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Writing this PhD-thesis has been like a very long cycle tour. At the beginning there was quite some disorientation and initially I headed off in the ‘wrong’ directions several times until finally I found my topics. Once on track, the most joyful part of the project followed. Delving into the existing literature and familiarising myself with the necessary methods for tackling the research questions at hand was a very interesting and rewarding task. However, at times I lost my ‘pedalling rhythm’. At some stage I also gave myself a relatively generous break and was even on the brink of abandoning the whole project. Besides the time constraints imposed by work-related obligations also the question of why am I doing this popped up. The fact that I have already been in a job made the thesis project a wholly private endeavour whose immediate purpose would not be clear to an outsider – another similarity to cycling 100 kilometres to some remote destination. But in the end, the clear objective somehow brought about the motivation and dedication to finally reach the finishing line. In retrospect I believe that the exhaustive and even frustrating periods I experienced during my work on the thesis also contributed to the satisfaction I draw from it now that it has finally been completed.

Needless to say that a project such as this also requires the necessary environment. Therefore my deepest thanks go to my girlfriend Julie who was very sympathetic with me and my self-imposed research obligations. Several of my holidays and many more evenings I spent on my thesis rather than spending them with her. Sometimes this was difficult both for her and for me but all in all I felt very much supported. I am also endlessly grateful that she was proof reading the papers despite the fact that their contents were obviously not arousing her enthusiasm.

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Roman Stöllinger, Vienna, July 2015

1 Introduction

This thesis has been written over a period of 6 years starting in 2009. This relatively long time span for finishing a thesis is related to the fact that its progress developed in parallel with other – partly related, partly entirely unrelated – research undertaken at my daily work. The overarching theme of the thesis is international economics. It consists of three articles each of which is dedicated to a rather different dimension of international economics. These dimensions are international trade, foreign direct investment and international technology spillovers, each of which is again a vast field in itself.

The three papers are empirical contributions to the literature employing a set of econometric methods. The first paper is a country study investigating the characteristics of Austrian exporters using a panel of Austrian manufacturing firms. The emphasis is on the differences in size and performance parameters of exporters compared to their non-exporting peers. The theoretical framework for the paper is the heterogeneous firm literature which focuses on firms as the main subject of analysis instead of industries or countries. A key prediction of the heterogeneous firm literature is that larger and more productive firms engage in export activities while firms with less favourable attributes have to contest themselves with serving the domestic market. To test this theoretical prediction the paper follows other country studies on this topic and regress sales, labour productivity and wages of Austrian manufacturing firms on a dummy variable for the export status of firms and a set of control variables. The major finding is in line with the theoretical hypothesis and other country studies: Austrian exporters are almost 40% larger and more productive than non-exporting firms and they also pay 11% higher wages. These export premia are also found to be increasing with firms' export intensity. Moving the analysis to the industry level reveals some important differences in the magnitude of the export premia across sectors most of which are rather difficult to explain. Importantly, however, the export premia and the pattern of the export premia by export intensity can be confirmed by the industry-level analysis. By allowing for firm fixed effects the panel regression on the export status delivers a result for export switchers, i.e. firms that change their export status over time. As expected these export switchers enjoy much more modest export premia. Finally, the data is also used to examine the probability of exporting depending on firm characteristics. The transition matrix already signals that export switching is a relatively rare event in the Austrian manufacturing sector. In this context, a probit model then suggests that having been an exporter in the previous period increases a firm's probability to export by 85 percentage points.

The main contribution to the literature of this article is the data. Since access to Austrian firm level data on export activities is rather limited, this paper was the first and continues to be the sole country study on this topic. This is both an unsatisfactory and surprising situation. It is unsatisfactory because the analysis of export behaviour on the basis of micro-data is a thriving branch of the trade literature from which Austria – as a subject of analysis – is very much excluded. This places Austrian researchers at a disadvantage because they have to take recourse to firm level data from other countries when working on this issue. This situation is surprising given that there is great interest from policy makers on this topic. Nevertheless academia in many cases is not in a position to respond to this interest by providing updated and additional results due to the lack of data access.

The second article is called '*International spillovers in a world of technology clubs'* and takes up the issue of international technology spillovers. It is very different from the first article with respect to geographical scope and level of aggregation as it is a cross-country growth regression analysis. The theoretical framework for the paper is the endogenous growth literature and in particular the idea of convergence clubs. In an open economy setting, countries may either grow as a result of domestic R&D efforts leading to innovations or as a result of imitation which is dependent on foreign technologies. According to the convergence club literature countries can be grouped into three distinct clubs. The first one is the innovation club whose members have the necessary skills and technologies to successfully perform R&D and come up with innovations. A second club, the imitation club, is comprised of countries which are in an intermediate position in the sense that they have the required technological capabilities to adapt and implement existing technologies but do not innovate themselves. Finally, the countries in the stagnation club lack the human capabilities and the technology required to benefit from foreign technology spillovers. The paper tests a central hypothesis of the convergence club literature which is that the imitation club should benefit most strongly from international technology spillovers. Empirically, the potential to benefit from such spillovers in terms of economic growth is proxied by each country's GDP per capita gap to the technological frontier, i.e. the country with the highest GDP per capita. The absorptive capacity required to turn the technology gap into a higher growth rate is associated with human capital (average years of schooling). In the literature, the growth effects of technology spillovers have been modelled by interacting the technology gap with the level of human capital. The growth effect of this 'catch-up term' can then estimated in a growth regression framework. The paper adds to the literature by using a threshold regression framework to test the technology-based convergence club hypothesis – or technology club hypothesis for short. Threshold regressions are particularly suitable for this purpose because they allow for different effects of the technology gap on economic growth for different subsets of countries. Importantly, this is done without pre-determining the boundaries of neither the clubs nor which country belongs to which club. Rather the thresholds are selected in the course of the estimation process by repeatedly estimating the model each time with the potential threshold set at a different level of human capital which serves as the threshold variable. The model with the highest explanatory power is selected. A nice feature of the threshold regression is that several thresholds can be set. To test for the convergence club hypothesis indeed two thresholds are found giving rise to the three clubs mentioned above. In the main specification the paper identifies a first threshold a the 17th percentile of the data which coincides with about 3.7 years of schooling. A second threshold is detected at the 70th percentile which is equal to 8.4 years of schooling. In this two threshold model the growth effect of the technology gap is found to be largest for the medium regime, i.e. the group with a medium level of human capital which is associated with the imitation club. A lower growth effect from the technology gap is found for the stagnation club. This result confirms the predictions of the convergence club literature. A slightly troubling point is that the growth effect for the technology gap for the stagnation club is still relatively large given the theoretical prediction that these countries should not benefit at all from technology spillovers due to their lack of absorptive capacity. Following a suggestion by a referee the paper also features a variant in which the thresholds are applied to the catch-up term, i.e. the interaction term between the technology gap and the level of human capital. In this specification, the thresholds are decided to lie at the 46th and the 90th percentile when using centred values of the interaction term (between the technology gap and the human capital variable). In this variant the growth effect of the catch-up term is still largest for the imitation club. As before a positive effect is also found for the innovation club but the coefficient for the stagnation club disappears.

The third article focuses on foreign direct investment which has equally become a major pillar of firms' internationalisation activities. More precisely, the paper addresses the issue of location choice focusing on agglomeration forces and – as a new element – international linkages as determinants of location decision by FDI investors. The sample consists of greenfield FDI projects undertaken by investors from six countries (Austria, Belgium, France, Germany, Italy and the Netherlands) and located throughout EU member states. Among the agglomeration forces investigated is the presence of other FDI investors, i.e. the number of projects that have already been realised in a particular host country in a particular industry. This presence of other firms is associated with agglomeration economies (knowledge spillovers) which are expected to make a potential location more attractive. Another agglomeration factor, which is particularly stressed in the New Economic Geography (NEG) literature, are backward and forward linkages between firms in the same country or region. To include such inter-industry linkages in the empirical model, backward and forward linkages in each host country are constructed using information from the World Input-Output Database (WIOD). The World Input-Output Table also allows constructing international inter-industry linkages. These international backward and forward linkages are constructed above all for linkages between an industry in a potential host economy and the industries in the FDI source economy (host-source linkages). Taking recourse to the offshoring literature it may be argued that such host-source linkages (which are at least partly the result of past FDI projects) are a signal for low co-ordination costs of offshoring and therefore for the attractiveness of countries or regions as a destination for FDI projects. In order to rule out any endogeneity problems the subject of analysis are only location decisions by first time investors, that is, firms that invest for the first time in a particular industry in a particular country. The effects of the agglomeration forces and the international linkages, along with a large set of control variables, are estimated with a conditional logit model and a nested logit model. In the latter case the EU-15 and the new EU member states serve as the nests in the analysis. Also the location decisions of the Greenfield FDI investors are estimated both at the country level, i.e. using the EU member states as potential destinations, and at the regional level using NUTS 2 regions as the alternative choices. In line with the literature a strong presence of other FDI investors turns out to increase the probability of a host country or region to attract investment projects. At the country level, the same is true for the presence of FDI investors from other countries but the effect is much smaller. Interestingly, the domestic backward and forward linkages do not improve the attractiveness of a location. In most cases the coefficients of the backward and forward linkages are not statistically significant and in the regional model, strong domestic inter-industry linkages are even suggested to be a locational disadvantage. In contrast, the host-source inter-industry linkages are found to be an attraction factor for FDI investors. This result holds both for backward and for forward linkages, irrespective of whether the national or the regional level is considered. Together with the negative impact of the wage level on location decisions of investors (which is found for the county level), the overall pattern of coefficients for the agglomeration forces and the international linkages suggest that the location decision of production-related FDI projects that are investigated are mainly driven by efficiency seeking motives. This result is certainly influenced by the particular sample which is deliberately restricted to production-related FDI projects. Arguably, these projects are of particular importance because they are often large and create new production and export capacity. In addition they typically offer high quality jobs. The particular choice of FDI projects links the paper's empirical results to the debate about 'de-industrialisation' and the growing concentration of manufacturing production in a relatively small number of EU member states. For this debate it is highly relevant that production-related investments are most likely the result of offshoring activities which contradicts the common finding that overall FDI in Europe is mainly motivated by market potential in the respective host economies.

From this short portray of the three articles it becomes obvious that the thesis covers rather distinct topics in the vast research field international economics. This diversity in topics reflects a wide spectrum of interests and a strong involvement in many research projects at the Vienna Institute for International Economic Studies (wiiw) – for which I have been working as a staff economist since 2008.

2 Synopsis of Publications and Manuscripts

This thesis is comprised of three articles of which two have already been published. The third paper has been submitted to a peer reviewed journal in early July 2015.

The first paper, dealing with the export premia of Austrian exporters, has been written jointly with two of my colleagues at the Vienna Institute for International Economic Studies (wiiw), Robert Stehrer and Johannes Pöschl. The paper was submitted in August 2010 to *Empirica* and was finally published early 2012 as:

> *Stöllinger, R., Pöschl, J., Stehrer, R. (2012) 'Austrian Exporters – Unique or alike? New insights and missing puzzle pieces', Empirica, 39(3), pp. 375-405.*

I can claim the main authorship of the paper which evolved out the research project "Characteristics of exporting and non-exporting firms in Austria" financed by the Austrian Federal Ministry of Economics, Family and Youth (BMWFJ) within the framework of the 'Research Centre International Economics' (FIW). My leading role in writing the paper, including the literature review and the discussion of econometric results, is reflected by the fact that I was corresponding author when submitting the paper to the journal. The initial econometric specification for the export premia was proposed by Robert Stehrer and together we figured out the final specifications included in the paper. This was a cumbersome process as our work was done by remote execute and we could never actually see the real data. Despite the great effort I put into the paper, Robert's contribution was in a way the most essential because it was him who negotiated the contract with Statistik Austria for getting access to the firm level data. He also set up a 'shadow dataset' which mimicked the actual data with respect to available variables but contained random figures. It was on this shadow dataset that we tested our program codes before sending them to Statistik Austria for execution on the real data. Johannes Pöschl contributed by writing parts of the interpretation of the results. In the working paper version we had a separate discussion of the export premia with regards to size measures and performance measures and Johannes was in charge of the latter. In the published version these two parts are discussed jointly. Another important contribution of Johannes was that he came up with the final title of the paper.

A summary of the article was also published in the Yearbook "Austria's External Economic Relations 2010" (Österreichs Außenwirtschaft 2010) under the title 'Exportpartizipation, Exportkonzentration und Exportprämien in Österreich – Ergebnisse einer Unternehmensdatenanalyse' (Chapter 9). Parts of this article plus some additional results on the productivity premium based on total factor productivity and the productivity development of export starters over time were published as a chapter in the FIW-publication "The Trade-Productivity Nexus in the European Economy" under the title 'Exporting and Productivity: Some initial results for Austria'. This publication is included as additional material in a separate chapter of this thesis.

I presented the paper inter alia at the ‘European Trade Study Group Conference’ in Lausanne in September 2010 and in the framework of the doctoral seminar at the University of Vienna in April 2011.

The second paper dealing with international spillovers and technology clubs is single authored. The paper evolved out of a contribution to an international economic research project for the European Commission, the AUGUR-project. The AUGUR project was a foresight study with the objective to develop scenarios for economic, technological and social developments in Europe and in the world until 2030. One of my contributions to this project was the work of convergence clubs. The resulting article was published in the journal *Structural Change and Economic Dynamics* as

> *Stöllinger, R. (2013) 'International spillovers in a world of technology clubs', Structural Change and Economic Dynamics, Vol. 27(C), pp. 19-35.*

This paper was presented twice, first at the Conference on ‘Schumpeter's Heritage - The Evolution of the Theory of Evolution’ in October 2011 and then at the ‘6th FIW Research Conference on International Economics’ in February 2013 with both events taking place in Vienna.

The third paper with the title ‘Agglomeration and FDI: Bringing international production linkages into the picture’ is also single authored. In contrast to the other two articles it is not published yet but has in the meantime been submitted to the journal *Open Economies Review*. As the initial work on the paper was done within a research project of the Jubilee Fund of the Oesterreichische Nationalbank, an initial version of the article is available as a research report with the title *“Agglomeration and international linkages in the location choices of European foreign direct investors”* (Project No. 15291).

The paper has been presented at various workshops and conferences, including at the ‘2nd Workshop in Applied Econometrics’ at the Vienna University of Economics and Business (May 2014), at the ‘INFER Workshop “Regions, firms, and FDI”’ in Gent (August 2014), at the ‘5th International Conference on “Economics of Global Interactions: New Perspectives on Trade, Factor Mobility and Development”’ in Bari (September 2014), at the ‘16th European Trade Study Group Conference’ (September 2014), in the framework of the Graduate Seminar at the University of Vienna (December 2014), at the ‘7th FIW Research Conference on International Economics’ (December 2014) and at the ‘17th Göttinger Workshop “Internationale Wirtschaftsbeziehungen”’ (February 2014). At all these occasions I benefitted strongly from comments and suggestions which is particular true for the INFER Conference in Gent and the Global Interactions Conference in Bari because very detailed feed-back was provided by a discussant. The final occasion for presenting the paper was again at the University of Vienna’s Graduate Seminar in June 2015.

3 Austrian Exporters: Unique or alike? New insights and missing puzzle pieces

3.1 Introduction

With the emergence of heterogeneous firm models, trade theory has finally gone beyond the analysis of countries and sectors and put firms, the major actors in the export business, in the centre of analysis. Following the every-day observation that the economy is not made up of “pure” export sectors on the one hand and import-competing sectors on the other, these models are able to account for the fact that within each sector there co-exist exporters and non-exporters and that the former are systematically different from the latter. Although a large strand of literature has developed in this field during the last years, still little is known about the situation in Austria which so far remains to a large degree a white spot on the map when it comes to the analysis of export activities of Austrian firms based on firm level data. The aim of this paper is to take up this issue in the form of an individual country study and shed light on some of these uncharted areas.

The paper thus attempts to document a major prediction that emerges from the theoretical heterogeneous firm literature and a central assumption, namely the significant size and productivity differences between exporters and non-exporters and the relevance of fixed costs of exporting for the decision to export.[1] More precisely, we estimate the export premia, that is, size and productivity advantages of exporting over non-exporting firms, in the Austrian manufacturing sector for the period 2002-2006 following the approach suggested by Bernard and Jensen (1999) and we investigate the influence of past export experience on the probability to export with the methodology developed by Roberts and Tybout (1997).

Applying the Bernard and Jensen approach to Austrian manufacturing firms we find large export premia. These results are fully in line with those found in other country studies. Our results on the export premia are robust with respect to the inclusion of firm characteristics such as employment and R&D related variables as control variables. We further document that the export intensity of firms matters: the higher the export intensity, the larger the export premium both at the level of manufacturing and at the industry level which turns out to be a very robust pattern. Estimating the export premia at the level of individual industries reveals that the export premia found for the total manufacturing sector is not the result of a few large industries but a common phenomenon detectable in the vast majority of manufacturing industries. Such estimates of export premia at the industry level are surprisingly little documented in the literature, given that heterogeneous firm models including the model by Melitz (2003) are typically stated as models of a particular industry. Explaining the large variation in

[1] Given the severe limitations with respect to accessing Austrian firm-level data, the aim of this paper is to document results for Austria on export premia and the role of export fixed costs which have already been investigated for a large number of other countries. The paper does not attempt to uncover entirely new empirical facts. However we do compare our findings with those of other countries to shed light on similarities and differences.

the size of the export premia across industries is difficult as the low number of industries does not allow us to reveal any statistically significant relationships between the export premia and industry characteristics. We find however that there is a negative correlation between the export premia and the export participation rate at the industry level. Further, we offer an alternative interpretation of the results when estimating the export premium with the approach of Bernard and Jensen (1999). We argue that such a specification estimates the size and productivity differences of switchers between periods where they export and periods where they do not export.

The second empirical fact, the importance of export entry cost, we investigate by means of a probit model. The probit model allows to estimate the impact of different firm characteristics, including the past export status, on the firms' probability to export. We find a very high persistence of exporting which in the literature is interpreted as evidence for export fixed costs (that new exporters have to incur) being relevant for the decision to export (Roberts and Tybout, 1997; Bernard and Jensen, 2004). Next to the past export status, higher labour productivity and employment also increase the probability of exporting.

The remainder of this paper is structured as follows: Section 3.2 provides a very short overview of related literature. Section 3.3 describes the data set which is used in Sections 3.4 where some stylized facts related to the export participation and export intensity of firms in the Austrian manufacturing sector are presented. Section 3.5 reports the results of our export premia estimations while Section 3.6 contains the findings on the probability of exporting and sunk export costs. Section 3.7 concludes.

3.2 Related Literature

The seminal paper by Melitz (2003) on heterogeneous firms and trade provides a useful theoretical background for country studies on the differences between exporting and non-exporting firms and the role of export fixed cost. It suggests a clear relationship between exporting and productivity: since exporting is assumed to entail fixed exporting costs (and variable trade costs), only the more productive firms can cover these costs and hence engage in export activities. In contrast, less productive firms choose to serve the domestic market only. This self-selection process of more productive firms into exporting is confirmed by studies on the causal relationship between exporting and productivity and is one of the most robust stylised facts that emerged from the literature.[2] The assumption of a constant price-cost mark-up in the Melitz set-up implies that the prices a firm charges and therefore its sales are directly related to the firm's productivity. We therefore expect exporters to be more productive and also larger than firms selling only on the domestic market.

[2] An alternative hypothesis is that firms are learning from exporting so that exporting makes them more productive. The empirical evidence for the learning-by-exporting hypothesis, however, is much weaker, in particular for developed countries. For an overview on this issue see for example Greenaway and Kneller (2007) and ISGEP (2008).

The Melitz model has been adapted and extended in various ways.[3] Melitz and Ottaviano (2008) for example allow for variable mark-ups and asymmetric countries where differences may stem particularly (though not exclusively) from differences in country size. Country size influences the zero-profit productivity cut-off level (which firms must meet to not exit the market) and the export cut-off for firms so that a larger market provides a more competitive environment – both for domestic firms and for firms exporting to this market. From an Austrian perspective this means that serving a larger market is more difficult due to the higher competition in that market. At the same time, demand and therefore export opportunities are also larger because it allows for spreading fixed costs, making larger markets more attractive. Hence, a priori it is unclear whether more exporters serve smaller or larger export destinations. In addition, the number of export markets that an exporter is able to serve also depends on the trade costs which may also vary across countries. Hence, in contrast to the Melitz model, this set-up allows for different export intensities of firms because an exporter may serve just one or only a few export markets.[4] Bernard et al. (2007) introduce comparative advantages based on factor endowment into the heterogeneous firm set-up à la Melitz and further allow for different size of trading partners and varying bilateral trade costs. One of the model's implications is that the export participation, other things equal, is expected to be higher in comparative advantage industries. But other factors of course do influence the zero-profit and the export cut-off productivity levels. These factors include the size of (variable and fixed) trade costs and the relative size of the trading partners. Higher trade costs and a smaller export market (relative to the domestic market) tend to make exporting more difficult so that only the most productive firms serve small markets and markets with high trade barriers. Hence, both the Melitz and Ottaviano (2008) and Bernard et al. (2007) allow for varying export intensities across firms and industries.

The empirical literature on firm heterogeneity and exporting is vast. The most important contribution relevant for our paper is Bernard and Jensen (1999) who propose a straightforward empirical equation to estimate the productivity and size advantages of exporting firms which became known as the 'export premium'. The approach consists simply of regressing firms' performance measures (such as labour productivity or total factor productivity) and size measures (such as sales or employment) on the export status, which is a dummy variable taking on the value one if the firm has positive export sales. Bernard and Jensen (1999) estimate this type of export premium for a wide range of firm characteristics including sales, employment, value added, labour productivity, total factor productivity, wages and capital and find sizeable export premia of US-firms for all their firm characteristics. Their regression set-up has been used extensively in various country studies employing firm-level data. An overview of the results on the export premium for different European countries (not including Austria) can be found in Mayer and Ottaviano (2007), Altomonte and Ottaviano (2008) as well as in the cross-country study by the International Study Group on Exports and

[3] A more extensive literature survey also including issues of organization of firms can be found in Helpman (2006).

[4] In terms of terminology we follow ISGEP (2008) and use the terms exporter participation rate to refer to the share of exporting firms in total firms and to the export intensity of firms as the share of overall sales generated from exports.

Productivity (ISGEP, 2008) which includes both European and non-European countries.[5] Typically, the export premium regressions include year and industry dummies as control variables and potentially other firm characteristics. For example, Bernard and Jensen (1999) also report results for the export premium controlling for employment.

For the second issue studied in this paper we draw on Roberts and Tybout (1997) who estimate the impact of various firm characteristics, including the past export experience as the main variable of interest, on the probability of exporting of US-firms in the food, textile, paper and chemical industry. They find a large impact of the export status in the previous period on the probability of exporting in the current period and interpret this result as evidence for large sunk cost of exporting. Their estimation methods include both a probit model and a dynamic probit model but on the basis of a likelihood-ratio they opt for the simpler probit model for their further analysis. In the choice of the firm characteristics and other control variables our specification is closest to Greenaway and Kneller (2004), which include productivity and employment variables as well as time, industry and regional dummies. Like these papers but also Bernard and Jensen (2004) we include only firms' export status of the previous period as explanatory variable without any further lags, implicitly assuming that firms have to reincur the full cost once they exit the export market, independent of the length of the export absence (see Bernard and Jensen, 2004).

Our paper is also related to De Loecker (2007), in the sense that productivity differences are also tracked at the industry level and not only in the manufacturing sector. De Loecker concentrates on learning-by-exporting and presents a methodology that enables him to document such learning effects for Slovenian exporters in most manufacturing industries. In contrast, our contribution is more modest and limited to the documentation of differing export premia across manufacturing industries.

To our knowledge the analyses of Austrian exporters based on firm level data so far is limited to results reported in the cross-country study by ISGEP (2008) mentioned above and a recent policy note on the global operations of European firms that includes Austrian data (Navaretti et. al., 2010). The latter is based on firm surveys including approximately 500 Austrian firms. The cross-country study by ISGEP (2008) reports results on export premia for 14 countries, including Austria. The study includes results on export premia but limit the analysis on labour productivity. For Austria, the labour productivity premium of exporters is found to be 17.5%, controlling for employment and a number of further firm control variables. While we also include labour productivity premia in our paper we also estimate export premia for sales and wages. Furthermore we report results at the industry level and show that the advantage of exporters over non-exporters is a general phenomenon in almost all manufacturing industries. Together with our results on the importance of export sunk costs and the persistence of exporting this paper therefore provides a more complete picture of the performance of exporters in Austrian manufacturing than is available so far. It should also constitute a

[5] This latter study does include results for Austria (see below).

first step in a possible catching-up process of Austria in the empirical research on the internationalisation of firms based on firm level data.[6]

3.3 Data

In this paper we use Austrian firm-level data provided by Statistics Austria via 'remote execute'.[7] The basic data sets are the 'Leistungs- und Strukturerhebung' and the 'Konjunkturstatistik'. From the 'Leistungs- und Strukturerhebung' we obtain firm-level information on a yearly basis for a number of indicators in each manufacturing NACE Rev. 1 2-digit industry, including the number of firms, sales, production value, employment, total investment and wages. From these indicators we mainly use sales, employment, wages (which subsume wages and salaries) and labour productivity which we calculate as production value over the number of employees. All indicators are in nominal values.

Information on the export status of firms is taken from the 'Konjunkturstatistik' which allowed generating indicators on the export status ('export markers'). The export markers also indicate the export intensity of exporting firms according to four categories: companies exporting equal to or less than 5, 30, 50 and more than 50 per cent of their sales respectively. However, unfortunately we do not have access to actual export sales figures. Throughout the paper we use the simplest (and also most widely used) definition of the export status. According to this definition, a firm is considered to be an exporter in any particular year if its export sales are greater than zero. This implies that individual firms can switch from being a non-exporter to being an exporter in the next year and vice versa. Hence, according to this definition, firms that only export sporadically and in very low amounts also count as exporters.

While both the 'Leistungs- und Strukturerhebung' and the 'Konjunkturstatistik' cover firms in NACE categories C to F we limit our analysis to manufacturing firms (NACE D) in the time period 2002-2006.[8] Both data sources are cut-off census with firms having 20 or more employees included. Due to the representativity criterion which demands that the sampled firms must represent at least 90% of the sales in each NACE 2-digit industry the firm size cut-off may be reduced, with a lower limit of 10 firms.[9] In the Leistungs- and Strukturerhebung, information on firms below the census cut-off is complemented with data from secondary sources (such as the tax registry). Still remaining missing firm characteristics are then estimated by Statistik Austria. Hence,

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6 A working paper version of this paper was published under the title 'Austrian exporters: A firm-level analysis', see Stöllinger et al. (2010).

7 We would like to thank Statistik Austria for providing the dataset and the access to data via several rounds of remote execute. Unfortunately, the restrictive regulations in Austria has not allowed for a more efficient procedure.

8 Data would be available for the period 1997-2006, however, in 2002 there was a major change in the sampling procedure for the 'Leistungs- und Strukturerhebung' which influences both the number and type of firms included in the sample. We therefore restrict our analysis to the shorter time period.

9 In 2006 the cut-off was 10 employees in NACE industries 18, 20, 22, 33, 36 and 37; 11 employess in NACE industry 28; 12 employees in NACE industry 15; 13 employees in NACE industry 26 and 15 employees in NACE industry 17. In all other industries the normal cut-off of 20 employees was applied. Moreover, all newly established firms are included in the 'Konjunkturstatistik', independent of the number of employees.

the Leistungs- and Strukturerhebung provides information on all firms filed in the Austrian company register. The Konjunkturstatistik on which we have to rely on for the export status information however only includes firms from the actual census.[10] Hence, the limiting factor in terms of the number of firms in our sample is the Konjunkturstatistik. At the same time, the linkage of both data sets ensures that we only have firm information from the census in our data set and no estimated values.

The reliance on the ‘Konjunkturstatistik’ for the export sales implies that our sample consists mainly of large firms and is therefore not a fully representative sample of Austrian manufacturing according to the company register. Since existing firms may move below or above the cut-off point, newly established firms are taken into the sample and the cut-off point for firms to be included in the sample may vary slightly from year to year. Therefore our data set is an unbalanced panel. Further, due to confidentiality issues, cells with less than 4 firms are not used in the results reported below.[11]

Table 3.1 provides an overview of our sample in the period 2002-2006. The total number of manufacturing firms according to the Austrian company register is about 27,600-28,700 firms depending on the year. However, the number of firms for which the export status is known ranges from roughly 6,000 in 2002 to about 6,300 firms in 2006. The share of exporters in our sample is slightly increasing over time, from 53.9% in 2002 to 55.9% in 2006.

Table 3.1: Sample overview, manufacturing (NACE D), 2002-2006

Year	Total number of firms	Firms with exports status known	Exporters	Non-exporters	Share of exporters (%)
2002	27,572	5,973	3,218	2,755	53.88
2003	28,581	6,054	3,303	2,751	54.56
2004	28,609	5,949	3,340	2,609	56.14
2005	28,374	5,719	3,248	2,471	56.79
2006	28,712	6,326	3,537	2,789	55.91

In the descriptive part of the paper we present our results according to NACE 2-digit industries (divisions) while for the econometric part in section 5 we aggregate the 23 NACE 2-digit industries to 13 NACE subsections. This aggregation is necessary in order to estimate the export premia at the level of individual industries which is problematic for very small ones. Due to their small firm population and our uneasiness about merging them with other industries, we drop the leather industry (NACE 19) and the refined petroleum industry (NACE 23) in all our export premia estimations. We however leave the medical, precision and optical instruments industry (NACE 33)

[10] Detailed information on definitions and methods are provided in ‘Standard-Dokumentation: Metainformationen (Definitionen, Erläuterungen, Methoden, Qualität) zur Leistungs- und Strukturstatistik, Teilprojekt Produzierender Bereich’, and ‘Standard-Dokumentation: Metainformationen (Definitionen, Erläuterungen, Methoden, Qualität) zur Konjunkturstatistik im Produzierenden Bereich’, both downloadable from www.statistik.at.

[11] Results dealing with only the number of firms but not their characteristics are not covered by this rule.

separated and do not merge it with NACE industries 30, 31 and 32 to form NACE subsection DL as this industry includes a sufficient number of observations and is an important high-tech industry.

3.4 Export participation and export intensity

We start by presenting some descriptive evidence on the overall engagement of manufacturing firms in export activities across individual industries. Table 3.2 reports the number of exporters and non-exporters by industries (NACE 15-37) and for total manufacturing, as well as the export participation rates, i.e. the share of exporters in the total number of firms.

We split-up the exporters into groups according to their export intensity, i.e. the share of their sales they generate from exports. We distinguish between four groups of exporters. The first group consists of exporters with exports up to 5% of their sales, and we label those as having ‘marginal’ export intensity or as ‘marginal exporters’. Exporters with exports between 5% and 30% of total sales are considered to have ‘low to medium’ export intensity. The third group indicates ‘high export intensity’ and covers all firms that generate more than 30% and up to 50% of their sales in export markets. Finally, for ‘very high intensity’ exporters this share is above 50%. The share of exporting firms is presented individually for marginal, low-to-medium, high and very high intensity exporters.

The data suggests that the export participation rate, is rather high in most manufacturing industries: in 13 of the 23 industries the export participation rate is above 80%. These industries also include Austria’s leading export industries, the machinery and equipment industry (NACE 29), the automotive industry (NACE 34) and the chemical industry (NACE 24). The industries with the lowest shares of exporters are the food and beverages industry (NACE 15) and non-metallic mineral products industry (NACE 26), not considering manufacturing n.e.c. (NACE 36). Although industry-specific export participation rates are high, the export participation in overall manufacturing is relatively low (56%). This is explained by the fact that some of the industries with the lowest export participation rates figure among those with the highest number of firms in our sample. In particular, these are the food and beverages industry (NACE 15) and the ‘catch-all’ industry manufactures not elsewhere classified (NACE 36).

Table 3.2: Number and relative share of exporters, 2006

NACE	Industry	Number of firms: Non-exporters	Number of firms: Exporters	Number of firms: Total	Share in % of total firms: Non-exporters	Exporters: Marginal	Exporters: Low to medium	Exporters: High	Exporters: Very high
15	Food and beverages	862	334	1,196	72.1%	9.6%	10.2%	3.8%	4.3%
16	Tobacco products	0	1	1	0.0%	0.0%	100.0%	0.0%	0.0%
17	Textiles	21	123	144	14.6%	4.9%	14.6%	16.0%	50.0%
18	Wearing apparel	20	62	82	24.4%	3.7%	26.8%	17.1%	28.0%
19	Leather	4	20	24	16.7%	12.5%	8.3%	4.2%	58.3%
20	Wood	296	308	604	49.0%	8.9%	14.7%	8.6%	18.7%
21	Pulp and paper	7	75	82	8.5%	8.5%	17.1%	13.4%	52.4%
22	Publishing and printing	152	300	452	33.6%	31.2%	25.9%	4.0%	5.3%
23	Refined petroleum	2	2	4	50.0%	0.0%	25.0%	25.0%	0.0%
24	Chemicals	13	114	127	10.2%	6.3%	20.5%	11.8%	51.2%
25	Rubber and plastic products	23	200	223	10.3%	5.8%	26.0%	15.2%	42.6%
26	Non-metallic mineral products	197	140	337	58.5%	9.8%	17.2%	4.2%	10.4%
27	Basic metals	2	92	94	2.1%	3.2%	10.6%	11.7%	72.3%
28	Fabricated metal products	487	568	1,055	46.2%	13.8%	18.8%	7.4%	13.8%
29	Machinery and equipment	56	483	539	10.4%	8.0%	15.6%	10.8%	55.3%
30	Office machinery and computers	2	4	6	33.3%	0.0%	0.0%	0.0%	66.7%
31	Electrical machinery	28	116	144	19.4%	6.3%	19.4%	8.3%	46.5%
32	Radio, TV, communication	5	46	51	9.8%	3.9%	13.7%	15.7%	56.9%
33	Precision & optical instruments	130	126	256	50.8%	7.8%	7.4%	6.3%	27.7%
34	Motor vehicles	10	82	92	10.9%	10.9%	15.2%	8.7%	54.3%
35	Other transport equipment	3	18	21	14.3%	4.8%	14.3%	14.3%	52.4%
36	Manufactures n.e.c.	464	302	766	60.6%	8.5%	14.4%	6.1%	10.4%
37	Recycling	5	21	26	19.2%	3.8%	11.5%	7.7%	57.7%
15-37	**Total manufacturing**	**2,789**	**3,537**	**6,326**	**44.1%**	**10.8%**	**15.9%**	**7.5%**	**21.7%**

Note: Export intensities are defined as follows: non-exporters = 'none'; >0% - 5% of sales exported = 'marginal'; >5% - 30% of sales exported = 'low to medium'; >30% - 50% of sales exported = 'high'; >50% of sales exported = 'very high'.

While the relative importance of the four groups of exporters is rather different across industries, it is noticeable that exporters with very high export intensity account for more than half of all firms in several major industries. This is the case for example in the machinery and equipment industry (NACE 29), the motor vehicle industry (NACE 34), the chemical industry (NACE 24) and the basic metals industry (NACE 27). As in the case of the export participation, the manufacturing wide results do not reflect well the relative importance of the firm groups because of the strong influence of the food and beverages industry (NACE 15).

The considerable variation in both the export participation rates and the export intensity of firms across industries is the result of the various factors influencing these measures. Some of these factors are incorporated in heterogeneous firm models, such as varying trade costs across industries and trading partners, the country size, and relative country sizes between exporting country and target market (Melitz and Ottaviano, 2008) and comparative advantages (Bernard et al., 2007). For example, the very high export intensity of the majority of exporters that we find in most industries may be related to Austria's relatively large share of intra-EU exports (about 70%) which means that trade costs (apart from transport costs perhaps) are very similar for the different export markets. In other words, if a firm finds it profitable to export to country A, it is likely to find it profitable to export to market B as well because of similar trade costs involved. We could also associate the high export participation in many industries with Austria being a small open economy though a higher share of exporters in small countries is actually against the prediction in Melitz and Ottaviano (2008).[12] In general, however, the emerging pattern of export participation and export intensities across industries is very hard to explain, also because the number of NACE 2-digit industries is too low in order to establish any statistically significant relationships. For example, the theoretical model by Bernard et al. (2007) predicts higher export participation in comparative advantage industries. The industries which show very high export intensity pattern, however, include both industries with comparative advantages (e.g. basic metal, NACE 27 and the machinery and equipment industry, NACE 29) as well as industries with comparative disadvantages as revealed by Austria's trade statistics (e.g. the textile, NACE 17 and the chemical industry, NACE 24).

Moreover, a lot of the cross-industry variation in the export participation and export intensities is probably due to firm and industry characteristics unknown to us. One main such firm characteristic is the impact of foreign direct investment (FDI) and foreign ownership. Theory suggests that firms engaging in FDI are the most productive ones (Helpman et al., 2004). Therefore Austrian subsidiaries of foreign multinationals would be expected to be, on average, more productive and to have higher export intensities (because they serve more markets) than domestic firms. Likewise, export participation would be higher in industries with higher presence of FDI firms.

Finally, our results for the export participation may also be influenced by our sample. This is because the sample does not include a proportionate number of firms in each industry and potentially also because the sample cut-off (number of employees) is not exactly the same across all industries.

[12] In the model by Melitz and Ottaviano (2008) larger markets will have, ceteris paribus, higher export participation because of the higher competitiveness of surviving firms and export intensity of firms is independent of the domestic market size. But there are other factors such as minimum and optimal operating scales which would lead to the opposite conclusion. A high minimum operating scale would lead to a higher export participation of firms in smaller countries. Navaretti et al. (2010) claim that country characteristics (such as market size) matter much less for export participation than firm characteristics.

We can compare the Austrian export participation rates with figures from other European countries as reported by Altomonte and Ottaviano (2008). Table 3.3 shows that Austria's manufacturing wide export participation rate of 56% is well within the rates found for other countries that range from only 16% in Hungary to 75% in Italy.[13]

Table 3.3: Export participation rates – international comparison

NACE	Industry	Bulgaria (%)	Spain (%)	France (%)	Hungary (%)	Italy (%)	Poland (%)	Slovenia (%)	Austria (%)
15	Food and beverages	26.3	55.8	38.1	11.9	66.0	26.0	16.7	27.9
16	Tobacco products	78.6	55.8	28.6	30.0	100.0			100.0
17	Textiles	71.6	63.5	73.5	24.6	81.0	55.0	37.6	85.4
18	Wearing apparel	54.0	63.5	64.1	19.7	84.0	61.0	29.2	75.6
19	Leather	52.5	70.2	62.8	32.9	86.0	61.0	47.5	83.3
20	Wood	40.0	54.6	41.6	14.5	65.0	67.0	37.9	51.0
21	Pulp and paper	40.0	86.3	57.3	16.1	68.0	46.0	39.5	91.5
22	Publishing and printing	21.6	39.1	36.1	3.5	48.0	15.0	6.0	66.4
23	Refined petroleum	33.3		46.3	36.4	34.0	47.0	100.0	50.0
24	Chemicals	57.6	81.4	77.9	27.9	78.0	48.0	56.7	89.8
25	Rubber and plastic products	48.7	87.0	67.0	26.6	83.0	55.0	43.1	89.7
26	Non-metallic mineral products	32.1	40.1	44.3	13.8	50.0	45.0	34.8	41.5
27	Basic metals	55.2	67.8	80.4	42.4	78.0	64.0	74.6	97.9
28	Fabricated metal products	37.7	57.9	51.5	19.8	64.0	55.0	31.3	53.8
29	Machinery and equipment	46.1	92.0	72.5	18.8	90.0	54.0	50.9	89.6
30	Office machinery and computers	40.0	86.7	73.0	8.4	67.0	27.0	6.7	66.7
31	Electrical machinery	68.1	83.3	64.7	23.9	82.0	55.0	38.4	80.6
32	Radio, TV, communication	42.1	83.3	62.1	22.9	70.0	56.0	49.5	90.2
33	Precision & optical instruments	52.9	86.7	71.0	13.2	83.0	50.0	32.6	49.2
34	Motor vehicles	44.4	81.8	66.8	43.7	75.0	64.0	66.7	89.1
35	Other transport equipment	26.3	76.1	71.5	20.9	79.0	55.0	45.7	85.7
36	Manufactures n.e.c.	41.5	85.9	59.4	12.7	86.0	68.0	37.0	39.4
37	Recycling		85.9	68.1	16.9		50.0	35.5	80.8
D	**Total manufacturing**	**49.7**	**66.9**	**61.4**	**16.0**	**75.0**	**50.2**	**44.3**	**55.9**

Source: Authors' calculations for Austria, Altomonte and Ottaviano (2008) for all other countries. Data refer to 2001 for Bulgaria, 2002 for Slovenia, 2003 for Hungary and Italy, 2004 for France, Germany and Spain, 2005 for Poland and 2006 for Austria.

13 The export participation rate we find is between the share reported for Austria by Navaretti et al. (2010) (40.44%) and ISGEP (2008) (71.4%).

Although all studies use the same definition of the export status, there are a number of reasons for these still existing large variations. Two major causes for the discrepancies across countries are the differing coverage of small firms and the varying nature of the firm level datasets ranging from census to surveys and samples (Dobrinsky and Pöschl, 2011). This has usually little effects on the coverage of large exporting firms but affects the reference group of domestic firms. If the cut-off points are low i.e. the minimum firm size included in the datasets is small, export participation rates will be lower and estimated export premia tend to be higher because of a lower productivity of small firms and scale effects. More interesting is therefore the search for common characteristics in industry specific export participation rates. Most countries share the pattern found in Austria: rather low export participation rates in the food and beverages industry (NACE 15) and high or very high ones in the basic metals industry (NACE 27), the automotive industry (NACE 34) and the chemical industry (NACE 24).

3.5 Export premium

3.5.1 Empirical strategy

In this section we apply the approach of Bernard and Jensen (1999), which has been used intensively in empirical work on firm heterogeneity and trade in estimating the export premia. The basic idea is to regress a size or performance measure, Y_{it}, in logarithmic form, on the export status represented by a dummy variable (ES) that takes the value 1 for exporting firms and 0 for non-exporters. The regression – which we estimate by ordinary least squares (OLS) – takes the form

(3.1) $$ln\, Y_{it} = \alpha + \beta \cdot ES_{it} + \sum_k \gamma^k \cdot IND^k + \sum_s \phi^s \cdot X_{it}^s + \sum_t \delta_t \cdot D_t + \varepsilon_{it}$$

where ES_{it} is a dummy variable taking the value 1 if firm *i* has positive export revenues in year *t* and zero otherwise. The corresponding coefficient β can be interpreted as the export premium and is the coefficient we are most interested in. Since the self-selection process into exporting suggests that exporters are larger and more productive than non-exporters we expect β to have a positive sign. The regression for the manufacturing-wide export premium also controls for the industry *k* a firm is operating in. These industry dummies are represented by IND^k with corresponding coefficient γ^k. The time fixed effects are represented by $\delta_t \cdot D_t$. In some specifications we also include additional firm-specific control variables X_{it}^s with ϕ^s denoting the corresponding vector for the *s* control variables included. Finally, ε_{it} is the error term. We report the export premium for three firm characteristics, sales, labour productivity and wages. Labour productivity is calculated as production value per person employed and wages are average wages and salaries per person employed. For the analysis at the industry level we distinguish 13 industries which are mainly NACE subsections (as discussed in Section 3).

In addition to the estimation of the simple export premia we use the Bernard and Jensen regression approach to estimate the export premia for firms with different export intensities. For this purpose we use the five groups of firms presented in section 4, and use a dummy variable, $EXINT_{it}^{m}$, that takes the value 1 if firm *i* belongs to export intensity group *m* in period *t*. The group of non-exporters serve as the reference group and we expect that the coefficients on these export intensities are all positive and increasing, i.e. firms with higher export intensity also exhibit a larger size or performance premia.

3.5.2 Estimation Results

The results for the export premia are provided in Table 3.4 for sales, labour productivity and wages. All results refer to the period 2002-2006. The number of firm-year observations varies between 28,253 and 29,828 depending on the measure used as dependent variable. Since we use a semi-log specification we have to transform our coefficient estimates in order to interpret them as the export premium.[14]

In specification (I) we estimate the export premia without controlling for firm characteristics apart from industry dummies. For all three variables, the export premia is statistically significant at the 1% level and sizeable. The results suggest that exporters are larger than non-exporters by a factor of 3.89 in terms of sales.[15] This size premium is considerably larger than the productivity premium (factor 1.7) or the wage premium (factor 1.24) of exporting firms. Put differently, exporters are 70% more productive and pay 24% higher wages than non-exporters.[16]

Specification (I) is likely to suffer from an omitted variable bias because no control variables were included apart from time and industry dummies. The bias stems from variation in firms' sales or labour productivity due to other factors such as investment in new technologies (in the form of R&D expenditures). To the extent that investment in new technologies is also correlated with the export status variable, the latter suffers from an (upward) bias. In order to remedy at least some of the bias we re-estimate the export premia, this time controlling for additional firm characteristics. In particular we introduce employment to control for size and technology-related variables: the share of R&D employees in total employees and the investment expenditures for software per employee, all in logarithmic form.[17]

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[14] We do this by simply making the estimated coefficient of *ES* (the export premium of the firms) the exponent of *e*. This retrieves a variable we can interpret in the usual way.

[15] The results are qualitatively the same for employment as size measure.

[16] Unfortunately we do not have information on the skill composition of the workforce of the firms in our sample. Therefore it is difficult to tell whether the wage premium is due to the fact that exporters, on average, have a more qualified workforce or whether it is really due to the export status.

[17] We also used R&D expenditure per employee instead of the share of R&D personnel as control variable. The results are qualitatively similar but the number of observations is significantly reduced in this specification due to data limitations. Results are available upon request.

Table 3.4: Export premium for Austrian manufacturing firms, 2002-2006 (OLS) – manufacturing total

Dependent variable: sales	(I)	(II)	(III)	(IV)
ES	1.358***	0.390***	0.384***	0.319***
	(84.035)	*(43.482)*	*(42.089)*	*(24.826)*
employment		1.161***	1.158***	1.139***
		(251.849)	*(240.833)*	*(192.105)*
share R&D personnel			0.715***	0.638***
			(2.616)	*(3.944)*
software/employee				0.078***
				(16.408)
R^2-adj.	0.348	0.856	0.857	0.876
Obs.	29854	29841	29841	12358
Implied export premium	3.89	1.48	1.47	1.38

Dependent variable: labour productivity	(I)	(II)	(III)	(IV)
ES	0.533***	0.397***	0.390***	0.318***
	(65.397)	*(44.407)*	*(42.437)*	*(24.896)*
Employment		0.162***	0.159***	0.142***
		(35.131)	*(32.743)*	*(24.403)*
Share R&D personnel			0.837***	0.852***
			(2.649)	*(5.280)*
Software/employee				0.080***
				(17.215)
R^2-adj.	0.282	0.329	0.333	0.306
Obs.	29828	29828	29828	12357
Implied export premium	1.70	1.49	1.48	1.37

Dependent variable: wage	(I)	(II)	(III)	(IV)
ES	0.215***	0.120***	0.118***	0.101***
	(53.883)	(29.307)	(27.907)	(16.811)
Employment		0.114***	0.113***	0.100***
		(61.294)	(55.637)	(40.176)
Share R&D personnel			0.312***	0.454***
			(2.366)	(5.902)
Software/employee				0.029***
				(15.248)
R^2-adj.	0.388	0.468	0.470	0.452
Obs.	29833	29833	29833	12355
Implied export premium	1.24	1.13	1.13	1.11

*Note: All regressions use a full set of industry dummies and time fixed effects. Coefficients of the constant, industry dummies and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level. The implied export premium is retrieved by making the coefficient of the export premium the exponent of e.*

In specification (II) we include employment as additional control variable. The export premium remains statistically significant for all firm characteristics but as expected the magnitudes of the export premia are strongly reduced. The size premium is suggested to be slightly less than 50% now (factor 1.48). The productivity premium is of a comparable size while the wage premium of exporters is reduced to 13%.

As a next step we add R&D related variables. In specification (III) we include the share of R&D personnel and in specification (IV) we further add software expenditures per employee. In both cases the export premia are further diminished: the implied size premium of exporters is 38% in specification (IV) which is our preferred specification. This size premium is still quite large, if one accounts for the fact that with employment, the regression already controls for another size measure.[18] The productivity premium according to specification (IV) amounts to 37% which is about half the size of the productivity premium resulting from the regression without firm control variables. The wage premium – which in all specifications is markedly smaller than the size and the productivity premium – amounts to 11%.

By adding software per employee as control variable we lose about half of the firms in the sample due to lack of information on software expenditure. We nevertheless keep this specification as our preferred one, also because the change in magnitudes of the export premia is not very large.

We now exploit the available information on the export intensity of firms and use the firm groupings by export intensity in the above regression set-up. To this end we replace the export status with dummy variables for the firm groupings. We exclude the dummy variable for the group of non-exporters so that all results are relative to non-exporters.

The regression on these export intensities confirms the existence of the export premium in the Austrian manufacturing sector (Table 3.5). The resulting pattern is clear: the export premia are strictly increasing from marginal exporters to exporters with very high export intensity. All coefficients remain statistically significant and there is no single deviation from the pattern of the export premium increasing with export intensity. For example, the results suggest that labour productivity of marginal exporters is 35% higher than that of non-exporters (factor 1.35) and that the labour productivity premium increases to 120% (factor 2.2) for firms with very high export intensity in specification (I). We also report the results for our preferred specification that include firm control variables (specification (IV) in Table 3.4). Here, too, the expected pattern comes out nicely, with the productivity premium increasing from 18% for marginal exporters to almost 70% for exporters with very high export intensity. For sales the export premium range is similar (in specification (IV)). So even if they generate only a small share of their revenue from exporting (up to 5%), exporters seem to be larger and more productive than purely domestically operating firms.

[18] There is no theoretical justification for including employment as control variable but we do this in line with Bernard and Jensen (1999) and the vast majority of the literature using their approach.

Table 3.5: Export premium by export intensity for Austrian manufacturing firms, 2002-2006 (OLS) – manufacturing total

	Specification (I)			Specification (IV)		
Dependent variable	Sales	Labour productivity	Wage	Sales	Labour productivity	Wages
EXTINT1	0.699***	0.299***	0.125***	0.169***	0.166***	0.066***
(marginal)	*(29.808)*	*(24.704)*	*(20.050)*	*(9.516)*	*(9.635)*	*(7.708)*
EXTINT2	1.069***	0.432***	0.187***	0.272***	0.263***	0.097***
(low)	*(50.511)*	*(41.239)*	*(35.795)*	*(18.497)*	*(17.975)*	*(13.555)*
EXTINT3	1.502***	0.607***	0.239***	0.396***	0.397***	0.121***
(high)	*(49.040)*	*(40.666)*	*(34.640)*	*(19.780)*	*(19.888)*	*(13.161)*
EXTINT4	2.107***	0.786***	0.304***	0.513***	0.527***	0.136***
(very high)	*(89.463)*	*(72.047)*	*(58.893)*	*(28.516)*	*(29.537)*	*(17.769)*
Employment				yes	yes	yes
Share R&D personnel				yes	yes	yes
Software/employee				yes	yes	yes
F-Test	1061.910	743.526	1076.031	4193.614	321.465	476.113
R^2	0.415	0.320	0.405	0.880	0.332	0.456
R^2-adj.	0.415	0.319	0.404	0.880	0.331	0.455
Obs.	29854	29828	29833	12358	12357	12355
Marginal export intensity	2.01	1.35	1.13	1.18	1.18	1.07
Low export intensity	2.91	1.54	1.21	1.31	1.30	1.10
High export intensity	4.49	1.83	1.27	1.49	1.49	1.13
Very high export intensity	8.22	2.19	1.36	1.67	1.69	1.15

*Note: All regressions use a full set of industry dummies and time fixed effects. Coefficients of the constant, industry dummies and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level. The implied export premium is retrieved by making the coefficient of the export premium the exponent of e.*

Finally, we want to compare our results with those from other European countries. For this purpose we use the export premia reported in Altomonte and Ottaviano (2008) for six other European countries. Table 3.6 shows these along with our results from the specification without firm controls (apart from industry dummies) to make them consistent with the other results. While potentially possible the comparison with results from 'richer' specifications is difficult as the control variables included vary from study to study.

The coefficients we obtain for the sales premium and the wage premium are both within the, admittedly very wide, range of coefficients found for other countries.[19] As pointed out in the previous section, the analysis of export premia across countries has to be carried out with care, since the size of the premia depend to some extent on the coverage of small firms in the country datasets. A general rule which can be observed is that the lower the cut-off for firms included in the sample, the higher are the premia.

19 Altomonte and Ottaviano (2008) do not report a productivity premium.

Again it is more interesting to look at patterns. For Austria we find that the sales premium exceeds by far the wage premium. This pattern also seems to be present in other countries as shown in Table 3.6.

Table 3.6: Cross-country comparison of export premia

	Bulgaria	Hungary	Spain	Italy	Poland	Slovenia	Austria
Size premium:							
Sales/output	2.067***	2.29***	0.461***	0.871***	0.639**	2.151***	1.358***
Employment	1.790***	1.64***	1.631***	0.663***	0.337**	1.726***	0.833***
Performance premium:							
Wage	0.537***	0.45***	0.084***	0.068***	0.146**	0.180***	0.215***

*Source: Authors' calculations for Austria, Altomonte and Ottaviano (2008) for all other countries. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level.*

We can also compare our result for the labour productivity premium with the one reported by ISGEP (2008) for Austria. ISGEP (2008) find a productivity premium of 17.5% for Austrian manufacturing firms for the period 1999-2005. In specification (IV) we found a productivity premium of 37% which is much higher than the 17.5%. We believe that the differences between the two estimates are due primarily to the fact that different control variables are included. In addition, the time period considered are not identical and ISGEP (2008) drop the top and bottom 1% of firms (in terms of labour productivity) from their sample.

After having documented substantial export premia for firms in the Austrian manufacturing sector we now turn to the industry level in order to investigate whether there are significant differences across industries, a point less addressed in the literature. For this we use the specification that includes employment, the share of R&D personnel and software per employee as control variables. The analysis at the industry level is motivated by the fact that despite the industry dummies included in the regression over all industries, the single estimated coefficient hides potential differences in the export premia across the 13 industries (mainly NACE-subsections).

Table 3.7 shows that in the overwhelming majority of industries, the export premia remain statistically significant at the 1% level. The sole exceptions are the mineral products industry (NACE subsector DI) and the transport equipment industry (NACE subsector DM) where exporters do not seem to be statistically different from their non-exporting peers. The rubber and plastic industry (NACE subsector DH) delivers mixed results with exporters enjoying a (small) sales premium and a wage premium but no productivity premium.

Table 3.7: Export premium for Austrian manufacturing firms, 2002-2006 (OLS) – individual industries

Dependent variable:	food, beverages, tobacco (DA)	Textiles (DB)	Wood (DD)	pulp, paper, printing (DE)	Chemicals (DG)	rubber and plastic (DH)	non-metallic mineral products (DI)	basic metals, metal products (DJ)	machinery and equipment (DK)	electrical equipment (DL 30-32)	medical, precision, optical instruments (DL 33)	transport equipment (DM)	other manufactures (furniture, toys,…) (DN)
Sales													
ES	0.756***	0.306***	0.487***	0.241***	0.462***	0.111*	0.001	0.170***	0.211***	0.206***	0.259***	-0.245	0.230***
	(16.756)	*(3.368)*	*(12.666)*	*(6.137)*	*(3.616)*	*(1.701)*	*(0.016)*	*(6.557)*	*(5.048)*	*(3.416)*	*(4.598)*	*(-0.916)*	*(8.988)*
Labour productivity													
ES	0.784***	0.297***	0.458***	0.237***	0.441***	0.055	-0.008	0.155***	0.183***	0.184***	0.383***	-0.299	0.231***
	(17.433)	*(3.396)*	*(12.045)*	*(6.147)*	*(3.185)*	*(0.843)*	*(-0.180)*	*(6.220)*	*(4.318)*	*(2.930)*	*(6.724)*	*(-1.101)*	*(8.849)*
Wages													
ES	0.180***	0.169***	0.057***	0.023	0.069*	0.094***	-0.015	0.074***	0.07***	0.068**	0.140***	-0.080	0.116***
	(10.152)	*(3.635)*	*(3.217)*	*(1.097)*	*(1.678)*	*(3.771)*	*(-0.850)*	*(5.917)*	*(2.811)*	*(2.227)*	*(3.543)*	*(-1.286)*	*(7.285)*
Employment	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Share R&D personnel	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Software/employee	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
F-test	1205.8	335.3	841.9	932.9	162.3	349.3	466.1	1884.7	1263.4	556.0	498.5	441.7	863.3
R^2	0.840	0.860	0.871	0.865	0.772	0.833	0.844	0.876	0.867	0.878	0.887	0.886	0.890
R^2-adj.	0.839	0.858	0.870	0.864	0.767	0.831	0.842	0.875	0.866	0.877	0.885	0.882	0.889
Obs.	1457	475	940	1306	371	609	666	2298	1524	620	455	263	1374
Implied export premium:													
Sales	2.13	1.36	1.63	1.27	1.59	1.12		1.19	1.23	1.23	1.30		1.26
Labour productivity	2.19	1.35	1.58	1.27	1.55			1.17	1.20	1.20	1.47		1.26
Wages	1.20	1.18	1.06		1.07	1.10		1.08	1.07	1.07	1.15		1.12

*Note: All regressions use time fixed effects. Coefficients of the constant and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level. The implied export premium is retrieved by making the coefficient of the export premium the exponent of e.*

There is also considerable variation in the magnitudes of the export premia across industries. The by far largest export premia are found in the food, beverages and tobacco industry (NACE subsector DA). Rather large export premia also seem to exist in the wood industry (NACE subsector DD), while in most other industries the export premia are smaller than those found for the entire manufacturing sector.

There are several potential reasons for this variation across industries with ambiguous effects on the export premia.[20] One explanation relates to the effect of (international) competition in the industry. If competition in an industry is high, fewer of the less productive firms are to survive. Ceteris paribus, the number of exporting firms relative to non-exporters increases so that the export participation rate in the industry increases. At the same time, when the lower end of the firm distribution is cut-off, i.e. the cut-off productivity is higher, the difference in average productivity between non-exporting and exporting firms decrease resulting in a negative correlation between export participation and the size of the export premium. In line with this "squeezing" of the lower range of surviving firms in more open and competitive environments (see e.g. Melitz and Ottaviano, 2008), we find a negative (albeit weak) correlation between the export participation rate and the size of the productivity premia of exporters across industries.

Another factor potentially influencing the export premia is the industry's capital intensity. One would expect capital intensive industries with a high degree of automatisation to have more potential to exploit economies of scale. This leads to an advantage of larger firms and, if small non-exporting firms still survive in the market (e.g. due to product differentiation), a higher export premium. If scale effects drive the smaller and less productive firms entirely out of the market, a relatively small export premium is to be expected because the dispersion of firm size and productivity within the industry declines. Hence, as in the case of competitive pressures, the effects on the export premia depend on the relative position (or shifts thereof following a change) of the cut-off productivity and the export cut-off productivity. Without knowledge of or assumptions on the distribution of firms within an industry, no clear predictions for the relative size of the premia in an industry with high or low scale economies emerges.[21]

Drawing on an overview in a report by the World Bank (2009), the textile industry (NACE DB) for example is typically found to have constant or only low increasing returns to scale. The export premia we found for the textile industry is rather small in comparison with the chemical industry (NACE DG) (the exception being the wage premium) which is regularly found to have high increasing returns to scale. The export premia of the wood industry (NACE DD), another industry with presumably limited scale economies, are however comparable or even slightly higher than those of the chemical industry. These high export premia are possibly related to the high number of surviving non-exporting firms in the industry.

[20] Given the small number of estimated export premia, we are unable to test the importance of each of these effects. A thorough analysis would require a cross-country dataset to pin down the effects of industry characteristics on export premia.

[21] The same is true for the degree of competition within the industry.

Apart from supply side effects, preferences also play a central role for shaping market structure and the firm distribution within industries. In a Dixit-Stiglitz framework (Dixit and Stiglitz, 1977) which assumes product differentiation and love of variety of consumers, lower demand elasticities (strong love for variety) lead to higher monopolistic power of firms and an increase in the number of products available as well as the number of firms operating on the market. In the Melitz framework strong love for variety lowers the productivity cut-off and tends to increase the size of the export premia in an industry. Hence, the very high export premia we found in the industry “food, beverages, tobacco” may to some extent be attributed to love for variety. Additionally, high export premia might be the result of particular Armington-type preferences. According to the Armington assumption, products are differentiated by nationality so that consumers view otherwise identical products as different varieties if they are produced in different countries. In the case of the food and beverages industries a bias in consumer preferences in favour of domestically (or even locally) produced varieties may as well be part of the explanation of the very high export premia in this industry.

Coming back to scale effects, we observe on-going changes in technology, affecting among other things optimal capital-labour ratios and outsourcing opportunities. Since the demography of firms reflects past characteristics, economies are constantly moving towards new equilibria. The speed of ongoing selection processes might differ across industries, also depending on the rigidity of consumer preferences. Effects of technological change on an industry, its convergence speed to the new equilibrium and differences in adjustment possibilities of firms thus alter the productivity advantages of large, exporting firms and the export premia.

Yet another major factor is the presence of multinationals in an industry as a result of inward foreign direct investments (FDI). Heterogeneous firm models which allow for a trade-off between exporting and FDI typically predict multinationals (including their subsidiaries) to be the most productive firms (Helpman et al., 2004). In empirical research FDI firms are indeed found to be more productive than exporters (e.g. Mayer and Ottaviano, 2007). Moreover, Helpman et al. (2004) also show that apart from trade costs and scale economies, also the firm dispersion within and industry has an impact on the share of exports relative to FDI. With regards to the export premium, two aspects matter here. First of all, potentially, some very productive Austrian firms may not export because they decided to serve foreign markets via FDI. Such a substitutional relationship between exports and FDI would tend to reduce the size of the export premium (or could even make it negative in extreme cases) as some very productive firms would be found among non-exporters. The second point relates to the subsidiaries of foreign multinationals in Austria. Depending on the function these subsidiaries have within the multinational corporation, they might be strongly involved in exporting, e.g. if they are set-up for processing and re-exporting some intermediate goods, or only operate domestically (e.g. supplying another domestic plant owned by the multinational). Hence, most likely the amount of inward FDI and the ownership status of firms in an industry will also affect the resulting export premia.

Moreover, as pointed out above, the export premia results (as well as the export participation rates) can be influenced by the fact that our firm sample is not fully representative for the Austrian manufacturing sector. Finally, the results are also dependent upon the industry definition of the classification used and the aggregation level since each of the industries includes a very diverse set of firms.[22]

In the appendix of the paper we also report the export premium across the export intensities of firms at the industry level (for sales and labour productivity). We find the same pattern of the export premium increasing with the export intensity of firms in almost all sectors. In a number of industries the marginal exporters are already significantly larger and more productive than non-exporters while in some industries it is really the firms with high or very high export intensity that are different. Thus, this analysis established that the manufacturing wide export premium is not driven by a small number of industries but is a general phenomenon in the majority of industries though the explanations of the cross-industry differences with respect to the size of the premia require further research.

3.5.3 Changing the hypothesis: a fixed effects model

With a panel data set an approach that suggests itself to further remedy a remaining omitted variable bias is a fixed effects estimator.[23] In our context this means adding a very large number of firm fixed effects. The firm fixed effects model takes the form:

(3.2) $$ln\, Y_{it} = \alpha + \beta \cdot ES_{it} + \sum_s \phi^s \cdot X_{it}^s + \sum_i \mu_i \cdot Z_i + \sum_t \delta_t \cdot D_t + \upsilon_{it}$$

where Z_i is a dummy variable for firm fixed effects and μ_i is the corresponding (firm-specific) coefficient. The error term is denoted by υ_{it} . All other variables are as before. In particular β remains the main variable of interest, although this strategy not only implies that we change the estimator but also the hypothesis to be tested. With a fixed effects estimator, only variations within firms are now exploited so that β captures the difference in the dependent variable due to within firm changes in the export status over time. Thus, the way to interpret the estimated coefficient of the export status dummy variable is now different. It does no longer indicate by how much exporters are larger or better performing than non-exporters; instead it indicates by how much, on average, firms that switch from being a non-exporter to being an exporter (or vice versa) are larger or better performing in periods when they are exporters.[24]

22 The list of factors that may matter for the size of an industry's export premia is far from complete. Many other factors may play a role, including tariffs, transportation costs and other trade barriers such as languages which may be relevant in the publishing industry.

23 A Hausman test suggests that a fixed effects model is to be preferred over a random effects model because of the latter lacking consistency.

24 This interpretation of the coefficient of the export dummy variable differs from that offered in the cross-country study by ISGEP (2008). There the estimated coefficients of the export dummy variable are interpreted as the export premium, similar to a pooled specification without firm fixed effects.

Table 3.8: Estimation results with firm fixed effects, simple export status (total manufacturing, 2002-2006)

Dependent variable	Sales	Labour productivity	Wage
ES	0.044*** (4.892)	0.017** (2.176)	0.003 (0.557)
F-test	240.587	219.313	490.170
R^2-overall	0.049	0.027	0.017
R^2-between	0.041	0.036	0.004
R^2-within	0.052	0.048	0.101
Test for poolability	114.215	32.300	20.334
Obs.	29854	29828	29833
Nb. of groups	8061	8045	8046
implied export premium	1.0450	1.0171	-

*Note: All regressions use a full set of firm and time fixed effects. Coefficients of the constant, firm and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level. The implied export premium is retrieved by making the coefficient of the export premium the exponent of e.*

Table 3.8 shows that in the fixed effects model the export status coefficient is statistically significant for the sales and the labour productivity regression but not for the regression on wages. The magnitude of the estimated coefficients becomes rather small. The implied premium in terms of sales for example, is now only of a factor 1.045. Again, this is not to be interpreted as a premium that exporters enjoy over non-exporters. It rather indicates that, on average, switchers have 4.5% higher sales in periods where they are exporting than in periods where they are not exporting.[25] For the productivity measure, this premium is only 1.7%. While these coefficients appear to be miniscule in comparison to the results from the previous specifications one has to bear in mind the difference in interpretation. The finding that switching firms are significantly larger and more productive in periods of exporting thus gives additional support to the existence of an export premium.

The result on the size and productivity premium of export switchers is all the more remarkable as the number of switching firms that drive this result is not too large. Only 6.3% of the firms-year observations where firms initially did not export are switches to exporting while among exporters 4.2% of the observations are switches to non-exporting (Table 3.9). In total just 5.1% of the firms are export switchers.

[25] When controlling for firm fixed effects, the export status variable does not add any information for those firms that are either always exporting or never exporting. In these cases the coefficient of the export status dummy does not pick up any variation in the left hand side because it is captured by the firm fixed effects.

Table 3.9: Exporting, non-exporting and switching firms (transition matrix)

		Non-exporters	**Switchers (to exporting)**	firm total
	no. of firms	**8,963**	**601**	9,564
	in % of total	**93.72**	**6.28**	100
		Switchers (to non-exporting)	**Exporters**	firm total
	no. of firms	**514**	**11,710**	12,224
	in % of total	**4.2**	**95.8**	100
firm total	no. of firms	9,477	12,311	21,788
	in % of total	43.5	56.5	100
switchers total	no. of firms	**1,115**		
	in % of total	**5.1**		

3.6 The probability of exporting

In this section we turn to a second empirically testable element in the Melitz model. Unlike the export premia it is not a prediction of the model but an assumption which is necessary for the selection of firms into exporters and non-exporters. Following the approach by Roberts and Tybout (1997) we use a probit model to regress several firm characteristics, including the export status in the previous period, on the current export status. A positive coefficient for the previous export experience, i.e. the lagged export status, then indicates that previous export experience increases the probability of exporting for a firm. Since incumbent exporters do not have to incur this fixed export entry cost, a positive influence of the past export status on the probability to export can be associated with the export fixed costs and interpreted as evidence in favour of their relevance for the decision to start exporting. The regression takes the following form:

(3.3) $$\Pr(ES_{it} = 1) = \Phi(\alpha + \sum_s \phi^s \cdot F_{i,t-1}^s + \beta \cdot ES_{i,t-1} + \sum_k \gamma^k \cdot IND_{it}^k + \sum_r \tau^r \cdot \Pi_{it}^r + \sum_t \delta_t \cdot D_t + \varepsilon_{it})$$

where $\Phi(\cdot)$ is the cumulative distribution function of a standard normal distribution. The firm control variables $F_{i,t-1}^s$ in our case are labour productivity and employment. These variables capture the impact of 'past talent' on the probability of exporting. In addition to industry dummies and time fixed effects, we also include regional dummies for the nine Austrian regions (*Bundesländer*) denoted by Π_{it} with corresponding coefficient τ.

In Table 3.10 we present results from several specifications of the probit model where marginal effects, evaluated at the mean of the explanatory variables, are reported. In specification (I) and (II) we include alternatively (one period) lagged labour productivity and lagged employment as firm controls while in specification (III) they are both included.

Table 3.10: The probability of exporting– total manufacturing, 2002-2006 (probit estimation)

Dependent variable: Export Status: (ES_t) Explanatory variables	(I)	(II)	(III)	(IV)
Labour productivity$_{t-1}$	0.167***		0.132***	
	(16.974)		(13.045)	
Employment$_{t-1}$		0.113***	0.091***	
		(16.453)	12.653	
ES_{t-1}	0.860***	0.858***	0.847***	0.847***
	(96.652)	(96.234)	(92.157)	(92.239)
Labour productivity$_t$				0.137***
				(13.645)
Employment$_t$				0.091***
				(12.605)
Pseudo-R^2	0.73	0.73	0.736	0.737
Obs.	21625	21629	21625	21624
Observed P	0.566	0.566	0.566	0.566
Predicted P	0.627	0.638	0.637	0.637

*Note: Results from probit regression. All regressions use a full set of industry dummies, time dummies and region dummies for the Austrian provinces. Coefficients of the constant, year fixed effects, industry and region dummies are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level respectively. Marginal effects evaluated at the mean of independent variables, except for the (lagged) export status where the marginal effect is the change in probability from a discrete change in this binary variable.*

In all specifications the by far largest impact on the probability to export comes from previous export experience. Being an exporter in the previous period increases the probability of exporting by 85 percentage points (specification III). This can be interpreted as solid evidence for a strong persistence of exporting and strongly supports the hypothesis of export sunk costs. The result is also robust with regards to whether the additional firm characteristics enter the regression in lagged or in current form (as is done in specification IV). This finding is in line with the result of Greenaway and Kneller (2004) for the United Kingdom and the relatively low number of export switchers in our firm sample.

Despite the overriding effect of past export experience, the influence of employment and labour productivity are also noteworthy. A 1% increase in productivity for example leads to an increase in the probability to export of 0.13 percentage points. It is tempting to give a causal interpretation and describe the positive impact of past capabilities of firms on the probability of exporting as evidence for self-selection. On the other hand specification (IV), which contains current instead of lagged employment and productivity, basically yields the same result as specification (III). Hence, the time structure does not seem to matter much and one is back to a simple correlation between exporting on the one hand and productivity and firm size on the other.

3.7 Conclusions

In this paper we found that Austrian exporters in the manufacturing sector are very much like exporters in other countries in the sense that they are significantly different from their non-exporting peers: they are larger and more productive. Employing a simple definition of the export status we estimated the export premium for three firm characteristics, sales, labour productivity and wages. The results from the panel regression suggest statistically significant and economically large export premia, ranging from 38% for sales to 11% for the wage premium in our preferred specification. These results are in line with those for other countries and close an existing gap in the literature, as for Austria a detailed study on this issue has so far not existed.

We also found significant export premia for exporting firms in the overriding majority of industries when estimating the export premia at the industry level. From this we conclude that the manufacturing wide export premia are not driven by the situation in a few important industries and that the export premium is a widespread phenomenon, present in almost all manufacturing industries. All these results were also confirmed when estimating export premia for exporters with different export intensities and a clear pattern emerges: the export premia are increasing along with export intensity, both at the manufacturing level and the industry level.

The magnitudes of the export premia are found to vary considerably across industries. This finding is up to now surprisingly little documented in the literature, given the fact that heterogeneous firm models including the model by Melitz (2003) are typically stated as models of a particular industry. We provide theoretical arguments in order to explain these differences in export premia across industries. Possible reasons for the observed variation are differing export participation rates and international competition, scale effects, love for variety on the demand side and product differentiation, effects of technological change and ongoing selection processes as well as the presence of multinationals. Empirically revealing the underlying reasons for the large differences across industries is a particularly interesting route for further research.

We further engaged in estimating the export premia with a firm fixed effects model. The fixed effects estimation of the export premia suggests that export switchers are 4.5% larger in terms of sales and 1.7% more productive in periods where they export. Apart from the result on switchers provided by the fixed effects estimation we also stressed the differences in hypothesis attested by a firm fixed effects model when applied to estimating the Bernard-Jensen type export premium.

Finally, we found that past export experience increases the probability of exporting by 85 percentage points. In line with the literature we interpret this as evidence for the importance of export fixed costs in the decision to export. There is also evidence for a positive impact of firms' past performance on the probability of exporting.

Since empirical research on the internationalisation of firms based on Austrian firm level data is still in its infancy there is ample room for extending the estimation of the export premia in Austrian manufacturing, for example by using total factor productivity as a performance measure. Moreover, the issue of causality could be further explored by comparing the productivity paths of export starters after their entry into export with those of a sample of matched (i.e. comparable) non-exporters. Other implications of exporting on factors such as employment (e.g. by skill or occupation) or the skill-premium would be useful and relevant for economic policy. This would however require merging already existing datasets and allowance of the Austrian research community to properly access them. The current severe constraints of the academic research community in Austria with respect to availability of and access to appropriate firm-level data therefore also impedes the development of micro-level based policy recommendations.

3.8 Appendix

Table 3.A.1: Export premium (sales) for Austrian manufacturing firms, 2002-2006, by export intensity (OLS) – individual industries

	food, beverages, tobacco (DA)	Textiles (DB)	Wood (DD)	pulp, paper, printing (DE)	Chemicals (DG)	rubber and plastic (DH)	non-mettalic mineral products (DI)	basic metals, metal products (DJ)	machinery and equipment (DK)	electrical equipment (DL 30-32)	medical, precision, optical instruments (DL 33)	transport equipment (DM)	other manufactures (furniture, toys,…) (DN)
EXTINT1	0.563***	0.133	0.073	0.168***	-0.429*	0.116	-0.066	0.039	-0.082	0.004	0.164**	-0.322	0.146***
(marginal)	(9.674)	(0.855)	(1.419)	(4.067)	(-1.716)	(0.880)	(-0.964)	(1.042)	(-1.423)	(0.050)	(2.110)	(-1.077)	(4.125)
EXTINT2	0.755***	0.240**	0.310***	0.223***	0.205	-0.044	0.046	0.110***	0.127**°	0.181***	0.117*	-0.267	0.167***
(low)	(13.746)	(2.233)	(6.948)	(5.759)	(1.487)	(-0.640)	(0.815)	(3.872)	(2.484)	(2.61)	(1.772)	(-0.950)	(5.168)
EXTINT3	0.952***	0.252**°	0.617**	0.287***	0.407***	0.192**°	0.069	0.222***	0.200***	0.111	0.258***	-0.045	0.306***
(high)	(12.593)	(2.503)	(9.689)	(4.549)	(2.899)	(2.165)	(0.932)	(4.531)	(3.776)	(1.221)	(2.775)	(-0.160)	(6.047)
EXTINT4	1.044***	0.427***	0.906***	0.553***	0.655***	0.236***	-0.066	0.431***	0.304***	0.320***	0.399***	-0.249	0.423***
(very high)	(16.944)	(4.508)	(16.371)	(5.503)	(5.093)	(3.214)	(-0.961)	(10.366)	(6.892)	(4.855)	(5.581)	(-0.915)	(9.040)
Employment	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Share R&D personnel	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Software/employee	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
F-test	939.2	242.6	850.1	845.4	157.2	282.5	348.6	1488.8	980.4	399.8	365.4	354.7	665.5
R^2	0.845	0.864	0.895	0.870	0.805	0.840	0.845	0.882	0.872	0.883	0.891	0.887	0.894
R^2-adj.	0.844	0.861	0.894	0.869	0.799	0.837	0.843	0.881	0.871	0.881	0.888	0.882	0.893
Obs.	1457	475	940	1306	371	609	666	2298	1524	620	455	263	1374
Implied export premium by export intensity (EXTINT)													
Marginal export intensity	1.76			1.18	0.65				0.92		1.18		1.16
Low export intensity	2.13	1.27	1.36	1.25				1.12	1.14	1.20	1.12		1.18
High export intensity	2.59	1.29	1.85	1.33	1.50	1.21		1.25	1.22		1.29		1.36
Very high export intensity	2.84	1.53	2.47	1.74	1.93	1.27		1.54	1.36	1.38	1.49		1.53

*Note: All regressions use time fixed effects. Coefficients of the constant and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level. The implied export premium is retrieved by making the coefficient of the export premium the exponent of e.*

Table 3.A.2: Export premium (labour productivity) for Austrian manufacturing firms, 2002-2006, by export intensity (OLS) – individual industries

	food, beverages, tobacco (DA)	Textiles (DB)	Wood (DD)	pulp, paper, printing (DE)	Chemicals (DG)	rubber and plastic (DH)	non-mettalic mineral products (DI)	basic metals, metal products (DJ)	machinery and equipment (DK)	electrical equipment (DL 30-32)	medical, precision, optical instruments (DL 33)	transport equipmen (DN)t	other manufactures (furniture, toys,…) (DM)
EXTINT1	0.604***	0.030	0.067	0.173***	-0.394	-0.060	-0.057	0.018	-0.139**	0.025	0.147*	-0.541*	0.144***
(marginal)	(10.205)	(0.205)	(1.317)	(4.217)	(-1.558)	(-0.623)	(-0.874)	(0.562)	(-2.283)	(0.330)	(1.816)	(-1.864)	(4.154)
EXTINT2	0.771***	0.156	0.270***	0.212***	0.092	-0.088	0.029	0.107***	0.104**	0.105	0.237***	-0.352	0.157***
(low)	(14.005)	(1.508)	(6.063)	(5.601)	(0.630)	(-1.309)	(0.534)	(3.753)	(2.057)	(1.476)	(3.291)	(-1.232)	(4.853)
EXTINT3	0.994***	0.266***	0.536***	0.291***	0.332**	0.166*	0.069	0.193***	0.167***	0.072	0.429***	-0.079	0.322***
(high)	(13.992)	(2.699)	(7.791)	(4.664)	(2.200)	(1.899)	(0.999)	(4.039)	(3.101)	(0.791)	(4.681)	(-0.277)	(6.153)
EXTINT4	1.053***	0.482***	0.910***	0.529***	0.681***	0.180**	-0.080	0.412***	0.280***	0.321***	0.583***	-0.255	0.439***
(very high)	(17.027)	(5.267)	(16.945)	(5.428)	(4.888)	(2.476)	(-1.263)	(10.042)	(6.298)	(4.718)	(8.112)	(-0.927)	(9.073)
Employment	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Share R&D personnel	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Software/employee	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
F-test	138.5	13.9	61.4	53.7	10.7	10.8	8.2	72.1	32.5	11.9	34.5	26.1	37.1
R^2	0.444	0.240	0.431	0.249	0.314	0.150	0.114	0.263	0.197	0.178	0.448	0.291	0.278
R^2-adj.	0.440	0.222	0.424	0.243	0.293	0.134	0.099	0.259	0.191	0.163	0.434	0.260	0.272
Obs.	1457	475	940	1306	371	609	666	2298	1523	620	455	263	1374
Implied export premium by export intensity (EXTINT)													
Marginal export intensity	1.83			1.19					0.87		1.16	0.58	1.15
Low export intensity	2.16		1.31	1.24				1.11	1.11		1.27		1.17
High export intensity	2.70	1.30	1.71	1.34	1.39	1.18		1.21	1.18		1.54		1.38
Very high export intensity	2.87	1.62	2.48	1.70	1.98	1.20		1.51	1.32	1.38	1.79		1.55

*Note: All regressions use time fixed effects. Coefficients of the constant and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at the 1, 5 and 10% level. The implied export premium is retrieved by making the coefficient of the export premium the exponent of e.*

4 International Spillovers in a World of Technology Clubs

4.1 Introduction

Technology is a key component of long-term growth and successful economic development. In an international context this implies that countries' economic growth does not only depend on domestic technological progress but also on technological developments abroad. If one assumes that technological progress –°be it by way of innovation or by imitation of existing foreign technologies –°is a costly process, not all countries will grow at the same rate. Therefore the level of technology (and hence productivity) differs greatly across countries, a fact which is hardly disputed.

One of the objectives in this paper is to use technology and human capital related indicators to classify countries according to their technological capacity. A country's technological capacity, in a broad sense, depends on both its capability to undertake research and development (R&D) and innovate and its ability to absorb foreign technologies that have been developed abroad. R&D and imitation represent two distinct activities that both feed into technological progress. While innovations add to the existing (global) technology stock and shift the (global) technological frontier outward, imitation is the process of being able to make productive use of existing innovations. The ability to imitate and adopt foreign technologies for local use must be assumed to be a highly human capital and knowledge intensive process (as are original innovation and R&D). For this reason we follow Nelson and Phelps (1966) in assuming that the capacity to benefit from foreign technologies via international spillovers depends primarily on the level of human capital available in the country. Hence, while it is true that countries with low levels of productivity have a high potential for receiving technology spillovers, de facto, they may find it hard to benefit from such spillovers because of the lack of human resources required for the imitation process. In this case Gershenkron's famous "advantage to backwardness" is counteracted by a lack of absorptive capacity.

Countries will perform neither innovation nor imitation activities if their levels of human capital do not meet the required threshold to undertake R&D and/or imitate foreign technologies. For example, R&D and patenting are highly concentrated activities with the EU, the US and Japan alone accounting for more than two thirds of the global expenditure on R&D in 2007 while the Sub-Saharan countries undertake very little R&D, a mere 0.5% of global R&D expenditures (UNESCO, 2010).

Countries undertaking either innovation, imitation or none may diverge on different growth paths and/or end up at different income levels. This constellation gives rise to the notion of convergence clubs suggesting a tripartite world consisting of an "innovation group", an "imitation group" and a "stagnation group". The innovation group includes countries that perform R&D and innovate thereby pushing the global technological frontier outward. Countries in the imitation group do not undertake R&D themselves but take on new technologies developed abroad through the absorption of foreign technologies. The stagnation group has insufficient endowments of human capital and skills in order to adopt and implement new foreign technologies. Therefore the countries in this group have very high technology gaps, that is, the difference in their productivity level to the country with the highest productivity.

As pointed out above we will use technology (R&D expenditure) and human capital related variables (literacy rate, years of schooling) to cluster countries into technology clubs. As it turns out, we find three rather distinct clubs which fit well the idea of innovation, imitation and stagnation groups.

In the second part of the paper, we test whether we can detect catch-up effects – that is growth effects from an existing technology gap – in a growth regression framework and to what extent these catch-up effects are associated with a country's absorptive capacity. Our simple growth equation contains, next to the traditional factors of production, a technology gap variable which is intended to capture the growth effects associated with international technology spillovers.

We employ the threshold regression approach developed by Hansen (1996, 1999, 2000) to allow for non-linearities in the catch-up effects of countries, splitting the sample along the human capital dimension. We find that for countries with intermediate levels of human capital there is a large catch-up effect, i.e. countries can to some extent translate their technology gap into higher growth. At the same time such a catch-up process cannot be taken for granted as countries with very low levels of human capital enjoy only limited growth effects from their technology gaps – though their technology gaps tend to be large. The contribution of the paper to the existing literature is threefold. First of all, by choosing a threshold regression approach we do not need to define the convergence clubs a priori but can let the data search for and determine the boundaries between the different clubs. In our view this approach improves the validity of the argument in favour of distinct growth regimes for different groups of countries. Secondly, we show that the resulting convergence clubs are very similar irrespective of whether these clubs are defined using human capital or an R&D related indicator (patent applications). This is also true for the 'mixed' threshold model, where the threshold between the stagnation and the imitation club is based on human capital (absorptive capacity) and the threshold between the imitation and the innovation club is based on the countries' R&D capacities. Thirdly, in addition to the differences in the growth effects from the technology gaps between the clubs we trace the development of these growth effects over time and show that they have been increasing in the case of the imitation club but not for the stagnation club.

The paper proceeds as follows: Section 4.2 discusses some of the related literature. Section 4.3 gives the data sources used in sections 4.4 and 4.5 which contain the results of our cluster analysis and the growth regressions respectively. Section 4.6 concludes.

4.2 Related literature

The conceptual background for this paper is the endogenous growth literature though the emergence of technology clubs may also be motivated by evolutionary approaches to economic growth. The endogenous growth literature explicitly models the law of motion for technology and productivity instead of assuming it to be an exogenous process.

Howitt (2000) provides a multi-country version of a vertical growth model à la Aghion and Howitt (1992) in which firms push the technological frontier by investing in R&D and rival firms can build on innovations of previous innovators. In this model, R&D performing countries with lower productivity will grow at the same pace as the leading country though it will not catch-up in terms of per capita income. The mechanism that ensures growth convergence is that if a firm innovates successfully, it brings the sector's productivity up to the *global* technological frontier. However, not all countries necessarily perform R&D so that some countries will not innovate. Since innovation is the sole source of technological progress the non-innovating countries will stagnate. Therefore there will be two groups or clubs of countries which differ in their growth regimes. However, there will be convergence in growth rates within the clubs.

In an extension of the Howitt (2000) growth model Howitt and Mayer-Foulkes (2005) develop a model with two types of technological advances: *(i)* R&D activity leading to innovations and *(ii)* imitation which is the process of implementing existing foreign technologies. Both innovation and imitation are skill intensive activities. In the convergence club model of Howitt and Mayer-Foulkes (2005) – which is our main theoretical reference model – countries select themselves into three groups, depending on their technological capabilities. A group of technologically advanced countries will perform R&D and come up with new innovations. This innovation club pushes the global technological frontier. A second group of countries, the imitation club, is successful in imitating and adapting existing technologies previously developed by the innovation group. In contrast, their level of productivity and human capital does not allow them to undertake original R&D. The imitation group successfully implements existing technologies because they have the required level of absorptive capacity which in turn depends on human capital. Here the idea developed by Nelson and Phelps (1966) that countries can benefit from their technology gap vis-à-vis leading countries comes in. Countries can benefit from their technology gap because it enables them to strongly draw on the existing technology (or knowledge) stock. As in several related models, the imitators and the R&D leaders converge to the same growth path but the former will not succeed in catching-up in terms of per capita income (e.g. Acemoglu and Ventura, 2002; Howitt, 2000).

Finally, there is a third group, the stagnation club, which consists of initially backward countries whose low levels of absorptive capacity prevent them from catching-up with the continuously expanding global technological frontier. These backward countries are trapped in a zero growth equilibrium and will fall behind in terms of productivity and GDP per capita leading to an ever increasing technology gap[26].

The emergence of convergence clubs due to different potential for catching-up can also be motivated by evolutionary growth models. The assumptions in evolutionary growth models about the sources and mechanics of the growth process are similar to those of new growth theory despite fundamental differences in the theoretical underpinning (Castellacci, 2007). For example, Verspagen (1991) develops a North-South type growth model in which countries belonging to the South, i.e. countries which are not on the technological frontier, may catch-up or fall further behind depending on their distance to the technological frontier and an 'intrinsic capability'. Like the absorptive capacity this intrinsic capability depends on factors such as the education of the workforce, the quality of the infrastructure and the structural similarity between the catch-up countries in the South and Northern technology leaders. The technology gap determines the potential spillovers of a country. However, a country will not be able to fully exploit these potential spillovers and the degree to which the spillovers can be reaped, i.e. the actual spillovers, depend on the intrinsic capability. The higher the intrinsic capability of a country, the higher are the actual spillovers. So the sources of growth (technological progress) and the mechanics for catching-up of follower countries in this model are quite similar to those in the model by Howitt and Mayer-Foulkes (2005). A main difference is though that in the model by Verspagen (1991) both Southern and Northern countries have domestic technological progress with the rate of progress being higher in the later while in the model of Howitt and Mayer-Foulkes (2005) only the technology leaders innovate and contribute to the technological progress. Another difference is that the distinction between leader and follower countries in the Verspagen model is exogenous and introduced by the assumption of different knowledge stocks and knowledge growth rates of countries in the South and the North. In contrast, the decision whether a country innovates or imitates is endogenously determined by the characteristics of the countries.

The idea of convergence clubs is also related to the concept of poverty traps (see e.g. Azariadis and Drazen, 1990; Azariadis, 1996) through the high importance attributed to initial conditions and threshold effects. In the poverty trap literature diverging growth regimes are the result of threshold externalities in accumulative factors (Azariadis and Drazen, 1990). A country may be trapped in a low growth, low income equilibrium for several reasons including demography, impatience, institutions (corruption), globalisation or technology (see Azariadis, 1996). The convergence clubs literature also relies on threshold effects that lead to a bifurcation in the law of motion of the countries' growth rates but it assigns the threshold effects to the technological realm, i.e. the innovative and the absorptive capacity of countries.

Empirically the notion of convergence clubs received support from findings on the existence of multiple growth regimes (Durlauf and Johnson, 1995) and research on the world income distribution which in the modern era saw the emergence of "twin peaks" (e.g. Quah, 1997). The existence of a bimodal distribution of per capita income across countries implies an accumulation of countries at very different levels of income. Convergence of countries to

[26] The migration from one club to another requires a shift in policies that induce an improvement in technology-related parameters. Our empirical model does not include such policy shifts although in the regression analysis some 'switches' between clubs of individual countries do occur.

different per capita incomes is clearly incompatible with a general growth convergence among all countries but perfectly in line with convergence within clubs.

Closely related to our work are the contributions by Castellacci (2008, 2011) and Castellacci and Archibugi (2008) who take up the issue of technology clubs empirically and use cluster techniques in order to sort countries into three technology clubs. Castellacci (2008) uses the number of journal articles as a proxy for innovative capacity and the literacy rate of the population representing absorptive capacity. We undertake a similar exercise but we employ a different cluster methodology and also have different variables entering the cluster analysis.

For our growth regressions we draw heavily on Benhabib and Spiegel (1994) and Crespo et al. (2004) as the growth equation we estimate is similar to their specifications. Starting from a Cobb-Douglas production function Benhabib and Spiegel (1994) endogenise the productivity term by introducing a law of motion for productivity. According to this law of motion for productivity, the change in productivity is a function of human capital and the country's distance to the technological frontier, i.e. the technology gap. Econometrically, the Benhabib-Spiegel approach leads to the substitution of the growth rate of human capital with the *level* of human capital. Benhabib and Spiegel also introduce a catch-up term which is created by interacting human capital with the technology gap. We will employ this catch-up term for measuring the growth effects from spillovers. In addition we will estimate our growth regression with the simple technology gap variable. The growth regression we estimate resembles that of Crespo et al. (2004) who estimate the growth effects of spillovers for a sample of OECD countries using the interaction between human capital and the technology gap as the catch-up variable.

We add to the existing literature on spillovers and absorptive capacity by searching for non-linearities in the spillover effect by splitting the sample into sub-samples where countries are sorted into these sub-samples according to their level of human capital. To this end we employ the threshold estimation technique developed by Hansen (2000). The main advantage of the threshold estimation procedure is that the threshold that splits the sample is not determined a priori but by the data during the estimation process. Hence, the threshold regression technique is an alternative method to account for the potential human capital related non-linearity in the effect of the technology gap on economic growth.

We detect thresholds in the human capital variable and relate them to the technology club literature. Given this theoretical framework we expect to find (at least) three different regimes with respect to the catch-up effect which we associate with the innovation, the imitation and the stagnation club. Moreover, we expect that the medium regime resulting from the threshold regressions – which we associate with the imitation club – to benefit most strongly from spillovers and that they therefore have the largest growth effects from the catch-up variable. In contrast, no or at least a smaller growth effect from spillovers are expected for the low regime, i.e. the country group with the lowest level of human capital which we associate with the stagnation club.

4.3 Data

Our primary source of data is the World Bank's World Development Indicators (WDI) database. From the WDI we take GDP per capita, gross fixed capital formation, labour force and population data as well as the literacy rate of the population aged 15 or over. We collect these variables for the period 1980-2009. We complement the human capital variables with data from the Barro-Lee database (Barro and Lee, 2010) from which we use the average years of schooling[27]. Our innovation variable in the cluster analysis is gross expenditure on R&D (GERD) as a percentage of GDP for which – due to our global coverage of countries – we turn to the UNESCO Institute for Statistics (UIS) data on Science and Technology indicators. The principal time coverage of the UNESCO data base is from 1996 to 2007. In the regression analysis we use the number of patent applications as proxy for innovation capacity because of the longer time series available. The patent data comes from the database of the Word Intellectual Property Organization (WIPO).

For the cluster analysis we have to impute some of the data in order to end up with a satisfactorily large dataset. In particular we lack data on the literacy rate for most developed countries as this type of data is typically not collected anymore. Hence, we follow the approach of UNEP in their calculation of the Human Development Index (HDI) and assume a literacy rate of 99% for these countries. Moreover, UNEP provides literacy rate data for some countries where the WDI database does not, so we complement the WDI data with UNEP data in these instances. Unfortunately, we also lack data on the R&D expenditure for a rather large number of countries, and in particular for African countries. In order not to lose too many observations we rely on regional averages provided by UNESCO (2010), except for the LDC countries where we apply the LDC's average rate. While this may be seen as a shortcoming of our approach for the clustering analysis we believe that the regional approximations are a permissible imputation method as we do not expect any serious outliers in the group of missing countries. In some instances, where we feel uneasy about using the region's average we either use the value of a neighbouring country or drop the country from the sample. This way we obtain a sample of 142 countries for the cluster analysis (see Table 4.A.1 in the Appendix for the full country list).

The capital stocks needed for the growth regressions are calculated with the perpetual inventory method with 1980 as the base year. We assume a depreciation rate of 6% (as Hall and Jones, 1999) and use the 1980-2005 annual growth rate to arrive at the capital stock in 1980.

4.4 Identifying technology clubs

Given our hypothesis of distinct technology clubs based on innovative and absorptive capacities, we first try to identify such convergence clubs and its members by way of cluster analysis. There exists a wide range of potential variables that may reflect the technological capacity and absorptive capacity of countries. As in Castellacci (2008) we adapt a

[27] The database is accessible at http://www.barrolee.com/data/full1.htm

parsimonious approach with respect to the number of variables we use for the cluster analysis. We rely on gross expenditure on R&D as a share of GDP to proxy for the innovative capability of countries. With respect to absorptive capacity we take the Nelson and Phelps (1966) view that the level of human capital is the main determinant of absorptive capacity. We use two human capital indicators, namely the literacy rate and the average years of schooling. The choice of these variables is to a large extent also determined by the availability of data. We base the analysis on the data for the average of the years 2005-2009.

The result from our cluster analysis is presented in Table 4.1a and Table 4.1b[28].

The first cluster consists of 38 countries with low values of both the innovation and the human capital variables. The group average for the R&D expenditure in percentage of GDP (R&D/GDP) is only 0.26%. The average literacy rate is just above 60% with the average person having about 4.3 years of schooling. Given our theoretical model we label this cluster the stagnation club (or marginalised group). Note also that this club comprises about a third of the total population of all the countries in the sample. The second cluster, which is the largest comprising 80 members, also scores low on the R&D dimension with a R&D/GDP ratio of about 0.5%. However, the human capital levels are rather high with a literacy rate of about 93% and on average almost 8.5 years of schooling. The characteristics of this cluster fits well with the notion of the imitation club whose members do not perform a lot of their own R&D but are quite capable of adopting foreign technologies. Finally, the third cluster includes 24 countries with a high R&D/GDP ratio amounting to 2.2%, close to complete literacy among the population and on average 10.7 years of schooling. These characteristics we associate with the innovation club consisting of the technology leaders.[29]

The result of the cluster analysis is to a large extent as expected and contains only few surprises. Most OECD countries are in the innovation club while the stagnation club is formed mostly by African countries supplemented by a few Central American countries, e.g. Haiti, and Asian countries (e.g. Laos, Cambodia). One of the few surprises is that Estonia ends up in the innovation club. The second surprise in our clustering result is the fact that India is sorted into the stagnation club, despite a rather high R&D/GDP ratio. For example, India's R&D/GDP ratio is higher than that of China. The reason why in our analysis India ends up in the stagnation club is its still very low literacy rate.[30]

[28] For details on the cluster methodology see Appendix 4.7.2.

[29] The result from the cluster analysis remains qualitatively the same if we perform the cluster analysis with a reduced country sample for which R&D data is available with hardly any differences in the club membership of the countries in the two methods. The major difference is that the number of the members in the stagnation club is largely reduced because of the many missing African countries.

[30] According the UNDP's Human Development Index India's literacy rate would be somewhat higher, around 66% for the period 1999-2007. In order to be in line with the majority of the other countries we stick to the World Bank data (WDI) for the Indian literacy rate. Moreover, there are vast differences in the literacy rates within India. According to Indian census figures from 2001, literacy rates in India range from only 47% in Bihar to more than 90% in Kerala. See http://india.gov.in/knowindia/literacy.php.

Table 4.1a: Characteristics of the technology Clubs resulting from the cluster analyses, 2005-2009

cluster #		R&D expenditure (% of GDP)	Literacy rate (in %)	Average years of schooling	Number of countries	Assigned name of club	Share of total population
1	cluster mean	0.26	60.02	4.27	38	Stagnation (marginalized)	34.26
	std. dev.	0.16	14.14	1.37			
	min	*0.03 (Sambia)*	*26.2 (Mali)*	*1.24 (Mozambique)*			
	max	*0.80 (India)*	*84.2 (Syria)*	*7.50 (Ghana)*			
2	cluster mean	0.47	92.94	8.41	80	Imitation (follower)	52.24
	std. dev.	0.31	6.23	1.52			
	min	*0.04 (Saudi Arabia)*	*72.6 (Algeria)*	*4.15 (Myanmar)*			
	max	*1.40 (China)*	*99.8 (Latvia, Cuba)*	*11.49 (Hungary)*			
3	cluster mean	2.22	98.88	10.74	24	Innovation (leader)	13.50
	std. dev.	0.74	0.92	1.23			
	min	*1.12 (Estonia)*	*94.7 (Singapore)*	*8.47 (Singapore)*			
	max	*3.68 (Sweden)*	*99.8 (Estonia)*	*12.75 (Czech Republic)*			

Note: Club averages are unweighted averages based on country values. (e.g. China and Macao are two distinct reporters here). Literacy rate of population aged 15+. The three technology clubs include the following countries: Stagnation club: Cote d'Ivoire, Papua New Guinea, Haiti, Central African Republic, Congo, Dem. Rep., Mozambique, Burundi, Gambia, Senegal, Mal, Benin, Mauritania, Nepal, Bangladesh, Togo, Liberia, Pakistan, Morocco, Niger, India, Afghanistan, Rwanda, Sudan, Sierra Leone, Yemen, Rep., Guatemala, Malawi, Iraq, Syrian Arab Republic, Lao PDR, Ghana, Congo, Rep., Tanzania, Uganda, Zambia, Cameroon, Egypt, Arab Rep., Cambodia.
Imitation club: Ecuador, Latvia, Tunisia, Tonga, Maldives, Algeria, Mauritius, Belize, Romania, Cuba, Panama, Mexico, Tajikistan, Malaysia, Nicaragua, Iran, Islamic Rep., Trinidad and Tobago, El Salvador, Macao SAR, China, Jordan, Qatar, Italy, Costa Rica, Lesotho, Bolivia, Jamaica, Poland, Serbia, Bahrain, Slovak Republic, Portugal, Gabon, South Africa, Zimbabwe, United Arab Emirates, Libya, Croatia, Paraguay, Bulgaria, Venezuela, RB, Indonesia, Botswana, Kuwait, Vietnam, Namibia, Malta, Saudi Arabia, Mongolia, Swaziland, Turkey, Kazakhstan, Cyprus, Moldova, Russian Federation, China, Dominican Republic, Greece, Myanmar, Chile, Thailand, Sri Lanka, Colombia, Albania, Honduras, Argentina, Kenya, Barbados, Armenia, Brazil, Kyrgyz Republic, Philippines, Fiji, Spain, Peru, Hong Kong SAR, China, Uruguay, Guyana, Hungary, Lithuania, Ukraine.
Innovation club: Austria, Estonia, France, Canada, Singapore, Iceland, Germany, Finland, United Kingdom, United States, Australia, Korea, Rep., Czech Republic, Netherlands, Japan, Sweden, Ireland, Belgium, New Zealand, Denmark, Switzerland, Slovenia, Luxembourg, Norway.

Table 4.1b shows the differences in the clubs' means across the three variables. As can easily be seen, there is a huge difference between the innovation group (cluster 3) and the imitation group (cluster 2) in terms of R&D/GDP amounting to 1.75 percentage points which is more than three times the current value of the imitation group. In contrast, the differences between these two groups in the literacy rate and average years of schooling are less dramatic as the imitation group also scores high on these dimensions. The opposite situation can be observed when comparing the imitation club with the stagnation club as the difference in the R&D/GDP ratio is small relative to the differences in the human capital variables. Therefore it seems that the distinctive feature separating the innovation club from the imitation club is indeed primarily the R&D/GDP ratio while the imitation club and the stagnation club mainly differ in terms of human capital which we claim is relevant for a country's absorptive capacity. The differences in the clubs' means in all three dimensions are statistically significant according to standard *t*-tests.

Table 4.1b: Differences between the Technology Clubs (cluster means), 2005-2009

cluster #	R&D expenditure (% of GDP)	Literacy rate (in %)	Average years of schooling
3-2	1.75 (16.87)	5.95 (4.64)	2.33 (6.84)
3-1	1.96 (15.77)	38.86 (13.41)	6.47 (18.78)
2-1	0.20 (3.76)	32.92 (17.59)	4.14 (14.24)

Note: Differences in R&D expenditures and literacy rates in percentage points; differences in average years of schooling in years; t-values in parenthesis.

4.5 Estimating growth effects of technology spillovers

The tripartite technology cluster solution presented in the previous section is based on the assumption that countries with different characteristics benefit to varying degrees from foreign technology spillovers. In this section we investigate whether we can detect such spillovers in a growth regression framework. We associate these spillovers with the effect of a catch-up term on economic growth where this catch-up term is an interaction of the technology gap and human capital. In particular we are interested whether the strength of such growth effects from the catch-up term varies with the level of human capital.

The starting point is the traditional (Cobb-Douglas) production function. By taking logs and first differences we get:

$$(4.1) \qquad \Delta ln\, Y_{it} = \alpha \cdot \Delta ln\, K_{it} + \beta \cdot \Delta ln\, L_{it} + \Delta ln A_{it} + \varepsilon_{it}$$

where ΔlnY_{it} is the growth rate of GDP of country *i* in period *t*, ΔlnK_{it} is the growth rate of the physical capital stock, ΔlnL_{it} is the growth rate of labour and ΔlnA_{it} is total productivity productivity growth. ε_{it} denotes the error term.

In line with the growth literature following Benhabib and Spiegel (1994) which stresses the (mainly indirect) role of human capital for the growth process through the impact on productivity growth we assume the following law of motion for productivity:

$$(4.2) \qquad \Delta \ln A_{it} = \gamma + \delta \cdot \mathrm{H}_{it} + \phi \cdot \left(H_{it} \cdot \left(\frac{A_t^{max} - A_{it}}{A_t^{max}} \right) \right)$$

Equation (4.2) assumes that the change in productivity depends on the *stock* of human capital, H_{it} which we proxy by the average years of schooling and the interaction of human capital and the technology gap, $\left(\frac{A_t^{max}-A_{it}}{A_t^{max}}\right)$. This interaction term forms the catch-up term. In the catch-up term the human capital stock serves as a proxy for the absorptive capacity which according to Cohen and Levinthal (1989, p. 569), is the *"ability to identify, assimilate, and exploit knowledge from the environment"* – in our case from other countries. Many other variables may matter for absorptive capacity but here we want to focus on human capital as enabling factor for technology spillovers.

There are also alternative definitions of the technology gap in the literature. We opt for calculating country *i*'s technology gap as the difference between the technologically leading country's productivity and the productivity of country *i*, divided by the leader's productivity. In our sample the United States is the technology leader throughout the periods. The productivity of country *i* is derived from the Cobb-Douglas production function following Hall and Jones (1999) yielding $\mathrm{A}_i = \frac{\frac{Y_i}{L_i}}{\left(\frac{K_i}{Y_i}\right)^{\frac{\alpha}{1-\alpha}}}$.

Using human capital as proxy for a country's absorptive capacity implies that human capital has a double role: it feeds directly into productivity growth but it is also relevant for the potential spillovers that arise from the technology gap.

As common in the literature (e.g. Benhabib and Spiegel, 2005; Crespo et al., 2004) we interpret the catch-up term as proxy for country's ability to absorb spillovers.

Combining equation (4.2) with equation (4.1) yields the following growth regression:

$$(4.3) \qquad \Delta ln\, Y_{it} = \gamma + \alpha \cdot \Delta ln\, K_{i,t} + \beta \cdot \Delta \ln L_{i,t} + \delta \cdot \mathrm{H}_{i,t-1} + \phi \cdot \left(H_{i,t-1} \cdot GAP_{i,t-1}\right) + \eta_t + \mu_i + \varepsilon_{i,t}$$

where $GAP_{i,t-1}$ is defined as $\left(\frac{A_{t-1}^{max}-A_{i,t-1}}{A_{t-1}^{max}}\right)$ and $\left(H_{i,t-1} \cdot GAP_{i,t-1}\right)$ is the catch-up term. In our empirical application we use lagged values of the human capital stock as well as the technology gap and we include time dummies (η_{it}) and country dummies (μ_{it}).

In this specification the main variable of interest is the catch-up term. The coefficient of the catch-up term is intended to capture the growth effect induced by international technology spillovers. Obviously, we expect a larger growth effect for countries with a large technology gap (as they have the highest potential for international technology spillovers) and larger human capital stocks (as they have higher absorptive capacity). In other words we expect a positive sign for the coefficient ϕ.

The main contribution of this paper is the use of threshold regressions to take into account that the growth effect from spillovers depends on the level of absorptive capacity, proxied by human capital. This is why in the threshold regression framework we chose human capital to be the threshold variable. This means that during the estimation process the sample is split into two (or more) sub-samples. The countries are allocated into the respective sub-sample on the basis of their human capital stock. Countries with levels of human capital below a certain threshold are allocated into a first sub-sample (low regime) and countries with human capital stocks above the threshold form the second sub-sample (high regime). The sample splitting allows introducing non-linearities in any dependent variable.

Two models are tested in the threshold regression framework. The two models differ with respect to the choice of the variable capturing the growth effect from spillovers. In equation (4.3) the catch-up term is intended to capture the growth effect of spillovers. In the first version we deviate from the law of motion for productivity in (4.2) by replacing the catch-up term with the technology gap. Hence, instead of building an interaction term between the technology gap and human capital we directly use the coefficients of the technology gap variable to measure the catch-up effects. The reason for this is that in the threshold regression framework the non-linearity in the effect of the technology gap on economic growth introduced by the interaction term is replaced in the threshold regression framework by allowing for different coefficients of the technology gap depending on the level of human capital. In other words, in this model the non-linearity in the technology gap arises from the fact that the coefficients of the technology gap may be different for the sub-samples which result from the sample-split.

In the threshold regression framework the first spillover model takes the form:

$$(4.4) \qquad \Delta ln\, Y_{it} = \gamma + \alpha \cdot \Delta ln\, K_{it} + \beta \cdot \Delta ln\, L_{it} + \delta \cdot \mathrm{H}_{i,t-1} + \theta_1 \cdot \left(GAP_{i,t-1}\right)\left(if\ \mathrm{H}_{i,t-1} \leq \lambda\right) + \theta_2 \cdot \left(GAP_{i,t-1}\right)\left(if\ \mathrm{H}_{i,t-1} > \lambda\right) + \eta_t + \mu_i + \varepsilon_{it}$$

where λ denotes the threshold in the human capital variable which is going to be decided during the estimation process.

The second model we estimate with threshold regressions is that in equation (4.3). This model is closer to the theoretical model but it is noteworthy that this model contains two non-linearities. The first non-linearity is built in the catch-up term because it is an interaction between the technology gap and absorptive capacity (human capital). The second non-linearity is introduced by the thresholds in human capital which allows for different coefficients of the catch-up term for countries with high and low levels of human capital.

$$(4.4') \qquad \Delta ln\, Y_{it} = \gamma + \alpha \cdot \Delta ln\, K_{it} + \beta \cdot \Delta ln\, L_{it} + \delta \cdot \mathrm{H}_{i,t-1} + \phi_1 \cdot \left(\mathrm{H}_{i,t-1} \cdot GAP_{i,t-1}\right)\left(if\ \mathrm{H}_{i,t-1} \leq \lambda\right) + \phi_2 \cdot \left(\mathrm{H}_{i,t-1} \cdot GAP_{i,t-1}\right)\left(if\ \mathrm{H}_{i,t-1} > \lambda\right) + \eta_t + \mu_i + \varepsilon_{it}$$

Before turning to the threshold regressions the results of the ordinary least square (OLS) estimation of the model in equation (4.3) are presented.

4.5.1 Results from OLS regressions

The sample is a balanced panel of 76 countries (see Table 4.A.2 in the Appendix) for the time span 1980-2009 where we divide this time span into six 5-year periods. Since the model is estimated in (log) differences the panel has the dimensions *i=76* and *t=5*. The variables that enter the equation in levels, i.e. human capital, the technology gap and the catch-up term, enter the regression in one period lagged form. In combination with the use of 5-year periods we hope to limit the potential endogeneity problem. For the capital stock and labour the endogeneity is reduced by the fact that first differences are used.

The results from the OLS panel regression of the model in equation (4.3) are presented in Table 4.2. In columns (1) and (2) we estimate a pooled version of equation (4.3) but since the results are qualitatively similar we can immediately proceed to the fixed effects results (columns 3-5).

Table 4.2: OLS estimation of growth effects from spillovers

Dependent variable: 5-year GDP growth rate ($\Delta \ln Y_{i,t}$)					
	Pooled		Fixed effects		
	base	full	base	full	productivity gap
	(1)	(2)	(3)	(4)	(5)
$\Delta \ln K_{i,t}$	0.4854*** (0.035)	0.4802*** (0.035)	0.4157*** (0.065)	0.4320*** (0.063)	0.4323*** (0.063)
$\Delta \ln L_{i,t}$	0.2312** (0.097)	0.2076* (0.105)	0.3846** (0.173)	0.3848** (0.171)	0.3824** (0.167)
$H_{i,t-1}$	-0.0039* (0.002)	0.0046 (0.005)	-0.0601 (0.014)	-0.0124 (0.016)	-0.0103 (0.011)
$(HxGAP)_{i,t-1}$	0.0092*** (0.003)	0.0001 (0.006)	0.0610*** (0.011)	0.0026 (0.020)	
$(GAP)_{i,t-1}$		0.0935 (0.063)		0.8161*** (0.255)	0.8446*** (0.142)
constant	0.0607* (0.021)	-0.0221 (0.051)	0.2339 (0.097)	-0.4407** (0.198)	-0.4643*** (0.141)
time dummies	no	no	yes	yes	yes
country dummies	no	no	yes	yes	yes
F-test	70.207	58.978	12.167	12.311	13.792
R^2	0.421	0.423	0.595	0.606	0.606
R^2-adj.	0.415	0.415	0.482	0.494	0.496
Obs.	380	380	380	380	380

*Note: Robust standard errors in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% level respectively.*

In the base specification we include the (lagged) catch-up term to measure growth effects from a human capital stock adjusted technology gap[31].

The results are largely as expected: we find a positive and statistically highly significant effect for the growth rate of the capital stock on GDP growth. Specification (3) suggests that a 1 percentage point increase in the growth of the capital stock increases the GDP growth by 0.42 percentage points.[32] The coefficient of the growth rate of the labour force is also positive, statistically significant and economically large[33]. The stock of human capital is positive but not statistically significant, a result often found in growth regressions including human capital.

Most importantly, however, the model yields a positive and statistically highly significant coefficient for the catch-up variable $(H_{i,t-1} \cdot GAP_{i,t-1})$. The positive sign of the catch-up term's coefficient suggests that the growth effect from the technology gap is the greater the higher the country's level of human capital is. This suggests that there is on the one hand a great potential for catching-up of countries with low productivity (high technology gap). On

[31] The specifications including interaction terms use centred values of $H_{i,t-1}$ and $GAP_{i,t-1}$.

[32] This growth effect appears to be large but remember that we use 5-year periods.

[33] In the growth literature population or labour force typically does not have strong growth effects. This may have to do with the fact that much of the literature uses GDP per capita as dependent variable while our dependent variable is GDP.

the other hand, the lack of human capital (absorptive capacity) may significantly reduce the strength of such a catch-up process or even prevent it.

Since the catch-up variable in specification (3) is an interaction term, the effect of the technology gap on GDP growth is non-linear (depending on the level of human capital) and cannot be read directly from the coefficient of the catch-up variable which is estimated to be 0.061.

The coefficient of the catch-up term implies that at the average level of human capital in the sample (6.7 years of schooling), the growth effect of a 1 unit change in the technology gap is about 0.41 percentage points (0.061(coefficient) x 6.7(average value of human capital) x 0.01(Δtechnology gap)). In comparison, with a human capital stock of 3.4 year – which corresponds to Cote d'Ivoire's stock in the period 2005-2009 – the growth effect of a 1 unit change in the technology gap is suggested to be about 0.21 percentage points.

The logic applied here to calculate the effect of the technology gap is in line with the interpretation of interaction effects. However, from an econometric point of view specification (3) is not ideal because it does not include the technology gap.[34] Therefore specification (4) presents a 'full' model which includes the technology gap next to the catch-up variable.

In this specification the productivity gap is statistically significant at the one percent level. The catch-up term is also positive but it is not statistically significant. In principle, this indicates that there is no additional effect of human capital on the growth effect of the technological spillovers. However, given that specification (3) corresponds more closely to the empirical model in equation (4.3) we will also estimate it in the threshold regression framework (cf. equation 4.4').

Finally, we also test the model that omits the catch-up variable. This is done in specification (5) where a statistically significant coefficient similar in magnitude to that in specification (4) is found. The size of the coefficient of the technology gap suggests that a 1% increase in the technology gap is associated with 0.84 percentage point higher GDP growth. Again, it should be noted that this large effect applies to 5-year growth rates. Of course, specification (5) does not capture the indirect effect of human capital on growth through technology spillovers. An alternative interpretation would be that the positive coefficient on the technology gap variable may just indicate that countries which are further away from the technological frontier tend to grow faster. The technology gap in specification (5) is in a way the counterpart of the initial income term in neo-classical growth regressions as these two variables are highly correlated. Neo-classical growth regressions à la Mankiw et al. (1992) interpret the coefficient of the income variable as indicating out-of-steady-state-convergence of countries with the same technology. In contrast, in the endogeneous growth framework, the process of convergence is triggered by a catch-up in the productivity level of technologically backward countries. This is why we associate the

[34] In principle, a regression model containing an interaction term should also include the main effect, i.e. the variables used for building the interaction term (see e.g. Jaccard and Turrisi, 2003).

coefficient of the technology gap in the econometric model with technological catching-up induced by international spillovers.[35]

4.5.2 Results from threshold regressions

We now turn to the estimation of the growth effects of spillovers using the threshold regression model presented in equations (4.4), the 'productivity gap model', and (4.4'), the 'catch-up model'.[36]

We start with the 'productivity gap model'. As pointed out above the threshold model allows for non-linearities in the growth effects stemming from the productivity gap because we allow for different coefficients for groups of countries which are distinguished by their human capital level. Relating this to the theory of technology clubs we would expect such a threshold somewhere at the lower range of the distribution of human capital stocks. Such a threshold separates the sample into a low and a high regime where we associate the low regime with the stagnation club.

Potentially we may also find further thresholds. In particular we may find a threshold which can be related to the separation of the imitation and the innovation club. Such a model with two thresholds, (λ_1) and (λ_2) corresponds to three distinct regimes with respect to the growth effect of the technology gap $(\theta_1, \theta_2$ and $\theta_3)$. Associating the low, the medium and the high regimes with the stagnation club, the imitation club and the innovation club we expect the highest growth effects from international spillovers for the imitation group.

Note that the threshold (or thresholds) are not pre-determined but is (are) selected in the course of the estimation process by repeatedly estimating the model each time with the potential threshold set at a different level of human capital. To our knowledge, this way of detecting and determining boundaries between the potential technology clubs has not been undertaken in the club convergence literature.

The threshold regression framework requires the estimation of the model with thresholds at each percentile of the data, where we limit the search range to the 10^{th} and 90^{th} percentile of the data in order to ensure a sufficient amount of observations in each group. The final threshold is found by comparing the explanatory power of the models and selecting the model with the lowest sum of squared errors.

The results from the threshold regression for the technology gap model are shown in Table 4.3. Column (I.1) shows that the data suggests a first threshold at the 17^{th} percentile of the human capital values which corresponds to approximately 3.7 years of schooling. The coefficients of the productivity gap are positive for both the low and the high regime. This corresponds to the pattern we expected: the growth effects from spillovers for countries with human capital (absorptive capacity) above the threshold are higher than those for countries

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35 For a discussion of different interpretation of growth regressions in the neo-classical growth framework and the endogenous growth framework see Klenow and Rodriguez-Clare (1997).

36 The two models contain the productivity gap and the catch-up term for capturing international technology spillovers respectively. The model containing the productivity gap corresponds to the OLS results of specification°(5) in Table 4.2 and the model with the catch-up term corresponds to specification (3) in Table 4.2.

below the threshold. However, given that we associate the low regime with the stagnation club the growth effects for the countries of the low regime are still of considerable size.

Table 4.3: Threshold regression – Productivity gap model

Dependent variable: 5-year GDP growth rate ($\Delta \ln Y_{i,t}$)		
Threshold variable: period lagged human capital ($H_{i,t-1}$)		
	Threshold variable	
	$H_{i,t-1}$	$H_{i,t-1}$
	Threshold 1	Threshold 2
Variables	(I.1)	(I.2)
$\Delta \ln K_{i,t}$	0.443***	0.422***
	(0.063)	(0.064)
$\Delta \ln L_{i,t}$	0.345**	0.386**
	(0.169)	(0.168)
$H_{i,t-1}$	-0.0163	-0.0114
	(0.011)	(0.011)
$GAP_{i,t-1}$ low regime	0.752***	0.794***
	(0.146)	(0.136)
$GAP_{i,t-1}$ medium regime		0.835***
		(0.131)
$GAP_{i,t-1}$ high regime	0.808***	0.769***
	(0.141)	(0.136)
constant	-0.386***	-0.431***
	(0.139)	(0.132)
F-stat	12.89	13.12
R^2	0.615	0.620
Threshold	3.743	8.401
Percentile	17	70
P-value	0.013	0.000
Obs.	380	380

Dependent variable: 5-year GDP growth rate ($\Delta \ln Y_{i,t}$)		
Threshold variable: period lagged human capital ($H_{i,t-1}$)		
	Threshold variable	
	$H_{i,t-1}$	$H_{i,t-1}$
	Threshold 1	Threshold 2
Variables	(II.1)	(II.2)
$\Delta \ln K_{i,t}$	0.446***	0.423***
	(0.063)	(0.065)
$\Delta \ln L_{i,t}$	0.346**	0.387**
	(0.170)	(0.168)
$H_{i,t-1}$	-0.016	-0.0106
	(0.011)	(0.011)
$PAT_{i,t-1}$	0.138	0.0273
	(0.269)	(0.235)
$GAP_{i,t-1}$ low regime	0.758***	0.796***
	(0.149)	(0.138)
$GAP_{i,t-1}$ medium regime		0.837***
		(0.134)
$GAP_{i,t-1}$ high regime	0.814***	0.770***
	(0.145)	(0.140)
constant	-0.395***	-0.438***
	(0.141)	(0.132)
F-stat	11.43	12.47
R-squared	0.614	0.619
Threshold	3.743	8.401
Percentile	17	70
P-value	0.010	0.000
Obs.	379	379

*Note: All estimations include country fixed and time fixed effects. Robust standard errors in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% level respectively.*

Table 4.3 also reports *p*-values which are derived from a likelihood test testing the hypothesis that the estimated coefficients obtained for the low and the high regime are the same. Hence the hypothesis to be tested is:

$$H_0: \phi_1 = \phi_2$$

where ϕ_1 and ϕ_2 are the estimated coefficients of the productivity gap term for the low and the high regime respectively. The null-hypothesis is tested by a likelihood ratio test. This likelihood ratio test has the following form:

$$F = i \cdot t \cdot \frac{RSS^{linear\ model} - RSS^{threshold\ model}}{RSS^{threshold\ model}}$$

where *F* is the value of the likelihood test, $RSS^{linear\ model}$ is the residual sum of squares from the linear model (i.e. the model without a threshold) and $RSS^{threshold\ model}$ is the residual sum of squares from the threshold model. The sample size is given by the number of countries, *i*, multiplied by the number of time periods, *t*.

For obtaining a test statistic for this likelihood test a bootstrap approach is employed. For this predicted values from the actual data are generated. These predicted values are used for the bootstrap procedure in which *i* times *t* fitted values are drawn (with replacement) from the sample containing the fitted values. These fitted values serve as dependent variables and are combined with the actual data for the explanatory variables. With this simulated data set both the threshold model and the linear model are estimated. As with the actual data, the likelihood ratios are calculated for these simulated data. This bootstrap procedure is repeated 1000 times.

The *p*-values reported in Table 4.3 are obtained by counting the number of cases where the value of the likelihood ratio test of the simulated ($F_{simulated}$) exceeds the value of the likelihood ratio test of the actual data (F_{actual}):

$$p - value = \sum_{b=1}^{1000} \frac{t_b}{1000} \qquad with \quad \begin{array}{l} t_b = 1\ if\ F_{simulated} > F_{actual} \\ t_b = 0\ \ else \end{array}$$

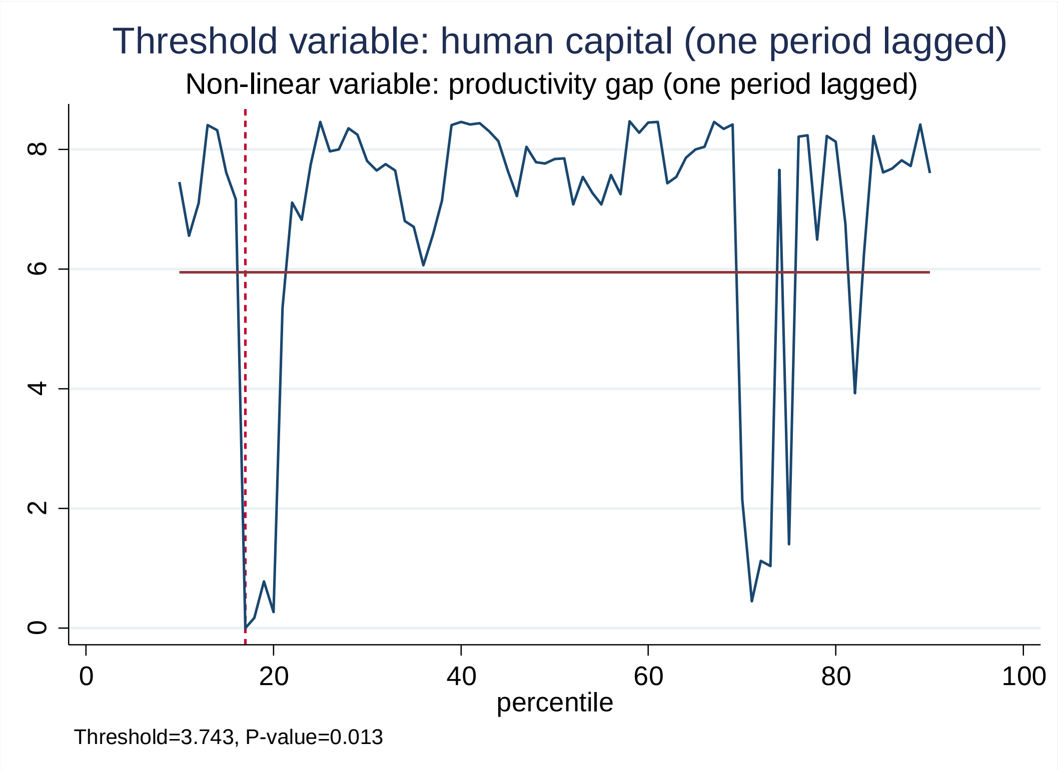
The *p*-value for the first threshold is 0.006 which implies that the estimated coefficients of the catch-up term are significantly different from each other even at the 1 percent level.

After the inspection of the estimated coefficients we may also check how precisely the threshold itself is estimated. The graph in Figure 4.1 shows likelihood ratios for models with alternative thresholds and the confidence intervals of the estimated threshold. The graph is obtained by performing a likelihood ratio test. This test consists of estimating equation (4.4) with the threshold imposed alternatively at each of the percentiles in the range of the 10th to the 90th percentile. In the actual likelihood test the residual sum of squares of the models with the alternative thresholds are compared with that of the threshold found in the estimation process. The horizontal line at the value of 5.94 is the critical value for the likelihood ratio at the 10% level of significance, provided by Hansen (2000). The graph in Figure 4.1 represents the likelihood ratio that results from the likelihood ratio test that compares the selected model with the model setting the threshold at the respective percentile. For all alternative models with likelihood values above this critical value of 5.94 we have a 90% probability that the fit of the selected model is significantly better, i.e. the alternative models have significantly larger residual sums of squares than the selected model. More precisely the likelihood ratio test for obtaining the confidence intervall has the following form

$$LR_p = i \cdot t \cdot \frac{RSS_p^{threshold\ model} - RSS_{selected}^{threshold\ model}}{RSS_{selected}^{threshold\ model}} \quad for\ all\ p \in\ [10{,}90]$$

where LR_p is the value of the likelihood ratio test with the threshold set at the p^{th} percentile of the data.

Figure 4.1: Likelihood ratio of the threshold



In our case the threshold at the 17th percentile is estimated rather precisely because both to the left and to the right of the 17th percentile the likelihood ratios of alternative models (i.e. models with the threshold at neighbouring percentiles) increase quickly and surpass the critical value in close vicinity of the 17th percentile. However, the confidence interval is very broad, reaching from shortly below the 20th percentile (where the graph and the line intersect the first time) to about the 75th percentile of the data. The reason for this very broad confidence interval is a drop in the likelihood ratio between the 70th and 80th percentile. This indicates that it is worth searching for an additional threshold.

The results from the threshold regression that allows for an additional threshold are reported in column (I.2) in Table 4.3.

The second threshold splits the sample of countries above 3.7 years of schooling into two further regimes (medium and high). The threshold is suggested to be at the 70th percentile corresponding to approximately 8.4 years of schooling. This results into a splitting of the sample into three distinct regimes. As can be seen the model finds the largest coefficient on the technology gap variable for the medium regime, amounting to 0.835. For the high regime, i.e. the countries with the highest level of human capital the coefficient is found to be the lowest (0.769). In the two-threshold model (specification I.2) the coefficient for the low regime (stagnation club) is somewhat larger than in the one-threshold model, amounting to 0.794. As pointed out before, this is lower than for the imitation club but still rather high.

Table 4.4 presents a variant of the productivity gap model where the patenting intensity – the number of patent applications per millions of GDP – is included in the regression as an additional control variable. This is an indicator of the technological capacity of a country but it does not turn out to be significant. The inclusion of the patent intensity affects neither the estimated coefficient of the technology gap nor the selection of the thresholds. However, despite the insignificance of the patent variable it can be used as threshold variable – instead of the human capital variable. This deviates from the model which suggests that the absorptive capacity depends on human capital. Moreover, the threshold variables can also be mixed.

Table 4.4: Threshold regression – Productivity gap model with alternative threshold variables

Dependent variable: 5-year GDP growth rate *(Δ ln $Y_{i,t}$)* Threshold variable: one period lagged patent intensity (*$PAT_{i,t-1}$*)/human capital (*$H_{i,t-1}$*)		
	Threshold variable	
	$PAT_{i,t-1}$	$PAT_{i,t-1}$
	Threshold 1	Threshold 2
Variables	(III.1)	(III.2)
Δ ln $K_{i,t}$	0.435***	0.453***
	(0.064)	(0.063)
Δ ln $L_{i,t}$	0.355**	0.371**
	(0.164)	(0.163)
$H_{i,t-1}$	-0.00816	-0.0129
	(0.011)	(0.012)
$PAT_{i,t-1}$	-0.115	0.119
	(0.342)	(0.270)
$GAP_{i,t-1}$ low regime	0.858***	0.835***
	(0.146)	(0.145)
$GAP_{i,t-1}$ medium regime		0.885***
		(0.147)
$GAP_{i,t-1}$ high regime	0.944***	0.849***
	(0.148)	(0.149)
constant	-0.497***	-0.452***
	(0.144)	(0.141)
F-stat	12.58	10.75
R^2	0.617	0.614
Threshold	0.021	0.003
Percentile	66	39
P-value	0.003	0.011
Obs.	379	379

Dependent variable: 5-year GDP growth rate *(Δ ln $Y_{i,t}$)* Threshold variable: one period lagged patent intensity (*$PAT_{i,t-1}$*)/human capital (*$H_{i,t-1}$*)		
	Threshold variable	
	$H_{i,t-1}$	$PAT_{i,t-1}$
	Threshold 1	Threshold 2
Variables	(IV.1)	(IV.2)
Δ ln $K_{i,t}$	0.446***	0.436***
	(0.063)	(0.064)
Δ ln $L_{i,t}$	0.346**	0.345**
	(0.170)	(0.166)
$H_{i,t-1}$	-0.016	-0.0146
	(0.011)	(0.011)
$PAT_{i,t-1}$	0.138	-0.0099
	(0.269)	(0.300)
$GAP_{i,t-1}$ low regime	0.758***	0.781***
	(0.149)	(0.149)
$GAP_{i,t-1}$ medium regime		0.827***
		(0.144)
$GAP_{i,t-1}$ high regime	0.814***	0.885***
	(0.145)	(0.147)
constant	-0.395***	-0.419***
	(0.141)	(0.142)
F-stat	11.43	11.19
R^2	0.614	0.617
Threshold	3.743	0.021
Percentile	17	66
P-value	0.0100	0.075
Obs.	379	379

*Note: All estimations include country fixed and time fixed effects. Robust standard errors in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% level respectively.*

In the first specification of Table 4.4 (III.1 and III.2) the patent intensity is used as threshold variable in the search for both thresholds. The results differ slightly from the original specification. The upper threshold is found to be at the 66th percentile of the data (instead of the 70th) and the lower threshold is found at the 39th percentile of the data – considerably higher than in the original model that uses human capital as the threshold variable. Note also, that the sequence of finding the thresholds is reversed as the data now decides the first threshold to be the higher one of the two. Importantly, however, the pattern of the coefficients for the technology gap is the same. In particular, the coefficient of the low regime, i.e. the stagnation club, is lower than that of the intermediate regime, the imitation club. The second specification in Table 4.4 (IV.1 and IV.2) is a 'mixed approach' that uses the human capital variable as the threshold variable for the search of the first threshold but is then looking for the second threshold using the patent intensity variable. As already known from Table 4.3, the first threshold in this case is found at the 17th percentile. The second threshold is found at the 66th percentile of the data (now ordered by patent intensity) which also corresponds to the percentile found in specification III. The coefficient is again lowest for the low regime which confirms the prediction from the theory of convergence clubs. However, the estimated growth effect from the technology club in this case is slightly higher for the high regime than the medium regime. With the exception of this switch in the relative size of the coefficients between the medium and the high regime, the additional specifications in Table 4.4 confirm the results from the original specification.

To summarise, the threshold regression results from the productivity gap model suggest that countries with lower productivity tend to grow faster but that the extent to which countries can capitalise on their "advantages from backwardness" depends on their level of human capital. Above all, the countries in the low regime, i.e. those below the lower threshold, reap lower growth effects from their productivity gap than those in the medium regime.

Hence, in line with the idea of technology clubs the countries with intermediate levels of human capital benefit most strongly from their technology gap in terms of the growth effect from spillovers. The members of the innovation club – according to our estimates – also benefit from technology spillovers though to a lesser extent than the imitation group (except for the mixed threshold variable model). The results are generally in line with the idea of convergence clubs except for one aspect. This is the fact that the countries with the lowest level of human capital are found to have positive growth effects from spillovers which does not really fit the idea of a stagnation club.

We now turn to the catch-up model and employ the same threshold regression approach as for the productivity gap model (see equation 4.4). We return to the original idea that human capital is the key determinant of absorptive capacity and therefore use the human capital variable as the threshold variable. The results are shown in Table 4.5. Two types of results are presented. The first specification in Table 4.5 (V.1 and V.2) uses the human capital and technology gap variables in their original form, i.e. in their non-centred form. The inclusion of the interaction term normally demands centring the variables but we first use the original versions in order to make them comparable to the productivity gap model. The second specification (VI.1 and VI.2) then uses the centred variables.

Table 4.5: Threshold regression – Catch-up model

Dependent variable: 5-year GDP growth rate (Δ *ln* $Y_{i,t}$) Threshold variable: one period lagged human capital ($H_{i,t-1}$)		
	Threshold variable	
	$H_{i,t-1}$ Threshold 1	$H_{i,t-1}$ Threshold 2
Variables	(V.1)	(V.2)
Δ ln $K_{i,t}$	0.426***	0.441***
	(0.065)	(0.064)
Δ ln $L_{i,t}$	0.342*	0.349**
	(0.175)	(0.175)
$H_{i,t-1}$	-0.0616***	-0.0644***
	(0.014)	(0.015)
$H_{i,t-1}$ x $GAP_{i,t-1}$ low	0.0404***	0.0417***
	(0.015)	(0.015)
$H_{i,t-1}$ x $GAP_{i,t-1}$ medium		0.0561***
		(0.011)
$H_{i,t-1}$ x $GAP_{i,t-1}$ high	0.0559***	0.0648***
	(0.011)	(0.013)
constant	0.277***	0.285***
	(0.098)	(0.098)
F-stat	11.27	10.02
R^2	0.603	0.606
Threshold	3.743	9.398
Percentile	17	82
P-value	0.036	0.000
Obs.	380	380

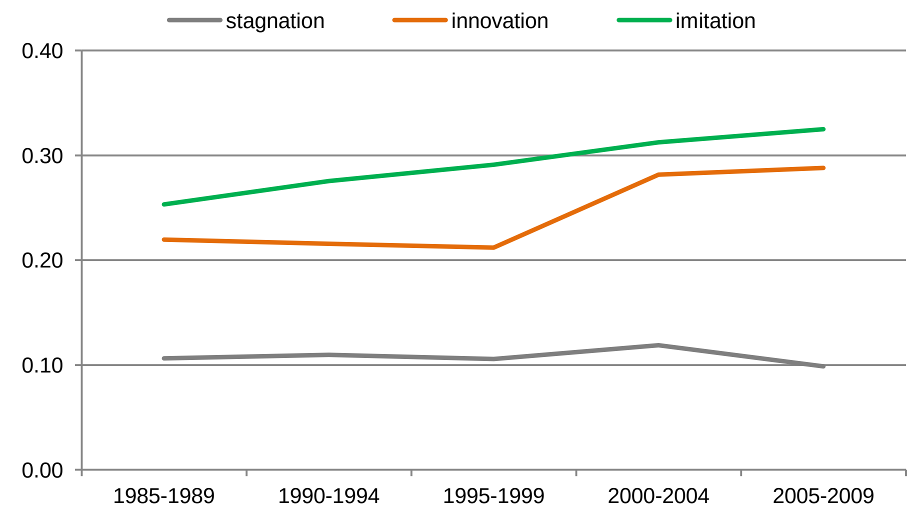
Dependent variable: 5-year GDP growth rate (Δ *ln* $Y_{i,t}$) Threshold variable: one period lagged human capital ($H_{i,t-1}$) (centred values)		
	Threshold variable	
	$H_{i,t-1}$ Threshold 1	$H_{i,t-1}$ Threshold 2
Variables	(VI.1)	(VI.2)
Δ ln $K_{i,t}$	0.403***	0.417***
	(0.065)	(0.065)
Δ ln $L_{i,t}$	0.295*	0.332*
	(0.170)	(0.171)
$H_{i,t-1}$	-0.004	-0.002
	(0.012)	(0.012)
$H_{i,t-1}$ x $GAP_{i,t-1}$ low	-0.066	-0.076
	(0.050)	(0.051)
$H_{i,t-1}$ x $GAP_{i,t-1}$ medium		0.159***
		(0.027)
$H_{i,t-1}$ x $GAP_{i,t-1}$ high	0.113***	0.118***
	(0.024)	(0.022)
constant	0.141***	0.138***
	(0.023)	(0.022)
F-stat	9.43	9.97
R-squared	0.582	0.589
Threshold	-0.472	3.339
Percentile	46	90
P-value	0.009	0.000
Obs.	380	380

*Note: All estimations include country fixed and time fixed effects. Robust standard errors in parenthesis. ***, **, * indicate statistical significance at the 1%, 5% and 10% level respectively.*

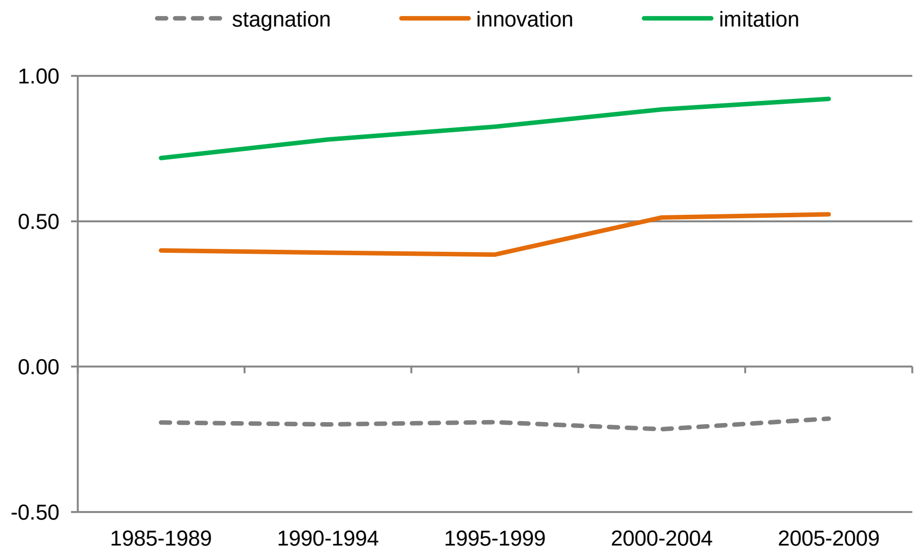
In the specification with the original values of human capital and the technology gap, the first threshold is found at the 17th percentile of the data which is identical to the one in the productivity gap model. The second threshold is set at the 82nd percentile of the data, somewhat higher than in the productivity gap model. The coefficients of the catch-up term – which now captures the growth effects from technological spillovers – are statistically significant at the 1% level for all three regimes. The magnitude of the coefficients is increasing, amounting to 0.0417 for the low regime, 0.0561 for the medium regime and 0.0648 for the high regime. However, given that the catch-up variable is an interaction term, the elasticity of the catch-up term with respect to GDP growth (i.e. the growth effect of technology spillovers) cannot be read off directly from the coefficient. Rather, it has to be evaluated at the respective level of human capital (see also Crespo et al., 2004). We do this for the average of each of the groups in each of the six 5-year periods in the sample, applying the group-specific coefficients resulting from the threshold regressions. This highlights the double non-linearity incorporated in the catch-up threshold model. The elasticities of the catch-up term with respect to GDP growth are shown in Figure 4.2.

Figure 4.2: Elasticities of the catch-up term with respect to GDP growth by technology club

Original values of lagged human capital and the technology gap



Centred values of lagged human capital and the technology gap



Note: The figures are based on the regime-specific estimated coefficients for the catch-up term in specifications V.2 (upper panel) and VI.2 (lower panel) in Table 4.5 evaluated at the (unweighted) average of the three regimes. Solid lines indicate statistically significant coefficients at least at the 10% level; dashed lines indicate that coefficients are not statistically significant.

The upper panel refers to the results from specification V.2 in Table 4.5. As can be seen, this elasticity is highest for the imitation club (medium regime) growing from 0.25 in the period 1980-1984 to 0.32 in the period 2005-2009. This increase is due to the fact that the human capital variable is trending upwards over time. Note, however, that there is no such upward trend elasticity of the catch-up variable for the stagnation club (low regime) which is also much smaller in magnitude (about 0.10). For the innovation club, the magnitude of the elasticity of the catch-up term is between the other two clubs, ranging from 0.22 to 0.29. Hence, also in the catch-up model the result confirms nicely the predictions of the convergence club theory. The main difference to the productivity gap model is that the growth effects of the international spillovers are estimated to be much lower. These changes in the catch-up model using centred values of human capital and the productivity gap (specification VI.1 and VI.2). The 'ranking' of the coefficients of the three regimes remains unchanged but there is one major difference: the coefficient of the low regime (stagnation club) is negative and not statistically significant. The coefficients of the two other regimes remain statistically significant. This specification, however, is very different from all other specifications with regards to the identified thresholds. According to specification VI., the first threshold separating the low regime from the medium regime is estimated to be at the 46th percentile which is much higher than in the other models. The second threshold separating the medium regime from the high regime is detected at the 90th percentile which is at the upper boundary of the search range defined in the threshold regression procedure. We can again retrieve the elasticity of the catch-up term with respect to GDP growth for each of the three regimes by evaluating them at the group averages. The result is shown in the lower panel of Figure 4.2. Again, the growth effects of the catch-up term are highest for the imitation group. For the imitation club the effect is comparable in size to that of the productivity gap; it is lower in the earlier periods and higher in the later periods. The distance to the innovation club is now larger and the effect of the stagnation club is negative though not statistically significant which is why the line for this group is dashed.

The estimated coefficients of the catch-up term in specification VI. fit best with the idea of different growth regimes for a stagnation, an imitation and an innovation club, in particular because the coefficient of the stagnation club turns out to be not statistically significant.

4.6 Conclusions

In this paper we clustered countries into three distinct groups of countries on the basis of their innovative and absorptive capacities. In line with theoretical models of technology clubs we termed these clusters innovation club, imitation club and stagnation club. There are large differences in the mean values of the innovation and absorptive capacity (human capital) variables used in the cluster analysis. The differences are particularly pronounced in the human capital variable when comparing the stagnation and the imitation group. Along the R&D dimension the differences are larger between the innovation and the imitation group.

In the growth regression framework we introduce the idea of technology clubs by letting the strength of the growth effect of the technology spillover vary with the level of human capital – our proxy for absorptive capacity. We do this by allowing for thresholds in the human capital variable. Hence, the threshold regression technique introduces the indirect growth effects of human capital which work through the absorption of technology spillovers by allowing different coefficients for different groups of countries for either the productivity gap or the catch-up term. We use these two variables as alternative proxies for the ability of a country to absorb international technology spillovers.

Importantly, the thresholds that distinguish the country groups or clubs are determined by the data in the course of the estimation process. The results from the threshold regressions suggest that the growth effects from international technology spillovers are strongest for countries with an intermediate level of human capital. Countries with very low levels of absorptive capacity benefit to a lesser extent from such catch-up effects. In the productivity gap model, the growth effects are still considerably large, whereas in the catch-up model the growth effects from technology spillovers are smaller or even insignificant. Apart from the catch-up model using centred variables of human capital and the productivity gap, the lower threshold is quite consistently estimated to be at the 17th percentile of the data. There is some variation in the position of the second threshold but in most specifications it is found to be at the 70th or the 82nd percentile. The lower threshold which separates the stagnation club from the imitation club is estimated to at a rather low level (the 17th percentile is at 3.7 years of schooling) which is due to the fact that African countries and other developing countries are underrepresented in our sample due to data constraints. Nevertheless the lower threshold is estimated quite robustly which we read as strong empirical support for the theory of convergence clubs. Despite the general support for the theory of convergence clubs, there are two potential contradictions with the notion of distinct stagnation, imitation and innovation clubs. The first issue is that the growth effects from spillovers for the stagnation club are rather large. The second issue is that the difference in the growth effect from spillovers between the imitation and the innovation club is rather small, at least in the productivity gap model and that some countries are switching clubs. The switching between regimes is due to the upward trending human capital variable. A regime switch can be explained by policy changes which lead to the elimination of impediments to growth which caused the country to end up in a low equilibrium.[37] We leave the inclusion of policy changes and their relevance for regimes switches between convergence clubs for future research.

[37] One such change in policy would be the introduction of a free trade regime.

4.7 Appendix

Appendix 4.7.1: Country lists

Table 4.A.1: List of countries in cluster analysis

WB code	Country	WB code	Country	WB code	Country
AFG	Afghanistan	GUY	Guyana	NOR	Norway
ALB	Albania	HKG	Hong Kong SAR, China	NPL	Nepal
ARE	United Arab Emirates	HND	Honduras	NZL	New Zealand
ARG	Argentina	HRV	Croatia	PAK	Pakistan
ARM	Armenia	HTI	Haiti	PAN	Panama
AUS	Australia	HUN	Hungary	PER	Peru
AUT	Austria	IDN	Indonesia	PHL	Philippines
BDI	Burundi	IND	India	PNG	Papua New Guinea
BEL	Belgium	IRL	Ireland	POL	Poland
BEN	Benin	IRN	Iran, Islamic Rep.	PRT	Portugal
BGD	Bangladesh	IRQ	Iraq	PRY	Paraguay
BGR	Bulgaria	ISL	Iceland	QAT	Qatar
BHR	Bahrain	ITA	Italy	ROM	Romania
BLZ	Belize	JAM	Jamaica	RUS	Russian Federation
BOL	Bolivia	JOR	Jordan	RWA	Rwanda
BRA	Brazil	JPN	Japan	SAU	Saudi Arabia
BRB	Barbados	KAZ	Kazakhstan	SDN	Sudan
BWA	Botswana	KEN	Kenya	SEN	Senegal
CAF	Central African Republic	KGZ	Kyrgyz Republic	SGP	Singapore
CAN	Canada	KHM	Cambodia	SLE	Sierra Leone
CHE	Switzerland	KOR	Korea, Rep.	SLV	El Salvador
CHL	Chile	KWT	Kuwait	SRB	Serbia
CHN	China	LAO	Lao PDR	SVK	Slovak Republic
CIV	Cote d'Ivoire	LBR	Liberia	SVN	Slovenia
CMR	Cameroon	LBY	Libya	SWE	Sweden
COG	Congo, Rep.	LKA	Sri Lanka	SWZ	Swaziland
COL	Colombia	LSO	Lesotho	SYR	Syrian Arab Republic
CRI	Costa Rica	LTU	Lithuania	TGO	Togo
CUB	Cuba	LUX	Luxembourg	THA	Thailand
CYP	Cyprus	LVA	Latvia	TJK	Tajikistan
CZE	Czech Republic	MAC	Macao SAR, China	TON	Tonga
DEU	Germany	MAR	Morocco	TTO	Trinidad and Tobago
DNK	Denmark	MDA	Moldova	TUN	Tunisia
DOM	Dominican Republic	MDV	Maldives	TUR	Turkey
DZA	Algeria	MEX	Mexico	TZA	Tanzania
ECU	Ecuador	MLI	Mali	UGA	Uganda
EGY	Egypt, Arab Republic	MLT	Malta	UKR	Ukraine
ESP	Spain	MMR	Myanmar	URY	Uruguay
EST	Estonia	MNG	Mongolia	USA	United States
FIN	Finland	MOZ	Mozambique	VEN	Venezuela, RB
FJI	Fiji	MRT	Mauritania	VNM	Vietnam
FRA	France	MUS	Mauritius	YEM	Yemen, Rep.
GAB	Gabon	MWI	Malawi	ZAF	South Africa
GBR	United Kingdom	MYS	Malaysia	ZAR	Congo, Dem. Rep.
GHA	Ghana	NAM	Namibia	ZMB	Zambia
GMB	Gambia, The	NER	Niger	ZWE	Zimbabwe
GRC	Greece	NIC	Nicaragua		
GTM	Guatemala	NLD	Netherlands		

Note: WB code = World Bank Country Code.

Table 4.A.2: List of countries in regression analysis

WB code	Country	W B code	Country
ARG	Argentina	ITA	Italy
AUS	Australia	JOR	Jordan
AUT	Austria	JPN	Japan
BEL	Belgium	KEN	Kenya
BGD	Bangladesh	KOR	Korea, Rep.
BGR	Bulgaria	LSO	Lesotho
BOL	Bolivia	MAR	Morocco
BRA	Brazil	MEX	Mexico
BWA	Botswana	MLI	Mali
CAN	Canada	MLT	Malta
CHE	Switzerland	MOZ	Mozambique
CHL	Chile	MUS	Mauritius
CHN	China	MYS	Malaysia
CIV	Cote d'Ivoire	NAM	Namibia
CMR	Cameroon	NIC	Nicaragua
CRI	Costa Rica	NLD	Netherlands
CUB	Cuba	NOR	Norway
CYP	Cyprus	NZL	New Zealand
DEU	Germany	PAK	Pakistan
DNK	Denmark	PAN	Panama
DZA	Algeria	PER	Peru
ECU	Ecuador	PHL	Philippines
EGY	Egypt, Arab Rep.	PRT	Portugal
ESP	Spain	PRY	Paraguay
FIN	Finland	SDN	Sudan
FRA	France	SEN	Senegal
GAB	Gabon	SLV	El Salvador
GBR	United Kingdom	SWE	Sweden
GRC	Greece	SWZ	Swaziland
GTM	Guatemala	SYR	Syrian Arab Republic
HKG	Hong Kong SAR, China	TGO	Togo
HND	Honduras	THA	Thailand
HUN	Hungary	TUN	Tunisia
IDN	Indonesia	URY	Uruguay
IND	India	USA	United States
IRL	Ireland	VEN	Venezuela, RB
IRN	Iran, Islamic Rep.	ZAF	South Africa
ISL	Iceland	ZMB	Zambia

Note: WB code = World Bank Country Code.

Appendix 4.7.2: Methodology for cluster analysis

In the cluster analysis we use the gross expenditure on R&D as a percentage of GDP as a technology variable and the literacy rate and the average years of schooling as a proxy for absorptive capacity. The cluster methodology combines a hierarchical cluster analysis with a non-hierarchical cluster approach. The advantage of this approach is that the number of clusters is not pre-determined but is based on a decision rule. Nevertheless this cluster strategy leads to a tripartite cluster solution in line with the technology club hypothesis.

The cluster analysis is performed in two steps. We start out with a hierarchical cluster analysis using the average linkage method. This delivers a first clustering result for a total of 142 countries with the number of groups (or clubs) not being pre-determined. We use the Calinski-Harabasz method as a stopping rule for determining the number of clubs. In a second step we use a non-hierarchical cluster analyses that starts out with a given number of clubs which we obtained from the hierarchical cluster analysis. The advantage of the non-hierarchical cluster process is that it allows repeated resorting of countries into different clusters during the course of the clustering process which is not the case in a hierarchical cluster process. The possibility of resorting countries tends to lead to more distinct clusters each with more similar elements. However, in the non-hierarchical cluster procedure the number of clusters is determined ex ante.

The hierarchical clustering procedure delivers a first cluster result. We apply the Calinski-Harabasz method for determining the appropriate number of clusters (stopping rule). In this method large values for the Pseudo-F value suggest more distinct clusters. This stopping rule and the cluster tree suggest either a clustering into 3 or 6 distinct country groups[38] (see Table 4.A.3 and Figure 4.A.1).

Table 4.A.3: Pseudo-F values from Calinski-Harabasz method for determining the number of clusters

Number of clusters	Calinski/Harabasz pseudo-F
2	102.74
3	166.89
4	140.82
5	117.70
6	175.53
7	149.05
8	157.73
9	145.53
10	131.96
11	131.05
12	140.45
13	133.67
14	129.31
15	129.98

[38] We exclude Israel from the analysis as it represents an outlier due to its very high R&D expenditures.

As a next step we perform a non-hierarchical cluster analysis imposing alternatively 3, 4, 5 or 6 clusters. In our case the results from both methods are rather similar with only a slight reordering of countries. Comparing the values of the Calinski-Harabasz stopping rule for the non-hierarchical cluster solutions with alternative numbers of pre-defined clusters confirms the preferred number of clubs being three (see Table 4.A.4).

Figure 4.A.1: Dendrogram for average linkage cluster analysis, 2005-2009 (upper part of the cluster tree)

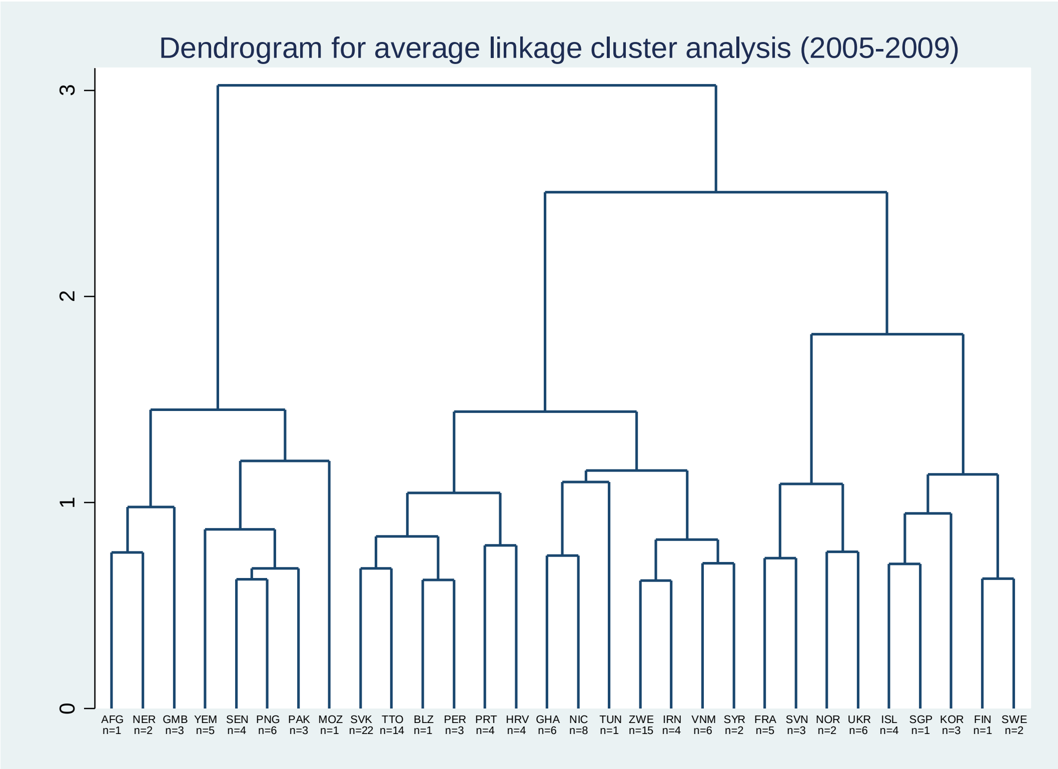


Table 4.A.4: Pseudo-F values from Calinski-Harabasz method from non-hierarchical cluster analysis with alternative numbers of resulting clusters

Number of clusters	Calinski/Harabasz pseudo-F
3	200.52
4	201.76
5	191.92
6	168.02

5 Agglomeration and FDI: Bringing international production linkages into the picture

5.1 Introduction

Foreign direct investment (FDI) has become the major pillar of internationalisation for firms (Sauvant, 2005) and attracting foreign direct investment forms part of many countries' trade and investment policies. Attracting FDI is deemed beneficial for its impact on job creation and aggregate investment and also because it supports structural upgrading and technology spillovers to other parts of the economy. Foreign direct investment, for example, is found to have played an important role in the catch-up process of the Central and Eastern European EU Member States (e.g. Landesmann and Stehrer, 2006; Damijan et al., 2013).

While many countries have specific FDI promotion programmes which are designed to attract foreign multinational enterprises (MNEs), empirical research on the location of FDI suggests that in general other factors tend to be more important (for a comprehensive survey see Bloningen, 2005). In particular, there is ample evidence that agglomeration forces play a major role for the location decisions of MNEs. Crozet et al. (2004) for example find a dominant influence of agglomeration economies, which in the FDI location literature is typically proxied by the presence of other firms, for FDI in France but very limited evidence for any effect of (regional) policy incentives while Kinoshita and Campos (2003) and Du et al. (2008) find that agglomeration economies and institutions are key factors for the location of FDI. However, the latter result is in contrast with the finding by Bloningen and Piger (2014) whose Bayesian estimation techniques attribute a very low inclusion probability for legal and political institutions as an explanatory factor for location decisions. Further evidence for the importance of agglomeration externalities relative to other factors comes from UNCTAD's World Investment Prospect Survey (UNCTAD, 2009) which suggests that 'following my competitors' is one of the main factors for firms' location decisions.

On the basis of its relevance for FDI location choice, this paper incorporates several agglomeration factors established in the empirical literature into a multinominal choice model. To capture agglomeration factors we follow the literature in including previous FDI investments in potential host countries as a measure for knowledge spillovers (agglomeration externalities). A second set of agglomeration variables are domestic inter-industry linkages in the potential host country which we proxy by backward and forward linkages retrieved from input-output data. In addition our model introduces the role of international inter-industry linkages as a new potential determinant of FDI. These international inter-industry linkages are potentially relevant for FDI investors because they reflect and potentially even affect the co-ordination costs of offshoring. In particular, we expect that well established trade links between the investor's economy and the host economy signal lower costs of offshoring to new investors. Hence, our argument is that in addition to traditional agglomeration factors stressed in the New Economic Geography (NEG) literature, offshoring and international production linkages also contribute to the potential concentration of production capacity in a selected number of EU member states (see IMF, 2013; Stöllinger and Stehrer, 2015).

The subject of analysis are investment decisions of MNEs from six ‘core’ European countries (Austria, Belgium, France, Germany, Italy and the Netherlands) across all EU Member States over the period 2003-2012. All six investor countries, which will be referred to as European core countries, are important sources of FDI for other EU Member States. The main methodological framework for identifying the determinants of FDI location is the conditional logit model developed by McFadden (1974). As a robustness check, we will also employ a nested logit model. Moreover, the analysis will be repeated at a more disaggregated level by replacing EU member state with NUTS 2 regions as the potential locations for FDI investors.

In order to avoid confusing agglomeration effects resulting from the presence of other firms and firms’ own investment histories, our empirical analysis is restricted to ‘first movers’. First movers are firms which invest for the first time in a particular industry in a particular country. We also restrict the analysis to greenfield FDI projects (and major extensions of existing facilities) in order to avoid aggregation bias by mixing different modes of FDI.

This paper adds to the existing literature along two dimensions. First of all, we investigate exclusively greenfield investment projects that are related to production. Production-related projects are defined as investment projects that lead to the creation of new production capacity. We disregard all other projects such as representative offices, logistic centres or customer services facilities. Put differently, we focus exclusively on the business function production within companies’ value chains. De facto, all projects entailing the creation of new production capacity are undertaken by manufacturing firms in our sample. However, our approach is different from a simple differentiation between manufacturing and services firms because the limitation to production-related projects disregards a large number of projects by manufacturing firms.

Secondly, the analysis of the location decisions of FDI investors incorporates international inter-industry linkages as potential attraction factors. The linkages between the investor’s economy and a potential host economy capture the production interdependences between the two countries. The hypothesis to be tested in this context is whether existing linkages between source and host country reduce the coordination costs of offshoring and are thus relevant for the location decision of potential investor firms. To our knowledge the combined role of agglomeration effects and of international linkages for the location decision of FDI projects has not been investigated in the literature before.

The paper is structured as follows. Section 5.2 provides a snapshot of the related literature. Section 5.3 explains the methodology including the definition of variables and the econometric specification. Section 5.4 describes the data followed by the empirical results which are presented in Section 5.5. Section 5.6 concludes.

5.2 Related literature and theoretical motivation

In line with other empirical contributions on location choices of MNEs this paper uses elements suggested by the New Economic Geography (NEG) literature to be relevant for firms’ location decisions. This is particularly true for the agglomeration variables. To motivate the inclusion of intra-industry linkages recourse to models of offshoring is taken.

The major theoretical arguments for why firms tend to agglomerate in certain locations have already been formulated by Marshall (1920). These ideas have been formalised by the New Economic Geography (NEG) literature (e.g. Krugman, 1991a; Fujita et al., 2001) which identifies three major advantages for firms to 'cluster' together in close proximity: *(i)* the spread of new ideas and innovations across firms, typically referred to as knowledge spillovers or agglomeration externalities, *(ii)* the availability of specialised labour and *(iii)* backward and forward linkages to local markets (e.g. Fujita et al, 2001).

NEG theory stresses in particular the role of inter-industry linkages for firm location (Fujita et al., 2001). In the model by Krugman and Venables (1995) manufacturing firms produce with increasing returns to scale and they sell not only to consumers but also to other firms. This implies that there are vertical (inter-industry) interactions between firms. Assuming that there are (non-prohibitive) trade costs, the region with a larger manufacturing sector will find it easier to attract additional manufacturing activity because it offers a larger market for the suppliers of intermediate goods. The larger market of intermediates thus acts as an attraction factor and will lead to further agglomeration. In turn, the greater variety of intermediate inputs translates into lower production costs for the final good producers thereby reinforcing the agglomeration of production in locations with some initial advantage.

However, these advantages of agglomeration are not boundless because they are counteracted by differences in wages levels between the core region and the periphery. This trade-off between efficiency gains from agglomeration and lower wage costs also depends on trade costs. The advantage of being close to intermediate suppliers (backward linkages) and close to customers (forward linkages) vanishes as trade costs decline because goods can be shipped cheaply from even remote places. In the extreme case, if trade costs go to zero, it does not matter where inputs are supplied from or which market the output is sold to. In such a situation the lower wages prevailing in the region with the smaller manufacturing sector, i.e. the periphery, will induce firms to locate there.

Studies on the geographic agglomeration of economic activity typically focus on domestic factors and domestic linkages have also been incorporated by the empirical literature on location choice. In a time of strongly reduced trade costs and ever more granular trade flows, however, also a country's (or region's) interconnectedness, i.e. its international linkages should be relevant for FDI investors. An important form of interconnectedness which is of particular interest for our purpose is the integration of economies into international production networks which according to Baldwin (2011; 2013) characterises 21st century trade. In international production networks the production process is not necessarily bundled in a specific location any more. Rather, the production activities (or a firm's value chain more generally) are geographically dispersed giving rise to offshoring of certain activities.[39] The offshoring literature (e.g. Feenstra and Hanson, 1996; Grossman and Rossi-Hansberg, 2008; Baldwin and Robert-Nicoud, 2014) identifies similar factors as the NEG literature as being relevant for the offshoring decision: changes in trade costs and wage differentials. The relevant trade costs are the co-ordination costs of offshoring which *"comprise the cost of*

[39] The phenomenon of geographically dispersed production has many names, including inter alia international production integration, production sharing, fragmentation of production and vertical integration.

organising tasks in different nations, e.g. the cost of exchanging coordination information" (Baldwin and Robert-Nicoud, 2014, p. 54). In the model by Grossman and Rossi-Hansberg (2008) production requires the input of low-skill tasks and high-skill tasks. Firms have the possibility to offshore low-skill tasks by setting up a foreign subsidiary thereby benefiting from lower wages abroad. The decision to offshore tasks then depends on the difference between domestic and foreign wages on the one hand and the cost of offshoring (which are assumed to be task-specific) on the other hand. The implication of an internationally dispersed production process is trade in intermediates. Clearly, such trade in intermediates and resulting international inter-industry linkages are created by FDI activities but for first time FDI investors (which are the ones whose location decisions will be investigated) the existence of such linkages can be expected to act as a signal for attractive investment locations. Hence, a simple way to incorporate costs of offshoring into an empirical location choice model is to associate them with existing international linkages of potential offshoring destinations (i.e. potential host countries for FDI). Assuming that investor-host-country linkages are essential for the proper functioning of global value chains, the existence of strong linkages between the source and the host country of FDI should imply reduced costs of offshoring. At least they signal lower costs of offshoring for new FDI investors.[40] In an adaptation of the logic behind the offshoring decision from *whether to offshore* to *where to offshore to* we hypothesise that strong linkages between the investor country and a potential host country make the latter more attractive as a destination for FDI. The assumption that existing inter-industry linkages affect offshoring costs creates an analogy between domestic inter-industry linkages stressed in the NEG literature and host-source inter-industry linkages implied by models of offshoring. Alternatively, the relevance of international linkages may also be motivated within the framework of the NEG literature: if trade costs are low enough, firms will be equally attracted by international production linkages as they are attracted by domestic linkages.

For the empirical implementation of these theoretical considerations we can draw on a vast literature on agglomeration and FDI location. Like any other firm, MNEs are assumed to maximise profits. On top of the optimal input decisions, MNEs also have to make a location decision for their FDI projects. This decision is the subject of the theory of location choice. With regard to FDI decisions it suggests that MNEs will choose the location which offers the highest profits under the assumption that it can transfer its technology abroad so that it operates with the same production function in any potential location. Despite this assumption on the transferability of technology, profits of MNEs may vary across locations due to location specific factors (such as agglomeration).

An early analysis of agglomeration effects in FDI activities is Woodward (1992) who uses McFadden's conditional logit model (1974) to estimate the effects of various state and county variables on the location decisions of Japanese start-up firms across US states and counties. One of the explanatory variables he uses is 'manufacturing agglomeration' which is proxied by the number of manufacturing establishments in the respective county. He finds positive

[40] Note, that there is a nuance in this. Established inter-industry linkages may themselves reduce co-ordination costs or they may simply reflect lower co-ordination costs. Our data does not allow us to differentiate between the two interpretations but we sympathise with the first view. Moreover, it also has to be kept in mind that international inter-industry linkages by definition constitute trade flows. Therefore the existing linkages could more generally reflect lower trade costs.

and statistically significant effects of this agglomeration variable in all of his specifications. The interpretation of this result is that firms expect to benefit from co-location with other firms in the same industry (even if this means more competition) because of knowledge spillovers.

A pioneering study in the FDI location literature is Head et al. (1995) who examine foreign direct investments of 751 Japanese manufacturing firms in the US. Within the framework of a conditional logit model they build agglomeration variables based on previous foreign direct investments by Japanese firms in the respective industry and region (US state). This variable allows them to identify a 'follow-the-leader' pattern of Japanese firms in their FDI activities in the US. This follow-the-leader pattern is attributed to Marshallian knowledge spillovers, i.e. agglomeration externalities.[41] As agglomeration measure serves the stock of foreign investment projects in the host economy already undertaken by firms from the source country (in their case Japan) and industry. Obviously, if agglomeration effects are large enough to influence the decision where to invest, everything else equal, the number of previous investments, undertaken by compatriot firms in the same industry increase the locational attractiveness of a host country and consequently lead to further accumulation of projects. The results in Head et al. (1995) suggest positive and sizeable agglomeration effects among Japanese firms which are even larger for firms belonging to the same keiretsu. The number of US firms operating in the respective region and industry is included in the analysis in order to control for industry-specific endowment effects.

A large number of empirical studies confirm the positive relationship between the presence of foreign firms and the location choice of new FDI investors for several countries. Examples for studies of FDI location in European countries include Guimarães et al. (2000) for new firms in Portugal; Basile (2004) for FDI in Italy; Crozet et al. (2004) for France; Boudier-Bensebaa (2005) for FDI in Hungary; Barrios et al. (2006) for location choices of MNEs in Ireland and Devereux et al. (2007) for location choices of MNEs in the UK. These studies take the view of a specific host country, in the sense that they focus on the location of FDI within a specific country (inward view). In addition there are also studies investigating the location of FDI from an outward perspective, i.e. they analyse investment projects undertaken by MNEs from one specific source country in different countries such as Balsvik and Skaldebo (2013) for Norwegian investors and Procher (2011) for French investors.

With regard to the destination markets, this paper is related to Head and Mayer (2004) who study the location decisions by Japanese investors in the EU. Siedschlag et al. (2013) also investigate the location choice for FDI projects across European countries but they focus on projects involving R&D activity whereas we are interested in production-related projects.

The paper by Procher (2011) analyses investments by French firms both in Europe and globally. An interesting element in this paper is the differentiation between FDI investors in general and 'first movers', i.e. firms which undertake a foreign direct investment for the first time. This approach avoids mixing-up agglomeration effects and the influence of a firm's own past investments on FDI location choices.

41 The location choice literature typically interprets the positive effect of past FDI projects realised in a particular host economy on location choice as the result of knowledge spillovers. There is, however, also another strand of literature which assigns this effect to herd bevaviour (see. e.g. Guillén, 2002).

The above mentioned literature includes past investments by MNEs as a measure of agglomeration externalities. There are also some contributions that use input-output linkages in the context of FDI location. The use of input-output linkages in this literature is twofold: on the one hand the linkages are used to put structure on spillover effects, on the other hand production inter-linkages are analysed as locational determinants by themselves (Jones and Wren, 2011). We will use backward and forward inter-industry linkages as location determinants by themselves as in Du et al. (2008) and Debaere et al. (2010). The latter paper undertakes a firm-level analysis of South-Korean FDI in China. Their contribution is closely related to our paper as it includes the agglomeration externalities variables together with forward and backward inter-industry linkages as relevant factors for location decisions of foreign direct investors. Debaere et al. (2010) distinguish between inter-industry linkages of the Korean FDI firm with upstream and downstream Korean FDI firms on the one hand and with all domestically operating firms on the other hand. They only find an effect on location choice for the inter-industry linkages to Korean FDI firms within China but not for the existing domestic inter-industry linkages to Chinese firms.

5.3 Methodology

This section first presents the conceptual framework regarding the agglomeration effects and international linkages in the location choice model. Secondly, it outlines the conditional logit and the nested logit model which are the two choice models used to carry out the analysis.

5.3.1 Agglomeration effects and international linkages

Our empirical model incorporates three types of agglomerations which are *(i)* agglomeration externalities (knowledge spillovers), *(ii)* backward inter-industry linkages and *(iii)* forward inter-industry linkages. In addition, the model accounts for international linkages as additional factors potentially relevant for the investment decisions of FDI investors.

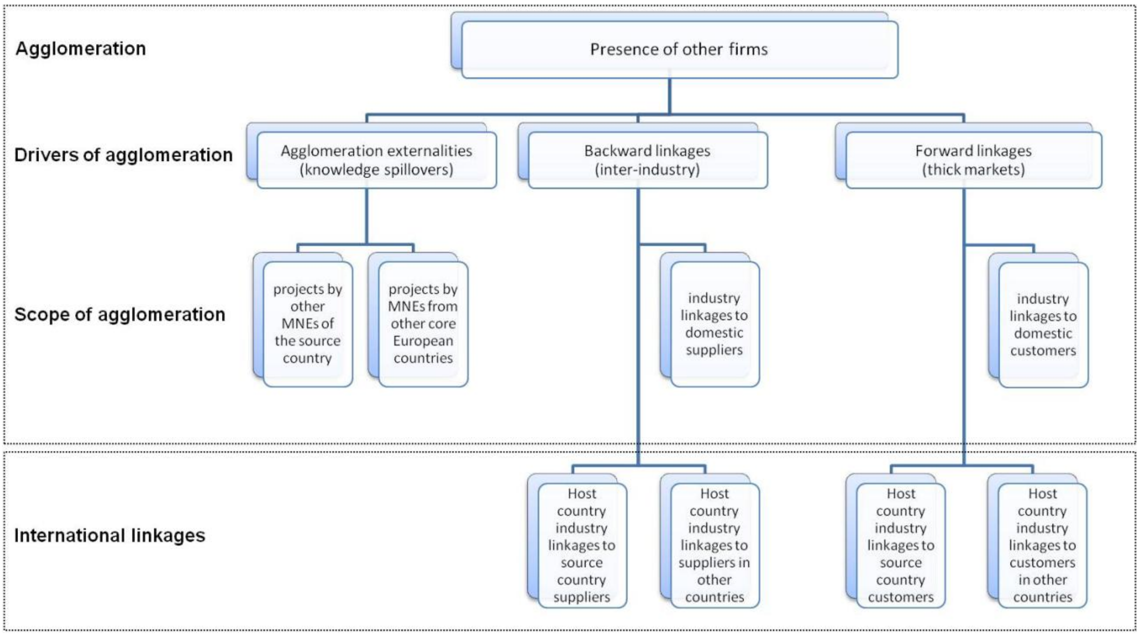
Figure 5.1 summarises the concept of agglomeration effects and international linkages effects.

At the most general level, agglomeration is associated with the presence of other firms (or markets) in the host economy. In the following the three agglomeration effects captured in the analysis will be shortly discussed.

The first agglomeration effect, the agglomeration externalities or knowledge spillovers in Figure 5.1, are measured by the number of investment projects already existing at the industry-host country-level at the time an MNE is taking its investment decision. For any source country *s,* the stock of investment projects, *n*, in period τ in a destination market *c* and industry *i*, is defined as follows:

$$projects(\tau)_{i,c}^{s} = \sum_{2003q1}^{\tau-1} d_{n(\tau),i}^{s} \quad with \{ \quad \begin{matrix} d_{n(\tau),i}^{s} = 1 \quad if \;\; project\, n\, is\, located\, in\, c \\ d_{n(\tau),i}^{s} = 0 \quad else \end{matrix}$$

Figure 5.1: Schematic representation of agglomeration effects and international linkages



This (industry-level) count variable is created separately for the outward projects of the six investor countries in each EU markets over the period 2003-2012. So $projects(\tau)^{S}_{i,c}$ is the number of investment projects from a source country *s*, say Austria, in a particular industry, *i*, say the chemical industry, in a particular host country, *c*, say Bulgaria that have been accumulated between period 1, (i.e. the 1st quarter of 2003) and period τ*-1,* say the 3rd quarter of 2010. The hypothesis in this context is that investors benefit from intra-industry knowledge spillovers among firms and thus we expect a positive effect of a high number of investment projects already undertaken in a country or region on its probability to be chosen as the location for a FDI project.

An interesting aspect in the context of these knowledge spillovers which has received relatively little attention to in the literature (a rare exception is Procher, 2011) is the 'national scope' of agglomeration externalities. Since we have observations for cross-border investment projects by six investor countries we can investigate whether the agglomeration effects are national or 'European' in scope or both. In the case of national agglomeration externalities, for example, Austrian FDI investors would care about previous investments by fellow Austrian companies but not by the investment activities of, for example, German or Italian investors.

To account for the possibility of 'European-wide' agglomeration externalities, a variable for the total of the six investor countries' projects in a respective industry and country is constructed in the same manner:

$$projects(\tau)^{EU-6}_{i,c} = \sum_{s=1}^{6} \sum_{2003q1}^{\tau-1} d^{S}_{n(\tau),i} \, with \ \begin{cases} d^{S}_{n(\tau),i} = 1 & if \ project \ n \ is \ located \ in \ c \\ d^{S}_{n(\tau),i} = 0 & else \end{cases}$$

To distinguish between national agglomeration externalities and those of the remaining five core European countries an agglomeration externalities variable for the 'other' five source countries is created:

$$projects(\tau)_{i,c}^{EU-5} = projects(\tau)_{i,c}^{EU-6} - projects(\tau)_{i,c}^{s}$$

Note that in order to avoid influences of contemporaneous investment projects we define the project stock variables as the sum of industry-host-specific projects up to the preceding period. Hence, for the FDI location decision of an Italian car manufacturer in the 3rd quarter of 2007, the national agglomeration externalities are proxied by the stock of projects undertaken by Italian investors in the transportation equipment industry until the 2nd quarter of 2007 in the respective host country.

The second driver of agglomeration are inter-industry linkages among firms. These include both forward and backward linkages which are derived from input-output tables. What is essential in the context of this paper is the geographic scope of the forward and backward linkages. In line with the schematic representation in Figure 5.1 the forward and backward linkages are limited to supplier-buyer relationships between firms operating in the host country. For example, domestic backward linkages in the Czech food industry only reflect the intermediate goods that it buys from other Czech industries but not those sourced from abroad. The hypothesis stemming from core-periphery models is that firms have a tendency to locate where inputs suppliers (backward linkages) and downstream firms (forward linkages) are abundant.

Following Jones and Wren (2011) we construct these agglomeration variables by interacting the input-output linkages with the industry-level employment in the respective host country, $E_{i(c)}$. In order to capture both direct and indirect linkages between industries, the backward linkages are calculated using the coefficients of the Leontief inverse. The elements of the Leontief inverse are denoted by l_{ij} where *i* is the 'selling' sector and *j* is the 'buying sector'. For host country *c*, the typical element of the Leontief inverse, $l_{i(c),j(c)}$, measures the additional amount of output in industry *i* associated with a one unit increase of demand in industry *j*. The domestic backward linkages of any industry *j* for the host economy *c* are then defined as the sum of industry *j*'s backward linkages to other industries (excluding itself) weighted by the employment in the respective upstream industry:

$$BW_{j(c)} = \sum_{i \neq j} l_{i(c),j(c)} \cdot E_{i(c)}$$

Note that we do not include the diagonal elements in the Leontief inverse in order to measure the industry *j*'s "backward dependence" on the rest of the economy (Miller and Blair, 2009). These backward linkages (as all other linkages variables) vary over time though the time subscripts are omitted here for ease of notation.

The equivalents to the coefficients of the Leontief inverse for the definition of the forward linkages are the coefficients of the output inverse suggested by Ghosh (Miller and Blair, 2009). In the Ghosh model sectoral gross production is related to the primary inputs.[42] The output inverse of the Ghosh model also captures direct and indirect linkages between industries. It can be derived in a similar way as the Leontief inverse though the 'column approach' has to be substituted with a 'row approach'. The typical element of the Gosh inverse, $g_{i,j}$, reflects the additional output in industry *j* associated with a one unit increase of value added in industry *i*. The domestic forward linkages of any industry *i* for the host economy *c* are then defined as the sum of industry *i*'s forward linkages to other industries (excluding itself) weighted by employment in the respective downstream industry:

$$FW_{i(c)} = \sum_{j \neq i} g_{i(c),j(c)} \cdot E_{j(c)}$$

Again, we omit the on-diagonal elements, i.e. the linkage of each industry with itself.

The main novelty of this paper is the inclusion of the host economy's international linkages. Of primary interest are the effects of the linkages between the host country and the source country (i.e. the investor's country of origin) on location choice.

The measure for the forward and backward linkages between the host and the source country are defined according to the same logic as the respective domestic linkages. The linkages are always viewed from the perspective of the host country, so that the backward linkages between the two countries capture purchases of intermediates from host country industry *j* from all other industries *i* in the source country *s*. Therefore the backward and forward linkages of an industry *i* in the potential host country *c* with the source country take the form:

$$BW_{j(c)}^{host-source} = \sum_{i} l_{i(s),j(c)} \cdot E_{i(s)}$$

$$FW_{i(c)}^{host-source} = \sum_{j} g_{i(c),j(s)} \cdot E_{j(s)}$$

As in the case of domestic linkages, the strength of these linkages is weighted with the employment in the respective industries in the source country. We expect that more intensive host-source industry linkages increase the attractiveness of a potential host country or region because they signal low co-ordination costs of offshoring for new investors. Potential endogeneity arising from the fact that FDI location decisions are likely to affect host-source linkages is mitigated by the fact that our analysis includes only location decisions by first time investors.

For the sake of completeness, we also include inter-industry linkages between the host economy and all other EU member states into the model. The linkages between the host

[42] The difference between the Ghosh model and the standard input-output model is that each element in each row of the transaction matrix is divided by the gross output of the sector associated with that row (normally, the technical coefficients in input-output models are calculated by dividing each element in each column of the transaction matrix with the gross output associated with the respective column).

economy and all other EU member states (except for the source country), $BW_{j(c)}^{host-foreign}$ $FWforeign_{i(c)}^{host-foreign}$, are constructed in analogy to the other linkages variables.

As indicated by the separate rectangle for the international linkages in Figure 5.1, the host-source linkages are not considered to represent agglomeration effects. This is because, they do not capture location advantages linked to domestic activity but rather reflect the host country's (or host region's) interconnectedness and in particular its integration in international production networks. To some extent the host country's trade connectedness in intermediates as a determinant of FDI location choice rivals the role of domestic linkages as drivers of agglomeration. Put differently, the more FDI investors care about international linkages the less will domestic linkages matter for them – and vice versa.

The construction of the backward and forward linkages based on inter-industry linkages fits well to our interest in production production-related projects. So, it is worthwhile stressing again that the objects of analysis are only greenfield FDIs which add new production capacity. We deem this to be appropriate because the types of agglomeration forces that we try to capture stem from the actual production of goods. Therefore we deliberately ignore the large number of projects by manufacturing firms that consist of establishing a non-producing subsidiary such as a sales representation or a logistic centre. We believe this to be an extremely important differentiation.

The rational for confining the analysis to greenfield investment projects is that location decisions for different types of FDI may be guided by entirely different motives (Friedman et al., 1992, Soci; 2007). A key difference between greenfield investment and mergers and acquisitions (M&A), which are the two major modes of FDI, is that for M&A transactions only locations with existing production facilities, i.e. locations with existing target companies, are potential choices. For greenfield investment projects the choice of locations is generally much larger. Moreover, M&A transactions are often motivated by a possible resale value of an existing asset and therefore have a shorter time horizon. In contrast, greenfield investments require the setting up of new facilities and therefore involve a longer-term planning horizon as considerable initial costs are involved (e.g. for entering a new market or supplying a new product or training an additional workforce). Therefore, combining various types of FDI potentially causes aggregation bias and *"obscures the underlying determinants of foreign location"* (Friedman et al., 1992, p. 405). This argument is also confirmed by Basile (2004) who finds important differences in the locational determinants, including knowledge spillovers, for greenfield FDI and M&A transactions in Italy. While both Friedman et al. (1992) and Basile (2004) conduct their analysis for the two modes of FDI separately we follow the advice of Soci (2007) and focus our analysis to greenfield investments – a choice that is also predetermined by data availability.

5.3.2 Empirical model

Models of location choice can be estimated at different levels ranging from the country to the city level. Our main level of investigation is the country level. We deem this to be the appropriate level of analysis because the EU Member States can be seen as the 'regions' of the EU. In this sense, this approach is in line with studies on the location choice of FDI for large countries such as China or the US which often use the provinces or states as the unit of analysis. However, as a robustness check we also undertake the analysis at the level of NUTS 2 regions. Due to data constrains, these regional variants of the analysis will have to work with the backward and forward linkages at the national level. Moreover, a smaller number of control variables is available in this case. The FDI investment decisions analysed relate to projects undertaken by MNEs from six EU investor countries which are Austria, Belgium, France, Germany, Italy and the Netherlands.

To model these location decisions of MNEs a conditional logit model is used. McFadden (1974) demonstrated that the logit choice probabilities can be derived from individual maximisation problems.

The model assumes that the profits an FDI investor can generate from a project *n* realised in a country (or region) *j*, $\Pi_{n,j}$, consists of an observable part, $V_{n,j}$, and an unobservable part, $\varepsilon_{n,j}$. Profit maximising firms will choose the location with the highest expected profit. The probability of a country *c* to be chosen as the location for investment project *n* $Prob(Y_n = c)$ – or $P_{n,c}$ for short – is then simply the probability that the expected profits when locating project *n* in country *c* exceeds that of all other potential locations *j*. Hence

$$P_{n,c} = Prob(V_{n,c} + \varepsilon_{n,c} > V_{n,j} + \varepsilon_{n,j} \quad \forall\, j \neq c)$$

$$P_{n,c} = Prob(\varepsilon_{n,j} < V_{n,c} - V_{n,j} + \varepsilon_{n,c} \quad \forall\, j \neq c)$$

This expression for the probability of a country to be chosen as the location for investment project *n* can be shown to result in the logit choice probability if two conditions are satisfied. Firstly, the unobserved part of the profit function must be assumed to be of the type I extreme value (Gumbel distribution). Secondly, it must be independently and identically distributed. With these assumptions $P_{n,c}$ results in the logit choice probability:

$$P_{n,c} = \frac{e^{V_{n,c}}}{\sum_j^J e^{V_{n,j}}}$$

which forms the basis of our location choice model with J being the number of possible alternative location choices *j* and both *j* and $c \in J$.

The assumptions that the errors are independent and identically distributed are essential because they imply the assumption of independence from irrelevant alternatives (IIA). If the IIA-assumption holds, the choice between any two alternative locations is independent of all the other potential location choices. For example, from the investor's viewpoint the comparison between locating a project in Spain or in the Czech Republic is independent from whether or not it is possible to choose Hungary as the host country.[43]

[43] In the estimating process we use clustered standard errors where the clusters are the investors. The reason for doing this is that our definition of first movers is a firm that has not invested yet in the same country in the same industry. Therefore there are a few firms that appear more than once in our sample. The clustered standard errors allow for correlation in the error term among the investment decisions by the same firm.

A nice feature of the conditional logit model is that the profit function only needs to include factors that vary over destination countries as long as firms can move their technology internationally. Profit maximising behaviour implies that investors choose for their investment projects the destination which yields the highest profits compared to all other destinations (Head at al., 1999). Therefore the firm level profit function in equation (5.1) can be reduced to include only agglomeration variables and the international linkages variables as well as some other location-specific factors. All remaining destination specific-factors are captured by host country effects. Therefore the profit function $\Pi_{n,i,c}$ can be written in the following form[44]:

(5.1) $$ln\Pi_{n,i,c} = \theta_c + lnA_{n,i,c} \cdot \varphi_1 + lnLINK_{i,c}^{DOM} \cdot \varphi_2 + lnLINK_{i,c}^{INT} \cdot \varphi_3 + lnX_{i,c} \cdot \beta_1 + lnX_c \cdot \beta_2 + \varepsilon_{n,i,c}$$

where time indices are suppressed in order to simplify notation. Equation (5.1) takes into account that any project *n* takes place in a specific industry *i* so that $\Pi_{n,i,c}$ are the firm's profits associated with locating an investment project *n* in country *c* taking into account the industry of the project. The matrix $lnA_{n,i,c}$ contains the set of agglomeration externalities (knowledge spillovers) described above and $lnLINK_{i,c}^{DOM}$ are the domestic backward and forward linkages. Both represent agglomeration forces. Apart from these agglomeration forces is the set of international inter-industry linkages comprised in the matrix $lnLINK_{i,c}^{INT}$. $lnX_{i,c}$ includes additional industry and destination-specific control variables, lnX_c are destination-specific control variables (which are discussed below) and θ_c are the host country specific effects that control for unobserved country characteristics.

Since all variables in equation (5.1) enter the expression in log-form, we add 1 to the number of investment projects in each of the agglomeration economies variables, $lnA_{n,i,c}$, in order to avoid the zero-problem.

Combining the expression for the probability of any country to be chosen as the host country for an investment project, $P_{n,c} = \frac{e^{V_{n,c}}}{\sum_j^J e^{V_{n,j}}}$, with the profit function in (5.1) yields:

(5.2) $$P_{n,i,c} = \frac{e^{\theta_c + lnA_{n,i,c} \cdot \varphi_1 + lnLINK_{i,c}^{DOM} \cdot \varphi_2 + lnLINK_{i,c}^{INT} \cdot \varphi_3 + lnX_{i,c} \cdot \beta_1 + lnX_c \cdot \beta_2}}{\sum_j^J e^{(\theta_j + lnA_{n,i,j} \cdot \varphi_1 + lnLINK_{i,j}^{DOM} \cdot \varphi_2 + lnLINK_{i,j}^{INT} \cdot \varphi_3 + lnX_{i,j} \cdot \beta_1 + lnX_j \cdot \beta_2)}}$$

As in the case of other maximum likelihood methods the conditional logit model uses the probabilities in equation (5.2) in a likelihood-function to estimate the coefficients of the explanatory variables and the country specific constants, θ_j. The probabilities of the individual countries to be chosen as the location for a firm's investment project are derived via a binary choice variable which represents the dependent variable. Hence, in this model framework the (left hand side) choice variable takes on the value 1 for the chosen location and 0 for all alternative destination countries that the investing company could have chosen.[45] Equation (5.2) will be estimated jointly for investment projects undertaken by firms in the six core European countries.

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[44] The log-log form of the profit function in equation (5.1) assumes a Cobb Douglas type production function.

[45] For the structure of the dataset this implies that the original dataset must be expanded by the number of possible alternative *J*. In our case *J=25* in the case of the country level analysis and *J*=221 in the case of the NUTS 2 level analysis. So for each

In addition to the agglomeration variables and the international linkages, the empirical model controls for various destination-specific factors. They can be grouped into different categories controlling for industry structures, the wage level, market size and growth, technology and human skills, policy support and economic institutions as well as a set of gravity variables. The discussion of these control variables refers to the country-level analysis.

Starting with the industry structure we follow Head et al. (1995) in controlling for the abundance of endowments required by the respective industry by including a proxy for the size of the industry which the project belongs to. In contrast to Head et al. (1995) we use industry value added instead of the number of firms (or establishments) for the simple reason that the latter proxy performs much better in the estimation process. Controlling for the potential effect of industry sizes in the host-countries is required for attributing the impact of the accumulated FDI project stock in the respective host economies on location choice to agglomeration effects. The value added variable is time, industry and host country specific.

On top of this control for industry size and endowments we add a relative specialisation measure. Among the various alternatives for specialisation indicators we opt for the Krugman specialisation index (*K-spec*) introduced in Krugman (1991b) and used for example by Midelfart-Knarvik et al. (2000). This indicator is the absolute value of the differences in industries' shares in total manufacturing value added in an economy to that of some reference country or country group. For our purposes we use the absolute value of the differences between the industry shares in each potential host economy relative to that of the source country. The reason for including a measure for industry specialisation is that FDI investors may be inclined to invest in countries with an industry structure similar to that of the source country because they can expect more similar supply and demand conditions.

Another very important aspect is the wage level. Since wages act as the counterbalancing forces for agglomeration dynamics in both NEG models and also in the offshoring literature it is useful to control for the wage level across potential host economies. We do this by including labour costs in the manufacturing sector.

The next set of variables consists of proxies for economic size and growth. Market size and economic growth are often among the most important determinants for FDI. Therefore we include population size, the real GDP per capita as well as real GDP growth into the empirical model.

Another important aspect in the context of FDI location and agglomeration in particular is the availability of skills and technology. We use the R&D expenditures per capita in the host economy to account for the effect of the available technology in the host economy and add the share of medium-skilled workers as well as the share of high-skilled workers in the workforce as a proxy for the availability of skill endowments.

While not the centrepiece of this study we still want to see whether in our sample policy incentives and institutions matter for the location decisions of FDI investors. Therefore we

investment project there are 25 respectively 221 rows in the dataset with the choice variable taking the value 1 in the row containing the chosen host country or region and 0 for the remaining *J-1* countries or regions.

include the amount of state aid to industry and services provided by each host country to account for the potential impact of subsidies and the government effectiveness respectively. The latter reflects the perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

Finally, a set of gravity variables are included which comprise the distance between the source and the host country, whether the two countries share a common official language, a common border and a dummy variable indicating whether the host and the source country had historically been part of the same country or empire.

We now return to the estimation procedure and the issue of the IIA-assumption. Using the example from above, the conditional logit model assumes that the probability of choosing Spain as the host country relative to the probability of locating in the Czech Republic should be independent from the probability of Hungary being chosen. However, if investors first decide on some subset of more similar countries, e.g. the new EU member states, then this assumption is violated. In this case the possibility of investing in Hungary reduces the possibility of the Czech Republic being chosen as the host country but would remain unaffected by that of Spain. As a result the conditional probability of the FDI investor choosing Spain increases in the direct comparison between locating in Spain or in the Czech Republic. The nested logit model can deal with this complication. The basic idea is to group more similar alternatives – in our case possible host countries – into nests. We will follow Disdier and Mayer (2004) who investigate the FDI location choices of French investors across EU countries and build two nests: the first nest comprises the EU-15 while the second nest comprises the new EU member states, i.e. those that joined the EU in 2004 or later.[46] Each of the two nests (i.e. the first decision level) comprises a number of alternatives which are the potential host countries (i.e. the second decision level). The nested logit model allows for correlation of errors between alternatives of the same nest. For example there may be correlation of errors between the Czech Republic and Hungary within the second nest and between Spain and Portugal in the first nest (see Cameron and Trivedi, 2010). This means that the IIA-assumption holds for pairs of alternatives within each of the nests but not between pairs of alternatives belonging to different nests (Greene, 2012). The probability of a country to be chosen as the host country for an FDI project now has two parts: the probability of choosing a particular nest and the probability of each alternative within a nest to be chosen. Formally, the choice probability for alternative *c* in the nested logit model is given by:

$$P_{n,c,b} = P_{n,c|b} \cdot P_b$$

where $P_{n,c|b}$ is the probability of location *c* to be chosen conditional on the nest *b* it belongs to being chosen and P_b is the probability that nest *b* is chosen. The first part is basically the conditional logit probability because the IIA-assumption holds within the nests:

[46] Note that we cannot include Croatia due to the lack of input-output data.

$$P_{n,c|b} = \frac{e^{V_{n,c|b}}}{\sum_j^{J_b} e^{V_{n,j|b}}}$$

where $V_{n,j|b}$ is the expected observable profit associated with alternative *c* conditional on nest *b* being chosen. J_b indicates the number of alternatives in nest *b*.

The expression for the choice of the nests is more complicated because the expected profit associated with an FDI investor locating project *n* in the host countries in nest *b* depends on how strongly the errors of the alternatives within the nest are correlated. The strength of this correlation is captured by the dissimilarity parameter τ_b which is zero if the alternatives in the nest are perfectly correlated and one if they are independent. Based on the dissimilarity parameter τ_b the inclusive value, IV_b, can be established. The inclusive value basically corrects for the correlation of errors among the alternatives within a nest. The inclusive value is defined as:

$$IV_b = \ln \sum_{j \in b}^{J_b} e^{\left(\frac{\mathrm{V_{j,k}}}{\tau_\mathrm{b}}\right)}$$

The probability for choosing nest *b* is[47]:

$$P_b = \frac{e^{\tau_b \cdot IV_b}}{\sum_{b=1}^{B} e^{\tau_b \cdot IV_b}}$$

Hence the full expression for the choice probability of alternative *c* indicated above is:

$$P_{n,c,b} = \frac{e^{V_{n,c|b}}}{\sum_j^{J_b} e^{V_{n,j|b}}} \cdot \frac{e^{\tau_b \cdot IV_b}}{\sum_{b=1}^{B} e^{\tau_b \cdot IV_b}}$$

The nested logit model is estimated as a robustness test for the results obtained from the conditional logit model.

5.4 Data

5.4.1 Data sources

The two most important data sources for this project are the fDi Markets database[48] collected and provided by Financial Times and the newly developed World Input-Output database (WIOD).[49]

The main data source for investment projects and hence the construction of the agglomeration externalities variable is the fDi Markets' crossborder investment monitor. This database records individual cross-border greenfield investment projects by industries and

[47] This is the version of the nested logit model without nest specific variables which is the case in our empirical specification.

[48] See: http://www.fdimarkets.com.

[49] See: http://www.wiod.org/new_site/home.htm

business functions from 2003 onwards. We use information on projects over the period 2003 to 2012. Data is available on a monthly basis but we use quarterly periods. This is done to reduce the potential influence of lags with which the projects are recorded in the database.

The fDi markets database only records new investment projects referred to as greenfield investments as well as major extensions of existing projects. This subset of FDI projects are more closely related to real investments – understood as additions to the capital stock – than the aggregate FDI stock which is for many countries dominated by mergers and acquisitions and inter-company financial flows. Another advantage of the fDi markets database is that it allocates the FDI projects to the ultimate destination country. This means that, for example, an Austrian investment in Romania involving a special purpose company located in Cyprus is still registered as an Austrian investment in Romania, while in the balance of payments, depending on the structure of the transaction, an Austrian investment in Cyprus and a Cypriote investment in Romania may be recorded.

One caveat is that the fDi markets database is less systematic compared to FDI data from official balance of payments data as the recorded projects reflect commitments or intentions of firms to undertake the respective investment projects. However, the database is cleared from projects that have not materialised and should therefore be reliable. It has also become a standard data source for UNCTAD's annual World Investment Report. More recently the database has also been used for research papers in a European context (e.g. Castellani and Pieri, 2013, Antonietti et al., 2015).

One complication is that the industry classification used in the fDi Markets database does not correspond exactly to standard international classifications such as NACE which is used by the WIOD. For many fDi industries, such as the semiconductor industry, a direct and unique match to the NACE Rev.2 industry can be found. Unfortunately, this is not the case for other industries such as the category consumer goods which does not have a unique correspondence in the NACE classification. Where no one-to-one correspondence between fDi industries and NACE industries exists, the project is assigned to the appropriate NACE industry individually. The fDi industry "space & defence" for example has no unique correspondence in the NACE classification and therefore had to be classified on a case by case basis. The investment project by Italian Selex Galileo – a company producing radar units and other electronic and information systems for the defence industry – undertaken in the UK is assigned to the computer, electronic and optical products industry (NACE Rev. 2 division 26). In contrast, the investment by Belgian company Herstal in Portugal is assigned to the motor vehicles industry (NACE Rev. 2 division 29) based on the information in the fDI database that the projects is linked to the production of '*Military armoured vehicles, tanks, & components*'. The correspondence between fDi Markets database and NACE industries according to the WIOD database is shown in Appendix 5.7.1.[50]

Having assigned all projects to the corresponding NACE industry divisions, we further aggregate some of the divisions in order to have a reasonable number of investment projects in all industry groups ending up with 14 industries. These are also listed in Appendix 5.7.1.

[50] The fact that the matching of projects to NACE industries is very time-consuming is also the reason why the sample was limited to only six investor countries where in principle we could have investigated greenfield investments by all EU member states.

The second main database is the World Input Output Database (WIOD). WIOD provides global input-output tables across 40 countries including 27 EU Member States[51], most other major industrialised countries and some large emerging markets. Given the scope of the project we use all relevant information for calculating the linkage variables for the EU-27 – the potential host countries. The unique advantage of the WIOD database is that it allows calculating inter-industry linkages not only within an economy but also the corresponding linkages between the industries of trading partners. We exploit this information on the domestic and international sourcing structures of industries to calculate the forward and backward linkages of the 27 EU Member States as presented in the previous section.

All information from the World Input-Output Table is available for the period 1995-2011. Therefore, data for 2012 has to be imputed. Since the location choice model relies on differences between locations we simply assume that the sourcing structures have not changed between 2011 and 2012 and therefore use the input-output coefficients of 2011 for the year 2012. The Krugman specialisation index is equally calculated with value added data from WIOD's World Input-Output Table.

Some of the additional control variables are drawn from other data sources. We rely on Eurostat for data on labour costs (in Euro per person), population, R&D expenditure per capita, employment by occupational attainment (according to ISCED), real GDP per capita and real GDP growth. Employment data for the years 2010-2012 is also obtained from Eurostat because the employment data in WIOD's Socio-Economic Accounts is available only until 2009. The gravity variables which include distance, common official language, common border and same country status are obtained from CEPII's GeoDist database (for details see Mayer and Zignano, 2011*)*. Information on state aid comes from the European Commission's State Aid Scoreboard Database. Government effectiveness, an overall measure for the role of institutions, is taken from the World Bank's World Governance Indicators (WDI) database.

It should also be noted that the data on forward and backward linkages from the WIOD database as well as most control variables are only available at an annual basis. Since the location decisions for investment projects take place at quarterly intervals, the annual data entry is used for each quarters of the year.

All data for the analysis at the level of NUTS 2 regions come from Eurostat database except for the distance measures which are obtained from Eurostat's Web Index of Locations for Statistics in Europe.[52]

5.4.2 Descriptives

The data sample stretches over the period 2003-2012 and consists of 3,058 production-related cross-border greenfield investment projects undertaken by firms in the six European core countries in EU Member States. Germany was by far the biggest investor country

[51] Croatia is not included in the WIOD.

[52] See http://epp.eurostat.ec.europa.eu/WebILSE/flatfiles.do

accounting for 1,340 or 44% of these investment projects.[53] The number of investment projects was constantly growing from 2003 to 2007, followed by a severe drop in 2009 due to the global economic crisis of 2008/2009. Since then the cross-border investment activity has somewhat recovered but remains clearly below the pre-crisis boom level (2005-2007). For the year 2012 only 163 projects are on record.

With regard to the host countries Poland emerges as the country which attracted the largest number of projects (393 projects) followed by Romania (361 projects) and Hungary (332 projects). France and Spain come in fourth and fifth position respectively.[54]

The distribution of projects across Member States indicates that two groups of countries attracted a high number of projects: large EU Member States on the one hand and the catching-up economies in Central and Eastern Europe on the other hand. This is shown in the left panel of Figure 5.2. The prominent role of the Central and Eastern EU Member States is unusual in FDI data and due to the fact that the FDI transactions in the sample are restricted to production-related greenfield investments.

The distribution of projects across host countries is strongly influenced by location decision of German firms due to their prominence in the sample. The overall distribution of projects therefore does not fully reflect the investment pattern of each source country and obviously there are some important differences in the location patterns and rankings of preferred destinations. For example, Spain is the prime location for French investors, Germany is the leading host country for Dutch MNEs and Hungary attracted the largest number of Austrian investment projects.

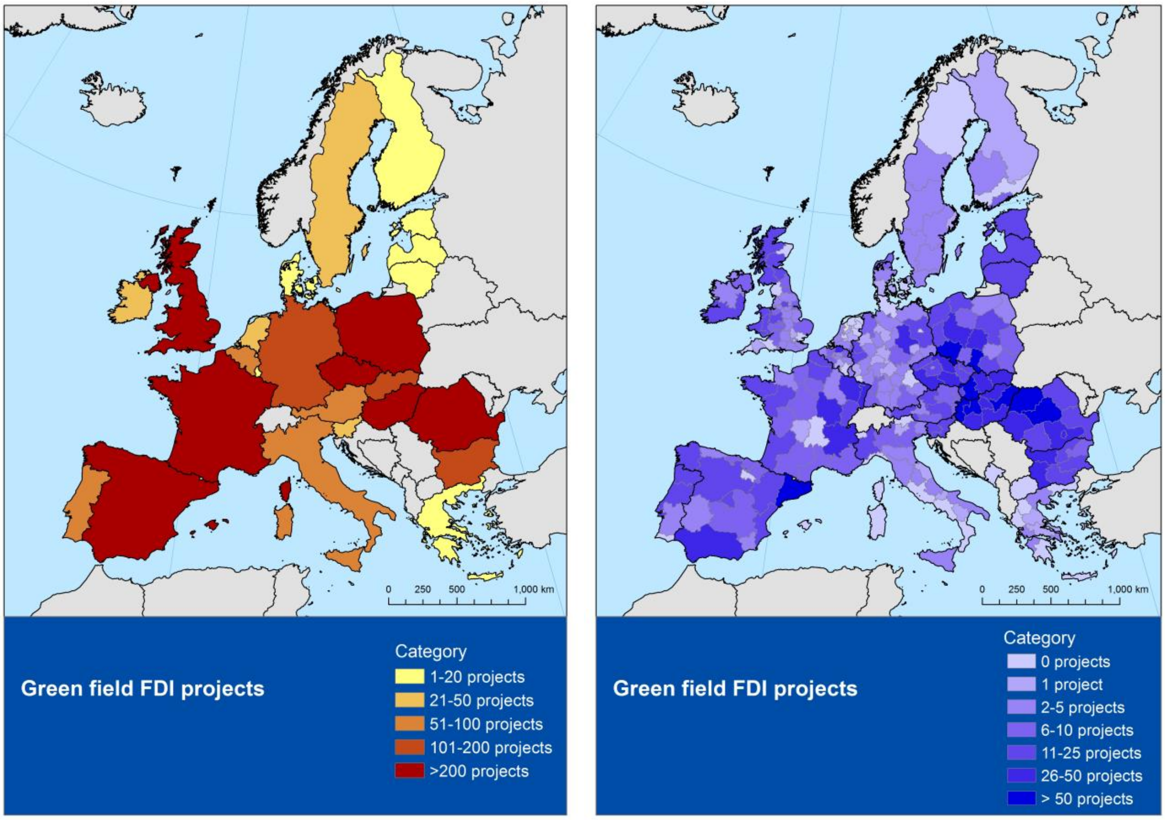
Figure 5.2 also shows the distribution of projects across NUTS 2 regions. Of the 270 NUTS 2 regions there are 221 regions where at least one project in our sample was located. Due to the fact that the fDi Markets database does not contain information for all projects on the region or city in which the project is located the sample for the regional analysis shrinks to 2,810 projects. The analysis is restricted to these 221 regions in which projects have been realised in our sample. In several of the larger Member States, the investment projects are rather unevenly distributed. This is for example the case in Poland or Spain. Interestingly, in several cases the regions which could attract the highest number of regions are border regions. This is for example true for the Polish region of Lower Silesia (Dolnoslaskie) where 80 projects were recorded – the highest number in our sample. The region with the second largest number of project is Catalonia in Spain with 76 project which is again a border region (with France). With 75 projects the Hungarian region of Western Transdanubia (Nyugat-Dunántúl), which borders both Slovakia and Austria, ranks third followed by Western Slovakia (Západné Slovensko) and the Hungarian Northern Great Plain (Észak-Alföld).

The number of projects a country or region managed to attract as presented here is obviously influenced by the economic size of a country or region. In the econometric analysis size is controlled for by the value added of the respective industry and by population.

53 For details see Appendix 5.7.2.

54 The relatively low number of projects in Germany is influenced by the fact that Germany is the most important FDI investor country and cannot undertake any foreign investment projects in Germany itself.

Figure 5.2: Number of greenfield investment projects by host country and regions



Note: Maps created with ArcGis ArcView.

There is also a wide variation in the number of FDI projects across industries ranging from only 12 in the *coke, refined petroleum and nuclear fuel industry* to 668 projects in the *transport equipment industry.* Production-related greenfield FDI activity in the latter is again strongly dominated by German MNEs but it is also an important industry for MNEs from France and Italy. Other important industries include the chemical industry and the machinery industry as well as the non-metallic minerals industry. The latter is for example, the primary industry of Austrian greenfield FDI investors, whereas Belgian and Dutch investors were most active in the chemicals industry.

5.5 Results

5.5.1 Country level

All estimation results are based on the location decisions of first mover firms[55] which results in a sample of 2,117 location decisions.[56]. Table 5.1 presents the results for the country level using a conditional logit model.

[55] Due to lack of data we cannot know whether a firm has already undertaken investment projects in any particular market before 2003.

The first specification in Table 5.1 includes – apart from the fixed set of control variables – only the agglomeration externalities, i.e. the number of investment projects already undertaken in each of the host economies in the respective industry by firms from the same source country (*projects*^{source}) and those by firms from the other five investor countries (*projects*$^{other\ EU\text{-}5}$). The estimated coefficient of *projects*^{source} is positive and statistically significant at the one percent level. This implies that a larger pool of existing greenfield FDI projects already realised in a particular host country increases the probability of that destination to attract further investments. In our model framework this is due to agglomeration externalities. In terms of magnitude the estimated coefficient of 0.285 is in the same order of magnitude as in related studies though it is somewhat lower than for example the effect found by Head et al. (1995) for investments by Japanese MNEs in US states or the results for Norwegian investors in Balsvik and Todel Skaldebo (2013).

Since the conditional logit model is a non-linear estimator, the coefficients do not directly indicate the marginal effects. Following Head et al. (1995) we calculate the average probability elasticities associated with our estimated coefficients as $\hat{\beta} \cdot \frac{J-1}{J}$ where $\hat{\beta}$ is the estimated coefficient of the respective variable and J is the number of potential host countries of FDI which is *25*.[57] The average probability elasticity is simply the sum over all host-country specific average marginal effects. Therefore the average probability elasticity would indicate that a 10% increase in the number of projects from the same investor country in a particular industry in a particular host country increases the probability of that host country to be chosen as FDI location by 2.7%. The presence of firms from the other investor countries (*projects*$^{other\ EU\text{-}5}$) in a particular host country also increases the probability of a host country to be chosen as FDI location but with 0.127 the coefficient is considerably lower. This indicates that the agglomeration economies between investors from different countries are smaller than those between compatriot investors.

This result on the scope of agglomeration externalities fits nicely with those in Crozet et al. (2004) who analyse French inward FDI and find that agglomeration economies between FDI investors with the same nationality are more than twice as large as those between FDI investors from different source countries. Procher (2011) in his analysis of French FDI, however, argues that the number of French firms present in the host economies has a similar effect than the presence of German firms.

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56 Note that the number of 'first moves' exceeds the number of investing firms in the sample (1,913) which is due to the fact that our decision of first movers is a firm that invests for the first time in a particular industry in a particular country. Therefore, some firms appear more than once in the sample. We also estimated the conditional logit models with an alternative definition of first movers including each firms only once. The results in this case are qualitatively the same.

57 The average probability elasticity can be retrieved from the conditional logit's marginal effects which (for the direct elasticities) is $p_{nj} \cdot (1 - p_{nj}) \cdot \hat{\beta}_k$ where $\hat{\beta}_k$ is the estimated coefficient of explanatory variable *k*. Since the variables enter in log-form, the marginal effects are already semi-elasticities. To retrieve the elasticity for alternative *k*, the marginal effects are divided by the probability p_{nj} to yield $(1 - p_{nj}) \cdot \hat{\beta}_k$. The average over all alternatives is then obtained by summing up over all alternatives *J* and taking the average, i.e. $\frac{1}{J} \cdot \sum_{j=1}^{J}(1 - p_{nj}) \cdot \hat{\beta}_k$. Since the probabilities add up to one this results to $\frac{J-1}{J} \cdot \widehat{\beta}$.

Table 5.1: Determinants of location choice: conditional logit model, country level, 2003-2012

	Dependent variable:	**Location chosen (=1) versus Location not chosen (=0)**			
		(1)	(2)	(3)	(4)
Agglomeration effects	projects^{source}	0.2849***	0.2791***	0.2277***	0.2258***
		(0.049)	(0.049)	(0.050)	(0.050)
	projects$^{other\ EU\text{-}5}$	0.1269***	0.1010**	0.0987**	0.0972**
		(0.047)	(0.048)	(0.048)	(0.049)
	BW linkages		-0.1799**	-0.1535*	-0.1658*
			(0.090)	(0.091)	(0.092)
	FW linkages		-0.0748	-0.0590	-0.0608
			(0.048)	(0.049)	(0.051)
International linkages	BW linkages$^{host\text{-}source}$			0.2356***	0.2511***
				(0.088)	(0.093)
	FW linkages$^{host\text{-}source}$			0.2313***	0.2316***
				(0.060)	(0.064)
	BW linkages$^{host\text{-}foreign}$				-0.1324
					(0.123)
	FW linkages$^{host\text{-}foreign}$				-0.0524
					(0.084)
Industry structure	value added^{industry}	0.3720***	0.3500***	0.4104***	0.4091***
		(0.059)	(0.062)	(0.064)	(0.064)
	K-spec	-1.0520***	-1.0165***	-0.5661*	-0.5489*
		(0.322)	(0.321)	(0.330)	(0.330)
Wage level	labour costs	-2.3339***	-2.3178***	-2.2279***	-2.2673***
		(0.421)	(0.426)	(0.425)	(0.428)
Market size & growth	population	2.2230	2.1633	2.0300	2.0808
		(2.278)	(2.267)	(2.262)	(2.260)
	real GDP per capita	-0.0956	-0.0289	-0.1052	-0.0581
		(0.524)	(0.523)	(0.524)	(0.527)
	real GDP growth	-0.0155	-0.0127	-0.0124	-0.0107
		(0.014)	(0.014)	(0.014)	(0.014)
Technology and skills	R&D exp per capita	0.8813***	0.8910***	0.8804***	0.8617***
		(0.297)	(0.298)	(0.298)	(0.298)
	medium-skilled workers	-0.0059	-0.0029	0.0002	-0.0016
		(0.030)	(0.031)	(0.031)	(0.031)
	high-skilled workers	-0.0028	-0.0073	-0.0078	-0.0067
		(0.041)	(0.041)	(0.041)	(0.041)
Policy and institutions	state aid	-0.0656	-0.0737	-0.0908	-0.0905
		(0.066)	(0.067)	(0.067)	(0.067)
	gov't effectiveness	0.6357	0.7218	0.7279	0.7236
		(0.863)	(0.865)	(0.864)	(0.864)
Gravity type variables	distance	-0.0938	-0.0915	0.0183	0.0217
		(0.075)	(0.076)	(0.077)	(0.077)
	common language	0.2634*	0.2468*	0.0391*	0.0277
		(0.150)	(0.149)	(0.150)	(0.150)
	common border	0.5324***	0.5361***	0.3653***	0.3494***
		(0.088)	(0.087)	(0.091)	(0.092)
	same country	0.3987**	0.4358**	0.3995**	0.4128**
		(0.173)	(0.173)	(0.165)	(0.165)
	log-likelihood	-5409.86	-5377.46	-5357.71	-5356.67
	obs.	52575	52300	52300	52300
	cases	2103	2092	2092	2092
	nb. of clusters	1913	1908	1908	1908

*Note: In all specifications the dependent variable is a binary variable which for each project takes the value 1 for the country where the project has been located and 0 for all other potential countries. Constants for alternatives included. Industry classification based on NACE Rev2. All variables except for dummy variables and variables expressed in shares enter the model in log-form. Same country = dummy for whether source and investor country used to be part of the same country/empire. ***, **, * indicate statistical significance at the 1%, 5% and 10% level respectively. Standard errors in parentheses. Standard errors are robust to clusters allowing for intra-firm correlation of errors.*

Specifications (2) to (4) add the agglomeration effects related to domestic inter-industry linkages as well as the international inter-industry linkages. The discussion mainly focuses on specification (3) as it is the model that corresponds closest to our model framework. The coefficients of the two agglomeration economies variables remain unaffected qualitatively from the addition of further variables, although they get slightly smaller in magnitude. The effect of a 10% increase in the number of projects from investors from the same source on the probability of host economy to be chosen as FDI location is now on average 2.2%.

A first surprising result is found for the inter-industry linkages in the host economy. These linkages turn out to be negative and in the case of the backward linkages the estimated coefficient is also statistically significant at least at the 10% level. This means that strong inter-industry linkages in a potential host economy are, if anything, a locational disadvantage. So the probability that an investor locates a project in a particular host economy declines with the strength of domestic backward linkages. This is in contradiction with the findings of Du et al. (2007) who find positive backward and forward linkages in the Chinese economy for FDI by US firms. However, Debaere et al. (2010), who investigate South Korean investments in Chinese regions, report negative though statistically not significant coefficients for the backward linkages in the Chinese economy. In their work only inter-industry linkages with other Korean firms present in China matter for the investment decisions.

Turning to the international linkages between the source and the host country ($BW\ linkages^{host\text{-}source}$ and $FW\ linkages^{host\text{-}source}$), we find positive and statistically significant effects on the probability of the host country to be chosen as location by FDI investors from the source country. For example, if Slovakia's transport equipment industry relies strongly on German inputs from German industries that are large (including the transport equipment industry itself) then Slovakia tends to become a more attractive FDI location for German car manufacturers and other producers of transport equipment. As pointed out earlier, we can attribute this positive effect of source-host inter-industry linkages to a signalling effect and to expected cost advantages. From the viewpoint of a new investor already well established supplier-buyer relationships among firms between the host and the source country indicate good offshoring opportunities and associated low co-ordination costs of offshoring. An alternative interpretation which would emerge from the NEG framework would be that transportation costs are so low that the availability of domestic suppliers and customers do not really matter much because inputs can be shipped from anywhere and output sold to other markets (including the investor's home market) at very low cost. Quantitatively, the effects of host-source backward and forward linkages on location choice are in the range of the national agglomeration externalities. A 10% increase in the backward linkage between host and source economy increases the probability to be chosen as the destination for an FDI project by 2.5%. The corresponding elasticity for the host-source forward linkages is 2.3%.

For the sake of completeness specification (4) incorporates also host country forward and backward linkages to all EU member states other than the source country. However, in neither of the two cases a statistically significant coefficient is obtained.

There are also a number of control variables which deserve attention. The first one is the industry-level value added which serves as proxy for host country industry size and the endowments required by the respective industry. Arguably, the number of domestic firms would be the more logical variable to control for the endowments in the host economy. We also performed the analysis with the number of firms in each industry instead of value added. However, this variable did not turn out to be statistically significant which is why industry value added was maintained to control for endowments and size. Controlling for endowments is important because it could well be that FDI investors follow the same investment pattern as firms in general. The coefficient of industry value added is positive and statistically significant at the 1 percent level. The magnitude of the coefficient is also large in comparison to the agglomeration externalities and the international linkages which indicates that this is an important control variable.

The measure for relative industry specialisation, the Krugman specialisation index (*K-spec*) turns out to affect location decisions negatively with the coefficient being statistically significant at the 10% level in specification (3). This implies that for the greenfield investments in the sample FDI investors rather select destinations with a distinct industry structure compared to their home country.

Given the theoretical motivations for our empirical model it is imperative to include the wage level into the analysis. A priori the role of wages for the attractiveness of a country is ambiguous. On the one hand, high wages may make a location more attractive if one associates wages with income and purchasing power in the economy. On the other hand, lower wages constitute a locational advantage because lower wages imply lower costs rendering the FDI investment ceteris paribus more profitable. This is the logic emphasised in the NEG literature and our results suggest that this effect indeed dominates. Lower wages (labour costs) increase the probability of a host country to attract greenfield FDI projects. The coefficient is very large exceeding the one for source country agglomeration economies by the factor 10. This result for wages together with the positive impact of host-source country linkages also hints on the motives for FDI. More precisely, the combined results suggest that many of the investment projects in our sample were driven by efficiency seeking motives for FDI.

It should be noted that the magnitude of our coefficient for the wage costs is considerably higher than those found in other studies such as Disdier and Mayer (2004) who investigate French investments across EU member states. Close in magnitude to our results on wages is Basile (2004) who finds a negative and statistically significant coefficient for unit labour costs in his analysis of FDI across Italian regions. In this contribution both foreign acquisitions and of greenfield investments in Italian regions are analysed and it turns out that the coefficient in the greenfield investments is about twice the size. This suggests that the negative effect of the wage variable is influenced by the fact that our sample consists only of greenfield FDI. Interesting is also the result in Gauselmann and Marek (2012) who estimate a conditional logit model for FDI in transition economies. They find a positive effect of high wages on locational attractiveness in their general sample but a negative effect for investments by industrial firms. In our case the analysis is not only limited to industrial firms but even to projects specifically related to the build-up of production capacity. This focus on production-related projects therefore also contributes to the strong attraction effect found for lower wage costs.

The specificities of our sample also explain (at least partially) why none of our market size and growth variables turn out to be statistically significant. The fact that neither population, nor real GDP per capita and real GDP growth seem to affect the location of production-related greenfield FDI projects may be the mirror image of the results for the inter-industry linkages and the wage variable which all point towards a primacy of offshoring and efficiency seeking motives for this mode of FDI.

Among the control variables for technological capabilities and the availability of skills in the host economies only the R&D expenditures per capita turn out to be a relevant attraction factor. The magnitude of the coefficient, which is quite high, could suggest that in addition to efficiency seeking motive based on low wages costs there may also be some technology seeking projects.

The provision of subsidies (*state aid*) by potential host economies and the effectiveness of the government do not affect the location decision of foreign investors. The result for the ineffectiveness of government support policies is in line with the conclusion in Crozet et al. (2004) who find very little impact of regional policies for foreign investments in French regions. Institutional quality is more often found to influence the location choices of FDI investors. Disdier and Mayer (2004) for example find that more political rights and civil liberties increase a country's attractiveness. The reason for the differences found in their study and ours may of course be explained by the fact that a different indicator is used but also because their sample period is very different from ours ranging from 1980 to 1999. For other regions there are also a number of studies which find some effect for institutions. Du et al. (2008), for example, find that US firms prefer to locate in Chinese regions with higher protection of intellectual property rights and lower government corruption. Because of the many positive results in the literature concerning institutional quality we also tested alternative indicators such as the economic freedom indicator from the Heritage foundations, some of their sub-indicators such as property rights, freedom from corruption and investment freedom, or economic restrictions from the KOF index of globalisation. However, none of these indicators turned out to affect location choice in our sample. We assign this to the fact that FDI investors consider the quality of institutions across EU member states as being sufficient for doing business so that the remaining differences are not decisive for their location choices.

In principle, the coefficients of the gravity type variables are all as expected. The only surprise may be the geographic distance between capitals of the involved countries which is positive and statistically not significant. This, however, is easily explained by the fact that the common border dummy already captures an important part of the distance effect. For common language the sign of the coefficient is also as expected but again it is not statistically significant. Countries are more likely to attract projects from a particular source country if they share a common border and this effect is statistically significant at the 1% level. The same is true if source and host country once formed one country or have historically belonged to the same empire. In our sample, this means for example that according to the estimation results firms from Austria are, ceteris paribus, more likely to invest in Hungary, Slovenia, the Czech Republic and Slovakia than in the other EU Member States since they once belonged to the Habsburg Empire.

These results were obtained based on the assumption that the probability of preferring one host country over another is independent of the availability of other alternatives (IIA-assumption). We now relax this assumption by switching from a conditional logit model to a nested logit model. We opt for two nests which are the EU-15 and the NMS.[58] Otherwise we leave the set-up of our empirical model unchanged. The results for specification (3) and (4) are summarised in Table 5.2.

Qualitatively the results from the nested logit model do not differ from those of the conditional logit model. However, almost all estimated coefficients turn out to be larger in the nested logit model. This is true in particular for the variables of main interest. For example, the coefficient of the backward linkages between the host and the source country (*BW linkages*$^{host\text{-}source}$) is estimated to be 0.307 compared to 0.251 in the conditional logit approach. The size of the coefficients obtained from the nested logit model can be compared to those from the conditional model but the interpretation is slightly different (see Disdier and Mayer, 2004). The coefficients, adjusted for $\frac{J-1}{J}$ indicate the country's increase in the choice probability compared to all the other alternatives within the same nest. Since alternatives within a nest are assumed to be closer substitutes also the effect on the choice probability of a country within a nest against that of other countries belonging to the same nest should be relatively larger.

The dissimilarity parameters obtained in the nested logit model exceeds one for both nests which actually indicates that the model – though mathematically correct – is incompatible with profit maximisation. A log-likehood ratio test, testing the restriction that the dissimilarity parameter is equal to one, is a common test for choosing between the conditional logit and the nested logit model. This test, however, can only be performed for models with non-robust standard errors. If we re-estimate the two models with non-robust standard errors, this log-likelihood test would favour the nested logit model.

[58] For the full decision tree of the nested logit model see Appendix 5.7.4.

Table 5.2: Location choice: Nested logit model, country level, 2003-2012

	Dependent variable:	Location chosen (=1) versus Location not chosen (=0)			
	Variable	(3)		(4)	
Agglomeration effects	$projects^{source}$	0.3466***	(0.088)	0.3467***	(0.089)
	$projects^{other\ EU\text{-}5}$	0.1559*	(0.081)	0.1528*	(0.081)
	BW linkages	-0.2025	(0.137)	-0.2283	(0.139)
	FW linkages	-0.1192	(0.080)	-0.1348	(0.086)
International linkages	BW $linkages^{host\text{-}source}$	0.2623*	(0.138)	0.3072**	(0.148)
	FW $linkages^{host\text{-}source}$	0.2472***	(0.091)	0.2219**	(0.100)
	BW $linkages^{host\text{-}foreign}$			-0.2596	(0.201)
	FW $linkages^{host\text{-}foreign}$			-0.0199	(0.126)
Industry structure	value $added^{industry}$	0.5831***	(0.107)	0.5802***	(0.107)
	K-spec	-1.4689*	(0.780)	-1.4911*	(0.804)
Wage level	labour costs	-3.9503***	(1.067)	-4.0170***	(1.085)
Market size & growth	population	1.9313	(3.760)	2.1156	(3.809)
	real GDP per capita	0.2109	(0.814)	0.2918	(0.823)
	real GDP growth	-0.0178	(0.022)	-0.0142	(0.023)
Technology and skills	R&D exp per capita	1.6476**	(0.667)	1.6366**	(0.671)
	medium-skilled workers	-0.0057	(0.049)	-0.0086	(0.050)
	high-skilled workers	-0.0001	(0.066)	0.0021	(0.066)
Policy and institutions	state aid	-0.1094	(0.107)	-0.1109	(0.107)
	gov't effectiveness	0.6579	(1.358)	0.6337	(1.370)
Gravity type variables	distance	0.1308	(0.117)	0.1405	(0.119)
	common language	0.0544	(0.201)	0.0361	(0.204)
	common border	0.6773***	(0.204)	0.6653***	(0.206)
	same country	0.7511***	(0.287)	0.7774***	(0.293)
	log-likelihood	-5349.73		-5348.68	
	obs.	52300		52300	
	Cases	2092		2092	
	nb. of clusters	1908		1908	
	dissimilarity parameters				
	τ EU-15	1.5572	(0.302)	1.5760	(0.311)
	τ NMS	1.7912	(0.319)	1.8028	(0.328)

*Note: In all specifications the dependent variable is a binary variable which for each project takes the value 1 for the country where the project has been located and 0 for all other potential countries. Constants for alternatives included. Industry classification based on NACE Rev2. All variables except for dummy variables and variables expressed in shares enter the model in log-form. Same country = dummy for whether source and investor country used to be part of the same country/empire. ***, **, * indicate statistical significance at the 1%, 5% and 10% level respectively. Standard errors in parentheses. Standard errors are robust to clusters allowing for intra-firm correlation of errors.*

5.5.2 Regional level

We have argued above that we consider countries to be an appropriate level of analysis. In order to rule out the possibility that the effects on location choice that were found for the agglomeration factors and the international linkages only exist at the national level we repeat the estimations using NUTS 2 regions as the possible locations for FDI investors.

We redo all the project stock variables at the level of NUTS 2 regions. For the inter-industry linkages (both domestic and international), however, we can only work with the national variables because both the international input-output data and the industry-level employment data are only available at the national level. Also, the regional model will have to be much more parsimonious with respect to control variables because not all information is available for NUTS 2 regions. We still try to get variables for all categories of controls, however, for the industry structure we can only use employment for the entire industrial sector instead of industry-specific employment or value added which was used for the model at the national level.

To control for market size we keep GDP per capita which here is at purchasing power parities (PPP) and population. Also available at the NUTS 2 level are industrial wages which are again proxied by the labour costs in the industrial sector. To control for skills, the share of medium-skilled and high-skilled workers in the workforce are used again but there is no proxy for technology because R&D data at the NUTS 2 level is too sketchy in order to be used in the analysis. Finally, we again use state aid and government effectiveness to account for the potential impact of state support policies and institutions though these indicators are defined at the national level. In these cases we deem these permissible as government institutions and subsidies are typically (though not exclusively) designed and provided by central governments.

Table 5.3 portrays the results of both the conditional logit and the nested logit model for the regional location choice model.

We take some comfort from the fact that our main results from the country level analysis are fully confirmed. Agglomeration economies (knowledge spillovers) among FDI investors from the same country ($projects^{source}$) continue to act as an attraction factor. The size of the coefficient is considerable larger than suggested by the country level results. Given the uneven distribution of projects across regions within many EU member states this result is not very surprising. The concentration of projects in selected regions can be explained by the fact that the spread of knowledge spillovers is geographically limited. Therefore they can be expected to be stronger within NUTS 2 regions than within the entire country. Admittedly, the analyses at the national and the regional level are not fully comparable because there are important differences with respect to the control variables included.

One difference with respect to the agglomeration externalities in the regional model is that it does not suggest an impact of the presence of FDI investors from other countries on the locational attractiveness of regions.

Table 5.3: Location choice: Conditional logit and nested logit model, regional level, 2003-2012

	Dependent variable:	**Location chosen (=1) vs Location not chosen (=0)**			
	Modell:		**conditional logit**		**nested logit**
		(1)	(3)	(4)	(4)
Agglomeration effects	projects^{source}	0.4879***	0.4447***	0.4429***	0.4906***
		(0.060)	(0.061)	(0.061)	(0.120)
	projects$^{other\ EU\text{-}5}$	0.0191	-0.0086	-0.0105	-0.0205
		(0.050)	(0.051)	(0.051)	(0.055)
(national)	BW linkages		-0.2612***	-0.2761***	-0.3008***
			(0.091)	(0.092)	(0.111)
(national)	FW linkages		-0.1090**	-0.1163**	-0.1371*
			(0.049)	(0.050)	(0.073)
International linkages	BW linkages$^{host\text{-}source}$		0.3257***	0.3547***	0.4017***
(national)			(0.088)	(0.093)	(0.133)
	FW linkages$^{host\text{-}source}$		0.1880***	0.1726**	0.1699**
			(0.063)	(0.068)	(0.075)
	BW linkages$^{host\text{-}foreign}$			-0.1450	-0.1777
				(0.125)	(0.153)
	FW linkages$^{host\text{-}foreign}$			0.0050	0.0199
				(0.087)	(0.095)
Industry structure	employment$^{industrial\ sector}$	0.2782	0.4202	0.5104	0.7478
		(0.401)	(0.406)	(0.413)	(0.550)
Wage level	labour costs	0.0363	0.0693	0.0700	-0.0023
(national)		(0.261)	(0.271)	(0.271)	(0.309)
Market size	population	2.1651	2.1963	2.3322	1.9415
		(1.516)	(1.531)	(1.529)	(1.680)
	GDP at PPP per capita	-0.8860*	-0.6676	-0.7049	-0.7477
		(0.485)	(0.493)	(0.495)	(0.569)
Technology and skills	medium-skilled workers	-0.0172	-0.0143	-0.0153	-0.0196
		(0.020)	(0.020)	(0.020)	(0.022)
	high-skilled workers	0.0317	0.0286	0.0281	0.0296
		(0.025)	(0.025)	(0.025)	(0.025)
Policy and institutions	state aid	-0.1213*	-0.1439**	-0.1437**	-0.1464*
(national)		(0.068)	(0.069)	(0.069)	(0.086)
	gov't effectiveness	0.3667	0.4854	0.4957	0.4653
		(0.856)	(0.855)	(0.855)	(0.870)
Gravity type variables	distance	-0.6225***	-0.3344***	-0.3252***	-0.3075***
		(0.059)	(0.075)	(0.077)	(0.086)
(national)	common language	0.3265**	0.0737	0.0597	-0.0013
		(0.147)	(0.149)	(0.149)	(0.140)
	log-likelihood	-9166.40	-9096.02	-9095.32	-9092.85
	obs.	373871	372317	372317	372317
	nb. of alternatives	211	211	211	211
	nb. of clusters	1792	1787	1787	1787
	dissimilarity parameters				
	τ EU-15				0.9013
	τ NMS				1.2625

*Note: In all specifications the dependent variable is a binary variable which for each project takes the value 1 for the country where the project has been located and 0 for all other potential countries. Constants for alternatives included. Industry classification based on NACE Rev2. All variables except for dummy variables and variables expressed in shares enter the model in log-form. Same country = dummy for whether source and investor country used to be part of the same country/empire. ***, **, * indicate statistical significance at the 1%, 5% and 10% level respectively. Standard errors in parentheses. Standard errors are robust to clusters allowing for intra-firm correlation of errors.*

Regarding the domestic inter-industry linkages and the international linkages we find the same pattern as before: the probability of a region to be selected as the destination by a FDI investors increases with the strength of the inter-industry linkages between the host and the source country. This holds for both the international forward and the backward linkages. The same is not true for the domestic linkages which in the regional specification even turn out to be highly statistically significant implying that strong domestic backward and forward linkages make a region less attractive for FDI investors.

Most control variables deliver rather disappointing results though in most cases this is in line with our findings for the national level. An important difference in the regional analysis is that the wage variable is not statistically significant anymore. This is somewhat surprising because the wages were highly significant in the country level model and the result also fit well with the pattern of the international linkages variables. A potential explanation for this difference is that investors consider the wage level when deciding between countries but for the actual region the wage level is less important. For example, Austrian investors may be attracted by low wages in Hungary but they do not necessarily choose the Hungarian region with the lowest wage level.

Somewhat of a surprise is the negative coefficient found for the state aid variable. Since the variable refers to the country level, the result has to be interpreted with care. Keeping this in mind, the negative sign would indicate that higher subsidies provided by the government reduce the regions probability to attract FDI greenfield projects. As pointed out above, finding government support policies to be ineffective is quite common but the negative effect is not expected. One potential – though in this context speculative – explanation is that eligibility for EU Cohesion Funds makes a region more attractive and that EU governments provide national subsidies mainly for non-eligible regions.

Among the gravity variables the distance measure, which now indicates the difference between the capital of the source country and the capital city of the NUTS 2 region on the side of the destination country, turns out to be statistically significant with the expected negative sign.

The nested logit model at the regional level maintains the nest structure employed at the national level, i.e. EU-15 countries and the new EU member states define the two nests.[59] This is in line with Disdier and Mayer (2004) and can be motivated by the results in Basile et al. (2009) who find that European multinationals potentially consider regions across different countries as relatively closer substitutes than regions within the country. Compared to the coefficients from the conditional logit model, the nested logit model delivers again larger coefficients. Otherwise there are no important differences between the two models. The sole difference is that the employment in the industrial sector becomes statistically significant at the 10% level.

Overall, the regional location choice model confirms the findings from the country-level analysis.

[59] A logical alternative would be to use the countries as nests but this model does not convergence, presumably due to the large number of nests implied by this structure.

5.6 Conclusions

In this paper we investigated the role of agglomeration forces and international linkages for the location decisions of MNEs from six European investor countries. The subject of the location decisions are production-related greenfield FDI projects. The analysis is undertaken at the country level and at the regional (NUTS 2) level. The results suggest that the presence of firms both from the investor's own country and from other investor countries is an important determinant for location choices. A larger number of past projects realised in a particular location therefore increases the probability for a potential host country (or region) to attract further investments. In our theoretical framework this reflects knowledge spillovers among firms which is one reason why firms tend to co-locate with compatriot firms from the same industry. The presence of FDI firms from other investor countries, however, is found to affect location decisions only at the national level.

The second type of agglomeration forces in our model, the backward and forward linkages among firms operating in the host economy, delivers a surprising result: strong domestic forward and backward linkages are suggested to make a location less attractive for FDI investors. This is surprising because it runs counter the idea that firms locate close to suppliers and customers in order to benefit from cheaper inputs and higher demand. Importantly, the opposite is found for the international linkages: backward and forward host-source country linkages act as an attraction factor which we associate with lower co-ordination costs of offshoring. These international linkages cannot be considered to be agglomeration factors in the usual sense as they do not reflect the degree of economic activity in the host country. Rather they are indicative of a country's position in international production networks and its interconnectedness more generally. Nevertheless, international linkages also contribute to the concentration of FDI projects in host countries which already have strong inter-industry linkages with any source country.

Taken together, the pattern of the agglomeration effects and the effects from the international linkages suggests that offshoring activities and efficiency-seeking motives dominate the location choice for production-related cross-border projects. This interpretation then also explains why the domestic inter-industry linkages as well as market size are basically irrelevant (or even counterproductive) for FDI location choices. Additional support for this interpretation is provided by the negative effect of wage costs on a country's probability to be chosen as the host for FDI projects even though this is only found at the country level.

All in all the pattern of coefficients fits the predictions of offshoring models and also the logic of NEG models in situations where the advantages of domestic linkages – one of the main agglomeration factor in the domestic economy – are dominated by the effect of the wage differentials. NEG predicts that this constellation is more likely when trade costs are low. Therefore this result is quite plausible. The fact that backward and forward linkages between host and source country improve the locational attractiveness of the former also fit to the story because with low trade costs FDI investors may then continue to rely on their supplier and buyer networks in their home market. Offshorable activities like production will continue to be moved to those host countries which have already well established supply-buyer relations with the source country because they signal lower co-ordination costs of offshoring costs.

The results we obtain depend to some extent on the particular sample we studied which only consists of FDI projects that create new productive capacity. But this choice was made deliberately because it established a closer link to the production linkages which are a key element in this investigation. Moreover, production-related FDI projects are important as they are often large and therefore add significantly to a country's aggregate investment. Moreover they contribute to the expansion of production and export capacity. This particular choice of FDI projects therefore also allows us to link our results to the debate about de-industrialisation and growing concentration of manufacturing production in some countries within the EU. For this debate, the fact that production-related investments are most likely the result of offshoring activities, is clearly important and contradicts – for this particular subset of FDI projects – the common belief that FDI in Europe is mainly motivated by market potential in the respective host economies.

The positive impact of the presence of other FDI investors in a country represents a form of path dependency. The same is also true for the attraction effect of strong host-source industry-linkages. In combination with the finding that both support policies as well as institutions have little effect on location choices (or are even counter-productive as in the case of state aid in the regional variant) indicates that any policy attempts to counter the concentration of production capacity in Europe will have to be very wisely designed in order to be successful.

5.7 Appendix

Appendix 5.7.1: Industry classifications

Table 5.A.1: Correspondence between fDi industries and NACE Rev. 2 divisions

fDi-Industries	NACE Rev.2 division	NACE industry descriptiom
Aerospace	30	Manufacture of other transport equipment
Alternative/Renewable energy	20	Manufacture of chemicals and chemical products
	35	Electricity, gas, steam and air conditioning supply
Automotive Components	29	Manufacture of motor vehicles, trailers and semi-trailers
Automotive OEM	29	Manufacture of motor vehicles, trailers and semi-trailers
Beverages	11	Manufacture of beverages
Biotechnology	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	26	Manufacture of computer, electronic and optical products
Building & Construction Materials	23	Manufacture of other non-metallic mineral products
Business Machines & Equipment	26	Manufacture of computer, electronic and optical products
Ceramics & Glass	23	Manufacture of other non-metallic mineral products
	28	Manufacture of machinery and equipment n.e.c.
Chemicals	20	Manufacture of chemicals and chemical products
Coal, Oil and Natural Gas	19	Manufacture of coke and refined petroleum products
	35	Electricity, gas, steam and air conditioning supply
	20	Manufacture of chemicals and chemical products
Communications	26	Manufacture of computer, electronic and optical products
Consumer Electronics	26	Manufacture of computer, electronic and optical products
Consumer Products	32	Other manufacturing
	26	Manufacture of computer, electronic and optical products
	20	Manufacture of chemicals and chemical products
	25	Manufacture of fabricated metal products, except machinery and equipment
	28	Manufacture of machinery and equipment n.e.c.
	31	Manufacture of furniture
	22	Manufacture of rubber and plastic products
Engines & Turbines	28	Manufacture of machinery and equipment n.e.c.
Food & Tobacco	10	Manufacture of food products
	12	Manufacture of tobacco products
Healthcare	26	Manufacture of computer, electronic and optical products
	20	Manufacture of chemicals and chemical products
Industrial Machinery, Equipment & Tools	28	Manufacture of machinery and equipment n.e.c.
Leisure & Entertainment	32	Other manufacturing
Medical Devices	32	Other manufacturing
	26	Manufacture of computer, electronic and optical products
	31	Manufacture of furniture
Metals	25	Manufacture of fabricated metal products, except machinery and equipment
	24	Manufacture of basic iron and steel and of ferro-alloys
Minerals	23	Manufacture of other non-metallic mineral products
Non-Automotive Transport OEM	29	Manufacture of motor vehicles, trailers and semi-trailers
	30	Manufacture of other transport equipment
	32	Other manufacturing
Paper, Printing & Packaging	17	Manufacture of paper and paper products
	18	Printing and reproduction of recorded media

Table 5.A.1 (con't): Correspondence between fDi industries and NACE Rev. 2 divisions

fDi-Industries	NACE Rev.2 division	NACE industry descriptiom
Real Estate	23	Manufacture of other non-metallic mineral products
	25	Manufacture of fabricated metal products, except machinery and equipment
	35	Electricity, gas, steam and air conditioning supply
Pharmaceuticals	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
Plastics	22	Manufacture of rubber and plastic products
Rubber	22	Manufacture of rubber and plastic products
Semiconductors	26	Manufacture of computer, electronic and optical products
Space & Defence	30	Manufacture of other transport equipment
	26	Manufacture of computer, electronic and optical products
	29	Manufacture of motor vehicles, trailers and semi-trailers
	25	Manufacture of fabricated metal products, except machinery and equipment
Textiles	15	Manufacture of leather and related products
	14	Manufacture of wearing apparel
	13	Manufacture of textiles
Transportation	49	Transport and storage
Warehousing & Storage	35	Electricity, gas, steam and air conditioning supply
Wood Products	16	Manufacture of wood and of products of wood and cork, except furniture
	31	Manufacture of furniture

Note: One 'manufacturing' project of the "Business Services" Industry was deleted because it turned out to involve the "Repair and installation of machinery and equipment". Projects involving the 'production' of software were excluded.

Source: fDi Markets database, own matching.

Table 5.A.2: List of industries used in the location choice models

nb	Industry
1	Food, Beverages and Tobacco
2	Textiles, Textile Products and Leather
3	Wood and Products of Wood and Cork
4	Pulp, Paper, Printing and Publishing
5	Coke, Refined Petroleum and Nuclear Fuel
6	Chemicals and Chemical Products
7	Rubber and Plastics
8	Other Non-Metallic Mineral
9	Basic Metals and Fabricated Metal
10	Electrical and Optical Equipment
11	Machinery, Nec
12	Transport Equipment
13	Manufacturing, Nec; Recycling
14	Electricity, Gas and Water Supply

Appendix 5.7.2: Data on production-related investment projects

Table 5.A.3: Production-related investment projects by core EU countries in the EU27, 2003-2012

year	Austria	Belgium	France	Germany	Italy	Netherlands	Total
2003	34	11	54	120	44	32	295
2004	52	13	60	149	49	30	353
2005	43	17	49	182	47	33	371
2006	46	34	48	206	53	43	430
2007	50	29	76	159	52	26	392
2008	46	28	75	145	44	47	385
2009	28	16	33	75	26	19	197
2010	21	12	34	94	25	26	212
2011	27	13	36	135	25	24	260
2012	10	10	36	75	22	10	163
2003-2012	357	183	501	1340	387	290	3058
share	11.7	6.0	16.4	43.8	12.7	9.5	100.0

Source: fDi Markets database, own calculations.

Table 5.A.4: EU core countries' production-related investment projects undertaken in the EU27 by destination country, 2003-2012

destination/source	Austria	Belgium	France	Germany	Italy	Netherlands	total
Austria		1	2	73	15	4	95
Belgium	4		19	44	7	17	91
Bulgaria	23	15	18	35	38	11	140
Czech Republic	26	11	18	126	13	10	204
Denmark	1			10		1	12
Estonia	7	1	1	3		2	14
Finland		1	2	6	2	1	12
France	18	35		155	48	34	290
Germany	42	15	41		32	47	177
Greece			1	4	4	2	11
Hungary	78	6	26	188	21	13	332
Ireland	2	3	12	7	2	4	30
Italy	1	11	23	16		9	60
Latvia	1	1	2	9	2	2	17
Lithuania	2	1	2	10	1		16
Luxembourg		1			3		4
Malta	1			3	2		6
Netherlands		4	6	11			21
Poland	31	24	57	192	67	22	393
Portugal		2	17	28	3	2	52
Romania	57	20	78	131	49	26	361
Slovakia	31	11	21	68	20	15	166
Slovenia	7		6	12	1		26
Spain	8	11	89	95	34	28	265
Sweden	1		3	11		12	27
UK	16	9	57	103	23	28	236
total	357	183	501	1340	387	290	3058

Source: fDi Markets database, own calculations.

Table 5.A.5: EU core countries' production-related investment projects in the EU27 by industry, 2003-2012

Industry description	Austria	Belgium	France	Germany	Italy	Netherlands	total
Food, Beverages and Tobacco	12	19	59	65	33	63	251
Textiles and Leather	14	7	15	28	32	6	102
Wood and Cork	31	3	4	13	8		59
Pulp and Paper	31	10	4	26	22	9	102
Coke, Ref. Petroleum, Nucl. Fuel	6		4	1		1	12
Chemicals	26	39	83	179	27	56	410
Rubber and Plastics	33	26	46	131	49	21	306
Other Non-Metallic Mineral	84	10	56	66	31	2	249
Basic and fabricated Metals	15	17	16	111	39	25	223
Electrical and Optical Equipment	26	21	23	124	36	37	267
Machinery	44	7	53	153	34	15	306
Transport Equipment	22	18	124	401	65	38	668
Manufacturing, Nec; Recycling	11	5	12	34	10	14	86
Electricity, Gas and Water Supply	2	1	2	8	1	3	17
Total	357	183	501	1340	387	290	3058

Note: Industry classification based on NACE Rev2.

Source: fDi Markets database, own calculations.

Appendix 5.7.3: Stylised structure of the World Input-Output Table

The general structure of the World Input-Output Table of the WIOD for the three country case (neglecting the industry dimension) is shown in Figure A1.

Figure 5.A.1: Structure of the World Input-Output Table of the WIOD (3 countries, 1 industry case)

		Country A Intermediate *Industry*	Country B Intermediate *Industry*	Rest of World Intermediate *Industry*	Country A Final domestic	Country B Final domestic	Rest of World Final domestic	Total
Country A	*Industry*	Intermediate use of domestic output	Intermediate use by B of exports from A	Intermediate use by RoW of exports from A	Final use of domestic output	Final use by B of exports from A	Final use by RoW of exports from A	Output in A
Country B	*Industry*	Intermediate use by A of exports from B	Intermediate use of domestic output	Intermediate use by RoW of exports from B	Final use by A of exports from B	Final use of domestic output	Final use by RoW of exports from B	Output in B
Rest of World (RoW)	*Industry*	Intermediate use by A of exports from RoW	Intermediate use by B of exports from RoW	Intermediate use of domestic output	Final use by A of exports from RoW	Final use by B of exports from RoW	Final use of domestic output	Output in RoW
		Value added	Value added	Value added				
		Output in A	Output in B	Output in RoW				

Take, for example, a firm in country A (source country) that undertakes an investment in country B (host country) in a certain industry. WIOD contains information on the inter-industry linkages of this industry in country B with all industries in the source country (country A). From the perspective of the host country, the (employment weighted) purchases of this industry in country A from all industries in country A represent the host-source backward linkages. Likewise, the (employment weighted) sales from this industry in host country B to the industries in source country A represent the host-source forward linkages.

Appendix 5.7.4: Structure in nested logit model

Figure 5.A.2: Nest structure in nested logit model

Decision

Nest	Alternative	cases	positve decisions
	Austria	1844	64
	Belgium	1954	41
	Denmark	2092	7
	Finland	2092	12
	France	1794	200
	Germany	1186	125
EU15	Greece	2092	7
	Ireland	2092	24
	Italy	1792	32
	Luxembourg	2092	3
	Netherlands	1890	14
	Portugal	2092	31
	Spain	2092	151
	Sw eden	2092	21
	UK	2092	146
	Bulgaria	2092	96
	Czech Republic	2092	147
	Estonia	2092	11
	Hungary	2092	255
NMS	Latvia	2092	13
	Lituania	2092	15
	Malta	2092	6
	Poland	2092	295
	Romania	2092	227
	Slovakia	2092	130
	Slovenia	2092	19
	total	***54144***	***2092***

Appendix 5.7.5: Conditional logit model - marginal effects

Appendix Table 5.A.6 shows the marginal effects implied by the coefficients in Table 5.1 in the main text.

Table 5.A.6: Conditional logit model - marginal effects, country level, 2003-2012

	Dependent variable:	**Location chosen (=1) versus Location not chosen (=0)**							
		(1)		(2)		(3)		(4)	
Agglomeration effects	$projects^{source}$	0.2735	***	0.2679	***	0.2186	***	0.2168	***
	$projects^{other\ EU\text{-}5}$	0.1219	***	0.0970	**	0.0948	**	0.0933	**
	BW linkages			-0.1727	**	-0.1473	*	-0.1592	*
	FW linkages			-0.0718		-0.0566		-0.0584	
International linkages	$BW\ linkages^{host\text{-}source}$					0.2261	***	0.2411	***
	$FW\ linkages^{host\text{-}source}$					0.2220	***	0.2223	***
	$BW\ linkages^{host\text{-}foreign}$							-0.1271	
	$FW\ linkages^{host\text{-}foreign}$							-0.0503	
Industry structure	$value\ added^{industry}$	0.3572	***	0.3360	***	0.3940	***	0.3928	***
	K-spec	-1.0099	***	-0.9759	***	-0.5435	*	-0.5270	*
Wage level	labour costs	-2.2405	***	-2.2250	***	-2.1388	***	-2.1766	***
Market size & growth	population	2.1341		2.0768		1.9488		1.9976	
	real GDP per capita	-0.0918		-0.0278		-0.1010		-0.0557	
	real GDP growth	-0.0149		-0.0122		-0.0119		-0.0103	
Technology and skills	R&D exp per capita	0.8461	***	0.8553	***	0.8452	***	0.8272	***
	medium-skilled worker	-0.0057		-0.0027		0.0002		-0.0015	
	high-skiled workers	-0.0027		-0.0070		-0.0075		-0.0065	
Policy and institutions	state aid	-0.0629		-0.0707		-0.0871		-0.0869	
	gov't effectiveness	0.6103		0.6929		0.6988		0.6946	
Gravity type variables	distance	-0.0901		-0.0878		0.0176		0.0208	
	common language	0.2529	*	0.2369	*	0.0376		0.0266	
	common border	0.5111	***	0.5147	***	0.3507	***	0.3354	***
	same country	0.3827	**	0.4183	**	0.3835	**	0.3963	**

6 Additional Material

This additional section contains my joint contribution with Neil Foster to the publication 'The Trade-Productivity Nexus in the European Economy. Empirical Evidence from Firm Level Data' published by the Research Centre International Economics (FIW). The article was written after the paper on the export premia of Austrian exporters contained in chapter 3 of this thesis had been published. It contains some of the results in the aforementioned paper but also some further results, such as export premia results with regard to total factor productivity (TFP) and the productivity growth paths of export starters.

6.1 Exporting and Productivity: Some initial results for Austria

This chapter first revisits the main theoretical framework for analysing the export decision of firms incorporating firm heterogeneity. This theoretical framework relating exporting to firm-level performance has largely been driven by stylised facts from firm-level studies. Second, it presents findings on the trade and productivity nexus for Austrian manufacturing firms. In line with the findings of a very large number of empirical studies for other countries we find that exporters are more productive – irrespective of whether measured in terms of labour productivity or total factor productivity – than their non-exporting peers, even after controlling for firm size, investment in information and communication technologies (ICT) and R&D intensity. Distinguishing between non-exporters, export starters, continuous exporters and export stoppers we find that export starters enjoy a small productivity premium over non-exporters supporting the idea of a self-selection mechanism of more productive firms into exporting. Focusing on export starters and tracking their productivity growth path over time reveals that productivity growth is not significantly higher in the period after their export start than in the period preceding their export engagement which can be interpreted as evidence against sustained learning effects of Austrian firms due to exporting. Given the wealth of studies for other countries more research in this field would be needed in order to establish firm results on the incidence of learning-by-exporting for Austrian firms.

6.1.1 Introduction

The purpose of this chapter is twofold. Firstly, it is intended as an introduction to the topic of this report, the trade and productivity nexus. To this end it revisits the basic theoretical framework for analysing the decision of firms to export and the role of productivity in this decision. Moreover, it presents some stylised facts that have been established by the empirical literature on the relationship between exporting and productivity. Secondly, some initial findings concerning the relationship between exporting and productivity for Austrian manufacturing firms are presented. These include results on the productivity premium of exporting firms over non-exporters, an exposition of the (labour) productivity differences between non-exporters, export starters, continuous exporters and export stoppers, as well as some initial insights from the productivity growth path of export starters covering the period before and after their entry into export markets.

6.1.2 Theoretical background and stylised facts from the empirical literature

The recent theoretical literature addresses two related issues; firstly, why some firms export and others choose to focus on production for the domestic market only, and secondly, the relationship between exporting and productivity. In terms of the second issue, there are two alternative – though not necessarily mutually exclusive – explanations as to why exporters may be more productive than non-exporters, namely self-selection and learning-by-exporting. Self-selection of the more productive firms into export markets may occur because there are additional costs associated with selling goods abroad. Such costs may include transport, distribution and marketing costs, the cost of personnel with skills to manage foreign networks, or production costs from modifying domestic products for foreign consumption (Fryges and Wagner, 2007). According to the learning-by-exporting hypothesis exporting results in an improvement in post-entry performance. Exporting can be an important channel of information flows with overseas buyers sharing knowledge of the latest design specifications and production techniques that might otherwise be unavailable, as well as providing a competitive environment, in which efficiency advantages can be obtained.

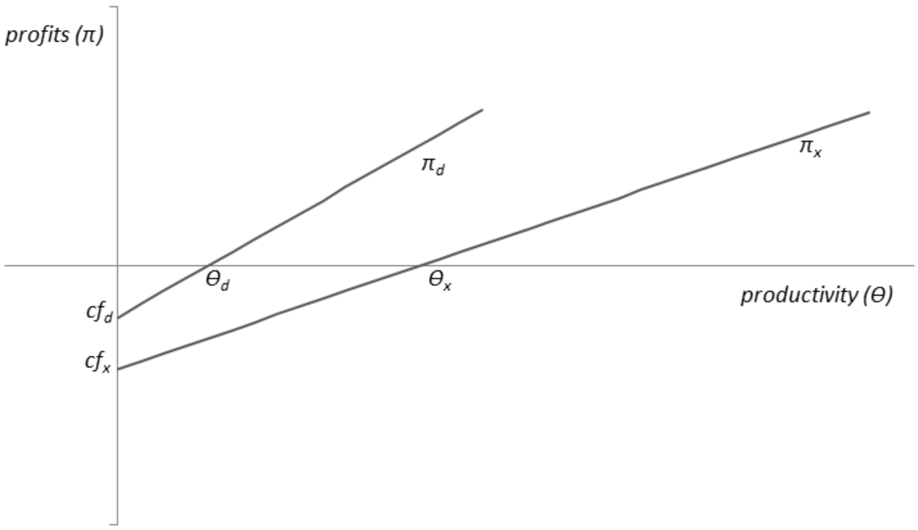
A useful theoretical framework incorporating heterogeneous firms and the decision to export has been developed by Melitz (2003) which has been highly influential for the heterogeneous firm literature (Bernard et al., 2011). In the Melitz model firms are 'born' by drawing at random a certain productivity level. If they are lucky enough to draw a sufficiently high productivity they will be able to cover the fixed cost of production and they will serve the domestic market charging a fixed mark-up on their marginal cost.[60] This is shown in Figure 6.1 where firm level productivity (Θ) is depicted on the horizontal axis and firm profits (π) at the vertical axis. As can easily be seen, a firm must have a productivity level of Θ_d – the cut-off productivity level – to break-even. Firms below this cut-off productivity will exit the market (in Figure 6.1 these are all firms to the left of Θ_d). Firms with a productivity level greater than Θ_d will stay in the market and earn positive profits (π_d).

If a country is open to trade, firms may also find it profitable to engage in exporting. This export decision depends again on their productivity. Assuming fixed costs of exporting, not all firms will be able to cover this additional fixed cost. Only firms with a productivity level above Θ_x – the export productivity cut-off – have large enough profits (because they have sufficiently large sales) to cover the fixed cost of exporting (as well as potential variable trade costs) and earn positive profits from exporting (π_x). Obviously, the Melitz model suggests a direct link between firm productivity and exporting: firms with sufficiently high productivity become

60 Melitz (2003) assumes constant cost mark-ups but the same analysis can also be made with variable mark-ups as in Melitz and Ottaviano (2008).

exporters while low productivity firms only serve the domestic market (or exit the market entirely).[61]

Figure 6.1: Schematic representation of firms' self-selection into exporting



Source: Adapted from Helpman (2006).

Hence, the Melitz model as well as other heterogeneous firm models suggests that the reason why some firms export and others don't is the presence of sunk costs of exporting. Such costs include market research, product modification costs, compliance and so on. In the presence of such costs profit-maximising firms will enter export markets only if the present value of their profits exceeds the fixed costs of entry (Girma et al., 2004).

The theory relating exporting to firm-level performance has largely followed and been driven by empirical results. Since the seminal study of Bernard and Jensen (1995) there have been a large number of research papers that have considered the relationship between exporting and firm-level performance, with new papers still appearing. These papers consider data on a large number of developed, developing and transition economies. Despite differences in methodology (i.e. ordinary least squares, quantile regression, stochastic dominance tests) and differences in country samples the results tend to be fairly consistent. With a couple of exceptions the results point to the conclusion that productivity is higher for exporters. In a recent meta-analysis of the existing empirical literature, Martins and Yang (2009) survey over 30 papers on the relationship between export status and productivity growth and find that: *(i)* the productivity premium from exporting (i.e. the exporter premium) is higher in developing than developed countries; *(ii)* the exporter premium is higher in the year that firms start exporting than in later years; *(iii)* the exporter premium is lower when only matched firms are considered. In addition to productivity, many studies examine the relationship between export

61 Such a self-selection mechanism of more productive firms into exporting is also present in earlier trade models featuring firm heterogeneity (e.g. Clerides et al., 1998). However, these models did not provide an explanation for there to be differences in pre-entry productivities across firms.

status and other indicators of performance, examples including employment, shipments, value-added, investment measures and capital intensity. The results from estimating such relationships tend to be consistent with those from considering the relationship between exporting and productivity and indicate that numerous firm performance measures are higher for exporters than for non-exporters.

6.1.3 Productivity premium of Austrian exporters

The Melitz framework suggests that only the more productive firms find it profitable to sell to foreign markets. Hence, exporting firms are expected to be more productive than non-exporters. Indeed, this is one of the most robust findings of the empirical heterogeneous firm literature. Table 6.1a and Table 6.1b show this for Austrian manufacturing firms.

Following the approach of Bernard and Jensen (1999) which has been used intensively in the literature we regress a dummy variable, the export status variable, which takes the value 1 if a firm is an exporter and 0 otherwise, on the (labour) productivity of firms (in log form). In this simple regression set-up the exporter premium is indicated by the coefficient on the export status variable. In specification (1) in Table 6.1a the export premium is estimated controlling only for industry and time fixed effects but no additional control variables. This yields an economically large and statistically highly significant coefficient implying a 70% productivity advantage of exporting over non-exporting firms.[62] In specifications (2) – (4) we add a number of control variables such as employment, the share of R&D personnel and software per employee to control for firm size, R&D intensity and ICT intensity of firms which are all supposed to be positively correlated to productivity. As can be seen in Table 6.1a the export premium is robust to the inclusion of control variables. For example, controlling for firm size by the number of employees (specification 2) reduces the export premium to about 50% but leaves fully intact its statistical significance. This shows that the export premium is not just due to the fact that exporting firms are larger than non-exporters and therefore more productive. Similarly, controlling for R&D intensity and ICT intensity further reduce the export premium, reducing it to 37% when all control variables are included (specification 4).

In specification (5) we change the dependent variable and regress the export status variable on total factor productivity (TFP), where total factor productivity has been estimated following the methodology suggested by Olley-Pakes (1996). The TFP regression yields a slightly larger coefficient which is again highly statistically significant. Hence, the productivity premium of exporters is also confirmed for the TFP measure ruling out the possibility that exporters have higher labour productivity just because they are more capital intensive.

[62] The export premium of 70% is retrieved by taking the estimated coefficient (0.533) to the power of one and deduct 1.

Table 6.1a: Productivity premia of Austrian manufacturing exporters

	labour productivity (2002-2006)				TFP (OP) (1997-2006)
	(I)	(II)	(III)	(IV)	(V)
export status	0.533***	0.397***	0.390***	0.318***	0.621***
	(65.397)	(44.407)	(42.437)	(24.896)	(86.141)
employment		0.162***	0.159***	0.142***	
		(35.131)	(32.743)	(24.403)	
share R&D personnel			0.837***	0.852***	
			(2.649)	(5.280)	
software/employee				0.080***	
				(17.215)	
R^2-adj.	0.282	0.329	0.333	0.306	0.304
Obs.	29828	29828	29828	12357	39499
implied export premium	*1.704*	*1.49*	*1.48*	*1.37*	*1.86*

*Source: Stöllinger et al. (2011); wiiw-calculations based on data from Statistik Austria provided via remote access. All regressions use a full set of industry dummies and time fixed effects. Coefficients of the constant, industry dummies and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at a 1, 5 and 10% level. TFP (OP) is total factor productivity estimated according to the methodology of Olley-Pakes (1996).*

The results in Table 6.1a therefore empirically support the prediction of the Melitz model that exporters are more productive than non-exports, a result which has also been found for many other European and non-European countries (see e.g. Mayer and Ottaviano, 2007; ISGEP, 2008).

As pointed out in the previous section, exporters seem to outperform non-exporters across a number of firm characteristics. A theoretical underpinning for the existence of a wage premium is provided by the model of Yeaple (2005), which assumes that firms can produce differentiated products as in Melitz (2003). Different to Melitz (2003) however, in the model of Yeaple (2005) firms do not draw their productivity from a random distribution but can chose whether to produce with high-tech or low-tech technology whereby the former requires an investment. Moreover, it can employ different types of workers, skilled or unskilled. The model predicts that only firms which invest in the high-tech technology (making them more productive) and employ high-skilled labour engage in exporting. Due to these characteristics exporters also pay higher wages than non-exporters.

In line with this we can also detect a 'wage premium' of exporting firms in the Austrian manufacturing sector (Table 6.1b). The wage premium is smaller in magnitude compared to the productivity premium, amounting to 11% in specification (4) when including the full set of control variables.[63] Note however, that the wage premium of exporters is highly significant and robust across all specifications.

[63] In this result no distinction between the pure productivity effect and the effect of exporting on wages is made. This is done in Leitner and Stehrer (2011).

Table 6.1b: Wage premia of Austrian manufacturing exporters

	wages (2002-2006)			
	(I)	(II)	(III)	(IV)
export status	0.215***	0.120***	0.118***	0.101***
	(53.883)	(29.307)	(27.907)	(16.811)
Employment		0.114***	0.113***	0.100***
		(61.294)	(55.637)	(40.176)
share R&D personnel			0.312**	0.454***
			(2.366)	(5.902)
software/employee				0.029***
				(15.248)
R^2-adj.	0.388	0.468	0.470	0.452
Obs.	29833	29833	29833	12355
implied export premium	*1.240*	*1.13*	*1.13*	*1.11*

*Note: All regressions use a full set of industry dummies and time fixed effects. Coefficients of the constant, industry dummies and year fixed effects are not shown; t-values in parenthesis. ***, ** and * denote coefficients being significantly different from zero at a 1, 5 and 10% level. All regressions include industry and time fixed effects.*

Source: Stöllinger et al. (2011).

6.1.4 More types of firms: Export starters and export stopper

In this section we refine the distinction between exporters and non-exporters and distinguish between four types of firms. In addition to non-exporters, these types are export starters, export stoppers and continuous exporters. These different types of firms are best explained by looking at the transition matrix by firm type which shows the frequency with which firms 'switch' from being an exporter to being a non-exporter or vice versa. Table 6.2 shows the transition for Austrian manufacturing firms over the period 1998-2006.

Looking at the first row in Table 6.2 reveals that over the whole sample period an overwhelming majority of firms (1,142 or 83%) that started out as non-exporters in a given year (period *t*) remained non-exporters in the next year (period *t+1*). In contrast, 213 firms or 17% of the initially non-exporting firms started to export in the subsequent year. Such firms, which switch from being a non-exporter to being an exporter, are classified as 'export starters'.

The transition of the export starters is shown in the second row of the transition matrix in Table 6.2. By definition, firms that are export starters in the initial year (i.e. they were exporting in period *t* but not in the period before) can either continue to export in the following year or they can quit again their export activities. In the former case, the firm turns from being an export starter to being a 'continuous exporter'; in the latter case the firm is considered as an 'export stopper'.[64]

Table 6.2: Transition matrix of Austrian manufacturing firms by firm type, 1998-2006

	firm type (period t+1)				
firm type (period t)	non-exporter	export starter	continuous exporter	export stopper	total nb. of firms
non-exporter	1142 (83.2)	231 (16.8)			1373
export starter			217 (77.0)	65 (23.1)	282
continuous exporter			1026 (88.7)	131 (11.3)	1157
export stopper	179 (87.8)	25 (12.3)			204
total nb. of firms	1321	256	1243	196	3016
share in total	43.8	8.5	41.2	6.5	100.0

Source: wiiw-calculations based on data provided by Statistik Austria via remote execute.

Table 6.2 shows that more than three quarters (77%) of export starters continue their export activities in the year following their export start while 23% stop exporting in the year following their export start. Turning to continuous exporters, which are firms that have been exporting for at least two years including the current year, it is obvious to see that these firms can either remain continuous exporters or they can stop exporting which would make them export stoppers. The third row of Table 6.2 shows that continuous exporters overwhelmingly stick to exporting (89%) providing evidence for the strong persistence of exporting. Only 131 or 11% of firms stop exporting after having exported for at least two years. This is a much lower share of export stoppers compared to the export starters which shows that first time exporters are much more likely to quit exporting than firms with a longer history of exporting. Finally, firms that are export stoppers in the initial year will in 88% of cases not export in the subsequent year making them non-exporters in that period. Only 25 firms or 12% start exporting again after having stopped exporting in the period before.

Having presented some descriptives of export starters, continuous exporters, export stoppers and non-exporters, we can investigate the productivity of these four types of firms as well as additional firm characteristics. As can be seen in Table 6.3 productivity levels in the Austrian manufacturing sector vary considerably across the different types of firms and they show a clear pattern. The average productivity is highest for continuous exporters and lowest for export stoppers. In between are export starters and non-exporters. It is interesting to note that export starters have a slightly higher labour productivity than non-exporters prior to exporting already. Nevertheless there is also a large productivity gap between export starters

[64] In this section we classify the firms as export starters (export stoppers) only in the year where they start (stop) exporting but not in the following years. Hence, a firm can only be an export starter for one period. 'Double switching' Firms, i.e. firm that start exporting twice over the sample period are excluded from the sample. An alternative way to classify the firms as export starters and export stoppers is in a permanent way meaning that an initially non-exporting firm is considered to be an export starter in the year where it starts exporting and all subsequent years and likewise for export stoppers. We will use these 'permanent' firm types later.

and continuous exporters. The productivity advantage of continuous exporters over non-exporters, which amounts to 31%, can be interpreted as the export premium as before. Most interestingly is the productivity difference between the export starters and non-exporters which can be interpreted as pre-export entry differences in productivity. Since this difference is positive (amounting to 6%) this provides evidence for the self-selection of more productive firms into exporting. Finally, the negative productivity differential of export stoppers (again relative to non-exporters) indicates that the decision of firms to quit exporting may be related to a negative productivity shock.

Table 6.3: Productivity and other firm characteristics by firm type, 1998-2006

firm type	number of firms	share of total	labour productivity	sales	employment	investment	investment intensity
non-exporters	1,522	44.9	120	12,626	81	781	7
export starters	301	8.9	127	12,035	73	699	8
continuous exporters	1,340	39.5	157	18,525	92	856	9
export stoppers	230	6.8	112	12,079	77	774	7

Source: wiiw-calculations based on data provided by Statistik Austria via remote execute.

The pattern found for labour productivity across the four types of firms is similar though not identical for other firm characteristics. While continuous exporters are also larger both in terms of sales and employment, export starters are not larger than non-exporters. The advantage of export starters over non-exporters is limited to labour productivity and investment intensity.[65]

Table 6.4 shows again labour productivity by firm type but now at the level of (selected) manufacturing industries. The results show that the productivity advantage of both continuous exporters and export starters is a general pattern across industries. The continuous exporters are, as expected, the most productive firms in all industries – and in most cases by a wide margin. The magnitude of the productivity advantage of export starters over non-exporters varies considerably across industries. In the textile industry or the transport equipment industry, the differences in labour productivity between non-exporters and export starters are comparable to or even larger than those between export starters and continuous exporters. In contrast, it is only marginal in the machinery industry.

One of the main insights to be gained from Table 6.3 and Table 6.4 is that continuous exporters are clearly a distinct set of firms which are more productive, larger and have higher investment intensity than both non-exporters and export starters. In contrast, the differences between export starters and non-exporters are generally less pronounced with the former being on average more productive but the latter being larger on average. The productivity premium of export starters over non-exporters, however, is to a varying degree a general feature found in all manufacturing industries which may be interpreted in favour of a self-selection of already initially more productive firms into exporting.

[65] Investment intensity is defined as gross investment expenditure per employee.

Table 6.4: Productivity by firm type in selected manufacturing industries, 1998-2006

	labour productivity – absolute level and relative to non-exporters							
Industry	non-exporters		export starters		continuous exporters		export stoppers	
Food, beverages, tobacco (DA)	164	*100%*	180	*110%*	244	*149%*	143	*87%*
Textiles (DB)	84	*100%*	103	*123%*	117	*139%*	103	*123%*
Chemicals (DG)	125	*100%*	136	*109%*	152	*122%*	82	*66%*
Metal products (DJ)	117	*100%*	131	*112%*	153	*131%*	122	*104%*
Machinery (DK)	134	*100%*	135	*101%*	137	*102%*	148	*110%*
Electronics (DL30-32)	88	*100%*	107	*122%*	114	*130%*	101	*115%*
Medical & optical instruments (DL33)	66	*100%*	79	*120%*	85	*129%*	59	*89%*
Transport equipment (DM)	72	*100%*	129	*179%*	138	*192%*	99	*138%*

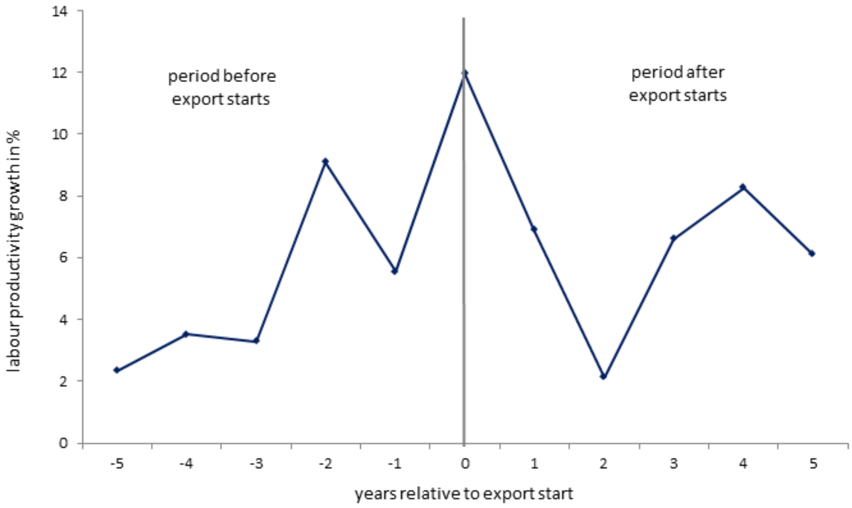
Source: wiiw-calculations based on data provided by Statistik Austria via remote execute.

6.1.5 Productivity growth path of export starters

The previous results suggest that exporters are, on average, already more productive than non-exporters in the year they begin exporting. We now focus on export starters and their growth rates at the time before their entry into exporting, in the year they start exporting and after they start exporting.

Figure 6.2: Productivity path of export starters

Austrian manufacturing firms, productivity growth in percentage points



Note: Numbers on horizontal axis indicate years before and after start of export.

Source: wiiw-calculations based on data provided by Statistik Austria via remote execute.

When considering the productivity growth path of export starters we change the definition of export starters. In line with Kraay (2002) we define export starters as firms that began exporting during the sample period. Figure 6.2 visualises the labour productivity growth path of export starters where period 0 indicates the year of export start of the respective firm. The graph shows that the productivity growth rate of firms tends to increase in the period preceding their entry into export markets. This development could indicate that firms are preparing to export and reap the benefits of their efforts (through investment in new machinery, innovation activity, etc.) at the time they start exporting. For example, in a recent contribution analysing Mexican firms, Iacovone and Javorcik (2012) find evidence on quality upgrading in firms that prepare for penetrating export markets. In their study this effect, which allows firms selling their output at a 'price premium', appears one year before export start. However, there is no upgrading after the entry into export markets. Alternatively, it could mean that firms which embark on a positive productivity path finally engage into export activities

The productivity path of Austrian export starters in Figure 6.2 suggests that productivity growth declines again after export entry. This development is in line with the finding of Martins and Yang (2009) who survey over 30 papers on the relationship between export status and productivity growth. This study comes to the conclusion that the productivity effect of exporting is higher in the year that firms start exporting than in later years.

In Table 6.5 we test for the statistical significance of productivity effects due to exporting. This is done by regressing a dummy variable that takes the value 1 if a firm starts exporting in that year and 0 otherwise ('time of export start'); and a second dummy variable that takes the value 1 in all periods after a firm's export starts and 0 otherwise ('time after export start') on the labour productivity. This set-up implies that the coefficients of the dummy variables indicate the difference in productivity growth rate relative to the period before export start (i.e. when the export starters were still non-exporters).

Table 6.5: Differences in firm productivity growth before, at and after export start

Austrian manufacturing firms, 1998-2006 – export starters only

	(1)	(2)	(3)	(4)
time of export start	6.830*	6.727*	7.379*	7.329*
	(1.856)	(1.864)	(1.772)	(1.792)
time after export start	0.911	0.519	2.662	2.384
	(0.739)	(0.416)	(1.275)	(1.216)
constant	5.122***	2.403*	9.153***	6.510**
	(6.525)	(1.935)	(2.700)	(1.965)
industry dummies	no	yes	no	yes
years dummies	no	no	yes	yes
F-test	1.843	0.915	1.228	0.885
R^2	0.005	0.013	0.01	0.018
R^2-adj.	0.004	0.006	0.005	0.007
Obs.	1854	1854	1854	1854

Source: wiiw-calculations based on data provided by Statistik Austria via remote execute.

The result confirms the result suggested by Figure 6.2, i.e. that at the time of export start, firms do indeed have exceptionally high productivity growth rates which are significantly higher than in the pre-export phase. For the time after export start the productivity growth rate is also higher compared to the pre-export period (indicated by the positive coefficient) but the difference in productivity growth is statistically not significant. This result could suggest that Austrian manufacturing firms do not benefit from learning-by-exporting effects – at least not in a sustainable manner. At the time of export start, however, there is a short term productivity boost which may be the immediate impact of the export orders. Alternatively, it may reflect the productivity gains firms can reap after a phase in which (the still non-exporting) firms prepare for exporting, e.g. by investing in new machinery or in R&D (see above).

6.1.6 Conclusions

This chapter presented some results on the link between exporting and productivity for a sample of Austrian firms in the manufacturing sector over the period from 1997-2006. In line with the findings from a very large number of empirical studies for other countries we find that exporters are more productive than their non-exporting peers, also when controlling for other firm characteristics like firm size, investment in ICT and R&D intensity. The result holds regardless of whether labour productivity or total factor productivity is considered. This result is in line with the predictions offered by heterogeneous firm models à la Melitz (2003) which suggest that only the more productive firms have sufficiently large profits to cover the fixed costs of exporting and therefore find it profitable to serve foreign markets. Distinguishing between non-exporters, export starters, continuous exporters and export stoppers we find that export starters enjoy a small productivity premium over non-exporters prior to exporting. While the advantage of export starters in terms of productivity does not extend to other firm characteristics such as firm size, it is robust across industries. This provides some evidence in favour of the self-selection mechanism of more productive firms into exporting. Another result is that continuous exporters are more productive, larger and invest more than non-exporters (and all other types of firms) which confirms the finding on the export premium. Focusing on export starters and tracking their productivity growth path over time reveals that productivity growth is not significantly higher in the period after their export start than in the period preceding their export engagement. While there are more sophisticated approaches to test for learning-by-exporting effects, this result may suggest that there are no sustained learning effects of Austrian firms due to exporting. However, there is a marked hike in the productivity growth of export starters in the year in which they start exporting which is another stylised fact established by the empirical heterogeneous firm literature.

References

Acemoglu, D., Ventura, J. (2002) The World Income Distribution, Quarterly Journal of Economics, 117(2), pp. 659-694.

Aghion, P., Howitt, P. (1992) A Model of Growth through Creative Destruction, Econometrica*,* 60, pp. 323-351.

Altomonte, C., Ottaviano, G.I.P. (2008) Internationalization of corporate activity and competitiveness of the European economy: theoretical and empirical issues, MicroDyn deliverable D28.

Antonietti, R., Bronzini, R., Cainelli, G. (2015) Inward foreign direct investment and innovation: evidence from Italian provinces, Banca d'Italia Working Paper, 1006, March 2015.

Azariadis, C. (1996) The Economics of Poverty Traps, Part One: Complete Markets, Journal of Economic Growth, 1(4), pp. 449-486.

Azariadis, C., Drazen, A. (1990) Threshold Externalities in Economic Development, Quarterly Journal of Economics, 105 (2), pp. 501-526.

Baldwin, R. (2011) 21st Century Regionalism: Filling the gap between 21st century trade and 20th century trade rules, CEPR Policy Insight, No. 56.

Baldwin, R. (2013) Global supply chains: why they emerged, why they matter, and where they are going, in: Elms, D.K., Low, P. (eds.), "Global Value Chains in a Changing World", pp. 13-59, Geneva: WTO Publications.

Baldwin, R., Robert-Nicoud, F. (2014) Trade-in-goods and trade-in-tasks: An integrating framework, Journal of International Economics, 92(1), pp. 51-62.

Balsvik R., Todel Skaldebo, L. (2013) Guided through the "Red tape"? Information sharing and foreign direct investment, SAM Discussion paper 3/2013, February 2013.

Barrios, S., Görg, H., Strobl, E. (2006) Multinationals' Location Choice, Agglomeration Economies and Public Incentives, International Regional Science Review, 29(1), pp. 81-107.

Barro, R.J., Lee, J.-W. (2010) A New Data Set of Educational Attainment in the World, 1950–2010, NBER Working Paper No. 15902, April 2010.

Basile, R. (2004) Acquisition versus greenfield investment: the location of foreign manufacturers in Italy, Regional Science and Urban Economics, 34(1), pp. 3-25.

Basile, R., Castellani, D., Zanfei, A. (2009) National boundaries and the location of multinational firms in Europe, Regional Science, 88(4), pp. 733–748.

Benhabib, J. & Spiegel, M. M. (1994) The role of human capital in economic development. Evidence from aggregate cross-country data, Journal of Monetary Economics, 34, pp. 143-173.

Benhabib J & Spiegel, M. M. (2005) Human capital and technology diffusion, in: Aghion, P., Durlauf, S. N. (eds.), "Handbook of Economic Growth" ,pp. 935-966, Amsterdam: North-Holland.

Bernard, A.B. (1995) Exporters and trade liberalization in Mexico: Production structure and performance*,* MIT, mimeo.

Bernard, A.B., Jensen, J.B. (1999) Exceptional exporter performance: cause, effect, or both?, Journal of International Economics, 47, pp. 1-25.

Bernard, A.B., Jensen, J.B. (2004) Why some firms export, Review of Economics and Statistics, 86(2), pp. 561-569.

Bernard, A.B., Redding, S.J., Schott P.K. (2007) Comparative Advantage and Heterogeneous Firms, Review of Economic Studies, 74, pp. 31-66.

Bernard, A.B., Jensen, J.B., Redding S.J., Schott, P.K. (2011) The empirics of firm heterogeneity and international trade, NBER Working Papers 17627.

Bloningen, B. A. (2005) A Review of the Empirical Literature on FDI Determinants, Atlantic Economic Journal, 33(4), pp. 383-403.

Bloningen, B. A., Piger, J. (2014) Determinants of foreign direct investment, Canadian Journal of Economics, 47(3), pp. 775–812.

Boudier-Bensebaa, F. (2005) Agglomeration economies and location choice. Foreign direct investment in Hungary, Economics of Transition, 13(4), pp. 605– 628

Cameron, A.C., Trivedi, P.K. (2010), Microeconometrics Using Stata, Stata Press.

Castellacci, F. (2007) Evolutionary and new growth theories. Are they converging?, Journal of. Economic Surveys, 21(3), pp. 585-627.

Castellacci, F. (2008) Technology clubs, technology gaps and growth trajectories, Structural Change and Economic Dynamics, 19(4), pp. 301-314.

Castellacci, F. (2011) Closing the Technology Gap?, Review of Development Economics, 15(1), pp. 180-197.

Castellacci, F., Archibugi, D. (2008) The technology clubs: The distribution of knowledge across nations, Research Policy, 37(10), pp. 1659-1673.

Castellani, D., Pieri, F. (2013) R&D offshoring and the productivity growth of European regions, Research Policy, 42(9), pp.°1581-1594

Cohen, W. M., Levinthal, D. A. (1989) Innovation and Learning: The Two Faces of R&D, Economic Journal, 99(397), pp. 569-596.

Clerides, S.K., Lach, S., Tybout, J.R. (1998) Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico and Morocco, Quarterly Journal of Economics, 113, pp. 903-947.

Crespo, J., Martín, C., Velázquez, F. J. (2004) The role of International Technology Spillovers in the Economic Growth of the OECD countries, Global Economy Journal, 4(2), pp. 1-18.

Crozet, M., Mayer, T., Mucchielli, J.-L., (2004) How do firms agglomerate? A study of FDI in France, Regional Science and Urban Economics, 34(1), pp. 27-54.

Damijan, J., Kostevc, Č., Rojec, M. (2013) FDI, Structural Change and Productivity Growth: Global Supply Chains at Work in Central and Eastern European Countries, GRINCOH Working Paper Series, 1.07.

Debaere, P., Lee, J., Paik, M. (2010) Agglomeration, backward and forward linkages: Evidence from South Korean investment in China, Canadian Journal of Economics, 43(2), pp. 520-546.

Devereux, M.P., Griffith, R., Simpson, H. (2007) Firm location decisions, regional grants and agglomeration externalities, Journal of Public Economics, 91(3-4), pp. 413-435.

De Loecker, J. (2007) Do exports generate higher productivity, Journal of International Economics, 73, pp. 69-98.

Disdier A.C., Mayer, T. (2004) How different is Eastern Europe? Structure and determinants of location choices by French firms in Eastern and Western Europe, Journal of Comparative Economics, 32(2), pp.280-296.

Dixit, A.K., Stiglitz, J.E. (1977) Monopolistic competition and optimum product diversity, American Economic Review, 67(3), pp. 297-308.

Dobrinsky, R., Pöschl, J. (2011) Launch of project database, MicroDyn deliverable D73.

Durlauf, S. N., Johnson, P. A. (1995) Multiple Regimes and Cross-Country Growth Behaviour, Journal of Applied Econometrics, 10 (4), pp. 365-384.

Du, J., Lu, Y. Tao, Z. (2008) FDI Location Choice in China: Agglomeration vs. Institutions, International Journal of Finance and Economics, 13(1), pp. 92-107.

Feenstra, R.C., Hanson, G.H. (1996) Globalization, Outsourcing, and Wage Inequality, American Economic Review, 86(2), pp. 240-45.

Friedman, J., Gerlowski, D.A., Silberman, J. (1992) What attracts foreign multinational corporations? Evidence from branch plant location in the United States, Journal of Regional Science, 32(4), pp. 403-418.

Fryges, H., Wagner, J., (2007) Exports and productivity growth – first evidence from a continuous treatment approach, ZEW Discussion Paper, 07-032.

Fujita, M., Krugman, P., Venables, A.J. (2001) The Spatial Economy. Cities, Regions, and International Trade, Cambridge MA, MIT Press.

Gauselmann, A., Marek, P. (2012) Regional determinants of MNE's location choice in post-transition economies, Empirica, 39(4), pp. 487-511.

Girma, S., Greenaway, D. Kneller, R. (2004) Does exporting increase productivity? A microeconometric analysis of matched firms, Review of International Economics, 12, pp. 855-866.

Greenaway, D. Kneller, R. (2004) Exporting and Productivity in the United Kingdom, Oxford Review of Economic Policy, 20(3), pp. 358-371.

Greenaway, D. Kneller, R. (2007) Firm Heterogeneity, Exporting and Foreign Direct Investment: A Survey, Economic Journal, 117, pp. 134-161.

Greene, W. (2012) Econometric Analysis (7^{th} ed.), Prentice Hall.

Grossman, G.M., Rossi-Hansberg, E. (2008) Trading Tasks: A Simple Theory of Offshoring, American Economic Review, 98(5), pp. 1978-97.

Guillén, M.F (2002) Structural inertia, imitation, and foreign expansion: South Korean firms and business groups in China, 1987-95, Academy of Management Journal, 45, pp. 509-525.

Guimarães P., Figueiredo O., Woodward D. (2000) Agglomeration and the Location of Foreign Direct Investment in Portugal, Journal of Urban Economics, 47, pp. 115-135.

Hall, R. E., Jones C. I. (1999) Why do Some Countries Produce So Much More Output Per Worker than Others?, Quarterly Journal of Economics, 114 (1), pp. 83-116.

Hansen, B. E. (1996) Inference When a Nuisance Parameter Is Not Identified under the Null Hypothesis, Econometrica, 64 (2), pp. 413-30.

Hansen, B.E. (1999) Threshold effects in non-dynamic panels: Estimation, testing, and inference, Journal of Econometrics, 93 (2), pp. 345-368.

Hansen, B. E. (2000). Sample Splitting and Threshold Estimation, Econometrica, 68 (3), pp. 575-604.

Head, K., Ries, J., Swenson, D. (1995) Agglomeration benefits and location choice: Evidence from Japanese manufacturing investments in the United States, Journal of International Economics, 38, pp. 223-247.

Head, K., Ries, J., Swenson, D. (1999) Attracting foreign manufacturing: Investment promotion and agglomeration, Regional Science and Urban Economics, 29, pp. 197-218.

Head, K., Mayer, T. (2004) Market potential and the location of Japanese investment in the European Union, Review of Economics and Statistics, 86(4), pp.°959-972.

Helpman, E. (2006) Trade, FDI, and the organisation of firms, Journal of Economic Literature, 44(3), pp. 589-630.

Helpman, E., Melitz, M.J., Yeaple, S.R. (2004) Export Versus FDI with Heterogeneous Firms, American Economic Review, 94(1), pp. 300-316.

Howitt, P. (2000) Endogenous Growth and Cross-country Income Differences, American Economic Review, 90(4), pp. 829–846.

Howitt, P., Mayer-Foulkes, D. (2005) R&D, Implementation, and Stagnation: A Schumpeterian Theory of Convergence Clubs, Journal of Money, Credit, and Banking, 37, pp. 147-177.

Iacovone, L., Javorcik, B. (2012) Getting ready: preparation for exporting, CEPR Discussion Papers, 8926.

ISGEP – International Study Group on Exports and Productivity (2008) Understanding Cross-Country Differences in Exporter Premia: Comparable Evidence for 14 Countries, Review of World Economics (Weltwirtschaftliches Archiv), 144(4), pp. 596-635.

IMF (2013) German-Central European Supply Chain – Cluster Report, IMF Country Report No. 13/263, August 2013.

Jaccard, J., Turrisi, R. (2003) Interaction Effects in Multiple Regression (2^{nd}. ed.), Quantitative Applications in the Social Sciences 72, Thousand Oaks, CA: Sage.

Jones, J., Wren, C. (2011) On the Relative Importance of Agglomeration Economies in the Location of FDI Across British Regions, SERC discussion paper 89, August 2011.

Kinoshita, Y., Campos, N. (2003) Why Does FDI Go Where it Goes? New Evidence from the Transitional Economies, IMF Working Paper, 3/228, November 2003.

Klenow, P. J., Rodriguez-Clare, A. (1997) Economic growth: A review essay, Journal of Monetary Economics, 40, pp. 597-617.

Kraay, A. (2002) Exports and economic performance: evidence from a panel of Chinese enterprises, in: Renard, M.-F. (ed.), "China and its regions. Economic growth and reform in Chinese provinces", Cheltenham: Edward Elgar, pp. 278-299. (Originally published in Revue d'Economique du Developpement, 1-2, 1999).

Krugman, P. (1991a) Increasing Returns and Economic Geography, Journal of Political Economy, 99(31), pp. 483-499.

Krugman, P. (1991b) Geogrphy and Trade, Cambridge MA: MIT Press.

Krugman, P., Venables, A. J. (1995) Globalization and the Inequality of Nations, Quarterly Journal of Economics, 110(4), pp.857-880.

Landesmann, M., Stehrer, R., (2006) Modelling international economic integration: patterns of catching-up and foreign direct investment, Economia Politica, 3, pp. 335-362.

Leitner, S.M., Stehrer, R. (2011) Do exporters share part of their rents with their employees? Evidence from Austrian manufacturing firms, wiiw Working Paper No. 73.

Mankiw, N. G., Romer, D., Weil, D. N. (1992) A Contribution to the Empirics of Economic Growth, Quarterly Journal of Economics, 107(2), pp. 407-437.

Marshall, A. (1920) Principles of Economics, Library of Economics and Liberty. Retrieved September 2015 from the World Wide Web: http://www.econlib.org/library/Marshall/marP.html.

Martins, P.S., Yang, Y. (2009) The impact of exporting on firm productivity: A meta-analysis of the learning-by-exporting hypothesis, Review of World Economics, 145, pp. 431-445.

Mayer, T., Zignano, S. (2011) Notes on CEPII's distances measures: The GeoDist database, CEPII Working Paper, 2011-25, December 2011.

Mayer, T., Ottaviano, G.I.P. (2007) The Happy Few: The Internationalization of European Firms. New Facts Based on Firm-Level Evidence, Bruegel Blueprint 3.

McFadden, D. (1974) Conditional logit analysis of qualitative choice behaviour, in: Zarembka, P. (ed.), "Frontiers in Econometrics", New York: Academic Press, pp. 105-142.

Melitz, M.J. (2003) The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, Econometrica, 71(6), pp. 1695–1725.

Melitz, M. J., Ottaviano, G.I.P. (2008) Market Size, Trade, and Productivity, Review of Economic Studies, 75, pp. 295 316.

Midelfart K.H., Overman, H.,Redding, S., Venables, A. (2000) The Location of European Industry, European Economy - Economic Papers, 142.

Miller, R.E., Blair, P.D. (2009) Input-Output Analysis: Foundations and Extensions (2nd ed.), Cambridge: Cambridge University Press.

Navaretti, G.B., Bugamelli, M., Ottaviano, G.I.P. Schivardi, F. (2010) The global operations of European firms, Bruegel policy brief, 2010/05.

Nelson, R., Phelps, E. (1966) Investment in humans, technological diffusion, and economic growth, American Economic Review: Papers and Proceedings, 51(2), pp. 69-75.

Olley, G.S., Pakes, A. (1996) The dynamics of productivity in the telecommunications equipment industry, Econometrica, 64(6), pp. 1263-1297.

Procher, V. (2011) Agglomeration effects and the location of FDI: evidence from French first-time movers, Annals of Regional Science, 46(2), pp. 295-312.

Quah, D. (1997) Empirics for Growth and Distribution: Stratification, Polarization, and Convergence Clubs, Journal of Economic Growth, 2(3), pp. 27–59.

Roberts, M.J., Tybout, J.R. (1997) The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs, American Economic Review, 87(4), pp. 545-564.

Sauvant, K. P. (2005) New Sources of FDI: The BRICs. Outward FDI from Brazil, Russia, India and China, Journal of World Investment & Trade, 6(5), pp. 639-709.

Siedschlag, I., Smith, D., Turcu, C., Zhang, X. (2013) What Determines the Location Choice of R&D Activities by Multinational Firms?, Research Policy, 42, pp. 1420-1430.

Soci, A. (2007) FDI: a difficult connection between theory and empirics, in: Fingleton, B. (ed.), "New directions in economic geography", London: Edward Elgar, pp. 277-314.

Stöllinger, R., Pöschl, J., Stehrer, R. (2012) Austrian exporters – unique or alike? New insights and missing puzzle pieces, Empirica, 39(3), pp. 375-405.

Stöllinger, R., Stehrer, R. Pöschl, J. (2010) Austrian Exporters: A Firm-Level Analysis, MicroDyn Working Paper, 18/10, August 2010.

Stöllinger, R., Stehrer, R. (2015) The Central European Manufacturing Core: What is Driving Regional Production Sharing?, FIW Research Reports 2014/15 No. 2.

UNCTAD (2009) World Investment Prospect Survey 2009-2011, New York, Geneva.

UNESCO (2010) UNESCO Science Report 2010: The current Status of Science around the World*,* Paris: UNESCO Publishing.

Verspagen, B. (1991) A new empirical approach to catching up or falling behind, Structural Change and Economic Dynamics, 2(2), pp. 359-380.

Woodward, D.P. (1992) Locational determinants of Japanese manufacturing start-ups in the United States, Southern Economic Journal, 58, pp. 690-708.

World Bank (2009) World Development Report 2009. Reshaping the Economic Geography, Washington D.C.

Yeaple, S.R. (2005) A simple model of firm heterogeneity, international trade, and wages, Journal of International Economics, 65, pp. 1-20.

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Urheberrechtserklärung

Hiermit erkläre ich, dass diese Dissertation von mir verfasst wurden, insoweit nicht anderweitig im Text kenntlich gemacht. Alle wörtlichen Zitierungen wurden durch Anführungszeichen deutlich gemacht. Quellen, welche nicht wörtlich zitiert werden, sondern lediglich Ideen anderer Autoren widerspiegeln, wurden den in den Wirtschaftswissenschaften gängigen Zitierregeln gemäß gehandhabt. Die drei Artikel wurden nicht im Zusammenhang mit dem Erwerb eines anderen akademischen Abschlusses verwendet.

Summary: English and German Abstracts

Chapter 3

Austrian Exporters: Unique or alike? New insights and missing puzzle pieces

Abstract – English

In this paper we provide detailed evidence on the performance of exporters compared to non-exporters in Austrian manufacturing industries based on firm-level data. The centrepiece of the study is the issue of the export premium, i.e. the size and productivity advantages of exporting firms compared to their purely domestic peers. We present evidence for the existence of sales, labour productivity and wage premia. These results are largely in line with the results found for other European countries. Furthermore we document the existence of large differences in these premia across industries and provide explanations for this finding. Our results are robust with regards to including additional firm control variables such as employment and R&D-related variables though the magnitudes of the export premia become much smaller. We also propose a new interpretation of the export premium estimation with firm fixed effects which we interpret as a result on export switchers. Finally, we employ a probit model to document the importance of sunk export costs for the decision to export.

Kurzdarstellung – Deutsch

Basierend auf Firmendaten werden in diesem Artikel detaillierte Ergebnisse über wesentliche Merkmale von Exporteuren im Vergleich zu nicht-exportierenden Unternehmen in der Sachgüterproduktion geliefert. Das Kernstück der Untersuchung stellt die Exportprämie dar, worunter Größen- und Produktivitätsvorteile von Exportunternehmen gegenüber ausschließlich am inländischen Markt agierenden Unternehmen zu verstehen sind. Wir präsentieren empirische Belege für die Existenz von Umsatz-, Arbeitsproduktivitäts- und Lohnprämien. Diese Ergebnisse sind weitgehend im Einklang mit jenen, die in vergleichbaren Länderstudien gefunden wurden. Darüber hinaus dokumentieren wir große Unterschiede in den verschiedenen Exportprämien über die einzelnen Industrien und stellen auch Erklärungen dafür bereit. Unsere Ergebnisse bleiben auch dann unverändert, wenn zusätzliche Kontrollvariablen wie Beschäftigung und F&E-Intensität in das Modell aufgenommen werden – allein die Größe der Exportprämien reduziert sich dadurch etwas. Wir schlagen auch eine neue Interpretation der Schätzung von Exportprämien unter der Kontrolle von fixen Firmeneffekten vor, die wir als ein Ergebnis für Unternehmen, die den Exportstatus wechseln (export switchers), interpretieren. Schließlich verwenden wir ein Probit-Modell um die Bedeutung von versunkenen Exportkosten für die Exportentscheidung zu dokumentieren.

Keywords: ***exports, firm heterogeneity, export premium, Austrian manufacturing firms***

JEL classification: ***F14, L25***

Chapter 4

International Spillovers in a World of Technology Clubs

Abstract – English

The technology club literature suggests a tripartite segmentation of countries into an innovation, an imitation and a stagnation club. We use a Benhabib–Spiegel type growth model embedded in a threshold regression framework to test for non-linearities in the impact of the technology gap on economic growth as suggested by the technology club hypothesis. Using human capital as the threshold variable we are able to identify three country groupings. In line with the technology club hypothesis we find the strongest effects of the technology gap on economic growth in the intermediate group which we associate with the imitation club.

Kurzdarstellung – Deutsch

Die Literatur der Technologie-Clubs geht von einer Dreiteilung der Länder in einen Innovation-, einen Imitations- und einen Stagnations-Club aus. Wir greifen auf ein Wachstumsmodell vom Typ Benhabib-Spiegel zurück und testen mittels eines ökonometrischen Verfahrens (threshold regression) die zentrale Hypothese der Technologie-Clubs Literatur, der zufolge Nicht-Linearitäten in den Wachstumseffekte von bestehenden Technologieunterschieden existieren. Unter der Verwendung von Humankapital als „Schwellenwert"-Variable (threshold variable) gelingt es uns drei Ländergruppen zu identifizieren. Im Einklang mit der Technologie-Clubs-Hypothese zeigen sich die stärksten Effekte bestehender Technologierückstände auf das Wirtschaftswachstum in der mittleren Ländergruppe, die den Imitations-Club darstellen.

Keywords: ***Technology clubs, Threshold regressions, Technology spillovers, Human capital***

JEL classification: ***O47, O41, I25, O33***

Chapter 5

Agglomeration and FDI: Bringing international production linkages into the picture

Abstract – English

The attractiveness of a country for foreign direct investors stems from domestic factors but also from its interconnectedness with the global economy. While knowledge spillovers and domestic inter-industry linkages have been examined by the literature on FDI location, international linkages have been neglected due to data constraints. Using global input-output data, this paper investigates the role of backward and forward production linkages between countries for location choices of first time greenfield FDI investors in the EU along with traditional agglomeration forces. In line with the literature it is found that firms tend to co-locate with other firms from the same country and industry. Most importantly, inter-industry linkages between the source and the host country emerge as an important attraction factor while the same does not hold for domestic inter-industry linkages.

Kurzdarstellung – Deutsch

Die Standortattraktivität eines Landes für ausländische Direktinvestoren ergibt sich aus heimischen Faktoren aber auch aus seiner Vernetzung mit dem globalen Wirtschaftssystem. Während Wissenstransfers (knowledge spillovers) und Produktionsverflechtungen zwischen inländischen Industrien bereits Eingang in die Literatur zur Standortwahl von ausländischen Direktinvestitionen (FDI) gefunden haben, blieben Produktionsverflechtungen mit dem Ausland aufgrund nicht vorhandener Daten bisher unberücksichtigt. Dieser Artikel untersucht mit Hilfe von Input-Output-Daten die Bedeutung von vorwärts- und rückwärtsgerichteten Produktionsverflechtungen zwischen Ländern für die Standortwahl von erstmaligen greenfield FDI-Investoren, wobei auch traditionelle Agglomerationsfaktoren berücksichtigt werden. Im Einklang mit der bestehenden Literatur zeigt sich, dass sich Firmen verstärkt dort ansiedeln wo bereits Unternehmen aus demselben Land und derselben Industrie ansässig sind. Vor allem aber lässt sich ein positiver Effekt von bestehenden Produktionsverflechtungen zwischen dem FDI-Quell- und dem FDI-Zielland auf die Standortattraktivität nachweisen. Gleiches gilt hingegen nicht für inländische Produktionsverflechtungen.

Keywords: ***foreign direct investment, multinational enterprises, location choice, agglomeration, international linkages***

JEL classification: ***F21, F23, R30***

Curriculum Vitae

Roman Stöllinger

PROFESSIONAL EXPERIENCE

06/2008 to date	**The Vienna Institute for International Economic Studies (wiiw)** Rahlgasse 3, 1060 Vienna, Austria Staff economist
Main activities:	International trade, FDI, industrial policy, structural change, catching-up of emerging markets
09/2012 – to date	**Vienna University of Economics and Business, Austria (WU Wien)** Welthandelsplatz 1, 1020 Vienna, Austria External lecturer
Main activities:	International Macroeconomics
10/2001 – 05/2008	**Oesterreichische Kontrollbank AG, Austria** Credit manager (team leader)
Main activities:	Negotiating loan contracts, product development, provision of advisory support on export credits to the Ministry of Finance
02/2000 – 01/2001	**University of Innsbruck, Austria** Tutor for Public Economics
Main activities:	Exercises and answering student questions
07/1999 – 09/1999	**Eurotunnel, France** Trainee
Main activities:	Conducting a competitiveness study on ferry services

EDUCATION

2005 to date	**University of Vienna, Austria** Ph.D. studies in Economics
Thesis title:	'Empirical Essays in International Economics'
1994 – 2000	**University of Innsbruck, Austria** International Economics Master of Social and Economic Sciences (Mag. rer. soc. oec.)
1998 – 1999	ESC Rouen, France (Erasmus Programme) Banking and Finance, Cross-Cultural Management
1997	Queensland University of Technology, Australia (Joint Study) International Macroeconomics, International Trade

ADDITIONAL SKILLS

Languages:	English: business fluent French: very good Italian: basic
Software skills:	MS Word, MS Excel, STATA, Eviews

PUBLICATIONS

Articles in refereed journals

'International spillovers in a world of technology clubs', *Structural Change and Economic Dynamics*, Vol. 27(C), 2013, pp. 19-35.

'Austrian Exporters – Unique or alike? New insights and missing puzzle pieces' (with Johannes Pöschl and Robert Stehrer), *Empirica*, Vol. 39, No. 12, 2012, pp. 375-405

'EU's trade with the BRICs and competitiveness challenges' (with Peter Havlik), *Statistika*, No. 2, 2010, pp. 136-157

Articles in non-refereed journals

'Veränderungen im Welthandel - Chancen und Herausforderungen für Europa', *Vol. 58*, 2011, No. 4, Wirtschaftspolitische Blätter, pp. 639-653.

'EU and BRICs: Challenges and opportunities for European competitiveness and cooperation' (with Vasily Astrov, Edward Christie, Bernhard Dachs, Jayati Ghosh, Peter Havlik, Gabor Hunya, Carolina Lennon, Olga Pindyuk, M. Poplawski Ribeiro and Waltraut Urban), *Industrial Policy and Economic Reform Papers*, No. 13, July 2009.

Articles in books

'Schuldenkrise und realwirtschaftliche Divergenzen im Euro-Raum' (with Leon Podkaminer), *Österreichs Außenwirtschaft 2010*, Chapter 11, Kompetenzzentrum FIW, Vienna, December 2010, pp. 196-208.

'Exportpartizipation, Exportkonzentration und Exportprämien in Österreich - Ergebnisse einer Unternehmensdatenanalyse', *Österreichs Außenwirtschaft 2010*, Chapter 9, Kompetenzzentrum FIW, Vienna, December 2010, pp. 173-180.

'Staatliche Wirtschaftslenkung und globale offene Märkte', *Österreichs Außenwirtschaft 2009*, Chapter 10, Kompetenzzentrum FIW, Vienna, December 2009, pp. 183-196.

'Entwicklungen der Weltwirtschaft im Kontext der Finanzmarktkrise' (with Michael Landesmann), *Österreichs Außenwirtschaft 2008*, Kompetenzzentrum Forschungsschwerpunkt Internationale Wirtschaft, Vienna, 2008, pp. 15-35.

Working Papers

'State Aid and Export Competitiveness in the EU' (with Mario Holzner), *wiiw Working Paper*, No. 106, Vienna, December 2013.

'International Spillovers in a World of Technology Clubs', *wiiw Working Paper*, No. 79, Vienna, May 2012

'Austrian Exporters: A Firm-Level Analysis' (with Johannes Pöschl and Robert Stehrer), MICRO-DYN Working Paper, No. 18/10, 2010.

Research Reports

'The Central European Manufacturing Core: What is Driving Regional Production Sharing?' (with Rober Stehrer), *FIW Studien*, 2014/15 No. 2, February 2015.

'Positioning Austria in the Global Economy: Value Added Trade, International Production Sharing and Global Linkages' (with Robert Stehrer), *FIW Studien*, 2012-2013 No 2, October, 2013.

'A 'Manufacturing Imperative' in the EU – Europe's Position in Global Manufacturing and the Role of Industrial Policy' (with Neil Foster-McGregor, Mario Holzner, Michael Landesmann, Johannes Pöschl and Robert Stehrer), *wiiw Research Report*, No. 391, October 2013.

'European Neighbourhood - Challenges and Opportunities for EU Competitiveness' (with Vasily Astrov, Peter Havlik, Mario Holzner, Gabor Hunya, Isilda Mara, Sandor Richter and Hermine Vidovic), *wiiw Research Report*, No. 382, September 2012.

'Trade in Intermediate Products and EU Manufacturing Supply Chains ' (with Jyrki Ali-Yrkkö, Neil Foster-McGregor, Doris Hanzl-Weiss, Petri Rouvinen, Timo Seppälä, Robert Stehrer and Pekka Ylä-Anttila), *wiiw Research Report*, No. 369, February 2011.

'Exporting and Productivity: Some initial results for Austria' (with Neil Foster-McGregor)*, in: FIW (ed.) The Trade-Productivity Nexus in the European Economy, FIW Special*, No. 5, pp. 4-14, June 2012.

'Long Term Patterns of International Merchandise Trade'*, International Economics*, November 2011.

'Characteristics of exporting and non-exporting firms in Austria' (with Johannes Pöschl and Robert Stehrer)*, FIW Research Reports 2009/2010*, No. 1, 2009.

'Foreign Direct Investment Flows between the EU and the BRICs' (with Gabor Hunya), *wiiw Research Report*, No. 358, December 2009.

'Trade in Goods and Services between the EU and the BRICs' (with Peter Havlik and Olga Pindyuk), *wiiw Research Report*, No. 357, November 2009.

Other publications

'Eine Anatomie des österreichischen Exportwachstums nach der Krise', FIW Policy Brief, Nr. 26, March 2015.

'Die Sachgüterproduktion Österreichs: Entwicklung und gesamtwirtschaftliche Bedeutung im internationalen Vergleich' (mit Robert Stehrer und Doris Hanzl-Weiss)*,* Materialien zu Wirtschaft und Gesellschaft, 133, Arbeiterkammer Wien, Oktober 2014.

'Green industries for Europe: mission abandoned ', Monthly Report No. 10/2014, *wiiw Monthly Report*, No. 10, October 2014, p. 13-16

'Trade in jobs: a counterfactual exercise' (with Robert Stehrer), Monthly Report No. 3/2014, *wiiw Monthly Report*, No. 3, March 2014, pp. 7-11

'State aid and export competitiveness in the EU – first results' (with Mario Holzner), Monthly Report No. 12/2013, *wiiw Monthly Report*, No. 12, December 2013, pp. 5-14.

'Croatia's EU membership and the dilemma of state aid', Monthly Report No. 4/2013, *wiiw Monthly Report*, No. 4, April 2013, pp. 1-7.

'The speed of catch-up depends on human capital', Monthly Report No. 2/2012, *wiiw Monthly Report*, No. 2, February 2012, pp. 5-9.

'Fokus Finanzsektor – Österreichs Direktinvestitionen in Mittel- und Osteuropa'*, FIW Policy Brief*, No. 6, August 2010.

'Vertical integration of trade with China', Monthly Report No. 1/2010, *wiiw Monthly Report*, No. 1, January 2010, pp. 9-13.

'New Shades of Protectionism and the Role of Multinationals' (with Joseph F. Francois)*, FIW Policy Brief*, No. 2, December 2009.

PRESENTATIONS

'Agglomeration and FDI: Bringing International Production Linkages into the Picture', Graduate Seminar, University of Vienna, 5 June 2015, Vienna.

'Global Value Chains and Structural Change', 11th International Conference on Challenges of Europe: Growth, competition and inequality, 27-29 May, Hvar, Croatia.

'Eine Anatomie des österreichischen Exportwachstums nach der Krise', 16th AW-Vorlesung, Federal Minister of Science, Research and Economy, 29 May 2015, Vienna.

'Manufacturing Specialisation: Challenges and Options ahead', wiiw-Spring Seminar "Options against an unravelling Europe", 26 March 2015, Vienna.

'Agglomeration and FDI: Bringing International Production Linkages into the Picture', 17th Göttinger Workshop "Internationale Wirtschaftsbeziehungen", 18-20 February 2014, Göttingen.

'Agglomeration and FDI: Bringing International Production Linkages into the Picture'', 7th FIW Research Conference, 12-13 December 2014, Vienna.

'Agglomeration and FDI: Bringing International Production Linkages into the Picture', Graduate Seminar, University of Vienna, 9 December 2014, Vienna.

'Global Value Chains and Structural Change', Workshop Explaining Economic Change, Sapienza University, 12 November 2014, Rome.

'Agglomeration and international linkages in the location choices of European foreign direct investors', 16th European Trade Study Group Conference, 11-13 September 2014, Munich.

'Agglomeration and international linkages in the location choices of European foreign direct investors', 5th International Conference on "Economics of Global Interactions: New Perspectives on Trade, Factor Mobility and Development", 8-9 September 2014, Bari (Italy).

'Agglomeration and international linkages in the location choices of European foreign direct investors', INFER Workshop "Regions, firms, and FDI", 21-22 August 2014, Gent, (Belgium)

'State Intervention in the Economy by EU Competitors", project presentation (Final Meeting), European Commission, 16 July 2014, Brussels.

'Agglomeration and international linkages in the location choices of European foreign direct investors', 2nd WU - Workshop in Applied Econometrics, Vienna University of Economics and Business, 8 May 2014, Vienna.

'Why Manufacturing is Special', FIW-Workshop "An Industrial Renaissance in Europe. Can it happen? Should it happen?", 6 June 2014, Vienna.

'State aid and export competitiveness in the EU', FIW-Workshop "An Industrial Renaissance in Europe. Can it happen? Should it happen?", 6 June 2014, Vienna.

'State Aid and Export Competitiveness', EIZ Conference "The Role of Europe's Industry in the 21st Century", 21 November 2013, Zagreb.

'BRICS or Beyond?', BRICS Conference 2013, Panelist at Panel: Political and economic developments, Außenwirtschaft Österreich, 12 November 2013, Vienna.

'State Aid and Export Competitiveness', 15th European Trade Study Group (ETSG) Conference, 12-14 September 2013, Birmingham.

'A Manufacturing Imperative in the EU? - Europe's positions in global manufacturing and the role of industrial policy', project presentation at the Interim Meeting for the European Competitiveness Report 2013, DG Enterprise, 18 April 2013, Brussels.

'Industrial Policy for Growth', wiiw-Spring Seminar "Is There a Growth Strategy for Central and Eastern Europe?", 21 March 2013, Vienna.

'International spillovers in a world of technology clubs', 6th FIW Research Conference, 22 February 2013, Vienna.

'Die Wertschöpfungskette als Wachstumsimpuls?', BRICS Conference 2012 "BRIC & Beyond", Außenwirtschaft Österreich, 20 November 2012, Vienna.

'Concepts and Measures of Competitiveness - A Trade Perspective', GIZ Competitiveness Seminar, 29 October 2012, Baku.

'Trade in Jobs: a counterfactual exercise', ETSG Conference, Leuven, 13-25 September 2012.

'Trade in Jobs: a counterfactual exercise', OEI Regensburg, 3 July 2012, Regensburg.

'Trade in Jobs: a counterfactual exercise', WIOD Final Conference, 24-26 April 2012, Groningen.

'Trade in Jobs: a counterfactual exercise', Trade Economists Network (TEN) – Meeting, 20 April 2012, Copenhagen.

'The European Rim Countries - Challenges and Opportunities for EU Competitiveness'', project presentation at the Interim Meeting for the European Competitiveness Report 2012, DG Enterprise, 22 March 2012, Brussels.

'Stylised facts of EU Foreign Direct Investments', project presentation at the Interim Meeting for the European Competitiveness Report 2012, DG Enterprise, 21 March 2012, Brussels.

'Introductory Comments: Export premia in Austria', 15th FIW-Workshop “The Trade-Productivity Nexus in the European Economy”, 16 March 2012, Vienna.

'Scenario Analysis: global business, trade patterns and technology diffusion', AUGUR-Workshop, 15 March 2012, Rome.

'International spillovers in a world of technology clubs', Conference on Schumpeter's Heritage - The Evolution of the Theory of Evolution, 27-29 October 2011, Vienna.

'Exportentwicklung in Mittel-, Ost-, und Südosteuropa während und nach der Krise: die Rolle von Mengen-, Preis- und Produktänderungen', wiiw General Assembly, 13 May 2011.

'Global patterns of trade specialisation: Past and current patterns of trade', AUGUR-Workshop, 2-6 May 2011, Rome.

'Austrian Exporters - Unique or alike? New insights and missing puzzle pieces', doctoral seminar, University of Vienna, 5 April 2011, Vienna.

'Austrian Exporters – Unique or alike? New insights and missing puzzle pieces', wiiw internal seminar, 28 March 2011, Vienna.

'Austrian exporters. A firm level analysis', ETSG Conference, 9-11 September 2010, Lausanne.

'Trade in Intermediate Products and EU Manufacturing Supply Chains', project presentation at the Interim Meeting for the European Competitiveness Report 2010, DG Enterprise, 27 April 2010, Brussels.

'Österreichs Außenwirtschaft 2009' presentation of the Yearbook „Austria's External Economic Relations“(press conference), 10th FIW Workshop "New Protectionism - A threat to world trade?", 21 January 2010, Vienna.

COURSES

'Fundamentals and Methods for Impact Evaluation of Public Policies', IRVAPP Winter School, 17-22 February 2014, Trento.

'Discrete Choice Models For Cross Section and Panel Data', 'X. NIPE Summer School, 26-28 June 2013, Braga.

'Cities, Productivity and Migration’, 11th International and Development Economics Summer School, Centro Studi Luca d'Agliano, 27-30 June 2012, Gargnano.