraint is the central determinant of the speed of output growth. The model suggests that, provided debt cannot be financed indefinitely and changes in relative prices do not affect trade in the long-term, each country's equilibrium growth rate must correspond to the ratio between its income elasticity of demand for exports and its income elasticity of demand for imports, multiplied by the growth rate of external demand (or world income). This relationship, known as Thirlwall's Law, was more recently disaggregated by Araújo and Lima (2007). The authors proposed a multi-sectoral version of this law, stressing that the aggregate income elasticities are weighted averages of sectoral elasticities, where the weights are the shares of each sector in trade. In this context, the contribution of this chapter to balance-of-payments constrained growth literature is twofold. First, the chapter reports estimates of import and export functions by technological sectors for 14 developed countries not yet investigated by the more recent multi-sectoral studies. Only two studies have estimated import and export functions by technological sectors, and both have focused on developing countries (Gouvêa and Lima, 2010; Romero et al., 2011). Furthermore, although Gouvêa and Lima (2013) have estimated sectoral import and export functions using a large panel of countries, the authors adopted a different classification of sectors. Moreover, the authors estimated the export and import functions using cross-country panels (for each sector), disregarding differences in income elasticities between countries. Second, the chapter introduces a new method of estimating import and export functions, which contributes to improve the robustness of the results. It is common practice in the balance-of-payments constrained growth literature to estimate export and import functions using Vector Error Correction Models (VECMs), while aggregate price indexes are used to deflate value series and to measure relative prices. The econometric investigation reported in this chapter compares the results found using the traditional method with estimates found using cross-product panels, which generate a sizable increase in the number of observations, while using quality-adjusted price indexes recently calculated by Feenstra and Romalis (2014) to deflate the value series and to calculate relative prices.

Thus, the third empirical contribution of the study is to provide more robust empirical evidence of the existence of differences in income elasticities of demand between technological sectors. According to the exercises presented in chapter 5, high-tech industries tend to present higher income elasticities than low-tech industries, which suggests that moving from the production of low-tech products to the production of high-tech products fosters an increase in the equilibrium growth rate according to Araújo and Lima's (2007) Multi-Sectoral Thirlwall's Law (MSTL). Moreover, the investigation also revealed that using a more recent time period generates estimates of income elasticities of demand for primary products and resource based manufactures that tend to be higher than the estimates found by studies that have used longer time periods, while the opposite holds for low-, medium-, and high-tech manufactures. This result is possibly explained by the considerable increase in the demand for primary products and resource based manufactures observed in the last decades. These findings indicate that differences in the supply-side characteristics of goods influence both the rate of growth of productivity, as shown in chapters 3 and 4, as well as the income elasticities of demand for exports and imports. Furthermore, they indicate that differences in income elasticities between sectors change through time.

Yet, the investigation presented in chapter 5 shows that moving exports (imports) from (to) low-tech industries to (from) high-tech industries might be necessary but not sufficient to increase long-term growth, given that countries with similar sectoral compositions of trade present different equilibrium growth rates. This suggests that it is important to carry out further research on the determinants of the magnitude of income elasticities. This task is carried out in chapters 6 and 7.

Chapter 6 investigates the impact of foreign and domestic productivity growth on export and import growth. This chapter discusses the specification of export and import functions, arguing that introducing relative productivity into these functions to capture non-price competitiveness contributes to a better understanding of the determinants of exports and imports. Furthermore, the chapter discusses the similarities between the Kaldorian and the Schumpeterian approaches to trade, demonstrating that the two traditions can be combined adopting more general specifications for the export and import demand functions than the specifications used in each of the literatures. Using these expanded export and import functions, an expanded Thirlwall's Law is derived. The chapter reports estimates of the expanded functions for low-tech and high-tech industries, showing that, based on the estimated parameters, the equilibrium growth rates calculated according to the expanded Thirlwall's Law and the expanded multi-sectoral Thirlwall's Law provide good fits for the actual output growth rates observed over the period investigated. In addition, the empirical investigation shows also that although introducing relative productivity influences the magnitude of the income elasticities of demand, these elasticities still vary across sectors, reflecting inter-sector non-price competitiveness.

This chapter presents the fourth empirical contribution of the study, providing evidence that foreign and domestic productivity growth impact on export and import growth. This evidence indicates that intra-sector differences in non-price competition influence sectoral trade performance. Yet, it also indicates that inter-sector differences in non-price competition, captured in the income elasticities of demand, are the main determinant of trade performance. Furthermore, the chapter demonstrates that the Kaldorian and the Schumpeterian literatures on the determinants of trade can be combined using more general specifications of export and import demand functions. Finally, the chapter shows that the proposed expanded Thirlwall's Law holds for the sample analysed. Thus, the findings of this chapter suggest that both demand and supply-side factors influence countries' trade performance, reinforcing and complementing the findings of chapter 5.

Chapter 7 investigates the impact of product sophistication on productivity and trade, using the methodologies proposed by Hausmann et al. (2007) and Hidalgo and Hausmann (2009) to assess the results found in chapter 6. More specifically, the chapter reports tests of the impact of changes in sophistication on productivity growth, and presents estimates of the export and import demand functions investigated in chapter 6 replacing productivity by sophistication growth. Using export data from UN Comtrade disaggregated by SITC (Revision 2) 4-digits product categories, industry sophistication indexes were calculated for each of the EU KLEMS industries and incorporated into the database used in chapters 3, 4 and 6.

This chapter presents the fifth empirical contribution of the study, reporting evidence that changes in product sophistication influence productivity, export and import growth. This chapter's tests suggest that productivity growth is associated with improvements in product quality, as argued in chapter 6. While the positive impact of product sophistication on productivity growth is only significant in high-tech industries, the impact of sophistication on exports is positive and significant for both groups of industries. Although the estimates are less robust than the estimates reported in chapter 6, these chapter's tests indicate that the impact of sophistication on exports is higher for high-tech industries.

Chapters 3 to 7, therefore, provide five contributions to understanding the process of economic growth. These chapters show, respectively:

(i) that increasing returns to scale are higher in high-tech industries than in low-tech industries, and that this difference has increased in the last decades;

(ii) that the degree of returns to scale depends on the level of research intensity observed in each industry, so that the difference between the scale economies observed between high-tech and low-tech industries can be partially explained by differences in the level of research intensity verified in each group;

(iii) that high-tech industries not only present higher returns to scale, but they also present higher income elasticities of demand for exports and imports, although the magnitude of this difference seems to have reduced in the last decades;

(iv) that domestic and foreign productivity growth influence the growth rate of exports and imports, capturing intra-industry non-price competitiveness, while income elasticities of demand still differ between industries due to inter-industry non-price competitiveness;

(v) that product sophistication influences subsequent productivity growth and impacts on export and import growth.

To integrate the five main contributions of chapters 3 to 7, Chapter 8 proposes a growth model that consistently combines the key insights from the Kaldorian and the Schumpeterian traditions, while keeping the importance of both demand and supply-side factors for long-term growth. The contribution of the chapter to growth theory is threefold. First, the chapter proposes an aggregate model that introduces the contributions provided in the previous chapters of the thesis into the KDT model. Moreover, this model addresses two important shortcomings attributed to the Kaldor-Dixon-Thirlwall (KDT) model: (i) by changing the channel through which cumulative causation operates from price to non-price competition; and (ii) by explaining why returns to scale vary between industries and through time.

The Schumpeterian contributions are incorporated into the model by introducing the effect of technological transfer as a determinant of autonomous technical progress, and by introducing research intensity as a determinant of the degree of returns to scale. The model is compatible with the existing empirical evidence on conditional convergence, and with the Kaldorian and the Schumpeterian empirical works. Hence, this model shows that the two traditions can be combined without subverting their core ideas as long as both demand and supply-side factors are allowed to play a role in long-term growth. Second, the chapter proposes a multi-sectoral version of the aggregate model to emphasise the importance of inter-sector interactions for long-term growth. Previous attempts to combine the two traditions have never before adopted a multi-sectoral framework. This chapter's model shows that in a multi-sectoral framework with balance-of-payments constraint, changes in the performance of a given sector affect the performance of the rest of the economy via inter-sector demand externalities. More specifically, an increase in productivity in a given sector leads to an increase in this sector's exports, which eases the balance-of-payments constraint, allowing higher output growth in the other sectors of the economy. Third, the model shows also that an increase in the growth rate of foreign output can exert a negative impact on the domestic economy if the negative effect of this increase on the trade performance of the domestic economy (via the increased foreign non-price competitiveness) is larger than the positive demand effect.

The model proposed in this study and the associated econometric evidence show that the Kaldorian and the Schumpeterian traditions can be combined without subverting their core ideas, as long as both demand and supply-side factors are allowed to play a role in long-term growth. According to the Multi-Sectoral Kaldor-Schumpeter growth model proposed and tested in this study, higher equilibrium growth rates can be achieved if: (i) the growth rate of foreign income raises, and the negative effect of this increase on the trade performance of the domestic economy (through non-price competitiveness) is smaller than the positive demand effect; (ii) the share of high-tech exports increases; (iii) the technology gap increases; and (iv) research intensity increases in any given sector of the domestic economy.

In sum, chapter 8 integrates all the contributions of the thesis, formalising the channels through which demand and supply interact to generate different growth rates in different industries and countries, as this study aims to demonstrate.

1. ECONOMIC GROWTH FROM A KALDORIAN PERSPECTIVE

1.1. Introduction

Nicholas Kaldor's works cover a number of different subjects in economic theory, such as cumulative causation, regional policy, taxation, income distribution, economic growth, balance-of-payments, and technical progress. Nonetheless, three of Kaldor's ideas were particular influential as explanations for economic growth (McCombie, 2002: 64-5): (i) increasing returns to scale; (ii) exports; and (iii) cumulative causation.

The objective of this chapter is to discuss the models derived from the three main Kaldorian insights, identifying gaps in the existing literature. This summary presents a brief review of the core Kaldorian ideas. A revised version of the chapter, however, has been recently accepted for publication in the Brazilian Keynesian Review (Romero, 2016a).

1.2. Canonical Kaldorian Models

1.2.1. Kaldor-Verdoorn's Law

The most influential of Kaldor's contributions to economic theory relates to the importance of increasing returns to scale for productivity growth. Kaldor (1966) strongly emphasised that the main source of productivity growth is technical progress. According to him, technical progress is determined by demand growth, which fosters increases in learning-by-doing and division of labour. Hence, following Keynes' (1936) demand-led approach, Kaldor's ideas contribute to understanding how demand growth influences technical progress. Kaldor's ideas about the role of demand growth in generating technical progress, productivity growth, and increasing returns are summarized in Kaldor-Verdoorn's Law, i.e. the positive (long-term) relationship between output growth and productivity growth.

After the seminal empirical evidence found by Verdoorn (1949) and Kaldor (1966) suggesting the existence of increasing returns in manufacturing, Kaldor-Verdoorn's Law was tested in a large number of works both for developed and developing countries (e.g. Hansen and Zhang, 1996; Harris and Liu, 1999; Oliveira *et al.*, 2006), across different sectors (e.g. McCombie and De Ridder, 1983; León-Ledesma, 2000; Angeriz *et al.*, 2009), and using different econometric techniques (e.g. McCombie and De Ridder, 1984; León-Ledesma, 2000; Angeriz *et al.*, 2008; Britto, 2008).

Yet, in spite of the large number of works that have investigated Kaldor-Verdoorn's Law, not much is known about the specific factors that determine differences in the degrees of returns to scale across countries, sectors or through periods.

1.2.2. Thirlwall's Law

Kaldor's (1970) second influential contribution to growth theory relates to the importance of exports for long-term growth. Keynesian economics emphasises the importance of investment for economic growth. Kaldor, however, stressed that export is the most important component of autonomous demand in open economies, given that long-term growth is constrained by balance-of-payments disequilibria, provided that growing debt cannot be indefinitely financed. Thus, again Kaldor extrapolates the Keynesian demand-led approach by stressing the importance of external demand for long-term growth.

Kaldor's (1970) ideas on the importance of exports for long-term growth were extrapolated and formalised by Thirlwall (1979). The model suggests that, provided debt cannot be financed indefinitely and changes in relative prices do not affect trade in the long-term, each country's equilibrium growth rate must correspond to the ratio between its income elasticity of demand for exports and its income elasticity of demand for imports, multiplied by the growth rate of external demand (or world income). This relationship, known as Thirlwall's Law, was more recently disaggregated by Araújo and Lima (2007). The authors proposed a multi-sectoral version of this law, stressing that the aggregate income elasticities are weighted averages of sectoral elasticities, where the weights are the shares of each sector in trade.

Thirlwall's Law has been tested for a large number of countries using a variety of estimation techniques (e.g. Bairam, 1988; Bairam and Dempster, 1991; Atesoglu, 1993a; 1993b; Andersen, 1993; Alonso and Garcimartin, 1998; Perraton, 2003; Jayme Jr., 2003; Britto and McCombie, 2009; Garcimartin et al., 2010). In addition, a number of works have tested the extended balance-of-payments constrained growth model that take into account capital flows, debt accumulation and debt payments, and in most cases the original Thirlwall's Law is found to hold (e.g. Thirlwall and Hussain, 1982; Barbosa-Filho, 2001; Moreno-Brid, 2003; Britto and McCombie, 2009). Most recently, following Araújo and Lima's (2007) multi-sectoral version of Thirlwall's Law, some works have been exploring the connection between the sectoral composition of trade and the magnitudes of aggregate income elasticities (e.g. Gouvea and Lima, 2010; Romero *et al.*, 2011).

In spite of the large literature on Thirlwwall's Law, however, as happens with the literature on increasing returns to scale, not much is known about the determinants of the income elasticities of demand.

1.2.3. Kaldor-Dixon-Thirlwall Model

Finally, Kaldor's third influential contribution to growth theory relates to the importance of cumulative causation in the process of economic growth. In contrast with neoclassical growth theory, which focuses on mechanisms that lead economies to converge, Kaldor (like Myrdal, 1957) emphasised the importance of cumulative mechanisms that slow down convergence or make economies diverge. This argument is closely linked to his emphasis on increasing returns, since the interplay between demand growth and productivity growth forms a cumulative circuit of growth, as formalized by Dixon and Thirlwall (1975).

Nonetheless, Dixon and Thirlwall's (1975) canonical model has been criticized due the fact that cumulative causation in model works through price competitiveness. A vast literature provides evidence that, in the long run, price elasticities of demand do not have a significant effect on export growth, either because relative prices are constant in the long-term, or because the Marshal-Lerner condition is not satisfied (Blecker, 2013). In these cases, the model's cumulative causation ceases to exist, given that productivity gains generated by increasing returns feed back on growth only via price competitiveness. Moreover, the more prominent role of price competitiveness in relation to non-price competitiveness in the KDT model is conflicting with the emphasis put into this type of competition in the balance-of-payments constrained growth models (see McCombie and Thirlwall, 1994).

1.3. Concluding Remarks

The literature review presented in this chapter identified three important gaps in the Kaldorian literature. Firstly, both in Kaldor-Verdoorn's Law and in Thirlwall's Law, the key parameters of the model have not been fully understood. In the former, it is still not clear what determines differences in the degree of returns to scale across countries, sectors and through time. In the latter, it is also not clear what are the specific determinants of the magnitudes of income elasticities of demand for exports and imports. In both cases, exploring the effects of additional variables could help clarify what determines the magnitudes of these parameters. Secondly, the fact that cumulative causation works through price competitiveness in the KDT model represents an important limitation of the model. A vast literature provides evidence that, in the long run, changes in relative price do not have a significant effect on export growth, either because relative prices are constant in the long-term, or because the Marshal-Lerner condition is not satisfied. In these cases, the model loses its mechanism of cumulative causation, given that productivity gains generated by increasing returns feed back on growth only through price competition. Thirdly, sectoral differences have not been fully explored in Kaldorian theory. Although several works have investigated the validity of Kaldor-Verdoorn's Law for different sectors, no work has ever tried to carry out a careful assessment of the relationship between increasing returns and specific characteristics of the goods produced in each sector. Similarly, only recently has Thirlwall's Law been disaggregated to test the differences in the income elasticities across different sectors to assess whether the economic structure of each country influences its aggregate income elasticities. Hence, further work is still necessary to properly assess the relationship between structural change and economic growth from a Kaldorian perspective.

As discussed in the general introduction, this study addresses these three gaps in the Kaldorian literature. First, it incorporates the main insights from Schumpeterian theory into the Kaldorian framework, aiming to improve the explanatory power of this approach. Second, it tests expanded versions of Thirlwall's Law, Kaldor-Verdoorn's Law and of the Kaldor-Dixon-Thirlwall model, disaggregating each relationship of the models to identify the importance of sectoral differences for long-term growth.

2. ECONOMIC GROWTH FROM A SCHUMPETERIAN PERSPECTIVE

2.1. Introduction

The Austrian economist Joseph Schumpeter is known for his seminal works on the importance of innovation for economic growth. His contributions range from the classification of different types of innovation to the analysis of the determinants of innovation, passing by the importance of finance for technical progress, the role of technological competitiveness in trade performance, and the role of imitation and technological transfer in economic growth (see Fagerberg, 2005).

Schumpeter's (1934, 1943) works have inspired research from different perspectives. On the one hand, Nelson and Winter (1982), Dosi (1982), Metcalfe (2005) and others have explored Schumpeter's ideas using an evolutionary framework. On the other hand, Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992; 1998; 2009), Acemoglu *et al.* (2006) and others have explored Schumpeter's ideas using growth models with endogenous technical progress. Still, in spite of the sharp differences in the microeconomic foundations of these two Schumpeterian traditions, the macroeconomic application of Schumpeter's insights is considerably similar between the two approaches (see Verspagen, 2005). In terms of the macroeconomic analysis of the determinants of innovation and growth, authors from both streams emphasise the importance of technological transfer (e.g. Griffith *et al.*, 2004; Verspagen, 1991), finance (e.g. Levine, Loayza, Back, 2000; Fagerberg and Srholec, 2008), research and development (R&D) (e.g. Madsen, 2008; Cohen and Levinthal, 1990; Fagerberg *et al.*, 2007; Archibugi and Coco, 2005), and institutions (e.g. Acemolgu *et al.*, 2006; Aghion and Howitt, 2009; Lundval, 1992; Nelson, 1993; Metcalfe and Ramlogan, 2008).

The objective of this chapter is to present a critical assessment of the Schumpeterian macroeconomic approach to economic growth. Taking as reference a representative sample of important works within this tradition, this chapter aims to identify the main contributions and limitations of the Schumpeterian literature to understanding economic growth. More specifically, the literature review carried out in this chapter focuses on three of Schumpeter's (1934; 1943) ideas that have become particularly influential in macroeconomic growth theory: (i) the role of technological transfer in productivity growth in follower countries; (ii) the importance of research intensity for technical progress in leading economies; and (iii) the prominence of technological competitiveness for trade performance.

2.2. Research Intensity

According to Schumpeter (1943), product differentiation (i.e. innovation) gives rise to temporary monopolies, which guarantee abnormal profits to innovators. This creates an incentive for firms to invest in research and development (R&D) in pursuit of innovations. This seminal idea represents the foundation of Schumpeterian models of economic growth (Valdés, 1999).

In a macroeconomic approach, research intensity captures the aggregate effort devoted to generate technological progress. Differences in research intensity between economies can result from differences in entrepreneurial capacity, government regulation, access to finance, access to inputs, average firm size, market size, amongst other factors. Consequently, the better the macroeconomic incentives for firms to invest in R&D are, the higher is the innovation/absorption effort in the economy. In other words, the degree of research intensity depends on the institutional arrangement set up in each economy. Indeed, R&D is not only carried out inside firms, but also in research institutes, universities, and technological parks. Thus, the aggregate investment in R&D might be higher than the sum of firms' individual expenses in research. Hence, the emphasis on the importance of research intensity for technological progress and productivity growth indirectly takes into account, at least partially, the importance of institutions for technological progress, as advocated by Gerschenkron (1962), Lundval (1992), Nelson (1993) and Freeman (1995), *inter alia*.

The impact of research intensity on technical progress was tested in a variety of forms, and the vast majority of works find that research intensity exerts a positive impact on output and productivity growth (e.g. Fagerberg, 1987; Jaffe, 1988; Fagerberg and Verspagen, 2002; Ha and Howitt, 2007; Madsen, 2008; Chang et al., 2013).

2.3. Technological Catch-up

The transposition of Schumpeter's (1934; 1943) microeconomic ideas on innovation and imitation to a macroeconomic setting led to the development of the technological catch-up hypothesis (Posner, 1961).

According to this approach, the existence of productivity gaps between countries opens up the opportunity for technological transfer from frontier to follower countries, which increases the growth rates of productivity and output of the latter. The technological catch-up hypothesis was formalised by Nelson and Phelps (1966), and expanded later by other authors (e.g. Verspagen, 1991).

The simple relationship between technological absorption and output and productivity growth emphasised in the technological catch-up literature has been tested in a number of works. The vast majority of works find a negative relationship between productivity growth and the magnitude of the gap, which suggests a connection between growth and technological transfer (e.g. Amable, 1993; Fagerberg and Verspagen, 2002; Griffith *et al.*, 2004).

2.4. Technological Competitiveness

In Schumpeter's (1934; 1943) seminal works, technological competitiveness is central for economic growth. Following this idea, a vast number of Schumpeterian studies investigate the importance of technological competitiveness for trade performance. Fagerberg's (1988) model presents the key features of the literature that studies the relationship between technology and trade from a Schumpeterian perspective.

Most studies in this tradition find evidence that technological competitiveness has a positive impact on trade performance (e.g. Soete, 1981; Hughes, 1986; León-Ledesma, 2005; Sharma and Gunawardana, 2012). Furthermore, Schumpeterian works have also investigated the existence of differences in the relevance of technological competitiveness for trade across different sectors (e.g. Greenhalgh, 1990; Lall, 2000; Magnier and Toujas-Bernate, 1994; Amable and Verspagen, 1995). In general, the results of these studies indicate that although price competitiveness is more important in low-tech sectors, technological competitiveness presents a relevant impact on the exports of most sectors.

2.5. Concluding Remarks

This chapter's discussion demonstrated that in spite of the contributions of the Schumpeterian literature to understanding the dynamics of technological progress, international trade, and economic growth, there are still some important limitations in this framework. Regarding the importance of research intensity for economic growth, the shortcoming of this approach lies in the explanation of why some countries have difficulty in increasing their levels of research intensity, and how this issue should be addressed. As the literature on National Innovation Systems emphasises, innovation depends on the institutional arrangements of each country. Still, there are few guidelines for what particular institutions foster higher research intensity. Thus, there is considerable room for improvement in the analysis of the relationship between institutions, technical progress and output growth. Furthermore, there is relatively little work on differences in the importance of research intensity and other variables on technical progress between sectors. Similar questions surround the literature that analyses the determinants of technological transfer and its impact on technical progress and economic growth. Although it is recognized that institutions and policies influence the pace of technological absorption, and in spite of the fact that a number of works have recently been focusing on understanding the particular variables that influence absorptive capacity, more research is still necessary in this area as well. As for the studies that investigate the relationship between technological competitiveness and trade, the importance of different sectors for trade performance still needs further development. Finally, the impact of income growth on technical progress, although mentioned in some Schumpeterian works (e.g. Dosi, 1982), is more often neglected in the econometric studies associated with this tradition. As such, this is yet another area that could benefit from more empirical work.

The remainder of the thesis, however, addresses only some of the shortcomings of the Schumpeterian literatures, focusing on the gaps in the Kaldorian literature, while trying to incorporate the core contributions of the Schumpterian tradition into the Kaldorian framework.

3. DIFFERENCES IN INCREASING RETURNS TO SCALE BETWEEN TECHNOLOGICAL SECTORS

A Panel Data Investigation using the EU KLEMS Database

3.1. Introduction

Kaldor's Cambridge Inaugural Lecture in 1966 represented the starting point of a long tradition of investigation into the existence of increasing returns to scale. In this lecture, Kaldor (1966) presented evidence of the positive impact of output growth on the growth rate of productivity, which was interpreted as an indication of the existence of increasing returns to scale in manufacturing. Kaldor called this relationship Verdoorn's Law, in reference to the Dutch economist Petrus Verdoorn (1949), who was one of the first to observe this empirical regularity. However, the relationship is often referred to as Kaldor-Verdoorn's Law, given the importance of Kaldor's contributions to this debate.

Following Kaldor's seminal work, Kaldor-Verdoorn's Law has been tested in several forms, using a variety of estimation methods, adopting different levels of aggregation, and focusing on different time periods and samples of countries. Kaldor-Verdoorn's Law is normally estimated for total manufacturing or by industry, and the vast majority of works finds that there are substantial increasing returns to scale in manufacturing, whereas the degrees or returns to scale vary between industries within manufacturing.

To date, however, Kaldor-Verdoorn's Law has not been tested adopting a technological classification of industries. In the Schumpeterian literature, technological classifications of industries are often used to stress differences in the dynamics of production, innovation and growth in different sectors (e.g. Pavit, 1984; Lall, 1992). Nonetheless, in spite of the interesting results found by the studies that follow this approach, only recently have Kaldorian studies started to carry out empirical investigations using technological classifications (e.g. Gouvêa and Lima, 2010). The existing works only indicate that returns to scale vary between industries, without providing any explanation for why this occurs. In contrast, using a technological classification provides a reason for why returns to scale vary across industries, in spite of the considerable differences observed between the industries within each technological class.

This chapter addresses one of the gaps in Kaldorian literature, namely, the lack of explanation for what determines the degree of increasing returns to scale. More specifically, this chapter investigates whether supply-side characteristics of goods produced in different groups of industries influence the degree of returns to scale observed in each of these groups, examining also if the degree of returns to scale change in different periods of time.

The purpose of this chapter, therefore, is twofold. First, the chapter investigates whether the degree of increasing returns to scale varies according to the technological content of industries, analysing estimates of Kaldor-Verdoorn's Law for low-tech and high-tech manufacturing industries. Second, following Millemaci and Ofria's (2014) investigation, the chapter examines whether the degree of increasing returns to scale varies through time, reporting estimates of Kaldor-Verdoorn's Law for different time periods.

The tests reported in this chapter provide also a contribution in terms of the method used to estimate Kaldor-Verdoorn's Law. To the best of my knowledge, there is no study to date which utilizes cross-industry panels to test this law. The majority or works employ cross-country or cross-region regressions. Nonetheless, using cross-country-industry panels to estimate Kaldor-Verdoorn's Law considerably increases the number of observations available, improving the efficiency and consistency of the regressions. Furthermore, the tests reported in this chapter employ modern panel data techniques not previously explored in this literature, while adopting the specification proposed by Millemaci and Ofria (2014). Moreover, the tests were performed using high-quality sectoral data from the EU KLEMS Database, which has never before been used to estimate Kaldor-Verdoorn's Law.

This summary presents the key findings of the chapter, which has been recently published in the *Journal of Economic Studies*. Hence, readers interested in the complete discussion about the specification of Kaldor-Verdoorn's Law, the database, and the estimation method are referred to Romero and McCombie (2016a)

3.2. Main Results

Table 1 reports the estimates of Kaldor-Verdoorn's Law using Instrumental Variable (IV-FE) and System-GMM (both with Fixed Effects) estimators. An important advantage of System-GMM as opposed to IV-FE using the Durbin ranking method to generate instruments, is that in the former case it is possible to test the validity of the instruments using Hansen's J Test of overidentification, while in the latter case this is not possible, given that the estimated equation is perfectly identified. In all the System-GMM regressions, the Arellano and Bond AR test for autocorrelation did not reject the null hypothesis of no autocorrelation in any of the regressions at the 5% significance level, while Hansen's J test did not reject the null hypothesis of the validity of the instruments at the 5% significance level.

Columns (i) and (ii) of Table 1 report the results found estimating equation (3.5) using IV-FE and System-GMM, respectively. In both these regressions the data are 5-year averages. The results found for total manufacturing reported in column (i) are similar to the estimates found by Verdoorn (1949), Kaldor (1966), Angeriz *et al*. (2009) and Alexiadis and Tsagdis (2010), with an estimate of "encompassing" returns to scale of 2.288. The estimates reported in column (ii), however, imply considerably larger returns to scale (3.135), although similar to the findings of Angeriz *et al*. (2008). The coefficient of output growth (the Verdoorn coefficient) is highly significant, while the technology gap is only significant in the System-GMM estimation, most likely because of the superiority of this instrumenting strategy.

Column (iii) reports the results found estimating equation (3.6) using System-GMM, with data in 5-year averages. As expected the lags are not significant, given that short-term variations have been removed through averaging. Nevertheless, the coefficients are similar to the ones found in columns (i)

Columns (iv) to (vi) report the estimates of equation (3.6) found using System-GMM, with data not averaged. For total manufacturing, the degree of returns to scale is similar to the estimates found in columns (i) and (iii). The results shown in columns (v) and (vi), however, indicate that low-tech industries present lower increasing returns than high-tech industries (1.423 as opposed to 2.990). Interestingly, in these regressions the technology gap is not significant, possibly because the lag of output growth already captures the effect of technological diffusion. The lag of TFP growth, in turn, is possibly capturing short-term inertial growth in productivity, stemming from ongoing increases in productivity.

Nonetheless, the average rate of growth of productivity has experienced some changes over the last decades, decreasing from the 1970s and 1980s to the 1990s, and then increasing again in the 2000s. Thus, in order to analyse whether these changes have any counterpart in the degree of increasing returns to scale, regressions were performed dividing the data into two

Table 1: Dynamic demand-side Kaldor-Verdoorn Law (1976-2006)

Dependent Variable	TFP Growth	TFP Growth	TFP Growth	TFP Growth	TFP Growth	TFP Growth
Method	IV-FE	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Aggregation	5-year averages	5-year averages	5-year averages	Years	Years	Years
Sample	All Industries	All Industries	All Industries	All Industries	Low-Tech	High-Tech
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Lag of Technology Gap	-0.0111	-0.0420*	-0.0482*	-0.0365	-0.0515	-0.00409
	(0.00944)	(0.0162)	(0.0208)	(0.0223)	(0.0352)	(0.0162)
Output Growth	0.563***	0.681**	0.548**	0.734***	0.703***	0.825***
	(0.0339)	(0.211)	(0.194)	(0.0921)	(0.0974)	(0.217)
Lag of Output Growth			-0.222	-0.435***	-0.515***	-0.435**
			(0.211)	(0.0825)	(0.0787)	(0.130)
Lag of TFP Growth			0.237	0.494***	0.368+	0.414**
			(0.340)	(0.0916)	(0.209)	(0.133)
Constant		-0.0151	-0.0167	-0.0257	-0.0280	-0.00213
		(0.0110)	(0.0134)	(0.0181)	(0.0233)	(0.0225)
Observations	660	660	660	3816	2544	1272
No. Instruments/Lags	2	13/2-4	13/2	48/3-7	48/3-7	48/2-6
R-Squared	0.523					
Arellano-Bond AR Test		0.869	0.454	0.303	0.586	0.401
Hansen J Test		0.299	0.288	0.656	0.451	0.534
Long-term coefficient (*n*)	0.563	0.681	0.548	0.591	0.297	0.666
Increasing returns (*v*)	2.288	3.135	2.212	2.444	1.423	2.990

Note: The figures reported for the tests are p-values. The Arellano-Bond AR Test reported refers to the test applied to the first lag used as instrument. Time dummies and robust standard errors are used in all the regressions. The sample comprises 11 OECD countries. Significance: +=10%; *=5%; **=1%; ***=0.1%.
Source: Author's elaboration.

periods of analysis, namely, 1976-1991 and 1992-2006. Although TFP growth has increased in the 2000s, using only data from 1999 onwards would reduce too much the number of years available in the sample. The periods adopted, therefore, divide the sample into two time periods of 15 years each. Moreover, Alexiadis and Tsagidis (2010) divide their sample in two similar periods (1977-91 and 1992-2005) due to the transition to the European single market.

Table 2 reports the results of the regressions dividing the period of analysis. This table shows that high-tech industries have higher economies of scale than low-tech industries in both sub-periods. The magnitude of the returns to scale in manufacturing in the first period is lower than the original estimates of Verdoorn (1949) and Kaldor (1966). The degree of returns to scale in all manufacturing increases from one period to the other, going from 1.477 to 1.956, which is similar to estimates found in the literature. Most importantly, while the returns to scale in low-tech industries remained roughly the same (1.273 to 1.222), the degree of returns to scale in high-tech industries increased considerably (1.974 to 2.334). Thus, the increase

Table 2: Dynamic demand-side
Kaldor-Verdoorn Law using different time periods (1976-2006): System-GMM

Dependent Variable	TFP Growth	TFP Growth	TFP Growth	TFP Growth	TFP Growth	TFP Growth
Period	1976-1991			1992-2006		
Sample	All Industries (i)	Low-Tech (ii)	High-Tech (iii)	All Industries (iv)	Low-Tech (v)	High-Tech (vi)
Lag of Technology Gap	0.00133	-0.0111	0.0266	-0.00853	-0.00677	0.00402
	(0.0197)	(0.0114)	(0.0326)	(0.0187)	(0.0429)	(0.0142)
Ouptut Growth	0.635***	0.667***	0.719***	0.695***	0.502***	0.748***
	(0.0789)	(0.105)	(0.0788)	(0.120)	(0.118)	(0.110)
Lag of Output Growth	-0.451***	-0.564***	-0.416*	-0.350***	-0.392**	-0.357***
	(0.0923)	(0.112)	(0.185)	(0.0889)	(0.133)	(0.0654)
Lag of TFP Growth	0.430***	0.520***	0.386+	0.294**	0.395*	0.316***
	(0.110)	(0.121)	(0.219)	(0.107)	(0.170)	(0.0854)
Constant	0.00412	-0.00695	0.0287	-0.00338	-0.00377	0.0127
	(0.0140)	(0.00827)	(0.0254)	(0.0153)	(0.0315)	(0.0128)
Observations	1836	1224	612	1980	1320	660
No. Instruments/Lags	52/2-12	37/2-7	52/2-12	54/2-12	54/2-12	42/2-8
Arellano-Bond AR Test	0.168	0.131	0.830	0.504	0.482	0.383
Hansen J Test	0.655	0.279	0.668	0.131	0640	0.445
Long-term coefficient (*n*)	0.323	0.215	0.493	0.489	0.182	0.572
Increasing returns (*v*)	1.477	1.273	1.974	1.956	1.222	2.334

Note: The figures reported for the tests are p-values. The Arellano-Bond AR Test reported refers to the test applied to the first lag used as instrument. . Time dummies and robust standard errors are used in all the regressions. The sample comprises 11 OECD countries. Significance: +=10%; *=5%; **=1%; ***=0.1%.
Source: Author's elaboration.

in the magnitude of returns to scale in the more recent period seems to be driven by the increase in the returns to scale in high-tech industries.

The analysis carried out in this section, therefore, suggests that high-tech manufacturing industries exhibit higher returns to scale than low-tech manufacturing industries. Moreover, it is interesting to note that although the magnitude of the Verdoorn coefficient is similar to the coefficients found in previous studies, taking into account the short-term variation of the variables brings the degrees of returns to scale closer to values that correspond to the original Verdoorn coefficient of around 0.5 manufacturing as a whole during the period 1976-2006. In addition, the lack of significance of the technology gap suggests that technological diffusion is possibly being captured by the lag of output growth. Finally, the results also suggest that the degree of returns to scale in manufacturing have risen over the last decades, and that this can be attributed to the increase in the returns to scale in the high-tech industries.

Hence, the results reported in this chapter contrast with the results found by Millemaci and Ofria (2014), which suggest that the Verdoorn coefficient has been stable during the period 1973-2006 for 11 OECD countries individually considered. The robustness of this chapter's tests, however, is reinforced by the quality of the data used, the high number of observations employed, and the robustness of the method adopted. These contrasting results indicate the importance of carrying out further research on the variations of the Verdoorn coefficient through time. An interesting possibility for further research is the use of long panels, which explores time-series techniques while providing more robust results than simple time-series analysis because of the higher number of observations in the panel.

To illustrate the importance of the differences in returns to scale between technological sectors reported in this paper, suppose the output of each technological sector in two countries is growing at the same 2% rate per annum. However, suppose one of the countries, called developed, produces 70% of high-tech goods and 30% of low-tech goods, while the opposite holds for the other country, called underdeveloped. Given the estimates presented in this section, this difference in the productive structure implies that productivity growth in the developed country will be 4%, while productivity growth in the underdeveloped country will be only 3.1%. Taking into account the sample of countries analysed in this paper and calculating aggregate productivity growth as the weighted average of TFP growth in each sector, Japan is the country with the highest average rate of productivity growth (3.07%) and is also the country with the highest average share of high-tech production (51.4%). In contrast, Australia has the lowest average productivity growth (1.05%) and also the lowest share of high-tech production (23%). Evidently, other factors influence productivity growth, such as technological transfer. In spite of that, the Spearman rank correlation between average aggregate productivity growth and average share of high-tech production in the sample analysed is relatively high, at 0.64, and significant. Consequently, the results presented in this paper indicate that it is crucial for developing countries to elaborate policies to foster structural change towards high-tech industries in order to increase productivity growth.

3.3. Concluding Remarks

This chapter investigated the existence of different degrees of returns to scale in low-tech and high-tech manufacturing industries using data from the EU KLEMS Database. First and foremost, the results reported in the chapter provide strong evidence in support of the existence of substantial increasing returns to scale in manufacturing as whole, corroborating the findings of previous works. Most importantly, the investigation presented in this chapter suggests that high-tech manufacturing industries exhibit higher degrees of returns to scale than low-tech manufacturing industries. Consequently, this result has an important policy implication: fostering structural change towards high-tech industries is crucial to increase productivity growth. The results also indicate that the technology gap is significant when the simple Kaldor-Verdoorn Law is estimated, but not when the lags of output growth and productivity growth are introduced to control for short-term fluctuations. This suggests that lagged output growth is possibly capturing the effect of technological diffusion in this specification. Furthermore, the analysis also revealed that the magnitude of the returns to scale in manufacturing as a whole has increased in the last decades, driven by increases in the returns to scale observed in high-tech industries.

It is important to note, however, that the OECD technological classification of industries adopted in this chapter is based on the level of research intensity observed in each industry, assuming that industries that invest more in R&D produce goods with higher technological content. Taking this information into account, therefore, this chapter's results can also be interpreted as indicating that higher research intensity leads to higher returns to scale. Hence, further work should be pursued to assess more carefully this hypothesis. This investigation is carried out in the following chapter of the thesis.

4. INCREASING RETURNS TO SCALE, TECHNOLOGICAL CATCH-UP AND RESEARCH INTENSITY

Endogenizing the Verdoorn Coefficient

4.1. Introduction

The investigation carried out in chapter 3 presented an interesting explanation for why returns to scale vary between industries. The results indicated that in industries with high technological content, technical progress is more responsive to output growth, which reflects in higher degrees of increasing returns to scale. Still, due to the fact that industries are classified according to their levels of research intensity, it is important to formally test whether it is research intensity that generates higher degrees of returns to scale and not other supply-side characteristics of the industries within the groups analysed.

The possible connection between the magnitude of returns to scale and the level of research intensity suggested by the results of chapter 3 indicates that it might be fruitful to incorporate Schumpeterian insights into the Kaldorian explanation for productivity growth. From a Kaldorian perspective, technological progress and productivity growth are determined by the growth rate of the market (e.g. McCombie and de Rider, 1983; 1984; Bairam, 1990; Angeriz *et al.*, 2008; 2009). From a Schumpeterian perspective, productivity growth is determined by research intensity, technological transfer and human capital (e.g. Griffith *et al.*, 2004; Acemoglu *et al.*, 2006; Madsen, 2008). Yet, in spite of the large number of Kaldorian and Schumpeterian works that have investigated the effects of different variables on productivity growth, there have been only a few attempts to combine these two literatures (e.g. Léon-Ledesma, 2002). Most importantly, combining the insights and evidence of these two streams of thought is not only relevant to assess whether the variables considered in each of the traditions are still significant when the two approaches are put together, but it is also crucial to better understand how demand and supply-side factors interact to generate productivity growth.

The purpose of this chapter, therefore, is to investigate the impact of output growth and research intensity on productivity growth. Two hypotheses are tested. Firstly, the chapter investigates whether the two variables have direct impacts on productivity growth, assessing if the basic Kaldorian and Schumpeterian models can be combined. Secondly, the chapter examines whether research intensity impacts on the degree of returns to scale, assessing if countries with higher research intensity benefit from higher returns to scale. The intuition behind this hypothesis is that higher research intensity generates higher knowledge, which allows faster technical progress (or dynamic returns to scale) in response to output growth.

The empirical investigation reported in this chapter is based on disaggregated data on patents and productivity not used before. The data used to calculate TFP growth is from the EU KLEMS Database, and comprises 12 manufacturing industries in up to 15 OECD countries over the period 1976-2006. Data on patents for each country, industry and year was gathered from the United States Patent and Trademark Office (USPTO), and aggregated by industry using the methodology developed by Lybbert and Zolas (2014). Thus, the investigation presented in this chapter extends previous works carried out using EU KLEMS data by incorporating innovation indicators into the database, as suggested by O'Mahony and Timmer (2009: F396).

This summary presents the key findings of the chapter, which has been recently accepted for published in the *Cambridge Journal of Economics*. Hence, readers interested in the complete discussion about the specification of the models tested, the database, and the estimation method are referred to Romero and Britto (2016)

4.2. Main Results

Table 3 presents the results of the basic Kaldorian and Schumpeterian models. Columns (i) to (iii) present the results found using OLS, while columns (iv) to (vi) present the estimates found employing System GMM to control for endogeneity. In all the models the Hansen J test indicates that the instruments are valid at the 10% level of significance, while the Arellano and Bond (1991) AR test indicates that there is not autocorrelation in the lags used as instruments. Columns (i) and (iv) test the basic Schumpeterian model. The results indicate that research intensity, measured by patents per millions of hours worked, has a positive and significant impact on TFP growth. The magnitude of the estimated coefficients is slightly lower than the magnitude commonly found in the literature (from 0.03 to 0.09 – see Griliches, 1990; Madsen, 2008; Chang *et al.*, 2013). Columns (ii) and (v), in turn, test the basic Kaldorian model. The results indicate that output growth has a positive and significant impact on TFP growth. The magnitude of the coefficient is similar to some

Table 3: Basic Kaldorian and Schumpeterian approaches

Model	OLS (i)	OLS (ii)	OLS (iii)	SYS-GMM (iv)	SYS-GMM (v)	SYS-GMM (vi)
Lag of Gap	-0.00302	-0.00348***	-0.00204*	-0.0213	-0.0838*	-0.0368
	(0.00173)	(0.00101)	(0.00100)	(0.0417)	(0.0328)	(0.0209)
Research intensity	0.0129***			0.0195*		
	(0.00242)			(0.00888)		
Output growth		0.728***	0.766***		0.666***	0.667***
		(0.0132)	(0.0133)		(0.116)	(0.103)
Lag of Output growth			-0.340***			-0.461***
			(0.0263)			(0.0754)
Lag of TFP growth			0.263***			0.501***
			(0.0319)			(0.0902)
Constant	0.0204***	0.00893***	0.00717**	0.00000160	-0.0496	-0.0241
	(0.00364)	(0.00213)	(0.00236)	(0.0328)	(0.0264)	(0.0168)
No. Observations	3948	3948	3816	3948	3948	3816
Adj. R-Squared	0.064	0.655	0.700			
No. Instruments/Lags				39/2-5	63/5-20	45/3-6
Arellano-Bond AR Test				0.297	0.348	0.253
Hansen J Test				0.514	0.087	0.568
Increasing returns (*v*)		3.676	2.370		2.994	1.703

Note: The dependent variable is the growth rate of TFP. Research intensity is measured by the number of patents per millions of hours worked by persons engaged in production. The figures reported for the tests are p-values. The Arellano-Bond AR Test reported refers to the test applied to the first lag used as instrument. Time dummies and robust standard errors were used in all the regressions. The sample comprises 11 OECD countries, 12 industries, over 1976-2006. Significance: *=5%; **=1%; ***=0.1%.
Source: Author's elaboration.

previous studies (e.g. Angeriz *et al.*, 2008; 2009), but slightly higher than what found in other studies (e.g. Tharnpanich and McCombie, 2014). Thus, following Millemaci and Ofria (2014), the first lag of output growth and of TFP growth were introduced to capture short-term effects. This reduces the magnitude of the returns to scale to a level closer to Kaldor's (1966) original estimates. All the variables are significant and with the expected signs. As expected, the technology gap has a negative impact on TFP growth. This impact, however, is small in all the models, and only significant in 3 of the 6 regressions, indicating that the gap is not very relevant in the sample analysed.

The results presented in Table 3, therefore, corroborate the results found in previous Kaldorian and Schumpeterian works.

Table 4, in turn, presents the results of regressions that combine the Kaldorian and the Schumpeterian frameworks using both OLS and SYS-GMM. The OLS results, presented in columns (i) to (iv), provide benchmark results to be compared with the estimates found using the robust SYS-GMM, which are presented in columns (v) to (viii).

Columns (i) and (v) report the estimates introducing research intensity along with output growth and the technology gap as determinants

Table 4: Expanded Kaldor-Verdoorn Law

Model	OLS	OLS	OLS	OLS	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Sample	All industries	All industries	Low-Tech industries	High-Tech industries	All industries	All industries	Low-Tech industries	High-Tech industries
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Lag of Gap	-0.00364***	-0.00371***	-0.000389	-0.00827***	-0.0509	-0.0329	-0.0240	-0.0261
	(0.00100)	(0.00100)	(0.000588)	(0.00193)	(0.0437)	(0.0205)	(0.0154)	(0.0247)
Output growth	0.725***	0.706***	0.680***	0.726***	0.274*	0.369***	0.266**	0.426*
	(0.0132)	(0.0167)	(0.0163)	(0.0211)	(0.110)	(0.0906)	(0.0956)	(0.181)
Research intensity	0.00440***	0.00289*	0.0104***	-0.00181	0.0167+	0.00404	0.00639	-0.00487
	(0.00125)	(0.00140)	(0.00184)	(0.00161)	(0.00863)	(0.00678)	(0.00745)	(0.00952)
Research intensity*Output growth		0.0496**	0.0566*	0.0980***		0.228**	0.330***	0.295*
		(0.0183)	(0.0272)	(0.0195)		(0.0758)	(0.0578)	(0.144)
Constant	0.00635**	0.00656**	-0.00596***	-0.00416	-0.0305	-0.0136	-0.0201	-0.0130
	(0.00221)	(0.00220)	(0.00163)	(0.00418)	(0.0374)	(0.0176)	(0.0124)	(0.0287)
No. Observations	3948	3948	6909	1316	3948	3948	6909	1316
Adj. R-Squared	0.656	0.657	0.561	0.746				
No. Instruments/Lags					41/2-4	109/2-20	53/2-6	41/2-3
Arellano-Bond AR Test					0.756	0.945	0.035	0.522
Hansen J Test					0.073	0.074	0.037	0.301
Long-term coefficient (δ)	0.725	0.723	0.697	0.778	0.274	0.445	0.362	0.583
Increasing returns (v)	3.636	3.606	3.296	4.509	1.377	1.802	1.568	2.399

Note: The dependent variable is the growth rate of TFP. Research intensity is measured by the number of patents per millions of hours worked by persons engaged in production. The figures reported for the tests are p-values. The Arellano-Bond AR Test reported refers to the test applied to the first lag used as instrument. Time dummies and robust standard errors are used in all regressions. The sample comprises 11 OECD countries, 12 industries, over 1976-2006. Significance: +=10%; *=5%; **=1%; ***=0.1%.
Source: Author's elaboration.

of productivity growth. These results indicate that both output growth and research intensity are significant determinants of TFP growth, even when endogeneity due to fixed effects and simultaneity is controlled for. In the SYS-GMM regression, the Hansen test and the Arellano-Bond AR test indicate the validity of the instruments used. The returns to scale found using SYS-GMM and introducing research intensity are much lower than the returns to scale found using OLS. One possible explanation for this finding is that movements in research intensity captures the short-term fluctuation of output, bringing the returns to scale to a magnitude similar to the one found when controlling for short-term movements in output and TFP growth, as presented in columns (iii) and (vi) of Table 3.

Columns (ii) and (vi) report the estimates introducing technology gap, research intensity, output growth and the interaction between the two latter variables as determinants of productivity growth. Output growth and the interaction term between output growth and research intensity are significant, while research intensity alone is not significant in the SYS-GMM regression, but only in the OLS regression. This suggests that the effect of research intensity on productivity growth is indeed stronger when combined with output growth. In other words, this finding indicates that although output growth generates productivity growth through increasing returns to scale, when the country has higher research intensity, the magnitude of the increasing returns is higher. Taking into account that in the sample used the average number of patents per millions of hours worked is 0.333, using this number and the coefficients estimated is possible to calculate the coefficient Verdoorn coefficient (δ), that links output growth to productivity growth. From this coefficient (δ) it is possible to calculate the degree of returns to scale v, given that $\delta = (1 - 1/v)$. The degree of returns to scale found in column (vi) of Table 4 is closer to degree found in column (vi) of Table 3, and not too distant from the seminal estimates of Kaldor (1966).

Columns (iii), (iv), (vii), and (viii), report the results found dividing the sample of sectors into low-tech and high-tech industries, following the OECD classification. In both the OLS and the SYS-GMM regressions, the magnitude of the coefficient of output growth is higher for high-tech industries, as found in chapter 4. Nonetheless, for the coefficient of the interaction between research intensity and output growth, the magnitude is higher for high-tech industries when using OLS, but it is similar to that of low-tech industries when using SYS-GMM. Hence, this result shows that although high-tech industries enjoy higher returns to scale, the effect of research intensity on productivity growth is the same in both low-tech and high-tech industries. However, for low-tech industries, the Hansen J Test rejects the validity of the instruments at 5% level.

Figure 1 shows the changes in the degree of returns to scale in the low-tech and high-tech sectors using the parameters reported in columns (vii) and (viii) and the average number of patents per million of hours worked of the countries analysed as the proxy for research intensity. This figure shows that not only the degree of returns to scale is much higher in the high-tech sector than in the low-tech sector, but that the difference between the returns to scale between the two sectors has been widening up. Hence, this figure corroborates the findings of chapter 3, which suggested that the degree of returns to scale in manufacturing have increased from the 1970s and 1980s to the 1990s and 2000s, mainly due to an increase in the scale economies observed in high-tech industries. Most importantly, this figure shows that the observed increase in the scale economies has resulted mainly from an increase in the level of research intensity in the high-tech sector. Research intensity increased from an average number of patents per million of hours worked of 0.22 in 1976 to 1.08 in 2006 in the high-tech sector, while in the low-tech sector in went from 0.09 to 0.40. This led to changes in returns to scale in these two sectors from 1.96 to 3.94, and from 1.42 to 1.66, respectively.

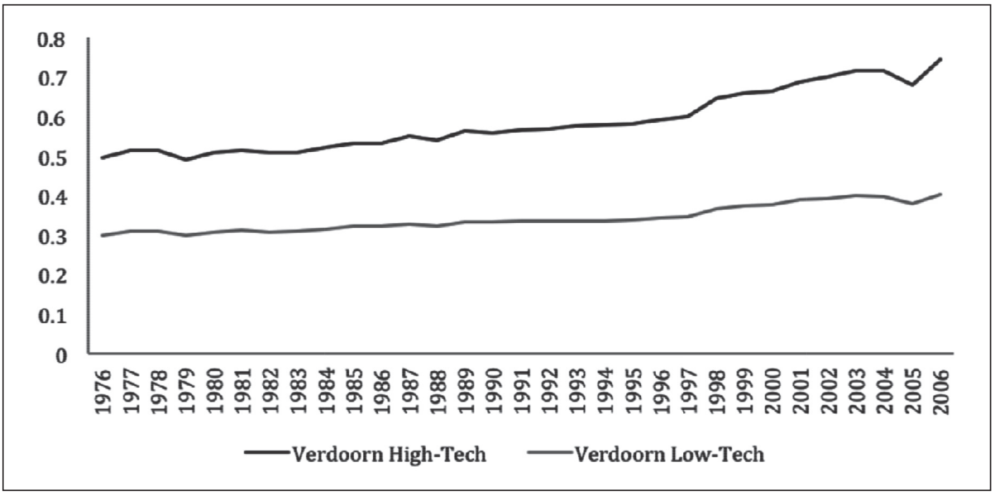
4.3. Concluding Remarks

This inquiry revealed that higher research intensity generates higher productivity growth (dynamic return to scale) when associated with output growth. This result is interpreted as an indication that higher research intensity generates higher knowledge, which allows faster technical progress in response to output growth.

It is crucial to note that the results presented in this chapter complement and reinforce the results found in chapter 3. In spite of the fact that research intensity influences the magnitude of returns to scale both in low-tech and in high-tech industries, the exogenous part of the Verdoorn coefficient (in relation to research intensity) is still higher in high-tech than in low-tech industries. In other words, although research intensity has a positive impact on scale economies, differences in supply characteristics generate distinct returns to scale in low-tech and high-tech industries.

The investigation carried out in this chapter demonstrated that it is possible to combine the Kaldorian and the Schumpeterian approaches to the determinants of productivity growth without subverting the main ideas associated with each tradition. The inquiry showed that combining the insights from these two approaches leads to a more comprehensive explanation for the determinants of productivity growth. The results also show that both demand and supply-side factors affect long-term productivity growth, as advocated in this thesis.

Figure 1: Changes in the Verdoorn Coefficient by Technological Sector



Source: Author’s elaboration.

5. THE MULTI-SECTORAL THIRLWALL'S LAW

Evidence from 14 Developed European Countries using Product-Level Data

5.1. Introduction

Chapters 3 and 4 have shown that productivity growth is determined by demand growth. Hence, taking into account the constraining effect that balance-of-payments disequilibria exert on the growth rate of domestic demand, this chapter and the next two investigate the determinants of export and import growth. These chapters follow the same strategy adopted in chapters 3 and 4. First, similarly to chapter 3, taking the Kaldorian approach to trade and growth as the main reference, the present chapter tests the validity of the Multi-Sectoral Thirlwall's Law, investigating whether income elasticities of demand vary across technological sectors. Second, similarly to chapter 4, chapters 6 and 7 assess if Schumpeterian insights on the determinants of trade can be incorporated into the Kaldorian framework.

In Keynesian fashion, economic growth is led by the growth of demand. The Kaldorian tradition, in turn, emphasises that balance-of-payments disequilibrium represents the most important constraint on demand growth. According to this approach, trade must be balanced in the long-term, given that current account deficit cannot be financed indefinitely, and provided that terms of trade vary only negligibly in the long run. In this framework, each country's equilibrium growth rate must correspond to the ratio between its income elasticity of demand for exports and its income elasticity of demand for imports, multiplied by the growth rate of external demand (or world income). This relationship, known as Thirlwall's Law (TL), has been tested in an extensive number of works, and most of the studies have found results that support the validity of this law (e.g. Thirlwall, 1979; Bairam, 1988; Bairam and Dempster, 1991; Andersen, 1993; McCombie and Thirlwall, 1994; Perraton, 2003).

In spite of the importance of the income elasticities of demand in the balance-of-payments constrained growth framework, not much effort has been put into understanding the specific determinants of these elasticities. More recently, a number of studies have been exploring the connection between the sectoral composition of each country's trade and differences in income elasticities of demand (Gouvêa and Lima, 2010; Romero et al., 2011; Tharnpanich and McCombie, 2013; Gouvêa and Lima, 2013). In this approach, aggregate income elasticities are weighted averages of the income elasticities of exports and imports from each sector, where the weights are the sectors' shares in total exports and imports, respectively. Araújo and Lima (2007) called this approach the Multi-Sectoral Thirlwall's Law (MSTL), and stressed the fact that even if the sectoral elasticities and the growth rate of world income are constant, it is still possible for a country to raise its long-term growth rate by favourably changing the sectoral composition of the economy's trade.

The contribution of this chapter to the existing literature is twofold. First and foremost, the chapter reports estimates of import and export functions by technological sectors for 14 developed countries not yet investigated by the more recent multi-sectoral studies. Only two studies have estimated import and export functions by technological sectors, and both focus on developing countries (Gouvêa and Lima, 2010; Romero et al., 2011). Furthermore, although Gouvêa and Lima (2013) have estimated sectoral import and export functions for a large number of countries, the authors have adopted a different classification of sectors. Second, the chapter introduces a new methodology for regressing import and export functions, which contributes to improve the robustness of the estimates. It is common practice in the balance-of-payments constrained growth literature to estimate export and import functions using Vector Error Correction Models (VECMs), while aggregate price indexes are used to deflate value series and to measure relative prices. The econometric investigation reported in this chapter compares the results found using the traditional method with estimates found using cross-product panels employing quality-adjusted price indexes recently calculated by Feenstra and Romalis (2014). These changes generate a substantial rise in the number of observations, increasing the robustness of the estimates.

This summary presents the key findings of the chapter, which has been recently published in the *International Review of Applied Economics*. Readers interested in the complete discussion about the specification of the model, the database, and the estimation method are referred to Romero and McCombie (2016b)

5.2. Main Results

A number of methods were used to estimate sectoral export and import functions. Firstly, export and import functions were estimated for each of the 5 technological sectors in each of the 14 countries using VECMs, which is the method normally employed in the vast majority of the balance-of-payments constrained growth literature. The estimates based on these regressions serve as benchmark to analyse the advantages of using cross-product panels and quality adjusted price indexes in the estimation of export and import functions. Secondly, the functions were regressed using cross-product panels with fixed effects (FE), while interactions between dummy variables for Lall's (2000) technological sectors and the logs of income and relative prices were introduced to capture differences between elasticities across sectors in each country. The base income elasticities of demand were always positive and significant, as expected, but several of the interaction terms were not significant. In spite of that, in general the income elasticities of the high-tech sector were significant and higher than the income elasticities of the other sectors. Thirdly, separate cross-product panels were regressed for exports and imports of all products, and for the products within each technological sector. This strategy was used to avoid introducing many endogenous variables in a single regression. Each model was regressed using the Instrumental Variables (IV) estimator with FE and Hausman's Instruments (see Baum *et al.*, 2007). Fourthly, cross-product panels were regressed using System GMM to provide further assessment on the previous results.

Table 5: Income elasticities of demand for exports and imports – VECM

	Exports					Imports				
Country	PP	RBM	LTM	MTM	HTM	PP	RBM	LTM	MTM	HTM
Austria	1.98**	1.02**	1.02**	2.12**	2.48**	1.52**	1.14**	1.09**	1.56**	1.62**
Denmark	1.58**	0.41**	1.19**	0.91**	2.41**	1.11**	1.50**	3.98**	2.08**	2.88**
Finland	0.96**	-0.09	0.61**	1.41**	5.48**	1.63**	1.63**	1.85**	2.44**	1.73**
France	0.66**	0.71**	0.75**	1.15**	1.98**	2.32**	0.95**	1.48**	1.74**	2.26**
Germany	2.35**	1.60**	1.53**	1.56**	2.17**	2.34**	1.44**	1.24**	2.64**	2.85*
Greece	0.06	-1.5**	-0.5**	2.20**	4.76**	2.57**	0.19**	0.71**	4.29**	2.17**
Italy	3.82*	0.65**	0.65**	1.24**	1.11**	4.04**	1.31**	2.70**	2.80**	1.47
Netherlands	0.33*	0.26**	0.81**	1.39**	2.71**	1.42**	0.42**	1.01**	1.53**	2.54**
Norway	2.64**	-0.8**	1.70	0.67**	1.72**	1.15**	3.96**	0.85**	0.99**	1.17**
Portugal	2.42**	0.41**	4.11**	2.29**	2.86**	1.88**	1.06**	3.12**	3.53**	2.29**
Spain	1.81**	1.59**	1.67**	2.57**	1.63**	1.87**	1.57**	2.08**	1.70**	1.73**
Sweden	1.28**	0.27**	1.00**	0.93**	2.33**	2.30**	0.63**	0.62**	1.01**	1.17**
Switzerland	1.03**	0.52**	0.65**	0.30**	2.51**	1.25**	0.49**	0.80**	1.02**	3.37**
U. K.	0.29*	0.37**	0.25	0.76**	1.86**	0.21	0.11	1.12**	0.88**	11.0**
Average 1	1.34	0.42	1.10	1.39	2.57	1.66	0.90	1.47	1.85	2.80
Average 2	1.49	0.74	1.34	1.45	2.22	1.78	1.05	1.67	1.79	2.05

Note: PP = Primary Products; RBM = Resource Based Manufacturing; LTM = Low-Tech Manufacturing; MTM = Medium Tech Manufacturing; HTM = High-Tech Manufacturing. Average 1=All countries; Average 2=Excludes Finland, Greece, Italy, Norway, and UK. Significance: **=0.1%; *=1%.
Source: Author's elaboration based on data from UN Comtrade and World Development Indicators.

The income elasticities found using VECMs and IV with Hausman's Instruments are reported in Tables 5 and 6 in order to illustrate the differences between the two methods.

Table 5 shows that the income elasticities found using VECMs. This table shows that the estimates present considerable volatility, which casts doubt on their robustness. Negative elasticities are found for three countries (Finland, Greece, and Norway), which is a very odd result. Furthermore, a strangely large elasticity is found for UK (11.0). Finally, even if these countries are excluded the amplitude of the elasticities is still high, ranging from 0.26 to 4.11. In spite of that, on average, the income elasticities of imports and exports are higher for High-Tech Manufactures.

Table 6, in turn, presents the results found using the IV estimator with Hausman's Instruments, which is the preferred model. This table shows that the cross-product panel estimates are more consistent than the VECMs', which reinforces once more the superiority of this estimation strategy. There are no negative elasticities, and only Greece presents an unusually large (5.47) income elasticity. Furthermore, the amplitude of the estimates is lower, ranging from 1.01 to 4.15 (excluding Greece), which is more consistent with the relative homogeneity of the countries under analysis. Table 6 also shows that, on average, the income elasticities of imports and exports are higher for MTM and HTM, respectively. On average, PP present the lowest income elasticities, followed by LTM,

Table 6: Income elasticities of demand for exports and imports – Hausman's Instruments

	Exports					Imports				
Country	PP	RBM	LTM	MTM	HTM	PP	RBM	LTM	MTM	HTM
Austria	3.14**	2.54**	1.87**	2.07**	2.91**	1.98**	2.54**	1.91**	2.32**	2.71**
Denmark	1.45**	1.68**	2.17**	2.10**	2.86**	1.98**	2.46**	2.47**	2.13**	3.27**
Finland	1.88**	1.83**	1.27**	2.52**	2.73**	1.65**	2.45**	1.36**	1.49**	1.54**
France	1.43**	1.64**	1.61**	1.66**	2.15**	1.27**	2.52**	2.35**	2.55**	3.00**
Germany	1.79**	1.92**	1.33**	1.80**	2.57**	1.30**	2.52**	2.44**	3.26**	4.41**
Greece	2.33**	2.68**	2.16**	4.26**	5.47**	2.17**	2.33**	2.82**	2.01**	3.34**
Italy	2.12**	1.91**	2.13**	1.93**	2.01**	2.14**	3.20**	4.15**	3.65**	3.40**
Netherlands	1.32**	1.76**	1.56**	2.03**	2.50**	1.28**	1.51**	1.01**	1.24**	2.30**
Norway	1.31**	0.69*	1.10**	1.41**	2.54**	1.14**	1.77**	1.02**	1.36**	1.78**
Portugal	3.02**	3.19**	2.57**	3.40**	3.34**	2.89**	3.43**	3.83**	2.42**	2.82**
Spain	3.27**	3.22**	3.24**	3.38**	4.01**	2.63**	2.89**	3.65**	2.85**	2.63**
Sweden	1.68**	1.59**	1.61**	1.66**	2.21**	1.44**	2.27**	1.36**	1.71**	1.83**
Switzerland	0.62	1.61**	1.03**	1.11**	1.31**	0.89*	2.12**	1.67**	2.36**	2.92**
U. K.	1.19**	1.64**	1.32**	1.40**	2.14**	1.01**	1.70**	2.14**	1.82**	2.60**
Average	1.90	1.99	1.78	2.20	2.77	1.70	2.41	2.30	2.23	2.75

Note: PP = Primary Products; RBM = Resource Based Manufacturing; LTM = Low-Tech Manufacturing; MTM = Medium Tech Manufacturing; HTM = High-Tech Manufacturing. Significance: **=0.1%; *=1%.
Source: Author's elaboration based on data from UN Comtrade and Feenstra and Romalis (2014).

and RBM. This result corroborates the findings of Gouvêa and Lima (2010) and Romero et al. (2011), indicating the importance of moving from the production of simple to high-technology goods.

The results reported in Table 6 convey two relevant pieces of information. Firstly, the income elasticities of exports of Greece, Portugal and Spain tend to be higher (in all sectors) than the figures found for northern countries. This result might seem counter-intuitive, given that the elasticities are supposed to capture non-price competitiveness, which is clearly higher in northern European countries. Nonetheless, this result might stem from supply bottlenecks[1] captured in the income elasticities of demand. In other words, as countries get to high stages of development, it becomes more difficult to train and transfer resources from low-tech to high-tech sectors. This reduces the pace of growth of high-tech production, given that, as the high-tech sector gets larger, it becomes progressively more difficult to keep the same rate of growth.[2] In fact, similar results are observed in Gouvêa and Lima's (2010) paper, where Colombia and Mexico present higher income elasticities of demand for high-tech exports than Korea, Malaysia and Singapore, which are the countries expected to have the highest elasticities (i.e. non-price competitiveness) in the sample analysed by the authors. Consequently, future research should aim to identify the specific factors that influence the magnitude of the income elasticities of demand of each technological sector.

Secondly, the elasticities for PP and RBM reported in Table 6 are higher than the ones estimated by Gouvêa and Lima (2010) and Romero et al. (2011). In contrast, for the other sectors the elaticities found here are lower than the ones found in the studies mentioned above. The difference between this chapter's estimates and Gouvêa and Lima's (2010) seems to stem from the fact that in the last decade there has been a considerable increase in the demand for PP and RBM products, especially from China. In the 2000s the average growth rates of exports of PP and RBM (8.94 and 7.74, respectively) have surpassed the average growth rates of MTM and HTM exports (7.25 and 5.56, respectively) for the

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[1]As Thirlwall (2013: 51) argues, "there may be at certain times skill bottlenecks, but if the industrial sector of an economy needs more labour, it will find it". The question, therefore, is the pace of this transfer whenever supply bottlenecks become relevant.

[2]The relatively high income elasticities of demand for imports found for Denmark, Germany and Italy (especially in the high-tech sector) seems to be the result of inter-industry trade between highly developed countries. Again, similar results are observed in Gouvêa and Lima's (2010) work, where Korea has the higher income elasticity of demand for high-tech imports.

first time in the period 1984-2007. Because of this recently augmented demand, relatively less productive countries in resource products, such as the European countries analysed here, have been able to expand their exports in these sectors. Thus, given that the data used in this chapter covers a smaller timespan than Gouvêa and Lima's (2010) work, higher weight is attributed to this recent movement. This explains the increase in the elasticities of demand for PP and RBM observed here. It is unlikely, however, that the growth of demand for resource-based products will keep growing at similar rates, given that Chinese demand will probably shift to more high-tech products as the country gets developed. Still, the sample of countries, the data treatment and the estimation method used in this chapter are different from Gouvêa and Lima's (2010) study. Therefore, no clear judgement can be made about the differences in the estimated elasticities and the search for a more conclusive explanation for this difference is left for future research. Nevertheless, the results presented here are informative despite of the data difference, given that there it little reason to believe that the income elasticities of demand for exports of primary products is higher for developed countries than for developing countries. However, it would be interesting to use the methodology adopted in this chapter to estimate export and import functions for the countries analysed by Gouvêa and Lima (2010). This would allow a clearer explanation for the differences discussed above. This task is left as a suggestion for future research.

Table 7: Differences between estimated and actual growth rates: the existing evidence

Paper	Form	Number of countries/Number of European countries	Average Difference: all countries	Average Difference: European countries
Thirlwall (1979)	Weak TL	15 / 9	0.973	0.572
Bairam (1988)	Weak TL	19 / 13	0.726	0.646
	Strong TL	19 / 13	0.973	1.023
Bairam and Dempster (1991)	Weak TL	11 / 0	1.518	-
	Strong TL	11 / 0	1.227	-
Perraton (2003)	Weak TL	34 / 0	2.669	-
	Strong TL	27 / 0	1.985	-
Gouvêa and Lima (2010)	Strong MSTL	8 / 0	1.290	-
	Strong TL	8 / 0	0.895	-
Bagnai (2010)	Weak TL	22 / 12	0.786	0.933
Gouvêa and Lima (2013)	Strong MSTL	90 / 13	1.128	0.610
Average			1.288	0.757
Present Chapter (SYS-GMM)			-	0.640
Present Chapter (IV)			-	0.480

Note: When the paper estimates the elasticities and the TL for several countries the value reported here is the average. The European countries taken into account are the ones analysed in this chapter.
Source: Author's elaboration.

It is important to mention that in the VECMs, although most of the price elasticities of demand for imports are negative, as expected, the opposite is verified for exports. Similar results are observed in other works (e.g. Gouvêa and Lima, 2013). This suggests that the aggregate measures of relative prices normally used in the balance-of-payments constrained growth literature are imperfect measures, especially when sectoral export and import functions are estimated. For the cross-product panels, however, both for exports and for imports the price elasticities are predominantly negative. The IV estimator with Hausman's Instruments is the estimation strategy that generates the highest number of negative price elasticities. Thus, these results indicate the superiority of using quality-adjusted price indexes and Hausman's instruments.

Table 7 reports the average difference between actual and estimated growth rates found in a sample of important works that assess Thirlwall's Law for different countries. This table shows that the average differences of 0.48 and 0.64 found in this chapter are considerably lower than the differences usually found in the literature. This result provides further evidence in support of the claim that using cross-country panels and quality-adjusted price indexes considerably improves the robustness and reliability of the estimates.

5.3. Concluding Remarks

This chapter reported estimates of import and export functions for five technological sectors in 14 developed European countries. These functions have never before been estimated by technological sectors for developed countries. The regression results indicated that the income elasticities of exports and imports are higher for medium- and high-tech manufactures, which suggests the importance of moving from the production of simple goods to goods with high technological content. As expected, primary products presented the lowest income elasticities, followed by low-tech manufactures, and resource based manufactures. Furthermore, the chapter provided also an important contribution in terms of the method of estimating import and export functions. Comparing the results found using VECMs with aggregate price indexes with the results found using cross-product panels with product-level quality-adjusted price indexes revealed that the latter estimation strategy generates more reliable and less volatile results. Moreover, the investigation indicated that the MSTL holds for the countries investigated.

However, moving exports (imports) from (to) low-tech sectors to (from) high-tech sectors seems to be necessary but not sufficient to increase long-term growth, given that countries with similar sectoral compositions of trade present different equilibrium growth rates. This suggests that it is important to carry out further research on the determinants of the levels of income elasticities. This investigation is carried out in the next chapters.

6. THIRLWALL'S LAW AND THE SPECIFICATION OF EXPORT AND IMPORT DEMAND FUNCTIONS

An Investigation of the Impact of Relative Productivity Growth on Trade Performance using Cross-Country-Industry Panels

6.1. Introduction

This chapter examines the relevance of other determinants of trade performance not investigated in the Kaldorian literature. This investigation not only contributes to understand the determinants of income elasticities of trade, which are crucial parameters in the Kaldorian framework, but it also addresses important critiques directed to the canonical Kaldorian model of long-term growth. Most importantly, this inquiry is carried out adopting a technological classification of industries, so that the sectoral differences identified in the previous chapter are taken into account and further explored.

The Kaldor-Dixon-Thirlwall (KDT) model developed by Dixon and Thirlwall (1975) is the canonical model of economic growth in the Kaldorian tradition. This model sought to integrate Kaldor's (1966; 1970) main contributions to understanding the process of economic growth, while providing a formal structure to describe this process. In this model, the growth of external demand leads to output and productivity growth, which results in gains in price competitiveness, leading to increases in export demand, and so on.

In spite of its importance, the original KDT model is inconsistent with another influential Kaldorian model: the balance-of-payments constrained growth model. The latter, developed by Thirlwall (1979), emphasises that balance-of-payments disequilibria constrain the growth of internal demand, curtailing the process of cumulative growth described by Dixon and Thirlwall (1975). In principle, this constraint can be incorporated into Dixon and Thirlwall's (1975) model (e.g. Thirlwall and Dixon, 1979; Blecker, 2013). However, in Thirlwall's (1979) approach, changes in relative prices do not affect export and import growth in the long-term, either due to the elasticity pessimism or due to the long-term constancy of relative prices (see Blecker, 2013). Without price effects on export growth, the mechanism of cumulative causation described in the KDT model ceases to operate and the model loses its relevance. This is a serious limitation, given that there is a considerable amount of evidence suggesting that price competition does not significantly affect export performance in the long-term (see McCombie and Thirlwall, 1994).

A possible solution to this limitation of the KDT model is to change the channel through which cumulative causation operates. As Roberts (2002) and Setterfield (2011) have stressed, if productivity growth impacts on both price and non-price competitiveness, then cumulative growth occurs in spite of the neutrality of price competitiveness in the long-term. In this alternative approach, external demand leads to output and productivity growth, which generates increases in the quality of production (instead of, or in spite of, reducing prices), which then leads to increases in export demand, and so on. Nonetheless, the quality of the products of competing countries must be taken into account as well, given that it influences the non-price competitiveness of local production. Thus, as normally considered regarding price competitiveness, for the non-price competitiveness of domestic production to improve, it is actually necessary to obtain higher productivity growth than that of foreign competitors.

Following this alternative approach, it is possible to derive an expanded Thirlwall's Law that explicitly incorporates the importance of non-price factors for long-term growth and solves the main critique directed to the KDT model. This expanded Thirlwall's Law is found using a balance-of-payments constrained growth framework, while adopting expanded export and import functions that explicitly account for non-price competitiveness via relative productivity growth. Empirical studies on the determinants of trade inspired in Schumpeter's (1943) ideas use measures of relative technological competitiveness and productive capacity amongst the determinants of trade performance (e.g. Fagerberg, 1988; Greenhalgh, 1990; Amable and Verspagen, 1995). These variables, however, are only part of the factors that encompass non-price competitiveness. Relative productivity growth, in turn, encompasses not only technological competitiveness, but also other non-price competitiveness factors. Evidently, productivity growth incorporates changes in costs/efficiency as well. However, in econometric investigations, the effect of productivity growth on export and import growth captures only non-price competitiveness when changes in relative prices are controlled for.

Furthermore, recent works have shown that the sectoral composition of trade influences the equilibrium growth rate due to differences in income elasticities of demand for goods from different sectors (e.g. Araújo and Lima, 2007; Gouvêa and Lima, 2010), as confirmed by the investigation presented in chapter 5. Consequently, it is also important to investigate whether non-price competitiveness has different effects on trade performance across sectors.

The contribution of this chapter is threefold. Firstly, it proposes a general specification for export and import functions that encompass the contributions of both Kaldorian and Schumpeterian literatures on the determinants of trade performance. Secondly, it shows that using these expanded export and import functions leads to an expanded Thirlwall's Law, which solves the inconsistency between the KDT and the balance-of-payments constrained growth models by introducing the direct effect of productivity growth on export and import growth via improvements in non-price competitiveness. Thirdly, the chapter investigates the impact of non-price competitiveness, measured by relative productivity growth, on export and import growth by technological sector. To the best of my knowledge, this relationship has never before been investigated empirically. In order to do so, this chapter's tests combine trade data with productivity data at industry-level, in a sample of 11 manufacturing industries in 7 developed countries over the period 1984-2006. Furthermore, the industries were divided in two groups, low-tech and high-tech, in order to assess whether the parameters differ between technological sectors. This empirical analysis provides evidence of the validity of the expanded export and import functions and of the expanded Thirlwall's Law.

This summary presents the key findings of the chapter. Readers interested in the complete discussion about the specification of the model, the database, and the estimation method are referred to Romero and McCombie (2016c)

6.2. Demand Functions

Notwithstanding the importance of the income elasticities in balance-of-payments constrained growth models, these elasticities are still a black box. Income elasticities are normally associated with non-price factors, so that the higher a country's non-price competitiveness is, the higher is its income elasticity of demand for exports, the opposite holding for imports. However, only a few empirical works have attempted to test what are the specific non-price factors behind the income elasticities of demand (e.g. Greenhalgh, 1990).

As a first approximation to the determinants of the income elasticities of demand for exports and imports, Setterfield (2011) has proposed that the magnitude of income elasticities depends on the levels of productivity in the domestic economy and in the world economy, respectively. According to Setterfield (2011: 415), “the basic hypothesis here is that the higher is the level of productivity, the higher is the quality of goods produced in a particular region, and so the larger will be the increase in demand for the region’s output associated with any given increase in income *(ceteris paribus)”*.[3]

However, the quality of the products of competing countries affects the magnitude of income elasticities as well, given that it influences the non-price competitiveness of local production. Thus, this effect must also be considered. In effect, works that estimate demand functions for specific products normally take into account the price and quality of competitors (e.g. Hausman, 1997; Nevo, 2001). Furtheremore, the demand functions used in the Kaldorian literature take into account both domestic and foreign prices when measuring price competitiveness. Hence, measures of non-price competitiveness should enter in a similar way.

Ideally, the demand function of a given good should take into account the features of the product and of the competitors’ products, as well as their prices and the income of the consumers (e.g. Hausman, 1997; Nevo, 2001). However, taking into account the different characteristics of each good is an extremely difficult task, especially in macroeconomic investigations. Traditionally, the Kaldorian literature considers that non-price factors are captured in the income elasticity of demand, assuming that goods with higher demand have higher quality, given relative prices. This specification, therefore, is a second-best option, adopted in face of unobservable differences in quality (amongst other non-price competitiveness factors). By contrast, introducing differences in productivity to capture differences in the non-price competitiveness of the products of competing countries provides more information on the determinants of export and import demand.

However, comparisons of productivity between countries are only meaningful at a disaggregated level. When using aggregate data, introducing relative productivity into demand functions involves a more stringent assumption, given that comparing the aggregate productivity of different countries disregards differences in the sectoral composition of production between

[3]It is important to note that the model has the same mechanism of the original KDT model, in which productivity growth impacts on export growth. The only difference is the channel through which this impact operates, changing from price to non-price competitiveness. Hence, the model does not subvert the Kaldorian demand oriented approach (see Setterfield, 2011).

countries. In this case, if two countries have different productive structures and different sectoral compositions of trade, then comparing their aggregate productivity is like comparing oranges and computers even if their productivity is exactly the same in each sector. Thus, although this critique could be directed to any investigation that does not adopt a perfectly disaggregated level of analysis, which is an impossible task, it is possible to argue that comparing the productivities of each industry in different countries involves a considerably less stringent assumption than comparing aggregate productivities.

To sum up, adopting a disaggregated approach to the determinants of export and import growth reveals that different goods present: (i) different income elasticities of demand, due to differences in their intrinsic characteristics, i.e. inter-product desirability; and (ii) different non-price elasticities of demand, due to differences in their quality and other non-price competitiveness factors, i.e. intra-product desirability. In other words, the demand for the production of a country can increase faster than the demand for the production of another country either: (i) because individuals prefer to consume the computers produced by the former in relation to the bananas produced by the latter when their income increases; or/and (ii) because the computers produced by the former present higher quality than the computers produced by the latter.

6.2.1. General demand functions

Combining the empirical evidence found in the Kaldorian and the Schumpeterian literatures, it is possible to arrive at a general form for export and import demand functions, given by:

$$X = a\left(\frac{EP_f}{P}\right)^{\eta}\left(\frac{N}{N_f}\right)^{\mu} C^{\sigma} Z^{\varepsilon} \qquad (6.1)$$

$$M = b\left(\frac{P}{EP_f}\right)^{\psi}\left(\frac{N_f}{N}\right)^{\nu} C^{\varsigma} Y^{\pi} \qquad (6.2)$$

where $N=(TO^{\omega})$ denotes non-price competitiveness, with *O* denoting other non-price competitiveness factors apart from technological competitiveness *(T)*. Hence, *N* is more general than the technological competitiveness *(T)* emphasised in the Schumpeterian literature. Thus, assuming that productivity growth is not only associated with cost reductions but also with quality improvements, productivity can be used as a proxy for *N* when prices are already accounted for. Moreover, *X* is exports, *M* imports, *Z* is foreign income, *Y* is domestic income, *C* is productive capacity, *E* is the exchange rate, *P* are prices, and the subscript *f* denotes the foreign economy.

Equations (6.1) and (6.2) encompass both the Kaldorian and the Schumpeterian approaches to trade performance. The difference between the two is represented in the assumptions made about the parameters of the general functions. On the one hand, the Kaldorian literature assumes that $\mu=\sigma=0$ for exports and $\nu=\varsigma=0$ for imports, so that non-price competitiveness factors and productive capacity are captured by the income elasticities of demand $\pi,\varepsilon\neq 0.$. On the other hand, the Schumpeterian literature assumes that $\mu,\sigma\neq 0$ for exports and $\nu,\varsigma\neq 0$ for imports, so that technological competitiveness and productive capacity are explicitly accounted for, while income elasticities of demand are assumed fixed $\varepsilon=\pi=1$ and other non-price competitiveness factors *(O)* are not taken into account, i.e. $\omega=0$.

As mentioned before, however, it is crucial to understand the implications of estimating these general demand functions for different sectors. In this case, although part of the non-price competitiveness factors associated with the production of each sector is removed from the income elasticities with the introduction of relative productivity in the demand functions, this variable captures only i*ntra-sector* non-price competitiveness, not taking into account inter-sector non-price competitiveness. This stems from the specification adopted for the demand functions, which does not take into account the cross non-price elasticities of demand. This specification, therefore, allows income elasticities of demand to differ between sectors, keeping the central role of these elasticities as stressed in the Kaldorian literature. Hence, as income grows, demand for different products grows at different rates following consumers' preferences *between different products*, in spite of the quality of each product in relation to the quality of its competitors *within the same product category*.

6.3. Main results

Tables 8 and 9 report regression results dividing the sample of industries into low-tech and high-tech.

Table 8: Export demand functions: by technological sectors

Dependent Variable Method Sample	Ln of Exports SYS-GMM Low-Tech Industries (i)	Ln of Exports SYS-GMM Low-Tech Industries (ii)	Ln of Exports SYS-GMM Low-Tech Industries (iii)	Ln of Exports SYS-GMM Low-Tech Industries (iv)	Ln of Exports SYS-GMM Low-Tech Industries (v)	Ln of Exports SYS-GMM High-Tech Industries (vi)	Ln of Exports SYS-GMM High-Tech Industries (vii)	Ln of Exports SYS-GMM High-Tech Industries (viii)	Ln of Exports SYS-GMM High-Tech Industries (ix)	Ln of Exports SYS-GMM High-Tech Industries (x)
Ln of Foreign Income	1.776***	1.755***	2.154***	2.107***	1.963***	2.609***	2.456++	3.065***	3.291*	2.646***
	(0.147)	(0.234)	(0.236)	(0.187)	(0.188)	(0.398)	(1.208)	(0.667)	(1.369)	(0.512)
Ln of Domestic Prices	-0.842	-0.118		-0.561	-0.00256	2.174	0.190		0.103	0.259
	(2.389)	(2.880)		(1.301)	(1.726)	(1.394)	(3.339)		(3.080)	(1.099)
Ln of Foreign Prices	0.882	0.439		0.432	-0.0529	-0.0449	1.564		1.635	0.541
	(2.340)	(2.736)		(1.213)	(1.768)	(1.613)	(4.779)		(4.919)	(2.060)
Ln of Domestic TFP		0.322	0.455++	0.230	0.430++		0.945	1.996**	1.380++	0.889++
		(0.418)	(0.265)	(0.293)	(0.257)		(1.332)	(0.678)	(0.697)	(0.438)
Ln of Foreign TFP			-0.737++	-0.540++	-0.529*			-1.728++	-1.078	-1.082+
			(0.419)	(0.289)	(0.242)			(0.992)	(1.061)	(0.648)
Ln of Capital Stock					0.273++					0.578**
					(0.139)					(0.151)
Constant	-33.18***	-33.21***	-43.85***	-42.47***	-40.45***	-54.75***	-52.49	-71.07**	-76.26++	-60.62**
	(4.461)	(6.564)	(6.614)	(5.313)	(5.557)	(13.11)	(36.86)	(19.45)	(42.43)	(16.38)
N. Observations	420	420	420	420	420	126	126	126	126	126
No. Groups	70	70	70	70	70	21	21	21	21	21
No. Instruments/Lags	6/2-3	9/2-3	6/2-3	9/2-3	13/2-3	6/2-3	11/3-5	5/2	12/3-5	19/2-5
Arellano-Bond AR Test	0.802	0.762	0.159	0.136	0.119	0.700	0.696	0.113	0.745	0.179
Hansen's J Test	0.654	0.459	0.125	0.309	0.386	0.455	0.218	0.833	0.182	0.354

Note: The values reported for the tests are p-values. The p-value reported for the Arellano-Bond AR Test refers to the first lag used as instrument in the regression.
Significance: ***=0.1%; **=1%; *=5%; ++=10%; +=15%.
Source: Author's elaboration.

Table 9: Import demand functions: by technological sectors

Dependent Variable Method Sample	Ln of Imports SYS-GMM Low-Tech Industries (i)	Ln of Imports SYS-GMM Low-Tech Industries (ii)	Ln of Imports SYS-GMM Low-Tech Industries (iii)	Ln of Imports SYS-GMM Low-Tech Industries (iv)	Ln of Imports SYS-GMM Low-Tech Industries (v)	Ln of Imports SYS-GMM High-Tech Industries (vi)	Ln of Imports SYS-GMM High-Tech Industries (vii)	Ln of Imports SYS-GMM High-Tech Industries (viii)	Ln of Imports SYS-GMM High-Tech Industries (ix)	Ln of Imports SYS-GMM High-Tech Industries (x)
Ln of Domestic Income	2.307***	2.345***	1.998***	2.365***	2.486***	2.599***	2.529***	1.799***	1.795*	1.957*
	(0.385)	(0.236)	(0.211)	(0.359)	(0.386)	(0.629)	(0.497)	(0.350)	(0.647)	(0.875)
Ln of Domestic Prices	-0.778	-0.647		0.695	-1.143	-0.551	0.0194		0.168	0.698
	(3.442)	(1.762)		(2.586)	(2.644)	(2.147)	(1.941)		(1.523)	(1.854)
Ln of Foreign Prices	1.097	1.010		-1.234	0.719	-0.275	-0.842		0.430	-0.240
	(3.618)	(1.721)		(2.648)	(2.708)	(2.844)	(2.694)		(2.867)	(2.589)
Ln of Domestic TFP		0.0662	-1.430*	-1.285++	-0.650		-0.182	-1.317+	-1.762+	-1.393++
		(0.385)	(0.562)	(0.645)	(0.596)		(0.936)	(0.786)	(1.047)	(0.769)
Ln of Foreign TFP			0.863+	0.568	0.0599			1.708*	1.960*	1.592*
			(0.520)	(0.560)	(0.520)			(0.747)	(0.761)	(0.638)
Ln of Capital Stock					0.133					-0.237
					(0.403)					(0.654)
Constant	-39.35***	-40.44***	-30.75***	-40.11***	-44.04***	-46.94*	-44.56**	-26.34**	-25.22	-27.73
	(10.14)	(6.080)	(5.250)	(8.830)	(8.809)	(18.09)	(12.81)	(8.830)	(17.90)	(20.68)
N. Observations	420	420	420	420	420	126	126	126	126	126
No. Groups	70	70	70	70	70	21	21	21	21	21
No. Instruments/Lags	8/2-3	11/2-3	6/3	9/2	11/2	8/2-3	11/3-4	8/2-3	9/2	11/2
Arellano-Bond AR Test	0.139	0.010	0.114	0.110	0.070	0.384	0.363	0.904	0.488	0.763
Hansen's J Test	0.356	0.459	0.209	0.551	0.426	0.940	0.521	0.674	0.624	0.339

Note: The values reported for the tests are p-values. The p-value reported for the Arellano-Bond AR Test refers to the first lag used as instrument in the regression.
Significance: ***=0.1%; **=1%; *=5%; ++=10%; +=15%.
Source: Author's elaboration.

The first five columns of Tables 8 and 9 report results for the sample of low-tech industries, while the last five columns report results for the sample of high-tech industries. In all regressions but one (column (iii) of Table 9) the Arellano and Bond (1991) AR Test and the Hansen's J Test suggest the validity of the instruments. Income elasticities are significant in all regressions, domestic and foreign TFP are significant in most regressions, as well as productive capacity, while prices are not significant.

Regarding exports, the income elasticity of demand decreases with the introduction of domestic TPF, then increases with the introduction of foreign TFP, and reduces somewhat with the introduction of productive capacity. Analogously, regarding imports, the income elasticity of demand increases with the introduction of domestic TFP, then decreases with the introduction of foreign TFP, and increases slightly with the introduction of productive capacity. This shows that the effect of these variables was being captured in the income elasticities, creating omitted variable bias. This indicates that these variables partially explain the magnitude of the income elasticities of demand.

Still, the results reported in Tables 8 and 9 convey two important pieces of information. First, the results indicate that the effect of non-price competitiveness (i.e. domestic and foreign TFP growth) on export and import growth is considerably different between technological sectors, estimated to be around 0.5 and 0.9 for low-tech industries and around 1 and 1.5 for high-tech industries, respectively. As expected, therefore, non-price competitiveness exerts a larger impact on high-tech industries than on low-tech industries, possibly due to the fact that in the latter group of industries there is less room for product differentiation. Second, in spite of this difference, income elasticities of demand are also considerably higher for high-tech than for low-tech industries. As argued before, this is not unexpected, given that different types of goods still face different demand even when controlling for non-price competitiveness. Regarding exports, in the simple export functions, the income elasticities of low-tech and high-tech industries are 1.8 and 2.6, respectively, while in the expanded export functions the income elasticities are 1.9 and 2.6. The results are slightly poorer for imports. Yet, in the simple import functions, the income ealsticities of low-tech and high-tech industries are also 1.9 and 2.6, respectively. However, in the expanded export functions the income elasticities of low-tech and high-tech goods become 2.5 and 2, respectively.

6.5. Concluding Remarks

This chapter showed that it is possible to derive export and import functions that encompass the contributions of both Kaldorian and Schumpeterian literatures to understanding the determinants of trade performance. These functions explicitly account for the effect of relative productivity on export and import demand via non-price competitiveness, given that changes in relative prices are controlled for, while considering the effect of income growth and productive capacity on export and import growth. This generates a more comprehensive explanation for the determinants of trade than the explanations provided by each of the traditions separately. Finally, an empirical investigation was carried out to assess the impact of non-price competitiveness, measured by relative productivity growth, on export and import growth, taking into account differences between technological sectors.

The econometric investigation reported in this chapter indicated that the growth rates of exports and imports are partially determined by relative productivity growth and productive capacity, which suggests the validity of the expanded export and import functions. Most importantly, although domestic and foreign productivity growth are only marginally significant in some of the regressions, in all the regressions the introduction of these variables leads to changes in the magnitude of the income elasticities of demand. This observation suggests that including these variables increases the explanatory power of the estimates, while their exclusion leads to omitted variable bias.

In addition, the tests indicated that low-tech industries present lower income and non-price elasticities of demand than high-tech industries. This suggests that moving the economy towards the production and export of high-tech goods contributes to increase long-term growth not only because the income elasticity of these goods are intrinsically higher than that of low-tech goods, but also because higher productivity growth in high-tech industries has a larger effect on trade performance and growth than in low-tech industries.

This chapter, therefore, provides an initial connection between the results found in chapters 3, 4 and 5. The econometric analyses presented in these chapters suggest that high-tech industries present not only higher income elasticities of demand, but also higher degrees of returns to scale. The present chapter, in turn, indicates that productivity growth feeds back into trade performance through non-price competitiveness, which creates a circuit of cumulative causation that does not depend on price competitiveness, as in Dixon and Thirlwall's (1975) model.

7. PRODUCT SOPHISTICATION, PRODUCTIVITY AND TRADE

Reassessing the Importance of Non-Price Competition for Trade Performance

7.1. Introduction

The investigation reported in chapter 6 provided evidence that productivity growth has a positive impact on export growth and a negative impact on import growth, showing also that the impact of productivity growth on trade varies between low-tech and high-tech industries. In chapter 6, it was argued that these impacts are explained by the fact that productivity growth is associated with improvements in non-price competitiveness (i.e. product quality or non-price competitiveness) when changes in relative prices are controlled for.

More recently, a number of works have been investigating the importance of product quality for trade and productivity growth using indexes of product and economic sophistication. Following the seminal work of Hausmann *et al*. (2007), Hidalgo and Hausmann (2009) developed measures of product and economic sophistication (or complexity) based on information on international trade. The authors defined the degree of product diversification of a country as the number of products that a country exports with Revealed Comparative Advantage (RCA – Balassa, 1965), and the degree of ubiquity of a product as the number of countries that export a product with RCA. Thus, the higher the diversification of a country's exports is, the higher this country's sophistication is. In contrast, the lower the ubiquity of a good is, the higher its sophistication is.

Using these indexes, Hidalgo and Hausmann (2009) and Felipe (2012) showed that economic growth is strongly correlated with the production of a diversified basket of goods that are not exported by many other countries i.e. that have low ubiquity. As Hidalgo and Hausmann (2009) argued, complex and sophisticated products are less ubiquitous. Furthermore, countries that possess a high number of capabilities are capable of producing a higher number of goods, which means they will tend to have more diversified productive structures. Indeed, Felipe (2012) found that the measures of economic and product sophistication proposed by Hidalgo and Hausmann (2009) are highly correlated with measures of technological capabilities used in Schumpeterian works (e.g. Archibugi and Coco, 2005). Consequently, this approach shows not only that diversification and ubiquity are negatively correlated, which means diversified countries tend to produce more sophisticated (less ubiquitous) goods, but it also shows that diversification is positively correlated with income level.

However, as Hidalgo and Hausmann (2009) and Hausmann *et al*. (2011) stressed, diversification and ubiquity are crude approximations of economic (or country) and product sophistication. On the one hand, the ubiquity of a product can be low because of its rarity, as is the case of diamonds, and not because of its sophistication/complexity. On the other hand, a country can have low diversification, but produce highly sophisticated/complex products. Nonetheless, ubiquity and diversity can be combined to obtain better measures of economic and product sophistication. A country with low diversification but that produces goods with low ubiquity can be considered more sophisticated than a country that has similarly low diversification but produces goods will high ubiquity. Analogously, a good with high ubiquity but produced by countries that have low diversification can be considered less sophisticated than goods with similarly high ubiquity but produced by countries that have high diversification. In other words, using the interaction between ubiquity and diversification it is possible to generate better proxies for economic and product sophistication.

In this chapter, an index of sophistication of the production of each industry *(IEXPS)* in each country was calculated as the weighted average of the sophistication of the products exported with RCA within each industry. Calculating this index for each of the industries in the EU KLEMS database allows to analyse the relationship between sophistication and productivity at the industry level. Moreover, using this level of aggregation allows also to assess the results found in chapter 6 by investigating the impact of sophistication on trade performance.

The objective of the present chapter, therefore, is to reassess the results found in chapter 6 using the methodologies proposed by Hausmann *et al*. (2007) and Hidalgo and Hausmann (2009) to test the impact of product sophistication on trade and productivity growth. More specifically, the chapter reports tests of the impact of changes in sophistication on subsequent productivity growth, and presents estimates of the export and import demand functions investigated in chapter 6 replacing productivity by sophistication growth.

7.2. Main Results

Table 10 reports estimates of the relationship between changes in sophistication and productivity growth. To assess the measures of sophistication calculated in this chapter, Hausmann's *et al*. (2007) test of the relationship between initial *EXPY* index and subsequent GDP per capita (a rough proxy for productivity growth) was replicated using cross-country OLS. The test was regressed using a consistent sample of 102 countries for which data is available for all years in the period 1996-2006. The test employed the average of each variable during the period investigated. The estimated regression is reported in column (i). The significance and magnitude of the estimated coefficients are very similar to the results of Hausmann *et al*. (2007: 19), showing that *EXPY* influences subsequent productivity growth. Columns (ii) to (v) report estimates of the impact of sophistication on productivity growth using industry-level data. Hence, the growth rate of GDP per capita is replaced by the growth rate of industry TFP, and *EXPY* is replaced by *IEXPS*. Moreover, System GMM is now utilized. Arellano and Bond's (1991) AR Test and Hansen's J Test indicate that the instruments are valid at a 5% significance level in all these regressions. Columns (ii) and (iv) of Table 10 replicate the specification tested in column (i) using samples of low- and high-tech industries, respectively. For low-tech industries none of the variables is significant and initial sophistication has a negative sign. For high-tech industries, however, initial sophistication is positive and significant, so that the results are similar to the estimates of Hausmann *et al*. (2007: 19). Finally, in columns (iii) and (v) the growth rate of value added is introduced and an expanded Kaldor-Verdoorn's Law is estimated. The results of these regressions are similar to the estimates of chapter 3, suggesting that returns to scale are slightly higher in high-tech industries. Nonetheless, while sophistication is positive and significant for high-tech industries, the opposite holds for low-tech industries. These results indicate once again that sophistication is more important for productivity growth in high-tech industries, while it seems to be less relevant for low-tech industries. Although not significant, the fact that sophistication has a negative sign for low-tech industries might be due to the fact that this variable is calculated based on the importance of diversification. In low-tech industries, however, where cost-competitiveness seems to be more important, specialization is likely to be more relevant than diversification. Furthermore, the measure of sophistication

Table 11 reports estimates of export and import demand functions. In only four of the eight regressions (columns

Table 10: Industry sophistication and productivity growth

Dependent Variable Method Sample	Growth rate of GDP per capita OLS Countries (i)	Growth rate of TFP SYS-GMM Low-Tech Industries (ii)	Growth rate of TFP SYS-GMM Low-Tech Industries (iii)	Growth rate of TFP SYS-GMM High-Tech Industries (iv)	Growth rate of TFP SYS-GMM High-Tech Industries (v)
Ln of initial Technology Gap	-0.0106*				
	(0.00436)				
Ln of initial *EXPY*	0.0378**				
	(0.0117)				
Lagged Technology Gap		0.100	0.00498	-0.0575	-0.0638**
		(0.206)	(0.0815)	(0.0415)	(0.0212)
Lagged Ln of *IEXPS*		-0.0318	-0.00314	0.0473++	0.0471*
		(0.0656)	(0.0269)	(0.0256)	(0.0173)
Growth rate of Value Added			0.557*		0.583*
			(0.273)		(0.240)
Constant	-0.239**	0.142	0.0202	-0.165	-0.187*
	(0.0768)	(0.257)	(0.108)	(0.112)	(0.0666)
N. Observations	102	350	350	105	105
No. Groups		70	70	21	21
No. Instruments/Lags		6/2-5	10/2-4	4/3	6/4
Arellano-Bond AR Test		0.753	0.662	0.653	-
Hansen's J Test		0.372	0.351	0.534	0.489

Note: The values reported for the tests are p-values. The p-value reported for the Arellano-Bond AR Test refers to the first lag used as instrument in the regression. The Sample "All Industries" comprises 13 goods-producing industries, excluding the Fuel and Chemical industries. Significance: ***=0.1%; **=1%; *=5%; ++=10%; +=15%.
Source: Author's elaboration.

(i) and (iii) to (v)) Arellano and Bond's (1991) AR Test and Hansen's J Test indicate that the instruments are valid at a 5% significance level. Nonetheless, given that foreign and domestic sophistication are highly correlated (0.71), the regressions that include only domestic sophistication present the most relevant results. In these cases, the instruments are valid for three out of the four regressions.

For the export demand functions (columns (i) to (iv)), the coefficients of income and domestic sophistication are positive and significant, except for sophistication in column (iv). Most importantly, focusing on the regressions that only include domestic sophistication, it is possible to observe that the coefficients of income and sophistication are slightly higher for high-tech industries. Nonetheless, comparing the estimates reported in Table 11 with the estimates of simple export demand functions presented in chapter 6, the income elasticities of demand increase when sophistication is introduced. Yet, the magnitude of the coefficients of domestic sophistication in low- and high-tech industries are similar to the coefficients of domestic productivity in the regressions presented in chapter 6, being around 0.5 in low-tech industries and around 1 for high-tech industries. Hence, the results presented in Table 11 reinforce the findings of chapter 6.

Table 11: Export and import demand functions

Dependent Variable Sample	Ln of Exports Low-Tech Industries (i)	Ln of Exports Low-Tech Industries (ii)	Ln of Exports High-Tech Industries (iii)	Ln of Exports High-Tech Industries (iv)	Ln of Imports Low-Tech Industries (v)	Ln of Imports Low-Tech Industries (vi)	Ln of Imports High-Tech Industries (vii)	Ln of Imports High-Tech Industries (viii)
Ln of Domestic Income					1.001*	1.066***	0.647*	0.951**
					(0.496)	(0.125)	(0.280)	(0.270)
Ln of Foreign Income	2.076***	2.215***	2.169***	2.495**				
	(0.189)	(0.212)	(0.363)	(0.739)				
Ln of Domestic Prices	-0.481	-2.529	0.548	1.803	-1.105	9.511**	-1.621	0.917
	(0.583)	(1.928)	(1.121)	(3.376)	(2.571)	(2.801)	(1.582)	(4.257)
Ln of Foreign Prices	0.469	2.579	0.361	-1.035	1.152	-9.654**	-0.737	-1.044
	(0.597)	(1.884)	(1.151)	(3.882)	(2.512)	(3.141)	(3.021)	(6.046)
Ln of Domestic *IEXPS*	0.635++	0.812*	0.850*	0.283	-1.250+	-1.420	2.475++	-0.0545
	(0.357)	(0.375)	(0.403)	(0.715)	(0.783)	(1.156)	(1.244)	(1.176)
Ln of Foreign *IEXPS*		0.0252		-0.0107		1.513++		1.251+
		(0.346)		(0.568)		(0.906)		(0.777)
Constant	-43.5***	-47.9***	-45.4***	-53.89*	-2.781	-8.833**	-4.726	-6.553
	(6.275)	(6.885)	(10.35)	(21.60)	(14.01)	(3.122)	(7.183)	(8.208)
N. Observations	420	420	126	126	420	420	126	126
No. Groups	70	70	21	21	70	70	21	21
No. Instruments/Lags	11/2-4	12/3-5	9/3-4	10/2-3	11/2-4	10/3-4	11/2-4	8/4
Arellano-Bond AR Test	0.431	0.477	0.155	0.696	0.571	0.768	0.138	0.003
Hansen's J Test	0.258	0.000	0.839	0.417	0.114	0.002	0.046	0.012

Note: The estimation method used is SYS-GMM. The values reported for the tests are p-values. The p-value reported for the Arellano-Bond AR Test refers to the first lag used as instrument in the regression. The Sample "All Industries" comprises 13 goods-producing industries, excluding the Fuel and Chemical industries. Significance: ***=0.1%; **=1%; *=5%; ++=10%; +=15%.
Source: Author's elaboration.

For the import demand functions (columns (v) to (viii)), the coefficients of income and of foreign sophistication are positive and significant, while the coefficient of domestic sophistication is negative and significant in column (v), but positive in column (vii), in contrast to what expected. Still, the instruments are valid in only one of the regressions, so that these results are considerably weaker than the results found for the export demand functions. These caveats notwithstanding, the magnitude of the income elasticities is considerably lower than the estimates reported in chapter 6, while the magnitude of the coefficient of domestic sophistication is much higher than the coefficient of domestic productivity presented in chapter 6.

In general, the results presented in this chapter are less robust than the results reported in chapter 6. Instruments are often not valid, failing to solve simultaneity, and the significance and magnitude of the variables are less robust across the different regressions. Statistically, the Ln of *IEXPS* has higher variance than the Ln of TFP. A possible explanation for the weaker results is the fact that measures of product sophistication such as the *PS* index are by construction fixed across countries. As a result, variation in product sophistication captured in *IEXPS* is only due to differences in export composition. This is an important limitation, given that the quality of products from a given category changes markedly between countries, in spite of similar export shares. Consequently, using productivity as a proxy for quality, as in chapter 6, seems to be a preferable strategy when data is available.

7.5. Concluding Remarks

The investigation presented in this chapter indicates that changes in product sophistication influence productivity, export and import growth. This chapter's tests suggest that productivity growth is associated with improvements in sophistication/quality, as argued in chapter 6. Nonetheless, the positive impact of industry sophistication on productivity growth is only significant in high-tech industries. This provides evidence that productivity growth in low-tech industries is to a larger extent associated with cost reductions (efficiency) and to a lesser extent associated with quality improvements, while the opposite holds for high-tech industries. However, given the limitations of the sophistication indexes employed in this chapter's investigation, the importance of quality improvements for productivity growth in low-tech industries should not be dismissed without further investigation. In spite of this, the impact of domestic sophistication on exports (imports) is positive (negative) and significant for both groups of industries. Most importantly, the impact of domestic sophistication on exports is higher for high-tech industries. Yet, the estimates are less robust than the estimates reported in chapter 6. These caveats notwithstanding, the findings of this chapter provide additional support to the results found in chapter 6.

8. A KALDOR-SCHUMPETER MODEL OF CUMULATIVE GROWTH

Combining Increasing Returns and Non-price Competitiveness with Technological Catch-up and Research Intensity

8.1. Introduction

Following the econometric investigations carried out in the previous chapters of the study, this chapter proposes a modified version of the KDT model that encompasses the findings of chapters 3 to 7, incorporating insights from the Schumpeterian literature into the Kaldorian framework.

As chapter's 1 and 2 have shown, both the Kaldorian and the Schumpeterian approaches to economic growth have strong foundations, with important contributions to macroeconomic growth theory and considerable support from a large number of empirical works.

The two approaches carry some important similarities. Both approaches emphasise the importance of endogenous technical progress and trade for economic growth, while recognizing the crucial role of non-price competitiveness for trade performance (e.g. Kaldor, 1970; Fagerberg, 1988). Furthermore, both streams emphasise the relevance of structural differences between sectors or industries for growth. In addition, both approaches stress the importance of cumulative mechanisms that guarantee positive growth rates in the long-term. In the Kaldorian tradition, cumulative causation comes from the impact of output growth on productivity growth (e.g. Dixon and Thirlwall, 1975), while in the Schumpeterian tradition cumulative causation comes from the impact of knowledge accumulation on productivity growth (e.g. Romer, 1990; Aghion and Howitt, 1992; 1998). And finally, both approaches are compatible with conditional convergence (see Roberts, 2007; Griffith *et al.*, 2004).

Similarities notwithstanding, the two traditions present an important difference. While Kaldorian theory emphasises the importance of demand growth for long-term growth, not investigating in depth the role of supply-side factors, the opposite holds for Schumpeterian theory. Although this difference does not make the two approaches necessarily incompatible, it does create an important difficulty, since combining these theories can subvert one of the two by attributing final role to either demand or to supply factors alone.

A number of works have sought to combine Kaldorian and Schumpeterian insights into models of cumulative growth. Amable (1993), for instance, put together a model that takes into account the importance of both research intensity and technological transfer for productivity growth. However, the model does not specify how productivity growth impacts on output growth nor considers the role of exports in long-term growth. In a similar attempt, Targetti and Foti (1997) created a model that stresses the importance of technological transfer for productivity growth. Yet, the model that disregards the roles of research intensity and non-price competitiveness for long-term growth. León-Ledesma's (2002) model, in turn, represents the most complete formalization of Kaldorian and Schumpeterian insights. The author expanded Dixon and Thirlwall's (1975) model by introducing the technology gap, research intensity and technological competitiveness into the Kaldorian model. Nonetheless, León-Ledesma's (2002) tests suggested that demand factors do not influence research intensity, while this variable has a positive impact on export growth. In contrast with the Kaldorian approach, therefore, this ends up attributing a more prominent role to supply-side factors in determining export growth. In addition, León-Ledesma's (2002) tests suggested also that research intensity does not impact on productivity growth, going against one of the key findings of the Schumpeterian literature. Thus, these issues indicate that some of the relationships adopted in the model might be problematic, casting doubt on its dynamics. Finally, it is also important to note that none of the models mentioned above take sectoral differences[4] into account or incorporate the importance of balance-of-payments constraint for long-term growth, as emphasised by Thirlwall (1979). In sum, none of these seminal works has managed to construct a model that satisfactorily encompasses the contributions of the Kaldorian and the Schumpeterian traditions.

As discussed in the introduction of this study, the empirical evidence

[4]Cimoli and Porcile's (2014) model seeks to combine Kaldorian and Schumpeterian insights taking into account sectoral differences. However, the model is inspired in a structuralist framework that is very different from the Schumpeterian and the Kaldorian models, and that does not take into account all the factors considered in these approaches.

reported in chapters 3 to 7 provides the foundations required to construct a model that encompasses both Kaldorian and Schumpeterian insights, while also considering the importance of interactions between different sectors.

This chapter's contribution to the existing literature is threefold. First, the chapter proposes a growth model that consistently combines the key insights from the Kaldorian and the Schumpeterian traditions, while keeping the importance of both demand and supply-side factors for long-term growth. This model not only formally integrates the two approaches, taking into account the results found in chapters 3 to 7, but it also addresses two important issues attributed to the Kaldor-Dixon-Thirlwall (KDT) model, namely: (i) that cumulative causation works through price competitiveness; and (ii) that the degree of returns to scale is left unexplained. The Schumpeterian contributions are incorporated into the KDT model by introducing the effect of technological transfer as a determinant of technical progress, and introducing research intensity as a determinant of the degree of returns to scale. The model is compatible with existing empirical evidence on conditional convergence, as well as with Kaldorian and Schumpeterian empirical works. Hence, this model integrates the contributions of the previous chapters of the thesis, showing that the Kaldorian and the Schumpeterian traditions can be combined without subverting their core ideas, as long as both demand and supply-side factors are allowed to play a role in long-term growth. Second, and most importantly, the chapter proposes a multi-sectoral version of the Kaldor-Schumpeter growth model presented in the first part of the chapter. This model demonstrates that, in a multi-sectoral setting with balance-of-payments constraint, increases in productivity growth in a given sector generate increases in productivity and output growth in the other sectors of the economy due to inter-sector demand externalities. Third, this multi-sectoral Kaldor-Schumpeter model shows also that increases in foreign output growth can exert a negative impact on the growth rate of the domestic economy, provided the negative effect on domestic exports and imports that results from higher foreign non-price competitiveness is larger than the positive demand effect on domestic exports.

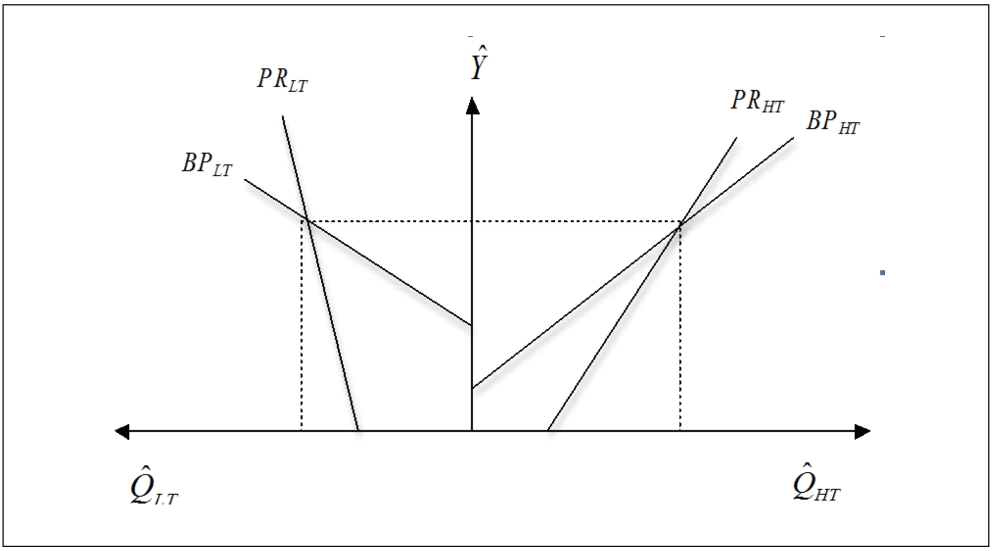
This summary does not present the equations that form the model. It focuses instead on discussing the key implications of the model and main contributions of the chapter. Readers interested in the complete discussion about the specification of the model are referred to Romero (2016b)

8.2. A Multi-Sectoral Kaldor-Schumpeter Growth Model

First, an increase in research intensity in the domestic economy *(T)* increases the equilibrium growth rate, *ceteris paribus*. Second, *ceteris paribus*, an increase in research intensity in the foreign economy *(Tf)* decreases the equilibrium growth rate, given that such increase raises the growth rate of productivity in the foreign economy, which benefits imports and hinders exports from the domestic economy. Third, the higher the technology gap is, the higher the equilibrium growth rate is, *ceteris paribus*. And fourth, the model´s equilibrium becomes Araújo and Lima's (2007) Multi-Sectoral Thirlwall's Law (MSTL) if it is assumed that relative productivity has no effect on exports and imports.

Figure 2 illustrates the equilibrium of the model using two sectors. This equilibrium is given by the joint intersection between the productivity curve (PR) and the balance-of-payments equilibrium curve (BP) of the two sectors. The figure shows that in equilibrium the two sectors jointly determine the equilibrium growth rate of aggregate output. Yet, each sector has different growth rates of output and productivity, determined by the parameters of the equations associated with each sector. Thus, following the model´s solution, increases in research intensity and in the technology gap in any sector

Figure 2: Equilibrium Output and Productivity Growth Rates in a Two-sector KS Model



Source: Author's elaboration.

increase the equilibrium growth rate by shifting the PR and BP curves upwards, *ceteris paribus*.

It is crucial to note, however, that introducing relative productivity in export and import functions does not change the classical Kaldorian approach, which emphasises the importance of income elasticities of demand for long-term growth.

Given that elasticities still differ between sectors in the Multi-Sectoral Kaldor-Schumpeter (MSKS) model, as in Araújo and Lima's (2007) MSTL, the MSKS model suggests that an increase in the share of sectors with higher income elasticities increases the equilibrium growth rate. Still, in the MSKS model, the growth effect of sectoral shifts in trade shares works not only through the income elasticity of demand for exports, but also through each sector's response of increasing returns to scale to research intensity, non-price elasticity of exports, and demand elasticities of output. Nonetheless, the values of these parameters most likely change together across sectors. In other words, sectors with large income elasticities of demand for exports will tend to have large responses of increasing returns to research intensity, as well as large non-price elasticities of exports and demand elasticities of output.

8.2.1. Model's Dynamics

In addition to sustaining the implications found in the previous chapters of the thesis, the MSKS model presented in this section generates two other important implications:

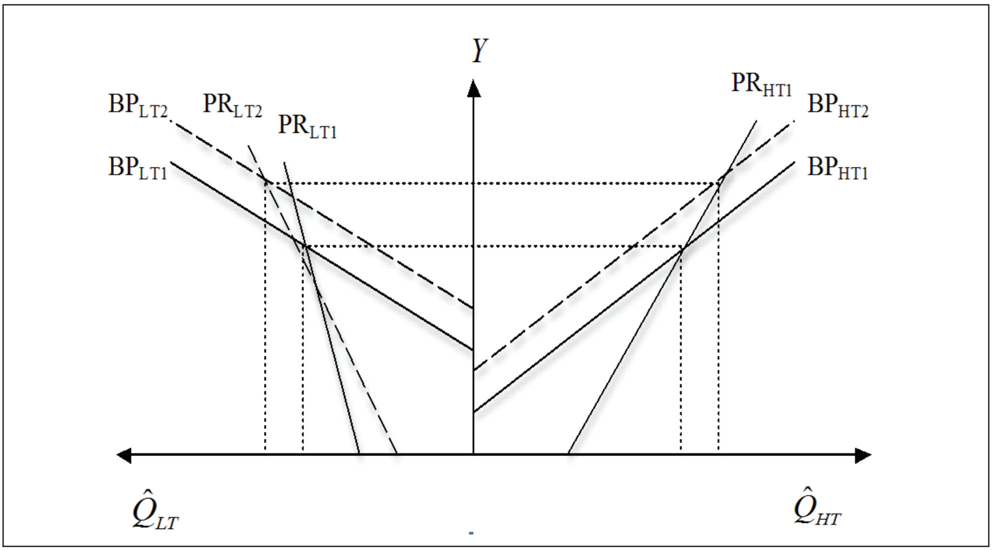
(i) the model stresses the importance of inter-sector demand externalities in a context of balance-of-payments constraint;

(ii) the model shows also that the effect of foreign output growth on the domestic economy is not necessarily positive, given that an increase in output growth in a given sector has not only a positive demand effect on the domestic economy, but also a negative non-price competitiveness effect of the domestic economy.

The most interesting aspect of the MSKS model outlined in this chapter is that it suggests that changes in a given sector impact on the performance of the other sectors through inter-sector demand externalities. This result follows from the fact that in the balance-of-payments equilibrium equation, increases in the growth rates of productivity in sectors $j = 1,...,k$ change the intercept of this curve for sector $i \neq j$. In other words, an increase in the growth rate of productivity in a given sector of the domestic economy eases the balance-of-payments constraint, which allows higher growth rates of domestic demand, impacting on the growth rates of output and productivity in the other sectors. Analogously, the opposite holds for increases in productivity growth in any given sector of the foreign economy.

Figure 3 uses a two-sector KS model to illustrate the growth effect of an increase in research intensity in one of the sectors of the domestic economy. In this figure, an increase in research intensity in the low-tech sector of the domestic economy leads to a rightward shift of the PR_{LT} curve from PR_{LT1} to PR_{LT}. The resulting increase in productivity growth in the low-tech sector generates an upward shift of the BP curve in the high-tech sector from BP_{HT1} to BP_{HT2}. This generates an increase in productivity growth in the high-tech sector, which leads to a shift in the BP curve in the low-tech sector from BP_{LT1} to BP_{LT2}, generating an additional increase in this sector's productivity growth. In other words, an increase in research intensity in the low-tech sector of the domestic economy leads to an increase in this sector's productivity growth rate, which eases the balance-of-payments constraint, increasing the growth rates of output and productivity in the high-tech sector. Nonetheless, a higher productivity growth rate in the

Figure 3: Shift in Equilibrium Output and Productivity Growth Rates in a Two-sector KS Model: Increase in Research Intensity in the Low-tech Sector

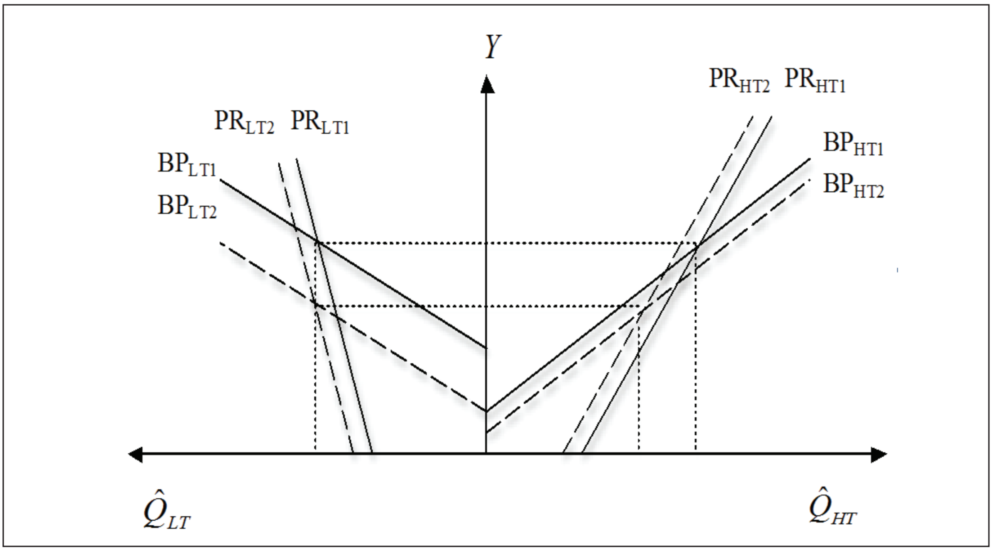


Source: Author's elaboration.

high-tech sector eases once again the balance-of-payments constraint, increasing the growth rates of output and productivity in the low-tech sector. Thus, this movement continues until a new simultaneous equilibrium in both sectors is reached, now associated with a higher equilibrium growth rate of aggregate output.

The dynamics of the MSKS model illustrated in Figure 3, therefore, stress the importance of inter-sector demand externalities in a multi-sectoral balance-of-payments constrained framework. In Araújo and Lima's (2007) MSTL, higher equilibrium growth rates are achieved through shifts in the sectoral composition of trade. In the MSKS model discussed in this chapter, higher equilibrium growth rates are achieved either through structural change, as in Araújo and Lima's (2007) model, or through increases in productivity growth in any sector of the economy, even when sectoral shares are assumed to be constant. This model shows, therefore, that in a balance-of-payments constrained framework, when multiple sectors are considered, better export performance in a given sector leads to higher growth rates of output and productivity in the other sectors as well, given the positive effect that an attenuation of

Figure 4: Shift in Equilibrium Output and Productivity Growth Rates in a Two-sector KS Model: Increase in Output Growth in the High-tech Sector of the Foreign Economy



Source: Author's elaboration.

the balance-of-payments constraint exerts on the growth rates of each sector.

Evidently, in a multi-sectoral framework, the magnitude of the externalities generated by an increase in productivity growth in a given sector will depend on the value of the parameters for this sector. In sectors with higher non-price elasticity of demand, the effect will be larger, given that an increase in productivity will lead to a larger attenuation of the balance-of-payments constraint. Moreover, the demand externalities will also be larger in countries with larger demand elasticities of output and larger research intensity.

The fact that the MSKS model presented in this chapter takes into account the effects of inter-sector demand externalities implies also that increases in research intensity in a given sector of the foreign economy have negative effects in all sectors of the domestic economy.

The second unique implication of the MSKS model refers to the ambiguous effect of an increase in the growth rate of foreign output. An increase in output growth in a given sector has both a positive and a negative effect on aggregate output growth. This ambiguous effect stems from the fact that although an increase in output growth in the foreign economy increases the demand for products from the domestic economy, it also increases the non-price competitiveness of the foreign economy, harming the export performance of the domestic economy.

Figure 4 illustrates the possible scenario of a negative growth effect stemming from an increase in the growth rate of output in the high-tech sector of the foreign economy. Thus, an increase in the growth rate of output in the high-tech sector shifts the PR_{HT} curve upwards, from PR_{HT1} to PR_{HT2}, and the BP_{HT} curve downwards, from BP_{HT1} to BP_{HT2}. These shifts lead to a downward shift in the BPLT curve, from BP_{LT1} to BP_{LT2}, reducing the growth rates of productivity and output in this sector as well. Yet, the PR_{LT} curve shifts downward as well, from PR_{LT1} to PR_{LT2}, compensating for the tightening of the balance-of-payments constraint.

8.2.2. Simulations

In order to quantify the implications of the MSKS model, the parameters estimated in chapters 4 and 6 were used as reference, with one of the auxiliary equations being estimated and reported in the thesis' appendix. Thus, using these estimates, the MSKS model becomes composed of two sectors, a low-tech sector (LT) and a high-tech sector (HT).

As in the KS model, using the values listed above, a considerable increase in research intensity is necessary to generate a meaningful effect on the equilibrium growth rate. With the values listed, the equilibrium growth rate is 4.33%.

An increase in domestic research intensity from 0.2 to 0.3 in the low-tech sector increases the equilibrium growth rate to 4.45%. This means that and increase of 0.1 in the number of patents created per millions of hours worked in the low-tech sector generates an increase in GDP growth of 0.22 percentage points. The growth rates of productivity in the low-tech and in the high-tech sectors, in turn, increase from 1.69 and 4.52%, to 1.85 and 4.59%, respectively. This illustrates the positive demand externality generated in the high-tech sector as a result of an increase in productivity growth in the low-tech sector.

Alternatively, if the increase in research intensity takes place in the high-tech sector instead of the low-tech, going from 0.3 to 0.4, the equilibrium growth rate increases to 4.68%, with a variation of 0.35 percentage points. Hence, this shows how the different magnitudes of the parameters associated with each sector influence the magnitude of the growth enhancing effect. In this case, the growth rates of productivity in the low-tech and in the high-tech sectors increase to 1.77% and 5.02%, respectively. This shows once again the effect of the inter-sectoral externality generated by an increase in productivity growth in a given sector. In this scenario, however, the total variation in the productivity growth rates is higher: 0.58 percentage points compared to 0.23 in the first scenario.

Increases in research intensity in the foreign economy have a negative effect on the equilibrium growth rate of the domestic economy. An increase in research intensity in the low-tech sector of the foreign economy from 0.6 to 0.7 decreases the equilibrium growth rate from 4.33 to 4.27%, with reductions also in sectoral output and productivity growth. Yet, an increase in research intensity in the high-tech sector from 0.9 to 1.0 generates a more significant decrease in the equilibrium growth rate to 4.1%.

In contrast, an increase in the output growth rate of the low-tech sector in the foreign economy from 2 to 3% has a large impact on the equilibrium growth rate of the domestic economy, increasing it from 4.33 to 5.87%. This positive effect highlights the importance of foreign demand for long-term growth, in spite of the negative effect of foreign output growth on domestic output growth through increased non-price competitiveness.

However, an increase in the output growth rate of the high-tech sector in the foreign economy from 5 to 6% exerts a negative impact on the equilibrium growth rate of the domestic economy, decreasing it from 4.33 to 4.22%. This negative effect occurs because output growth in the foreign economy generates a negative non-price competitiveness effect large enough to offset the positive demand effect, as illustrated in Figure 4.

8.4. Concluding Remarks

Taking into account the relevance of the Kaldorian and the Schumpeterian contributions to macroeconomic growth theory, this chapter proposed a growth model that consistently combines the insights of these two traditions while addressing important critiques directed to the Kaldor-Dixon-Thirlwall model. The most interesting characteristic of this model is that it takes into account the main factors emphasised by Kaldorian and Schumpeterian literatures, while keeping the importance of both demand and supply-side factors for economic growth. From the demand side, long-term growth is determined by foreign output growth and domestic productivity growth, while the latter is influenced by demand growth, forming a circuit of cumulative causation through non-price competitiveness. From the supply side, the effect of output growth on productivity growth, i.e. the degree of returns to scale, depends on the level of research intensity, which means that the capacity of each economy to take advantage of growing demand to increase technical progress and productivity growth depends on research intensity. Furthermore, productivity growth is also influenced by technological transfer. Thus, although demand (especially foreign demand) is still crucial for growth, as the Kaldorian tradition highlights, supply-side factors such as research intensity and technological transfer are also key determinants of long-term growth rates.

The proposed Kaldor-Schumpeter was elaborated in a multi-sectoral setting. Firstly, this multi-sectoral model highlights that changes in the sectoral composition of trade influence the magnitude of long-term growth rates. Secondly, this model shows that in a multi-sectoral framework with balance-of-payments constraint, changes in the performance of a given sector affect the performance of the rest of the economy via inter-sector demand externalities. More specifically, an increase in productivity in a given sector, by increasing this sector's non-price competitiveness and its exports, eases the balance-of-payments constraint, which allows higher growth of domestic demand, generating higher productivity and output growth in the other sectors of the economy. Thirdly, the model also shows that an increase in the growth rate of foreign output can exert a negative impact on the domestic economy, provided the negative effect this increase generates on the trade performance of the domestic economy (through non-price competitiveness) is larger than the positive demand effect created.

The model proposed in this chapter provide several contributions to Kaldorian growth theory. It not only addresses important limitations attributed to the canonical Kaldorian growth model, but it also consistently integrates Schumpeterian contributions into the Kaldorian framework without subverting the demand-side orientation of this approach.

To sum up, the model discussed in this chapter integrates the contributions of chapters 3 to 7 of the study, providing the main contribution of thesis. Most importantly, this chapter shows how combining the findings of the previous chapters in a formal model leads to results not observed when each relationship is analysed separately.

CONCLUSIONS

This study proposed a multi-sectoral growth model that consistently combines Kaldorian and Schumpeterian approaches, offering a more comprehensive explanation for long-term growth. In general terms, taking into account the contributions of the Kaldorian and the Schumpeterian theories, the thesis advocated in this study was that both demand and supply-side factors influence long-term growth. Moreover, this study showed also that different sectors are subject to different dynamics, so that structural change and inter-sectoral interactions affect long-term growth. More specifically, the novelty of the thesis was threefold: (i) it integrated the Kaldorian and the Schumpeterian traditions in an unprecedented form; (ii) it provided more specific explanations for how demand and supply interact; and (iii) it provided more detailed information about how structural change and sectoral dynamics influence long-term growth.

The Kaldorian approach to growth constituted the main theoretical foundation of the thesis, while elements from the Schumpeterian theory were incorporated into the Kaldorian framework to enrich its explanation of the process of economic growth. The literature review presented in chapter 1 identified three important gaps in the Kaldorian approach, showing that: (i) there is still no clear explanation for what determines differences in the degree of returns to scale across countries, industries and through time, nor for what determines the magnitudes of income elasticities of demand for exports and imports; (ii) sectoral differences have not been fully explored in Kaldorian theory; and (iii) the KDT model of cumulative growth has received two important critiques that have not yet been satisfactorily addressed, namely: (i) that cumulative causation works through price competitiveness; and (ii) that the degree of returns to scale is left unexplained.

This study addressed these three gaps in the Kaldorian literature. First, following the review of the Schumpeterian approach carried out in chapter 2, the main insights from Schumpeterian theory were incorporated into the Kaldorian framework, aiming to improve the explanatory power of the latter. Second, expanded versions of Kaldor-Verdoorn's Law, Thirlwall's Law and of Dixon and Thirlwall's model were proposed and tested, disaggregating each relationship of the models to identify the importance of sectoral dynamics for long-term growth.

Thus, following the discussion carried out in the first two chapters of the thesis, chapters 3 to 7 provided five contributions to understanding the process of economic growth. These chapters showed, respectively:

(i) that increasing returns to scale are higher in high-tech industries than in low-tech industries, and that this difference has increased in the last decades;

(ii) that the degree of returns to scale depends on the level of research intensity observed in each industry, so that differences in scale economies between high-tech and low-tech industries can be partially explained by differences in the level of research intensity verified in each sector;

(iii) that high-tech industries not only present higher returns to scale, but that they also present higher income elasticities of demand for exports and imports, although the magnitude of this difference seems to have reduced in the last decades;

(iv) that domestic and foreign productivity growth influence the growth rates of exports and of imports, capturing intra-industry non-price competitiveness, while income elasticities of demand still differ between industries due to inter-industry non-price competitiveness;

(v) that product sophistication influences subsequent productivity growth and impacts on export and import growth.

Finally, chapter 8 presented the main contribution of the study to growth theory, proposing a Kaldor-Schumpeter growth model that provides important pieces of information regarding how the process of economic growth unfolds. More specifically, the contribution of this chapter to growth theory was threefold. First, the chapter proposed an aggregate model that introduces the contributions provided in the previous chapter of the thesis into the KDT model. This model not only formally integrates the contributions of the thesis, but it also addresses two important critiques directed to the KDT model, namely: (i) that cumulative causation works through price competitiveness; and (ii) that the degree of returns to scale is left unexplained. Second, and most importantly, the chapter also proposed a multi-sectoral version of this model to demonstrate that in a multi-sectoral setting with balance-of-payments constraint, increases in productivity growth in a given sector generate increases in productivity and output growth in the other sectors of the economy due to inter-sector demand externalities. Third, the chapter showed that, in a multi-sectoral framework, increases in foreign output growth can exert a negative impact on the growth rate of the domestic economy, provided the resulting negative effect on domestic exports and imports through non-price competitiveness is larger than the resulting positive demand effect on domestic exports. This chapter, therefore, shows how combining the findings of chapters 3 to 7 in a formal model leads to results not observed when each relationship is analysed separately.

In sum, chapter 8 integrated all the contributions of the thesis, formalising the channels through which demand and supply interact to generate different growth rates in different industries and countries, as this study sought to demonstrate.

The model proposed in this study and the associated econometric evidence show that the Kaldorian and the Schumpeterian traditions can be combined without subverting their core ideas, as long as both demand and supply-side factors are allowed to play a role in long-term growth. According to this Multi-Sectoral Kaldor-Schumpeter growth model, higher equilibrium growth rates can be achieved: (i) if the growth rate of foreign income raises, and the negative effect of this increase on the trade performance of the domestic economy (through non-price competitiveness) is smaller than the positive demand effect; (ii) if the share of high-tech exports increases; (iii) if the technology gap increases; and (iv) if research intensity increases in any given sector of the domestic economy.

The novelty of this model, therefore, is not only that both the technology gap and research intensity influence long-term growth, but also that higher output growth in the foreign economy can exert a negative impact on the domestic economy. Most importantly, the model shows that an increase in productivity growth in any given sector, by easing the balance-of-payments constraint, leads to increases in output growth in the other sectors of the economy.

The contributions of this thesis have important implications in terms of development policies. As King (2010: 166) stressed, an important critique addressed to the Kaldorian balance-of-payments constrained growth models regards its limited policy implications.

Araújo and Lima (2007) used their multi-sectoral approach to balance-of-payments constrained growth to argue that changing the sectoral composition of trade leads to higher long-term equilibrium growth rates, given that different sectors present different income elasticities of demand. Following this approach, policymakers should foster structural change towards sectors with faster demand growth in order to increase the country's share in trade in the target sectors, which would raise the long-term equilibrium growth rate.

Nonetheless, Araújo and Lima's (2007) approach did not provide any explanation for how an increase in production in a given sector would lead to higher exports from this sector. In other words, unless it is assumed that there is a repressed demand in the target sectors, there is no reason to expect that a structural change towards some particular sectors would lead to increased exports from these sectors.

This thesis addressed these issues. The tests presented in chapter 6 showed that increases in productivity growth impact on export and import growth, given that productivity growth is associated with increases in non-price competitiveness when changes in relative prices are controlled for, as suggested by the findings of chapter 7. Moreover, the tests reported in chapter 4 showed that the magnitude of returns to scale is partially determined by differences in research intensity between sectors. Finally, the model presented in chapter 8 provided additional contributions to understanding the importance of inter-sector interactions.

The contributions of this thesis, therefore, generate two main policy implications. First, the results presented in chapter 4 suggest that policymakers should elaborate policies that foster increases in research intensity, especially in high-tech industries. Given that higher research intensity generates higher productivity growth in response to output grows, as shown in the models presented in chapter 8, increasing research intensity leads to a higher equilibrium growth rate of aggregate output. Moreover, given that high-tech industries present higher increasing returns and non-price elasticities, increasing the level of research intensity in these industries generates a higher equilibrium growth rate than increasing the level of research intensity in low-tech industries. Second, the test results presented in chapter 4 and the model proposed in chapter 8 suggest that policymakers should elaborate policies to ease technological transfer. Combining the empirical results and the model's dynamics indicates that technological transfer has a significant impact on productivity growth and therefore also on aggregate output growth. Consequently, devising policies that help increase the role of technological transfer would contribute to raise the equilibrium growth rate.

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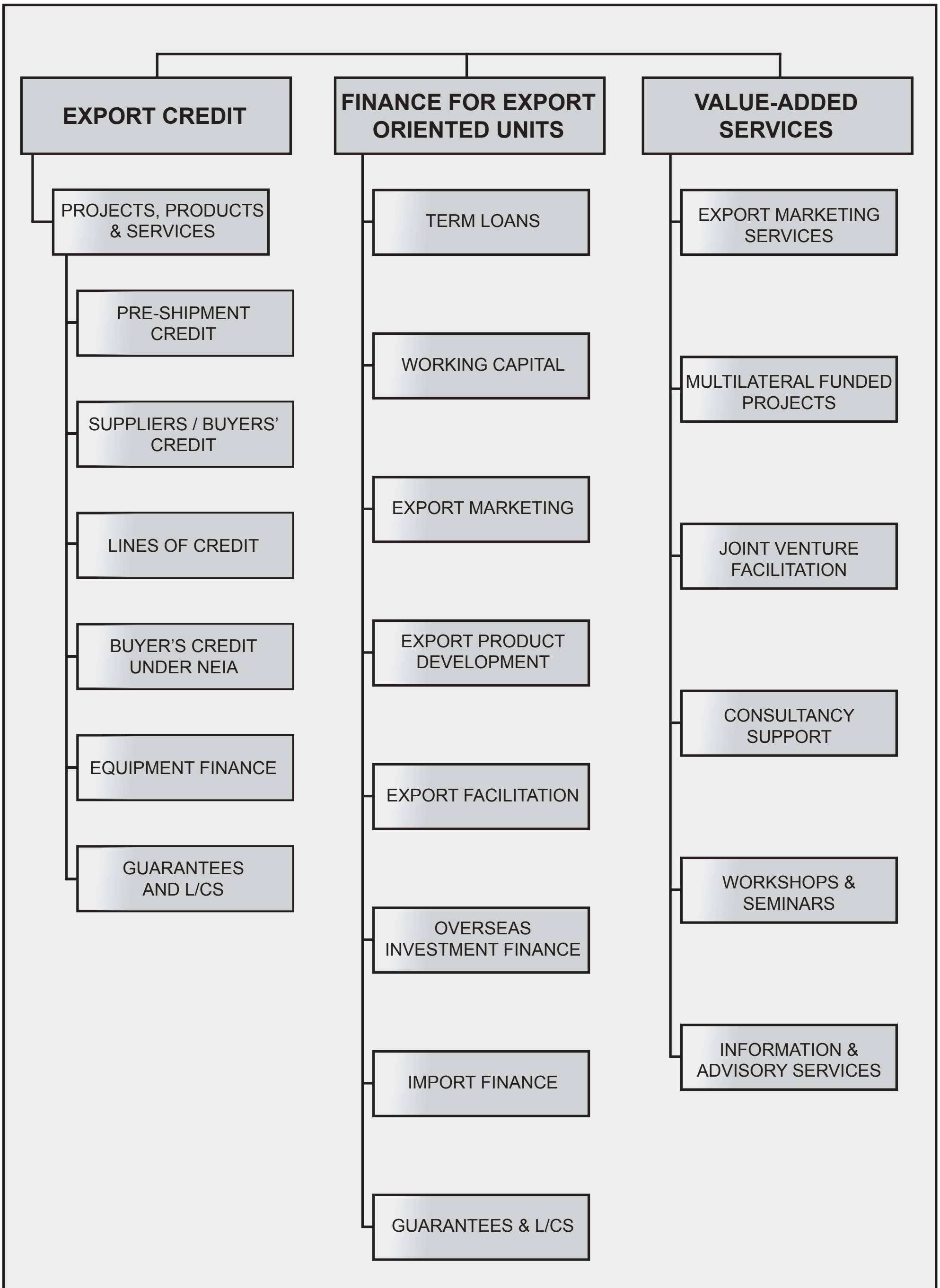

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Sakar II, 1st Floor,
Next to Ellisbridge Shopping Centre, Ellisbridge P. O.,
Ahmedabad 380 006
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18, M. G. Road,
Bangalore 560 001
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Chandigarh
C- 213, Elante offices, Industrial Area phase 1,
Chandigarh 160 031
Phone : (91 172) 4629171-73
Fax : (91 172) 4629175
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Chennai
Overseas Towers,
4th and 5th Floor, 756-L, Anna Salai,
Chennai 600 002
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Dispur, Guwahati 781 006
Phone : (91 361) 2237607/609
Fax : (91 361) 2237701
E-mail : eximgro@eximbankindia.in

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Golden Edifice, 2nd Floor, 6-3-639/640,
Raj Bhavan Road, Khairatabad Circle,
Hyderabad 500 004
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Fax : (91 40) 23317843
E-mail : eximhro@eximbankindia.in

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Vanijya Bhawan, 4th Floor,
(International Trade Facilitation Centre),
1/1 Wood Street, Kolkata 700 016
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E-mail : eximkro@eximbankindia.in

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New Delhi 110 001.
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44, Shankarseth Road, Pune 411 037.
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OVERSEAS OFFICES

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Bole Kifle Ketema, Kebele - 19, (03/05),
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