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THREE EMPIRICAL ESSAYS ON THE IMPACT OF COMPLEMENTARITIES BETWEEN IMPORTS AND ABSORPTIVE CAPACITY

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IMPRIMATUR POUR LA THÈSE

Three Empirical Essays on the Impact of Complementarities between Imports and Absorptive Capacity

Niccolò CANNARSA

UNIVERSITÉ DE NEUCHÂTEL
FACULTÉ DES SCIENCES ÉCONOMIQUES

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Abstract

This thesis investigates empirically the impact of complementarities between different types of imports, capital and intermediate, and absorptive capacity on countries' performance. The investigation is conducted at different aggregation levels. In the first chapter, the study is conducted at the macro-level with a cross-country analysis including 72 low, middle and high-income countries covering the 1995-2014 period. A positive impact of complementarities on the economic growth of recipient countries does not emerge. The findings suggest that the macro aggregation level may not be the most effective one to perform the analysis as firms and sectors' heterogeneities between and within countries are masked. The second chapter performs the analysis for European industries belonging to the manufacturing sector during the 2008-2014 period. Robust evidence emerges in favor of a specific complementarity between capital imports and an absorptive capacity proxy related to workers' higher education. Indeed, the interaction between these two variables produces a complementarity positively affecting labor productivity in European manufacturing industries. The result suggests that for effective absorption, capital imports need a high-skilled workforce. The industry-level analysis provides interesting insights but firms' heterogeneity between and within countries and industries is still masked. The third chapter performs the analysis for Mexican manufacturing plants over the 1994-2003 period. This study provides robust evidence in favor of a positive impact of two types of complementarities on plants' productivity. Indeed, interactions between high-skilled workers and capital imports and between basic-skilled workers and intermediate imports produce complementarities that positively affect plants' productivity. This result suggests that for effective absorption, capital imports require a higher skilled workforce compared to intermediate imports. Overall, the thesis provides evidence in favor of the relevance of complementarities being contingent on the aggregation level at which the analysis is conducted, the considered type of imports and the chosen proxy for absorptive capacity.

Keywords: Imports, Capital Imports, Intermediate Imports, Absorptive Capacity, Economic Growth, Labor Productivity, Productivity, Plant

JEL classification: D22, D24, F14, F43, F61, J24, O47

Résumé

Cette thèse analyse empiriquement l'impact des complémentarités entre la capacité d'absorption et différents types d'importations, capital et intermédiaire, sur la performance des pays. L'enquête est menée à différents niveaux d'agrégation. Dans le premier chapitre, une recherche au niveau macroéconomique est réalisée, incluant 72 pays à revenu faible, moyen et élevé, de 1995 à 2014. Aucun impact significatif et positif en faveur des complémentarités n'est trouvé. Les résultats suggèrent que le niveau d'agrégation macroéconomique n'est pas le plus approprié, car il masque les hétérogénéités des industries et des entreprises entre les pays et en leur sein. Dans le deuxième chapitre, l'analyse est menée au niveau des industries manufacturières européennes de 2008 à 2014. Une complémentarité robuste est identifiée entre les importations de capital et une mesure de la capacité d'absorption liée à l'éducation supérieure des travailleurs. En effet, une interaction entre ces deux variables produit une complémentarité qui impacte positivement la productivité du travail dans les industries manufacturières européennes. Ce résultat suggère que, pour une absorption efficace, les importations de capital nécessitent une main-d'œuvre hautement qualifiée. Bien que l'analyse au niveau industriel produise des résultats intéressants, l'hétérogénéité des entreprises entre et au sein des pays et industries reste toujours masquée. Dans le troisième chapitre, l'analyse est réalisée sur des usines manufacturières mexicaines de 1994 à 2003. Un impact positif et robuste sur la productivité des usines est observé pour deux types de complémentarités. En effet, les interactions entre les importations de capital/intermédiaires et les travailleurs hautement qualifiés/peu qualifiés produisent des complémentarités ayant un impact positif sur la productivité des usines. Ce résultat suggère que, pour une absorption efficace, les importations de capital nécessitent une main-d'œuvre plus qualifiée que celles intermédiaires. En somme, cette thèse montre que la pertinence des complémentarités dépend du niveau d'agrégation choisi pour l'analyse, du type d'importations considéré, et de la mesure choisie pour la capacité d'absorption.

Mots-clés: Importations, Importations de capital, Importations intermédiaires, Capacité d'absorption, Croissance économique, Productivité du travail, Productivité, Usine
Classification JEL: D22, D24, F14, F43, F61, J24, O47

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General Introduction

The impact of international trade activities on economic performance can be explored from various perspectives. An interesting lens of analysis is the complementarity between these activities and absorptive capacity. Specifically, the complementarity between technology spillovers associated with the importing process (Lumenga-Neso et al., 2005) and absorptive capacity provides an interesting perspective. Indeed, the ability of countries to absorb the technologies embedded in imports may be crucial to fully benefit from these knowledge transfers. However, the relationship between absorptive capacity and capital imports, due to the technology the embody (Caselli and Wilson, 2004), may differ from that with other types of imports. Thus, it is essential to differentiate between different types of imports, capital and intermediate (Caselli, 2018), to deepen our understanding of how these complementarities affect countries' performance.

1. Adressing the Import-Productivity Link

The best suited level of aggregation to perform the analysis on how complementarities between different types of imports and absorptive capacity affect countries' performance is not evident. A macro-level study (e.g. Wacziarg and Welch, 2008) examining the effect of these complementarities on countries' economic growth would provide a global perspective. However, this aggregation level obscures sectors and firms' heterogeneity within and between countries. An inquiry on industries belonging to the same sector (e.g. Bournakis et al., 2018) analysing how complementarities affect labor productivity for a similar group of countries would provide a regional perspective. Moreover, the possibility of an industry to outsource the absorptive process to another industry in the same sector can be considered by using the absorptive capacity of the whole sector. However, this level of aggregation still obscures firms' heterogeneity between and within countries and industries. A firm-level study (e.g. Caselli, 2018) analysing the impact of complementarities on firms' productivity for a single country can deepen our understanding on the mechanisms governing the relationship between different types of imports and absorptive capacity proxies by finding relationships obscured at higher aggregation levels. To gain a broad understanding on how complementarities affect countries' performance, it is therefore beneficial to conduct empirical investigations at multiple levels of aggregation.

This thesis examines the relevance of complementarities between different types of imports, capital and intermediate, and indicators of absorptive capacity across three distinct aggregation levels. The initial chapter includes an empirical cross-country study investigating the influence of different complementarities on the economic growth of recipient nations. Moving to a more disaggregated level, the second chapter delves into the impact of complementarities on labor productivity within European manufacturing industries. Finally, the third chapter focuses on the effect of complementarities on productivity at the plant level in Mexico. The indicators of absorptive capacity are related to the countries' population education in the first chapter. In the second and third chapters in addition to education-related proxies, workers job characteristics are also used as absorptive capacity proxies. The time periods under consideration vary according to data availability. The first chapter encompasses the years 1995 to 2014, the second chapter covers the period from 2008 to 2014, while the third chapter examines data from 1994 to 2003.

The goal of this thesis is to assess the relevance of complementarities between different types of imports (capital and intermediate goods) and absorptive capacity proxies in explaining countries' performance. This implies using specifications where different types of imports are interacted with absorptive capacity proxies to verify if these interactions produce complementarities that positively affect the left-hand side variable. The analyses performed in this thesis consider, in all the chapters, the potential endogeneity issue arising when variables related to import activity are used to explain countries' performance. In the first chapter, we construct geography-based instrumental variables following the Frankel and Romer (1999)'s procedure and we also use the system GMM regression method. In the second chapter, endogeneity is managed by developing instrumental variables inspired by Autor et al. (2013)'s approach, which involves instrumentalizing imports with those of a comparable country group. Lastly, in the third chapter, the analysis follows the approach of Vogel and Wagner (2010) and Caselli (2018) to identify the role of complementarities in a learning by importing context. We indeed differentiate learning by importing from self-selection by explaining productivity differences with changes in trade statuses.

In the first chapter, the results provide no endogeneity-robust evidence in favor of a positive complementarity impact on the economic growth of recipient countries. However, positive evidence in favor of complementarities is found in the second and third chapters when education-related variables are used as proxies for absorptive capacity. In the second chapter, the results provide endogeneity robust evidence in favor of a positive impact of the complementarity between capital imports and a high-education proxy on labor productivity in European manufacturing industries. In the third chapter, the interaction between capital imports and high-skilled workers (tertiary education) generates a complementarity that positively impacts the productivity of Mexican manufacturing plants. Moreover, in the third chapter, the interaction between intermediate imports and basic-skilled workers (primary and lower-secondary education) also produces a complementarity that positively affects plants' productivity.

The thesis' findings suggest that the significance of complementarities between imports and absorptive capacity on countries' performance depends on the considered type of imports and on the level of aggregation at which the analysis is performed. Research at a lower aggregation level than the macro one needs to be performed to unravel the mechanisms with which complementarities impact countries' performance. The distinction between different types of imports is also crucial given that in both the second and third chapters, the results suggest that the technology embedded in capital imports requires a highly skilled workforce for effective absorption.

Moreover, the relevant complementarity including intermediate imports emerging in the Mexican plant level study suggests that the technology embedded in intermediate imports needs, for plants' effective absorption, to be combined with a lower skilled workforce than capital imports.

2. The Learning by Importing Concept in the Literature

The thesis' empirical investigations on the impact of complementarities on the performance of importing countries is related to the general body of work analysing the impact of trade openness on the countries engaging in this process. This body of literature is extensive and was already explored as soon as the nineties. The early results in that decade generally provided positive evidence in favor of trade openness with the findings of Dollar (1992), Sachs et al. (1995) and Edwards (1998) converging towards a positive outcome. However at the end of the decade, Rodriguez and Rodrik (2000) challenged the findings of these papers finding major statistical limitations in all of them. This debate highlighted the necessity for further research on the impact of trade openness on the performance of countries engaging in the process.

The empirical inconclusiveness of the late nineties led to a flurry of additional studies to improve our understanding of the links between trade openness and growth performance, the conditions under which a positive relationship might still appear, and the mechanisms which may be at work. The ”skeptical” view has progressively been replaced by a new battery of empirical evidence insisting on country specificities, such as the dynamics of the trade liberalization episodes followed by Wacziarg and Welch (2008) or the set of economic policy reforms considered by Easterly (2019). The recent and systematic survey by Irwin (2024) highlights that most studies find a positive *average* impact of trade reforms on economic growth, even if there is a large heterogeneity of results across countries. In this context, trade liberalization of intermediate goods appears to be critical in boosting productivity performance of domestic firms producing final goods. It is this particular channel of influence that the present thesis aims to investigate further.

The performance impact of importing can be examined through various lenses, including import competition (Berthou et al., 2019, Chen and Steinwender, 2021) imports variety (Broda and Weinstein, 2006, Hsieh et al., 2020) and learning by importing. Lumenga-Neso et al. (2005)'s approach is rooted in the technology spillovers nexus, thus closely related to the learning by importing phenomenon. The role of imports as a mechanism for technology diffusion was initially introduced in the seminal work of Coe and Helpman (1995) with the direct technology spillovers concept that was later challenged by Keller (1998). Lumenga-Neso et al. (2005) contributed to the discussion in the following decade reconciling the original findings with the criticisms by introducing the concept of indirect technology spillovers.

The notion of indirect technology spillovers suggests that technological transfers can occur even when trading with a less developed country. This concept is based on the idea of available research and development (R&D) rather than domestically produced R&D. It suggests that when a less developed country A imports from a more developed country B, its available R&D stock now in addition to the domestically produced one also includes parts of the one produced in country B. Therefore, if a developed country C would import from A, it would benefit from the available R&D stock that also contains R&D from B. As a consequence, imports can serve as conduits for technology spillovers regardless of their origin.

The addition of a complementaritiy dimension to the learning by importing concept can offer interesting research avenues. A complementarity approach was undertaken by Chang et al. (2009) and Freund and Bolaky (2008) who analysed the case of complementarities between trade and domestic policies on countries' performance. More specifically, an approach derived from the learning by importing concept should focus on imports' combination with absorptive capacity. Indeed, as in the foreign direct investment case studied by Borensztein et al. (1998), it might be the case that in order to fully benefit from technology spillovers, countries need to have the capacity of absorbing these technologies. Moreover, to deepen the understanding on how complementarities affect economic growth, distinguishing between different types of imports, capital and intermediate, is crucial. Indeed, capital imports, given the technology they embody

(Caselli and Wilson, 2004), may exhibit a different relationship with absorptive capacity than intermediate imports.

3. Contributions of the Thesis

The first chapter of the thesis analyses the impact of complementarities between different types of imports and countries' absorptive capacity on economic growth. The study is performed using a panel of 72 low, middle and high-income countries over the 1995-2014 time period. A dynamic panel growth specification is used to perform the analysis. This consists on explaining differences in GDP per capita every five years by aggregated explanatory variables over the corresponding five years periods. As imports-related variables are used to explain economic growth, this specification presents endogeneity issues that need to be addressed. We develop imports instrumental variables following the Frankel and Romer (1999)'s procedure, consisting on constructing imports variables that are driven by geography. We construct these variables for each kind of imports and use them in instrumental variables regressions. In addition to the endogeneity issue, we also need to consider the dynamic panel bias arising when the lagged value of the dependent variable is used as an explanatory one. In the dynamic growth regression we include the GDP per capita at the beginning of each five years periods to control for the catching up effect and a method controlling for this bias is required. We therefore also use the system GMM that simultaneously controls for the panel bias and the endogeneity issue. The results of the first chapter do no provide endogeneity-robust evidence in favor of positive complementarities between any type of imports and absorptive capacity on economic growth.

The first chapter's findings suggest that an analysis performed at the macro-level is too aggregated, masking sectors and firms' heterogeneities between and within countries. In order to unravel the mechanisms explaining the impact of complementarities between different types of imports and absorptive capacity proxies on countries' performance, analyses at lower aggregation levels need to be performed. A transition from macro-level research to more granular studies is also in line with what occurred in the literature examining the effects of trade openness on countries' performance since Melitz (2003)'s seminal paper. In this paper, firms where put at the center of an analysis where trade openness facilitates the reallocation of resources from less to more productive firms, thereby enhancing overall productivity. This shift in focus is gradually becoming evident in research exploring the impact of imports on firms' productivity as well. The existing body of research on this topic yields mixed findings, with some studies providing positive evidence, (Kasahara and Rodrigue, 2008, Paul and Yasar, 2009, Smeets and Warzynski, 2013, Yu and Li, 2014, Halpern et al., 2015) while others, do not (Vogel and Wagner, 2010, Van Biesebroeck, 2008, Conti et al., 2014). We suspect that these mixed results may derive from a lack of consideration of the complementarity dimension between imports and absorptive capacity.

The impact of complementarities between absorptive capacity and imports on firms' performance has been analysed at the firm level by Augier et al. (2013) for Spain, Yasar (2013) for China and Abreha (2019) for Ethiopia. However, due to data availability, none of these studies differentiated between capital and intermediate imports when analysing the role of complementarities. This omission may be crucial as different complementarities between different types of imports and absorptive capacity might impact differently firms' performance. Indeed, in a plant level study performed for Mexico, Caselli (2018)'s findings suggest that capital imports play a more prominent role in technology diffusion than intermediate imports. This implies that given the technology they embody, the interaction between capital imports and absorptive capacity might play a bigger role in explaining firms' performance than the interaction with intermediate imports. Distinguishing between these two categories of imports appears therefore important. An interesting additional complication arises from the issue of which level of aggregation is appropriate to capture the relevant degree of absorptive capacity. This is not evident as the effective absorptive capacity might not be confined to the firm or the industry itself. Indeed, an industry in a particular sector could outsource the absorptive capacity to another industry within the same sector. An industry level analysis on the relevance of complementarities can therefore be, as in Bournakis et al. (2018), an interesting level at which the analysis can be conducted.

The second chapter of the thesis empirically analyses the impact of complementarities between different types of imports, capital and intermediate, and absorptive capacity on the labor productivity of European manufacturing industries. We use 18 manufacturing industries for 16 European countries covering the 2008-2014 time period. In order to account for possible outsourcing of the absorptive capacity of an industry to other industries in the manufacturing sector, we use proxies for absorptive capacity at the manufacturing sector level. Moreover, in addition to absorptive capacity proxies related to workers' tertiary education levels, we also use proxies related to their occupation types. The later consists on workers employment in science and technology-related jobs. We also consider the endogeneity issue arising when imports related variables are used to explain industries' labor productivity by performing instrumental variables regressions. In line with Autor et al. (2013), we develop instruments by instrumentalizing the imports of a country's industry in a certain year by the imports of the same industry in a similar group of countries for the same year. The results of this study provide endogeneity-robust evidence in favor of a positive impact of complementarity when a particular import type is combined with a particular absorptive capacity proxy. Indeed, the interaction between capital imports and a tertiary education-related proxy produces a complementarity that positively impacts labor productivity while other interactions do not. The results suggest that for effective absorption, capital imports need to be combined with a highly educated workforce.

The second chapter's findings provide evidence supporting the importance of differentiating between different types of imports when testing for the impact of complementarities on European manufacturing industries. However, the industry aggregation level masks the heterogeneity of firms and potentially limits our understanding on how complementarities between different types of imports and absorptive capacity proxies affect firms' productivity. A firm level research is therefore needed to unravel the mechanisms governing the relationship between imports, absorptive capacity and firms' productivity that were potentially hidden at higher aggregation levels. Additionally, in order to expand our understanding on complementarities it would also be interesting to focus on a country that is at a lower development stage, such as a Latin American or an African nation. A firm level analysis for such a country could expand our understanding on how complementarity works as certain types of imports might require certain types of workers for effective firms' absorption. In previous firm level study focusing on the topic (Augier et al., 2013, Yasar, 2013, Abreha, 2019), the only proxy used for absorptive capacity was skilled labor. However, given the potential different workforce needs for effective absorption, an analysis using a basic-skilled proxy in addition to the high-skilled one would be of particular interest.

The third chapter empirically investigates the impact between different types of imports, capital and intermediate, and absorptive capacity proxies on the productivity of Mexican manufacturing plants. The time period covered is 1994-2003 and the absorptive capacity proxies are related to the skills and the occupation types of the workers. The skills related to workers' education, are basic (primary and lower secondary) and high (tertiary) while the occupation types of the workers are related to their collar, blue or white. The productivity variable used to test the chapter's research question is developed using the Wooldridge-Levinshon-Petrin estimator (Levinsohn and Petrin, 2003, Wooldridge, 2009). This approach takes into account the endogeneity of the labour and material variables in the estimation of the production function. We subsequently test for the significance of complementarities considering the potential self-selection phenomenon. This phenomenon arises when the most productive plants are the ones more likely to engage in international trade related activities. We therefore use a procedure similar to that used by Vogel and Wagner (2010) and Caselli (2018) to test the relevance of complementarities in a learning by importing context. The results provide evidence that the relevance of complementarities depends on which type of imports is complemented with which type of absorptive capacity proxies. We find that the interaction between capital imports and high-skilled workers and the interaction between intermediate imports and basic-skilled workers produce complementarities that positively affect productivity. These results suggest that for effective plants' absorption, the technology embedded in capital imports needs to be interacted with a higher skilled workforce compared to the intermediate imports case.

Chapter 1

Imports, Absorptive Capacity and Economic Growth*

This chapter empirically estimates the impact of complementarities between imported goods and absorptive capacity on national economic growth. We analyze either total imports or four categories depending on the type of imported goods. The research is carried out on a sample of 72 low, middle and high-income countries during the 1995-2014 time period. To deal with endogeneity issues, we use IV and system GMM estimation methods. The instrumental variables for imports, used in the IV regressions, are constructed following the gravity-based Frankel and Romer (1999)'s procedure. The results provide no robust empirical evidence in favour of a positive impact of complementarities on nations' economic growth.

Keywords: Imports, Absorptive Capacity, Economic Growth

*This chapter is based on a single author paper.

1.1 Introduction

The impact of international trade openness (TO) on economic growth has already received much attention in the economic literature. In the nineties, several empirical investigations reported a positive impact of TO on economic growth (e.g. Dollar, 1992, Sachs et al., 1995, Edwards, 1998). However, Rodriguez and Rodrik (2000) famously criticized the robustness of these early empirical results. Wacziarg and Welch (2008) responded to these criticisms founding again an average positive impact of TO on economic growth, while the review by Irwin (2024) proposes a more nuanced view. Overall, these results give rise to the question on why do some countries may benefit from TO while others do not ? What are the required characteristics that a country should exhibit in order to positively benefit from TO and can these characteristics be influenced by specific policies ?

The literature on the link between technology spillovers and TO offers promising avenues to treat these questions. Coe and Helpman (1995) and Lumenga-Neso et al. (2005) found that TO, through the importing process, is beneficial for countries due to technology spillover effects. This suggests, as in the foreign direct investment case studied by Borensztein et al. (1998), that the absorptive capacity of importing countries may be crucial to enhance a positive impact of TO on economic growth through technology spillovers. Indeed, countries' ability to absorb the technologies brought by imports may be crucial to fully benefit from knowledge transfers. Therefore, the goal of this study is to empirically test for the complementarity impact of TO and absorptive capacity on the growth performance of importing countries.

This study being based on the technology spillovers arising through the importing process, we analyse the complementarity between imports and absorptive capacity by interacting these two variables. Furthermore, in order to deepen our understanding of the TO-technology spillovers relationship, we also disaggregate the imports into four subcomponents. These subcomponents are the capital, consumer, intermediate and raw material imported goods. We also test for the complementarity between absorptive capacity and each one of these subcomponents to test if the explanatory power of the interaction depends on the type of goods a country imports.

The chapter's question is treated by using a sample of 72 low, middle and high-income countries covering the 1995-2014 time period. The twenty years analysed in this research are divided in four five years time periods. As import demand depends on growth performance, the econometric specification used to explain economic growth may give rise to endogeneity issues. We address this empirical caveat with two techniques. We use IV and system GMM estimation methods. In the IV regressions, this study uses as instrumental variables imports driven by geography, either for total imports or for the four import categories. To construct these variables, we follow the gravity-based approach of Frankel and Romer (1999). In the IV regressions, only the imports variables and their interactions with absorptive capacity are treated as endogenous. In the system GMM regressions, all the explanatory variables are treated as endogenous and their lags are used as internal instrumental variables. However, in order to avoid overfitting biases, we only use the first appropriate lags as internal instrumental variables. Overall, the results provide no robust evidence in favor of a positive complementarity impact between total/disaggregated imports and absorptive capacity on growth.

The remainder of the chapter is organized as follows. The next section presents the literature that inspired the research question. Then the methodology used for the empirical estimation is presented. Subsequently, the chapter's results are discussed, followed by the conclusion.

1.2 Literature Review

The literature investigating the impact of trade openness on economic growth is large, with variation between different measures of TO and empirical methods. This section focuses on the most influential papers regarding our specific research question.

The early empirical evidence was quite encouraging for TO. During the nineties, the results of influential papers (e.g. Dollar, 1992, Sachs et al., 1995, Edwards, 1998) converged to the same positive outcome. Indeed, Dollar (1992) by creating two different indices of trade closeness, Sachs et al. (1995) by developing TO dummy variables and Edwards (1998) by using different pre-existing measures of TO, found a positive impact of TO. These results contributed to an optimistic view about the impact of TO on economic growth.

However, these early findings were criticized in detail by Rodriguez and Rodrik (2000); who found that they were not robust, identifying statistical issues in all of these early papers. By questioning the nineties papers, Rodriguez and Rodrik (2000) showed that further research on the matter was still needed.

Wacziarg and Welch (2008) empirically investigated the impact of TO on economic growth by taking into account the Rodriguez and Rodrik (2000)'s critics. To do so, they created date of liberalization dummy variables. However, even though the average impact of their dummy variables was positive, it substantially differed across countries. An average positive impact of TO on countries' growth coupled with significant heterogeneities across nations also emerges in Irwin (2024)'s recent survey of the literature. These findings give rise to the question on why do some countries may benefit from TO while others may not and, what are the conditions for a country to positively benefit from TO?

These issues can be analysed through a ”policy complementarities” lens, as in Freund and Bolaky (2008) and Chang et al. (2009), focusing on interactions between TO and other countries domestic policies. Although the empirical setting is different (cross-country analysis for the former, panel data for the latter) both studies find that complementarities are important to fully benefit from TO.[1]

When this complementarity dimension is combined with the literature linking TO with technology spillovers, the role of absorptive capacity appears crucial. Coe and Helpman (1995) found

[1] It is also worth noting that both papers included among their set of domestic policies an educational investment one.

that imports are beneficial for countries through direct technology spillovers. Following Keller (1998)'s critics, Lumenga-Neso et al. (2005) strengthened the Coe and Helpman (1995)'s result by introducing the concept of indirect technology spillovers.

In addition to confirming the Coe and Helpman (1995)'s original findings, the Lumenga-Neso et al. (2005)'s results contributed to the literature with a key insight: a country may benefit from technological spillovers even when trading with a less technologically advanced country. A knowledge transfer process occurring in this scenario may appear counterintuitive at first. However, the concept of indirect technology spillovers changes the narrative by focusing on domestically *available* R&D rather than *domestically* produced R&D. For example, a low-income country A would benefit from a technological transfer by importing from a high-income country B. In this scenario, the R&D available in country A would be the sum of its domestically produced R&D and the R&D produced in country B. Hence, if a third high-income country C would import from country A, it would benefit from a knowledge transfer due to the available R&D in A that includes the technological innovations produced in B. By following this logic, total imports values should be taken into account since imports play a technological transfer role covering not only the country they directly come from but a web of trade relationships.

Thus, it can be expected that the interaction between imports and absorptive capacity may positively impact economic growth. As in the foreign direct investment scenario empirically investigated by Borensztein et al. (1998), absorptive capacity may play a central role on the effect of these technology transmissions on economic growth[2]. Indeed, in the Borensztein et al. (1998) article, in order to benefit from the technology spillovers occurring through the foreign direct investment process, countries' ability to absorb these technologies was crucial. A similar relationship may exist between imports, absorptive capacity and economic growth.

The literature presented in this section inspired the purpose of this chapter, which is to empirically test for the complementarity impact between total or disaggregated imports and absorptive

[2] See also Grether (1997) for a theoretical model in which low absorptive capacity contributes to FDI not playing a technological transfer role for domestic firms.

capacity on countries' economic growth.

1.3 Methodology

1.3.1 Econometric Specification

In order to investigate the impact of complementarities, we use the following dynamic growth equation:

$$
\begin{aligned}
&\ln GDPC_{i,t} - \ln GDPC_{i,t-1} = \alpha_1 \ln GDPC_{i,t-1} + \alpha_2 \ln ABS_{i,t} \\
&+ \alpha_3 \ln \left(\frac{TGI}{GDP}\right)_{i,t} + \alpha_5 \ln ABS_{i,t} \times \ln \left(\frac{TGI}{GDP}\right)_{i,t} \\
&+ \alpha_6 CV_{i,t} + \varepsilon_{i,t}
\end{aligned}
\tag{1.1}
$$

In order to focus on medium-term variables, in Equation (1.1) the 1995-2014 total sample length is divided in four five years ”time periods” denoted by t, for each country i. Indeed, the 1995-1999, 2000-2004, 2005-2009, 2010-2014 time intervals are respectively represented by the time periods $t = 2,3,4$ and 5[3].

The dependent variable $\ln GDPC_{i,t} - \ln GDPC_{i,t-1}$ is the real average growth rate of GDP per capita over the time period (five years). The explanatory variable $\ln GDPC_{i,t-1}$ is the ln value of GDP per capita at the end of the previous period. It is included to control for the convergence effect. The $ABS_{i,t}$ variable corresponds to the absorptive capacity at the beginning of period t.

The rest of the explanatory variables are averaged over each five years time periods. The $\left(\frac{TGI}{GDP}\right)_{i,t}$ variable represents the total good imports ratio. The $\ln ABS_{i,t} \times \ln \left(\frac{TGI}{GDP}\right)_{i,t}$ represents the interaction term between absorptive capacity and total good imports. We also add a set of control variables commonly used in the growth literature. This set of control variables, $CV_{i,t}$, includes a measure of inflation, savings rate, investments rate and population growth[4] Finally,

[3]Time period 1 (1990-1994) is only used to obtain values for the dependent variable and to control for the convergence in GDP effect for the second time period.

[4]See Table 1.A4 for the complete list of the variables, their sources and how they were constructed.

the error term is represented by $\varepsilon_{i,t}$.

As already stated in the introduction, we further investigate the TO-technology spillovers relationship by disaggregating the total good imports ratio into four subcomponents. The enriched specification is the following:

$$\begin{aligned}
\ln GDPC_{i,t} - \ln GDPC_{i,t-1} &= \alpha_1 \ln GDPC_{i,t-1} + \alpha_2 \ln ABS_{i,t} + \alpha_3 \ln \left(\frac{KGI}{GDP}\right)_{i,t} \\
&+ \alpha_4 \ln \left(\frac{CGI}{GDP}\right)_{i,t} + \alpha_5 \ln \left(\frac{IGI}{GDP}\right)_{i,t} + \alpha_6 \ln \left(\frac{RMI}{GDP}\right)_{i,t} + \alpha_7 \ln ABS_{i,t} \times \ln \left(\frac{KGI}{GDP}\right)_{i,t} \\
&+ \alpha_8 \ln ABS_{i,t} \times \ln \left(\frac{CGI}{GDP}\right)_{i,t} + \alpha_9 \ln ABS_{i,t} \times \ln \left(\frac{IGI}{GDP}\right)_{i,t} + \alpha_{10} \ln ABS_{i,t} \times \ln \left(\frac{RMI}{GDP}\right)_{i,t} \\
&+ \alpha_{11} CV_{i,t} + \varepsilon_{i,t}
\end{aligned} \tag{1.2}$$

Equation (1.2) differs from Equation (1.1) in how the importing values are included. In Equation (1.2) total good imports are disaggregated into 4 subcomponents. These subcomponents are the capital good imports ratio, the consumer good imports ratio, the intermediate good imports ratio and the raw material imports ratio. In Equation (1.2), these variables are respectively represented by $\left(\frac{KGI}{GDP}\right)_{i,t}$, $\left(\frac{CGI}{GDP}\right)_{i,t}$, $\left(\frac{IGI}{GDP}\right)_{i,t}$ and $\left(\frac{RMI}{GDP}\right)_{i,t}$. The complementarities between absorptive capacity and the subcomponents are captured by the interaction terms added to the econometric specification.

The interaction terms included in Equation (1.1) and Equation (1.2) empirically test for the chapter's hypothesis. Indeed, their estimated coefficients are the ones showing if the import-absorptive capacity's hypothesis is supported by the empirical findings.

1.3.2 Data

The imports data source is the World Integrated Trade Solution (WITS) of the World Bank while the control variables are taken from the World Development Indicators (WDI) of the World Bank. This paper uses the average years of total secondary schooling for total population aged 15 and above as a proxy for absorptive capacity [5]; taken from the Barro and Lee (2013)'s database. The authors constructed this proxy every five years over the 1950-2010 time period for a large panel of countries. Therefore, since we match the WITS, the WDI and the Barro and Lee (2013)'s database, the empirical investigation begins in 1995 due to the limited availability of imports and control variables data in 1990[6].

The sample of countries used to empirically estimate Equation (1.1) and Equation (1.2) includes 72 low, middle and high-income countries. These countries have been selected because they are the ones for which import and control variables data are available every year during the 1995-2014 time period. Moreover, they are also present in the Barro and Lee (2013)'s database[7].

1.3.3 Estimation Methods

This section explains the estimation methods used to estimate Equation (1.1) and Equation (1.2). We start by running simple OLS regressions. We subsequently introduce time and countries effect in Equation (1.1) and Equation (1.2) and run fixed effect regressions. The estimation by fixed effect does not control for reverse causality biases that may arise when the explanatory variables are also explained by the dependent one. We face this endogeneity issue by using two different methods. The first method consists on constructing imports driven by geography variables by following the Frankel and Romer (1999)'s procedure[8]. These variables are subsequently used as instrumental variables in the IV regressions. The second method consists on using the system GMM estimation method. This methods controls for reverse and dynamic panel biases by using lags as internal instrumental variables.

Before the results section, this study gives a detailed explanation on how we constructed the imports driven by geography variables and on the specification choices we made for the system GMM method.

[5] A similar proxy for absorptive capacity has been used by Borensztein et al. (1998) to test for the complementarity between foreign direct investment and absorptive capacity in their impact on economic growth.

[6] 1990 is the first year before 1995 for which data are available in the Barro and Lee (2013)'s database.

[7] Further information on selected countries and the variables are available in the Appendix sections 1.A.1 and 1.A.2

[8] Busse and Groizard (2008) used a similar method in their study on how technology imports (coming from OECD countries) affect countries GDP per capita.

IV

We construct measures of total good imports driven by geography (TGIG) to use them as instrumental variables in the IV regressions. These measures are constructed by closely following the gravity-based Frankel and Romer (1999)'s two steps procedure. The first step consists of estimating the impact that geographical variables have on the imports of total goods from one country to another. The second step uses the estimated coefficients obtained in the first step to construct the TGIG.

In the first step, we estimate a gravity equation running OLS regressions for each year of the 1995-2014 time period[9] to obtain the estimated coefficients on a yearly bases[10]. The specification is the following:

$$
\begin{aligned}
\ln\left(\frac{TGI_{i,j}}{GDP_i}\right) &= \alpha_0 + \alpha_1 \ln DIST_{i,j} + \alpha_2 \ln A_i + \alpha_3 \ln A_j + \alpha_4 \ln POP_i + \alpha_4 \ln POP_j + \alpha_5 L \\
&+ \alpha_6 S + \alpha_7 S \times \ln DIST + \alpha_8 S \times \ln A_i + \alpha_9 S \times \ln A_j + \alpha_{10} S \times \ln POP_i + \alpha_{11} S \times \ln POP_j \\
&+ \alpha_{12} S \times L + \varepsilon_{i,j}
\end{aligned} \tag{1.3}
$$

In Equation (1.3), index i represents the country receiving the imports while index j represents the country from which the imports come from. The dependent variable $\left(\frac{TGI_{i,j}}{GDP_i}\right)$ is the total good imports of country i[11] coming from country j divided by the GDP of country i[12]. The explanatory variables are geography-related. $DIST_{i,j}$ is a variable measuring the distance between

[9] Gravity equations results for the years 1995, 2000, 2005 and 2010 (corresponding to the beginning of each time period) are available in the Appendix section 1.A.3. The results for the other years are available upon request.

[10] We do it every year because the impact that these geographical variables have on bilateral trade may vary over time. See Lendle et al. (2016), for an example on how the development of new technologies, such as ebay, changes the impact that distance has on bilateral trade.

[11] In our estimation, we use a sample of 77 low, middle and high-income receiving countries. This sample includes countries for which imports data are available every year during the 1995-2014 time period (except for Russia: 1996-2014) and that are included in the Barro and Lee (2013)'s database. However, due to the inclusion of control variables in the econometric specification, five countries for which the instrumental variables have been developed are not included in the growth regressions. The countries included in this sample are presented in the Appendix section 1.A.1.

[12] In the original Frankel and Romer (1999)'s procedure, the dependent variable is the ratio of the sum of exports plus imports to GDP.

the two countries. A and POP are variables measuring the area and the population of country i and j. S is a variable taking the value of one if the two countries share a border and zero otherwise. L is a landlockedness measure derived by summing two dummy variables taking the value of one if the country is landlocked and zero otherwise. The remaining explanatory variables are interaction terms between the share border dummy variable and the explanatory ones. Finally $\varepsilon_{i,j}$ is the error term.

In the second step, we sum countries expected bilateral good imports with every other country in the world to obtain measures of TGIG. This is illustrated by the following equation:

$$\left(\widehat{\frac{TGIG_i}{GDP_i}}\right) = \sum_{i \neq j} e^{\hat{\alpha}' X_{i,j}} \tag{1.4}$$

In Equation (1.4), $\left(\widehat{\frac{TGIG_i}{GDP_i}}\right)$ represents the ratio of TGIG of country i. This measure is constructed by summing the expected bilateral good import ratios driven by geography between country i and all the countries (j) in the world.

This procedure is repeated for each year of the 1995-2014 time period to construct yearly measures of TGIG for all the countries used in this paper. Once the yearly measures of TGIG are obtained for the 1995-2014 time period, the averages over each five years time periods are used as instrumental variables for the total good imports in the IV regressions.

The averages over each time periods of the capital, consumer, intermediate and raw material good imports driven by geography (KGIG, CGIG, IGIG, RGIG) are respectively used as instrumental variables for the capital, consumer, intermediate and raw material good imports in the IV regressions. Values of KGIG, CGIG, IGIG and RMIG are constructed by following the same procedure used to construct the TGIG ones.

System GMM

In addition to the IV regression techniques, this paper also uses the system GMM regression method developed by Blundell and Bond (1998)[13]. We use this technique to further control for endogeneity. Indeed, the other explanatory variables may also be affected by reverse causality with economic growth and we hence also treat them, as is commonly done in the literature, as endogenous.

Furthermore, this regression technique also allows to control for the dynamic panel bias arising when a lag value of the dependent variable is included as an explanatory one. This is the case in this chapter as we test for the convergence in GDP effect. This bias becomes less relevant as the number of time period increases. However, since the number of time periods at our disposal is limited, it seems appropriate to also test Equation (1.1) and Equation (1.2) with a regression method that takes this bias into account.

This is a regression method that is frequently used in applied macroeconomics studies dealing with similar issues. For example, Chang et al. (2009) used it to test for the complementary impact of TO and other domestic policies on economic growth. It has also been used to treat other growth related issues. For example, Aisen and Veiga (2013) rely on system-GMM to investigate the impact of political stability on economic growth, while Heid et al. (2012) used it to empirically investigate the impact of income on democracy.

When implementing system GMM, there is a risk of using too many lags as instruments. This could give rise, as stated by Roodman (2009), to overfitting biases issues. We therefore limit the proliferation of instrumental variables by using only the first appropriate lags[14] as instruments. We also verify that the number of instruments does not surpass the number of countries used in the regressions. Finally, the Windmeijer (2005)'s correction of the standard errors for a small

[13]The development of this estimation method is based on the work of Holtz-Eakin et al. (1988), Arellano and Bond (1991) and Arellano and Bover (1995).

[14]This implies that only the second lags of the variables are used as instruments for the first difference equations and, only the once lagged first difference are used in the level equations.

sample is applied.

1.4 Results

The chapter's results are presented in the following sections. In the preliminary results section, we present the OLS and fixed effect findings. Subsequently, we present the results obtained when we control for endogeneity in the IV and system GMM results sections.

1.4.1 Preliminary Results

The OLS results are presented in Table (1.1). In all the columns, the dependent variable is the real GDP per capita growth presented in Equation (1.1) and Equation (1.2). The first column reports the results obtained when the dependent variable is regressed on the explanatory variables that are not import-related. The estimated coefficients have the expected signs. Indeed, the lag value of GDP per capita, the inflation and the population growth are negative while the proxy for absorptive capacity, the savings and the investments are positive. Moreover, except for inflation, all the explanatory variables are statistically significant. These results are similar in all the columns.

The second and third columns respectively present Equation (1.1)'s estimated result without and with the interaction term. The total good imports variable is positive but insignificant in both columns as is the interaction term in the third. In the following columns, we present the results obtained when the total good imports are disaggregated into the four subcomponents presented in Equation (1.2). The fourth and fifth columns report Equation (1.2)'s estimated results with the inclusion of the interaction terms only present in the fifth. We notice that none of the interaction terms are significant. The OLS results do not therefore provide evidence supporting the chapter's hypothesis.

Table 1.1: Complementarities and Economic Growth, OLS Results

	1	2	3	4	5
Lag Ln GDP per Capita	-0.009***	-0.009***	-0.009***	-0.009***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln Average Years of Total Secondary Schooling	0.009**	0.008**	0.006	0.009**	-0.004
	(0.004)	(0.004)	(0.007)	(0.004)	(0.017)
Ln Inflation	-0.014	-0.012	-0.012	-0.019	-0.016
	(0.020)	(0.020)	(0.020)	(0.018)	(0.019)
Gross domestic savings	0.041**	0.039**	0.041**	0.015	0.015
	(0.018)	(0.018)	(0.019)	(0.020)	(0.020)
Gross Capital Formation	0.119***	0.117***	0.114***	0.121***	0.126***
	(0.023)	(0.023)	(0.023)	(0.022)	(0.023)
Population Growth	-0.125***	-0.122***	-0.124***	-0.119***	-0.130***
	(0.032)	(0.032)	(0.031)	(0.039)	(0.038)
Ln Total Good Imports (ratio of GDP)		0.002	0.004		
		(0.002)	(0.006)		
Ln Capital Good Imports (ratio of GDP)				0.008**	0.001
				(0.003)	(0.006)
Ln Consumer Good Imports (ratio of GDP)				-0.004*	-0.000
				(0.003)	(0.005)
Ln Intermediate Good Imports (ratio of GDP)				-0.000	0.003
				(0.004)	(0.014)
Ln Raw Material Imports (ratio of GDP)				-0.001	0.002
				(0.002)	(0.004)
Ln Total Good Imports (ratio of GDP)×			-0.002		
Ln Average Years of Total Secondary Schooling			(0.005)		
Ln Capital Good Imports (ratio of GDP)×					0.007
Ln Average Years of Total Secondary Schooling					(0.005)
Ln Consumer Good Imports (ratio of GDP)×					-0.005
Ln Average Years of Total Secondary Schooling					(0.005)
Ln Intermediate Good Imports (ratio of GDP)×					-0.003
Ln Average Years of Total Secondary Schooling					(0.010)
Ln Raw Material Imports (ratio of GDP)×					-0.003
Ln Average Years of Total Secondary Schooling					(0.004)
Constant	0.063***	0.066***	0.070***	0.072***	0.081***
	(0.017)	(0.016)	(0.015)	(0.016)	(0.021)
Observations	286	286	286	286	286
R^2	0.375	0.379	0.379	0.397	0.406

The dependent variable is the real GDP per capita growth and country clustered standard errors are in parentheses.

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

Nevertheless, the OLS findings need to be taken with caution since this method doesn't control for time and countries effect. We include these effects in Equation (1.1) and Equation (1.2) and perform the analysis using the fixed effect regression method[15]. The fixed effects' results are presented in Table (1.2) where the columns include the same explanatory variables as the ones in Table (1.1).

Table (1.2)'s first column results are similar to the OLS ones. Indeed, all the explanatory variables have the expected signs. The only differences are that the inflation variable becomes significant and that the population growth and the proxy for absorptive capacity become insignificant. These results are similar in all the columns. In the second and fourth columns, reporting the estimated coefficients of the imports-related variables without the inclusion of the interaction terms, the results differ from the OLS ones as all the imports-related variables have a positive sign.

In the third and fifth columns, presenting the results obtained when the interaction terms are included, we notice that only the interaction including capital imports is significant. Indeed, the interaction between capital imports and the absorptive capacity proxy produces a complementarity positively impacting the economic growth of the recipient countries. Therefore, the fixed effect results provide evidence in favor of the chapter's hypothesis that need to be however taken with caution as this method does not control for endogeneity. In the next sections, we present the results obtained when we control for endogeneity using the IV and the system GMM regression methods.

[15]These effects are also included in the IV and system GMM specifications controlling for endogeneity.

Table 1.2: Complementarities and Economic Growth, Fixed Effect Results

	1	2	3	4	5
Lag Ln GDP per Capita	-0.063***	-0.056***	-0.060***	-0.059***	-0.064***
	(0.015)	(0.013)	(0.015)	(0.014)	(0.015)
Ln Average Years of Total Secondary Schooling	0.014	0.002	0.018	0.001	0.014
	(0.009)	(0.010)	(0.016)	(0.010)	(0.027)
Ln Inflation	-0.066***	-0.074***	-0.073***	-0.072***	-0.060**
	(0.023)	(0.022)	(0.023)	(0.024)	(0.023)
Gross domestic savings	0.135***	0.125***	0.125***	0.135***	0.135***
	(0.044)	(0.042)	(0.042)	(0.042)	(0.043)
Gross Capital Formation	0.088**	0.065	0.089*	0.056	0.113***
	(0.044)	(0.041)	(0.045)	(0.034)	(0.041)
Population Growth	-0.165	-0.153	-0.149	-0.163*	-0.193**
	(0.116)	(0.103)	(0.105)	(0.094)	(0.092)
Ln Total Good Imports (ratio of GDP)		0.037***	0.029**		
		(0.009)	(0.012)		
Ln Capital Good Imports (ratio of GDP)				0.012	-0.005
				(0.008)	(0.011)
Ln Consumer Good Imports (ratio of GDP)				0.023***	0.023*
				(0.008)	(0.013)
Ln Intermediate Good Imports (ratio of GDP)				0.006	-0.000
				(0.013)	(0.023)
Ln Raw Material Imports (ratio of GDP)				0.004	0.015
				(0.007)	(0.010)
Ln Total Good Imports (ratio of GDP)×			0.009		
Ln Average Years of Total Secondary Schooling			(0.007)		
Ln Capital Good Imports (ratio of GDP)×					0.021**
Ln Average Years of Total Secondary Schooling					(0.009)
Ln Consumer Good Imports (ratio of GDP)×					-0.002
Ln Average Years of Total Secondary Schooling					(0.012)
Ln Intermediate Good Imports (ratio of GDP)×					0.003
Ln Average Years of Total Secondary Schooling					(0.015)
Ln Raw Material Imports (ratio of GDP)×					-0.010*
Ln Average Years of Total Secondary Schooling					(0.005)
Constant	0.535***	0.546***	0.562***	0.640***	0.659***
	(0.127)	(0.118)	(0.127)	(0.120)	(0.109)
Observations	286	286	286	286	286
R^2	0.048	0.066	0.067	0.058	0.058

The dependent variable is the real GDP per capita growth and country clustered standard errors are in parentheses.
Time and country fixed effects in all specifications. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

1.4.2 IV Results

This section presents the results obtained when we use our constructed total/disaggregated imports driven by geography variables as instruments to control for endogeneity[16]. The IV results are presented in Table (1.3). The first two columns respectively report Equation (1.1)'s estimated results without and with the interaction term when the total good imports driven by geography (TGIG) are used as instruments. In the complete specification, the interaction between the TGIG and the proxy for absorptive capacity is used as an additional instrumental variable. We notice that except for the absorptive capacity proxy, all the variables have the expected sign and that the interaction term does not significantly affect countries' growth.

The last two columns report Equation (1.2)'s estimated results with the inclusion of the interaction terms only present in the fourth one. In both columns the capital, consumer, intermediate and raw material imports driven by geography (KGIG, CGIG, IGIG and RGIG) are used as instrumental variables and their respective interactions with absorptive capacity are used as additional instruments in the last column. We notice that the variables not related to imports, except for investing, have the expected sign. Moreover, we also notice in the fourth columnn that none of the interaction terms is significant. In particular, the significance of the interaction between capital good imports and the proxy for absorptive capacity, found in the fixed effect regressions, does not hold when we control for endogeneity.

Nevertheless, this method does not consider the potential endogeneity of the other non imports-related explanatory variables and the dynamic panel bias. We therefore also use the system GMM regression method to verify that the non-significance of complementarities when controlling for endogeneity also holds when a different method is applied. The system GMM results are presented in the following section.

[16]The first stages F-statistics are reported in the corresponding appendix section for all the IV regressions presented in the chapter. The reported F-Statistics don't support a weak instruments scenario. The detailed results for all the first stages remain also available upon request.

Table 1.3: Complementarities and Economic Growth, IV Results

	1	2	3	4
Lag Ln GDP per Capita	-0.039*	-0.044**	-0.143*	-0.147
	(0.023)	(0.022)	(0.084)	(0.205)
Ln Average Years of Total Secondary Schooling	-0.029	-0.009	0.003	0.096
	(0.029)	(0.030)	(0.048)	(0.207)
Ln Inflation	-0.097***	-0.095***	-0.027	-0.028
	(0.030)	(0.030)	(0.069)	(0.056)
Gross domestic savings	0.098*	0.099*	0.320	0.292
	(0.058)	(0.057)	(0.261)	(0.357)
Gross Capital Formation	0.005	0.034	-0.236	-0.020
	(0.073)	(0.063)	(0.387)	(0.684)
Population Growth	-0.123	-0.118	-0.039	0.124
	(0.086)	(0.090)	(0.261)	(0.736)
Ln Total Good Imports	0.136	0.124		
	(0.089)	(0.080)		
Ln Capital Good Imports			0.114	0.072
			(0.106)	(0.097)
Ln Consumer Good Imports			0.186	0.060
			(0.300)	(0.523)
Ln Intermediate Good Imports			-0.200	-0.117
			(0.186)	(0.282)
Ln Raw Material Imports			-0.030	-0.025
			(0.127)	(0.354)
Ln Total Good Imports (ratio of GDP)×		0.011		
Ln Average Years of Total Secondary Schooling		(0.018)		
Ln Capital Good Imports (ratio of GDP)×				0.036
Ln Average Years of Total Secondary Schooling				(0.056)
Ln Consumer Good Imports (ratio of GDP)×				-0.017
Ln Average Years of Total Secondary Schooling				(0.192)
Ln Intermediate Good Imports (ratio of GDP)×				-0.038
Ln Average Years of Total Secondary Schooling				(0.469)
Ln Raw Material Imports (ratio of GDP)×				0.032
Ln Average Years of Total Secondary Schooling				(0.179)
Constant	0.575***	0.594***	1.387*	1.156
	(0.140)	(0.154)	(0.815)	(1.980)
Observations	286	286	286	286
R^2	0.065	0.068	0.001	0.010

The dependent variable is the real GDP per capita growth and country clustered standard errors are in parentheses. Time and country fixed effects in all specifications. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

1.4.3 System GMM Results

This section presents the results obtained when the system GMM method is used to control for endogeneity. The system GMM results are presented in Table (1.4), where columns one and three respectively report Equation (1.1) and Equation (1.2)'s estimated results without interaction terms. In the first two columns, all the non import-related explanatory variables, except for inflation, have the expected signs and the interaction term is negative and not significant[17]. We also notice that in the third column all the subcomponents are positive but none is significant.

In the fourth column, only the interaction between the capital good imports and the proxy for absorptive capacity is added. The other interaction terms are not included to limit the proliferation of instrumental variables causing, as mentionned in section 1.3.3, overfitting biases issues. We choose to keep the interaction between capital imports and absorptive capacity to further control for the validity of the positive and significant interaction found in the fixed effects setting[18].

The fourth column hence tests if by controlling for endogeneity with the system GMM method, a result similar to the IV one is obtained. We notice that it is the case as the interaction term is not significant. We can therefore conclude that the system GMM results presented in Table (1.4) reinforces the pattern identified by IV estimates and show no evidence in favor of the chapter's hypothesis.

[17]We also notice that both the Hansen and the autocorrelations tests pass. The tests reported in the following columns also pass.

[18]In addition, due to the technology embedded in capital imports (Caselli and Wilson, 2004), we suspect that the relevance of absorptive capacity might be of particular importance for this subcomponent.

Table 1.4: Complementarities and Economic Growth, System GMM Results

	1	2	3	4
Lag Ln GDP per Capita	-0.021***	-0.022***	-0.021***	-0.022***
	(0.005)	(0.005)	(0.004)	(0.005)
Ln Average Years of Total Secondary Schooling	0.029***	0.014	0.026***	0.014
	(0.010)	(0.023)	(0.009)	(0.022)
Ln Inflation	0.038	0.015	0.018	-0.008
	(0.045)	(0.042)	(0.046)	(0.044)
Gross domestic savings	0.057	0.103*	0.082	0.082
	(0.039)	(0.055)	(0.073)	(0.074)
Gross Capital Formation	0.101***	0.067	0.087*	0.076
	(0.038)	(0.070)	(0.049)	(0.060)
Population Growth	-0.134*	-0.142*	-0.138*	-0.131*
	(0.073)	(0.086)	(0.077)	(0.071)
Ln Total Good Imports (ratio of GDP)	0.013*	0.018		
	(0.008)	(0.014)		
Ln Capital Good Imports (ratio of GDP)			0.002	0.010
			(0.010)	(0.012)
Ln Consumer Good Imports (ratio of GDP)			0.002	0.001
			(0.009)	(0.009)
Ln Intermediate Good Imports (ratio of GDP)			0.003	-0.002
			(0.009)	(0.009)
Ln Raw Material Imports (ratio of GDP)			0.002	0.002
			(0.005)	(0.005)
Ln Total Good Imports (ratio of GDP)×		-0.012		
Ln Average Years of Total Secondary Schooling		(0.014)		
Ln Capital Good Imports (ratio of GDP)×				-0.004
Ln Average Years of Total Secondary Schooling				(0.007)
Constant	0.175***	0.188***	0.190***	0.200***
	(0.043)	(0.049)	(0.052)	(0.066)
Observations	286	286	286	286
AR(1) test (p-value)	0.012	0.015	0.015	0.018
AR(2) test (p-value)	0.588	0.625	0.602	0.453
Hansen test (p-value)	0.195	0.202	0.340	0.198
Instruments	34	38	46	50

The dependent variable is the real GDP per capita growth and corrected standard errors are in parentheses. Time and country fixed effects in all specifications. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

1.5 Conclusion

This chapter empirically analyses the impact of complementarities between total/disaggregated imports and absorptive capacity on economic growth. We estimate a dynamic growth equation using a sample of 72 low, middle and high-income countries during the 1995-2014 time period and use IV and system GMM regression methods to control for endogeneity. In spite of careful attempts to vary the specification and the proxies for key variables, the results of this chapter provide no empirically robust evidence supporting a positive complementarity impact.

One potential explanation of these non-significant findings is that the macro aggregation level is not the most effective one to empirically investigate the research question. This level, used to provide a global perspective, has the disadvantage to mask firms and sectors' heterogeneities between and within countries. This potentially limits our understanding of the phenomenon. Further investigations at deeper aggregation levels could hence be conducted to unravel the mechanisms explaining how complementarities between different types of imports and absorptive capacity affect countries' performance.

Future research could perform the analysis focusing on industries belonging to the same sector for a similar group of countries. For instance, an analysis on the impact of complementarities between different types of imports and absorptive capacity on the performance of European manufacturing industries could provide interesting insights. Indeed, the investigation would be performed at a lower aggregation level while sill providing a regional perspective. Moreover, it could consider the possibility of absorptive capacity outsourcing between industries belonging to the manufacturing sector. This is what we do in chapter 2 of the thesis.

An industry level analysis could potentially provide interesting insight but still masks firms' heterogeneities between and within countries and industries. A research for a single country at the firm level, investigating the relevance of complementarities between different types of imports and absorptive capacity in explaining firms' productivity, could therefore be of particular interest. Moreover, if the industry level analysis is performed for European manufacturing industries, conducting the analysis for a country at a different development stage, such as a Latin American or an African nation, could enhance a more global understanding of the phenomenon. This is why we analyse the specific case of Mexican manufacturing in chapter 3.

Chapter 1 Appendix

1.A Appendix

1.A.1 Samples

Table 1.A1: Reporter Countries Included in Gravity/Growth Equations

	Countries	
Algeria	France	Norway
Argentina	Gambia, The	Panama
Australia	Germany	Paraguay
Austria	Greece	Peru
Belgium-Luxembourg	Hong Kong, China	Poland
Belize*	Hungary	Portugal
Bolivia	Iceland	Romania
Brazil	India	Singapore
Burundi	Indonesia	Slovak Republic
Cameroon	Ireland	Slovenia
Canada	Israel	South Africa
Central African Republic	Italy	Spain
Chile	Japan	Sweden
China	Korea, Rep.	Switzerland
Colombia	Latvia	Tanzania
Costa Rica	Lithuania	Thailand
Cote d'Ivoire	Malaysia	Trinidad and Tobago*
Croatia	Maldives*	Tunisia
Cyprus	Malta	Turkey
Czech Republic	Mauritius	Uganda
Denmark	Mexico	United Kingdom
Ecuador	Morocco	United States
Egypt, Arab Rep.	Netherlands	Uruguay
El Salvador	New Zealand	Zambia*
Estonia	Nicaragua*	Russian Federation
Finland	Niger	

* Countries not included in the growth regressions.

Table 1.A2: Partner Countries Included in Gravity Equations

Countries		
Afghanistan – AFG	Canada – CAN	Fiji – FJI
Albania – ALB	Cape Verde – CPV	Finland – FIN
Algeria – DZA	Cayman Islands – CYM	France – FRA
Andorra – AND	Central African Republic – CAF	French Guiana – GUF
Angola – AGO	Chad – TCD	French Polynesia – PYF
Anguila – AIA	Chile – CHL	Gabon – GAB
Antigua and Barbuda – ATG	China – CHN	Gambia, The – GMB
Argentina – ARG	Christmas Island – CXR	Georgia – GEO
Armenia – ARM	Cocos (Keeling) Islands – CCK	Germany – DEU
Aruba – ABW	Colombia – COL	Ghana – GHA
Australia – AUS	Comoros – COM	Gibraltar – GIB
Austria – AUT	Congo, Dem. Rep. – ZAR	Greece – GRC
Azerbaijan – AZE	Congo, Rep. – COG	Greenland – GRL
Bahamas, The – BHS	Cook Islands – COK	Grenada – GRD
Bahrain – BHR	Costa Rica – CRI	Guadeloupe – GLP
Bangladesh – BGD	Cote dIvoire – CIV	Guatemala – GTM
Barbados – BRB	Croatia – HRV	Guinea – GIN
Belarus – BLR	Cuba – CUB	Guinea-Bissau – GNB
Belgium-Luxembourg–BEL	Cyprus – CYP	Guyana – GUY
Belize – BLZ	Czech Republic – CZE	Haiti – HTI
Benin – BEN	Denmark – DNK	Honduras – HND
Bermuda – BMU	Djibouti – DJI	Hong Kong, China – HKG
Bhutan – BTN	Dominica – DMA	Hungary – HUN
Bolivia – BOL	Dominican Republic – DOM	Iceland – ISL
Bosnia and Herzegovina – BIH	East Timor – TMP	India – IND
Botswana – BWA	Ecuador – ECU	Indonesia – IDN
Brazil – BRA	Egypt, Arab Rep. – EGY	Iran, Islamic Rep. – IRN
British Virgin Islands – VGB	El Salvador – SLV	Iraq – IRQ
Brunei – BRN	Equatorial Guinea – GNQ	Ireland – IRL
Bulgaria – BGR	Eritrea – ERI	Israel – ISR
Burkina Faso – BFA	Estonia – EST	Italy – ITA
Burundi – BDI	Ethiopia(excludes Eritrea) – ETH	Jamaica – JAM
Cambodia – KHM	Faeroe Islands – FRO	Japan – JPN
Cameroon – CMR	Falkland Island – FLK	Jordan – JOR

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Table 1.A2 – *Continued from previous page*

Countries		
Kazakhstan – KAZ	Namibia – NAM	San Marino – SMR
Kenya – KEN	Nauru – NRU	Sao Tome and Principe – STP
Kiribati – KIR	Nepal – NPL	Saudi Arabia – SAU
Korea, Dem. Rep. – PRK	Netherlands – NLD	Senegal – SEN
Korea, Rep. – KOR	Netherlands Antilles – ANT	Seychelles – SYC
Kuwait – KWT	New Caledonia – NCL	Sierra Leone – SLE
Kyrgyz Republic – KGZ	New Zealand – NZL	Singapore – SGP
Lao PDR – LAO	Nicaragua – NIC	Slovak Republic – SVK
Latvia – LVA	Niger – NER	Slovenia – SVN
Lebanon – LBN	Nigeria – NGA	Solomon Islands – SLB
Lesotho – LSO	Niue – NIU	Somalia – SOM
Liberia – LBR	Norfolk Island – NFK	South Africa – ZAF
Libya – LBY	Northern Mariana Islands – MNP	Spain – ESP
Lithuania – LTU	Norway – NOR	Sri Lanka – LKA
Macao – MAC	Oman – OMN	St. Kitts and Nevis – KNA
Macedonia, FYR – MKD	Pakistan – PAK	St. Lucia – LCA
Madagascar – MDG	Palau – PLW	St. Vincent and the Grenadines – VCT
Malawi – MWI	Panama – PAN	Suriname – SUR
Malaysia – MYS	Papua New Guinea – PNG	Swaziland – SWZ
Maldives – MDV	Paraguay – PRY	Sweden – SWE
Mali – MLI	Peru – PER	Switzerland – CHE
Malta – MLT	Philippines – PHL	Syrian Arab Republic – SYR
Marshall Islands – MHL	Pitcairn – PCN	Taiwan, China – TWN
Martinique – MTQ	Poland – POL	Tajikistan – TJK
Mauritania – MRT	Portugal – PRT	Tanzania – TZA
Mauritius – MUS	Puerto Rico – PRI	Thailand – THA
Mexico – MEX	Qatar – QAT	Togo – TGO
Micronesia, Fed. Sts. – FSM	Reunion – REU	Tokelau – TKL
Moldova – MDA	Romania – ROM	Tonga – TON
Mongolia – MNG	Russian Federation – RUS	Trinidad and Tobago – TTO
Montserrat – MSR	Rwanda – RWA	Tunisia – TUN
Morocco – MAR	Saint Helena – SHN	Turkey – TUR
Mozambique – MOZ	Saint Pierre and Miquelon – SPM	Turkmenistan – TKM
Myanmar – MMR	Samoa – WSM	Turks and Caicos Isl. – TCA

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Table 1.A2 – *Continued from previous page*

Countries
Tuvalu – TUV
Uganda – UGA
Ukraine – UKR
United Arab Emirates – ARE
United Kingdom – GBR
United States – USA
Uruguay – URY
Vanuatu – VUT
Venezuela – VEN
Vietnam – VNM
Wallis and Futura Isl. – WLF
Western Sahara – ESH
Yemen – YEM
Zambia – ZMB
Zimbabwe – ZWE

The corresponding iso3 countries codes are reported next to the countries names.

1.A.2 Variables

Table 1.A3: Gravity Equations Variables

Variable	Description	Source
Total good imports of country i coming from country j	AllSubHeading–All HS6 Codes. Bilateral total good imports (1000US$)	WITS
Capital good imports of country i coming from country j	UNCTAD-SoP4–Capital Goods. Bilateral capital good imports (1000US$).	WITS
Consumer good imports of country i coming from country j	UNCTAD-SoP3–Consumer Goods. Bilateral consumer good imports (1000US$).	WITS
Intermediate good imports of country i coming from country j	UNCTAD-SoP2–Intermediate Goods. Bilateral intermediate good imports (1000US$).	WITS
Raw material imports of country i coming from country j	UNCTAD-SoP1–Raw Materials. Bilateral raw material imports (1000US$).	WITS
Country_i GDP	GDP (current US$)	Head et al. (2010), Head and Mayer (2014)
Distance	Weighted distance	Head et al. (2010), Head and Mayer (2014)
Country_i Area	Area (kilometers squares)	Head et al. (2010), Head and Mayer (2014)
Country_j Area	Area (kilometers squares)	Head et al. (2010), Head and Mayer (2014)
Country_i Population	Total population (millions).	Head et al. (2010), Head and Mayer (2014)
Country_j Population	Total population (millions).	Head et al. (2010), Head and Mayer (2014)
Landlocked	Dummy taking the value of one if the country is landlocked.	Mayer and Zignago (2011)
Share a Border	Dummy taking the value of one if two countries share a border.	Head et al. (2010), Head and Mayer (2014)

Table 1.A4: Growth Equations Variables

Variable	Description	Source
Real average rate of per capita GDP growth	We take the difference between the natural logarithm of the GDP per capita (constant 2010 US$) at the end of the period and the one at the end of the previous period. We normalize the difference by the length of the period (five years). For example, for time period 2, the variable equals $\frac{\ln \text{GDPC}_{i,1999} - \ln \text{GDPC}_{i,1994}}{5}$.	WDI
Lag GDP per capita	It corresponds to the natural logarithm of the GDP per capita (constant 2010 US$) at the end of the previous period. For example, for time period 2, the variable equals $\ln \text{GDPC}_{i,1994}$.	WDI
Absorptive capacity	We take the natural logarithm of the average years of total secondary schooling for total population aged 15 and above at the beginning of the period. For example, for time period 2, the variable equals $\ln \text{ABS}_{i,1995}$.	Barro and Lee (2013)
Total good imports ratio	We take the averages over each five years time periods of the ratios of total good imports (US$ thousand) to GDP (current US$). We then transform these averages into their natural logarithm. For example, for time period 2, the variable equals $\ln\left(\frac{1}{5}\sum_{y=1995}^{1999}\left(\frac{\text{TGI}}{\text{GDP}}\right)_{i,y}\right)$.	WITS,CEPII
Capital good imports ratio	We take the averages over each five years time periods of the ratios of capital good imports (US$ thousand) to GDP (current US$). We then transform these averages into their natural logarithm. For example, for time period 2, the variable equals $\ln\left(\frac{1}{5}\sum_{y=1995}^{1999}\left(\frac{\text{KGI}}{\text{GDP}}\right)_{i,y}\right)$.	WITS,CEPII
Consumer good imports ratio	We take the averages over each five years time periods of the ratios of consumer good imports (US$ thousand) to GDP (current US$). We then transform these averages into their natural logarithm. For example, for time period 2, the variable equals $\ln\left(\frac{1}{5}\sum_{y=1995}^{1999}\left(\frac{\text{CGI}}{\text{GDP}}\right)_{i,y}\right)$.	WITS,CEPII
Intermediate good imports ratio	We take the averages over each five years time periods of the ratios of intermediate good imports (US$ thousand) to GDP (current US$). We then transform these averages into their natural logarithm. For example, for time period 2, the variable equals $\ln\left(\frac{1}{5}\sum_{y=1995}^{1999}\left(\frac{\text{IGI}}{\text{GDP}}\right)_{i,y}\right)$.	WITS,CEPII
Raw material imports ratio	We take the averages over each five years time periods of the ratios of raw material imports (US$ thousand) to GDP (current US$). We then transform these averages into their natural logarithm. For example, for time period 2, the variable equals $\ln\left(\frac{1}{5}\sum_{y=1995}^{1999}\left(\frac{\text{RMI}}{\text{GDP}}\right)_{i,y}\right)$.	WITS,CEPII
Total good imports driven by geography	See section 3.3.1.	Own Calculation.
Capital good imports driven by geography	See section 3.3.1.	Own Calculation.
Consumption good imports driven by geography	See section 3.3.1.	Own Calculation.
Intermediate good imports driven by geography	See section 3.3.1.	Own Calculation.
Raw material imports driven by geography	See section 3.3.1.	Own Calculation.
Measure of Inflation	We take the averages over each five years time periods of the Inflation Consumer Prices (annual %). We then transform these averages into $\ln\left(1 + \frac{\texttt{Inflation}}{100}\right)$ to avoid heteroskedasticity issues.	WDI
Savings rate	We take the averages over each five years time periods of the Gross domestic savings (% of GDP). We then divide the averages by 100 to facilitate the analysis of the results.	WDI
Gross capital formation rate	We take the averages over each five years time periods of the Gross capital formation (% of GDP). We then divide the averages by 100 to facilitate the analysis of the results.	WDI
Population Growth	We take the difference between the natural logarithm of the total population at the end of the period and the one at the end of the previous period.	WDI

1.A.3 Gravity Equations Results

Table 1.A5: Gravity Equations Results, 1995

	Total	Capital	Consumer	Intermediate	Raw Material
Ln Distance	-1.129***	-0.992***	-1.246***	-1.164***	-1.028***
	(0.036)	(0.049)	(0.040)	(0.042)	(0.039)
Ln Area$_i$	-0.167***	0.036	0.013	-0.110***	-0.184***
	(0.019)	(0.027)	(0.021)	(0.022)	(0.021)
Ln Area$_j$	-0.193***	-0.416***	-0.428***	-0.118***	0.240***
	(0.017)	(0.025)	(0.020)	(0.022)	(0.020)
Ln Population$_i$	-0.012	-0.516***	-0.418***	-0.141***	0.044
	(0.025)	(0.036)	(0.028)	(0.030)	(0.028)
Ln Population$_j$	1.074***	1.225***	1.257***	0.972***	0.505***
	(0.021)	(0.031)	(0.025)	(0.027)	(0.024)
Landlocked	-0.977***	-0.783***	-0.976***	-1.026***	-0.916***
	(0.056)	(0.085)	(0.065)	(0.070)	(0.064)
Share Border	4.682*	3.718	6.995**	2.896	-0.047
	(2.687)	(3.394)	(2.833)	(2.911)	(2.581)
Share Border × Ln Distance	-0.028	-0.115	-0.323	-0.266	-0.274
	(0.423)	(0.526)	(0.446)	(0.454)	(0.401)
Share Border × Ln Area$_i$	0.208	0.019	0.291	0.244	0.195
	(0.215)	(0.264)	(0.225)	(0.227)	(0.203)
Share Border × Ln Area$_j$	-0.042	-0.104	0.130	-0.022	-0.139
	(0.171)	(0.213)	(0.180)	(0.184)	(0.163)
Share Border × Ln Population$_i$	-0.502***	-0.283	-0.611***	-0.386*	-0.279
	(0.191)	(0.239)	(0.201)	(0.203)	(0.182)
Share Border × Ln Population$_j$	0.192	0.262	0.088	0.238	0.417**
	(0.185)	(0.235)	(0.197)	(0.204)	(0.182)
Share Border × Landlocked	0.563**	0.415	0.519*	0.637**	0.230
	(0.280)	(0.354)	(0.296)	(0.301)	(0.268)
Constant	-12.548***	-9.925***	-8.724***	-11.293***	-11.813***
	(0.469)	(0.665)	(0.527)	(0.562)	(0.515)
Observations	10419	7400	8783	7896	7407
R^2	0.417	0.331	0.413	0.367	0.334

Each column dependent variable is the logarithmic transformation of the ratio of the corresponding type of imports to GDP. Standard errors are in parentheses, the R^2 reported is the adjusted one and * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.A6: Gravity Equations Results, 2000

	Total	Capital	Consumer	Intermediate	Raw Material
Ln Distance	-1.372***	-1.219***	-1.433***	-1.351***	-1.196***
	(0.037)	(0.048)	(0.041)	(0.043)	(0.041)
Ln $Area_i$	-0.162***	-0.001	-0.026	-0.125***	-0.281***
	(0.019)	(0.025)	(0.021)	(0.022)	(0.021)
Ln $Area_j$	-0.245***	-0.447***	-0.498***	-0.121***	0.257***
	(0.018)	(0.025)	(0.021)	(0.022)	(0.021)
Ln $Population_i$	0.052**	-0.315***	-0.307***	-0.072**	0.277***
	(0.025)	(0.035)	(0.029)	(0.031)	(0.029)
Ln $Population_j$	1.204***	1.342***	1.433***	1.032***	0.543***
	(0.022)	(0.031)	(0.026)	(0.027)	(0.025)
Landlocked	-1.218***	-1.074***	-1.174***	-1.216***	-1.189***
	(0.056)	(0.079)	(0.065)	(0.070)	(0.065)
Share Border	5.003*	5.172	7.123**	2.196	1.910
	(2.842)	(3.485)	(3.066)	(3.044)	(2.749)
Share Border × Ln Distance	-0.095	-0.586	-0.242	-0.157	0.058
	(0.450)	(0.547)	(0.492)	(0.478)	(0.434)
Share Border × Ln $Area_i$	0.260	0.255	0.434*	0.175	0.457**
	(0.214)	(0.260)	(0.232)	(0.226)	(0.207)
Share Border × Ln $Area_j$	0.066	-0.113	0.063	-0.069	-0.229
	(0.173)	(0.210)	(0.186)	(0.184)	(0.169)
Share Border × Ln $Population_i$	-0.541***	-0.492**	-0.777***	-0.346	-0.673***
	(0.204)	(0.251)	(0.221)	(0.215)	(0.198)
Share Border × Ln $Population_j$	0.101	0.390	0.156	0.269	0.437**
	(0.190)	(0.239)	(0.206)	(0.208)	(0.186)
Share Border × Landlocked	0.771***	0.499	0.662**	0.682**	0.748***
	(0.294)	(0.365)	(0.320)	(0.314)	(0.287)
Constant	-13.166***	-12.593***	-10.723***	-11.891***	-14.223***
	(0.479)	(0.641)	(0.542)	(0.566)	(0.538)
Observations	11819	8967	10292	9035	8354
R^2	0.427	0.339	0.414	0.363	0.329

Each column dependent variable is the logarithmic transformation of the ratio of the corresponding type of imports to GDP. Standard errors are in parentheses, the R^2 reported is the adjusted one and * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.A7: Gravity Equations Results, 2005

	Total	Capital	Consumer	Intermediate	Raw Material
Ln Distance	-1.442***	-1.314***	-1.552***	-1.465***	-1.228***
	(0.039)	(0.049)	(0.043)	(0.045)	(0.041)
Ln Area$_i$	-0.196***	-0.045*	-0.078***	-0.136***	-0.319***
	(0.020)	(0.026)	(0.022)	(0.023)	(0.022)
Ln Area$_j$	-0.232***	-0.508***	-0.448***	-0.123***	0.307***
	(0.019)	(0.024)	(0.021)	(0.023)	(0.021)
Ln Population$_i$	0.117***	-0.284***	-0.231***	-0.023	0.312***
	(0.026)	(0.034)	(0.029)	(0.031)	(0.029)
Ln Population$_j$	1.225***	1.425***	1.425***	1.115***	0.547***
	(0.023)	(0.030)	(0.026)	(0.028)	(0.025)
Landlocked	-1.303***	-1.185***	-1.198***	-1.263***	-1.280***
	(0.058)	(0.078)	(0.066)	(0.072)	(0.068)
Share Border	7.552**	7.581**	8.716***	2.729	4.523
	(3.008)	(3.552)	(3.222)	(3.195)	(2.827)
Share Border × Ln Distance	-0.274	-0.539	-0.250	-0.369	-0.115
	(0.474)	(0.566)	(0.509)	(0.504)	(0.448)
Share Border × Ln Area$_i$	0.508**	0.589**	0.596**	0.430*	0.374*
	(0.225)	(0.270)	(0.240)	(0.238)	(0.214)
Share Border × Ln Area$_j$	0.116	-0.188	0.068	-0.079	-0.084
	(0.183)	(0.218)	(0.200)	(0.194)	(0.173)
Share Border × Ln Population$_i$	-0.787***	-0.908***	-0.945***	-0.612***	-0.567***
	(0.216)	(0.260)	(0.230)	(0.228)	(0.203)
Share Border × Ln Population$_j$	0.046	0.451*	0.108	0.403*	0.205
	(0.200)	(0.248)	(0.222)	(0.217)	(0.193)
Share Border × Landlocked	0.710**	0.446	0.692**	0.832**	0.615**
	(0.314)	(0.372)	(0.336)	(0.335)	(0.297)
Constant	-13.798***	-12.517***	-10.885***	-13.108***	-14.807***
	(0.495)	(0.638)	(0.549)	(0.582)	(0.536)
Observations	12418	9991	11130	9584	8642
R^2	0.425	0.343	0.411	0.368	0.339

Each column dependent variable is the logarithmic transformation of the ratio of the corresponding type of imports to GDP. Standard errors are in parentheses, the R^2 reported is the adjusted one and * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.A8: Gravity Equations Results, 2010

	Total	Capital	Consumer	Intermediate	Raw Material
Ln Distance	-1.550***	-1.425***	-1.649***	-1.524***	-1.341***
	(0.039)	(0.049)	(0.044)	(0.046)	(0.042)
Ln $Area_i$	-0.177***	-0.065***	-0.061***	-0.111***	-0.280***
	(0.020)	(0.025)	(0.023)	(0.024)	(0.022)
Ln $Area_j$	-0.214***	-0.501***	-0.463***	-0.112***	0.323***
	(0.019)	(0.024)	(0.022)	(0.023)	(0.022)
Ln $Population_i$	0.158***	-0.217***	-0.248***	0.024	0.336***
	(0.027)	(0.034)	(0.030)	(0.032)	(0.029)
Ln $Population_j$	1.301***	1.497***	1.553***	1.172***	0.571***
	(0.024)	(0.030)	(0.027)	(0.030)	(0.027)
Landlocked	-1.494***	-1.099***	-1.367***	-1.413***	-1.469***
	(0.058)	(0.076)	(0.067)	(0.072)	(0.068)
Share Border	9.932***	9.094**	9.291***	8.176**	6.304**
	(3.139)	(3.716)	(3.428)	(3.388)	(2.996)
Share Border × Ln Distance	-0.447	-0.332	-0.918*	-0.428	-0.340
	(0.498)	(0.593)	(0.544)	(0.539)	(0.476)
Share Border × Ln $Area_i$	0.340	0.414	0.485*	0.311	0.415*
	(0.229)	(0.270)	(0.249)	(0.247)	(0.220)
Share Border × Ln $Area_j$	0.166	-0.033	0.390*	0.177	-0.269
	(0.196)	(0.232)	(0.214)	(0.212)	(0.188)
Share Border × Ln $Population_i$	-0.626***	-0.750***	-0.618***	-0.525**	-0.637***
	(0.220)	(0.259)	(0.239)	(0.238)	(0.212)
Share Border × Ln $Population_j$	-0.108	0.138	-0.151	-0.084	0.357*
	(0.204)	(0.246)	(0.229)	(0.227)	(0.197)
Share Border × Landlocked	0.865***	0.471	0.698**	1.035***	0.872***
	(0.313)	(0.369)	(0.341)	(0.342)	(0.306)
Constant	-15.258***	-13.897***	-11.898***	-14.845***	-15.346***
	(0.510)	(0.642)	(0.573)	(0.607)	(0.558)
Observations	12414	10403	11273	9684	8883
R^2	0.425	0.340	0.411	0.351	0.330

Each column dependent variable is the logarithmic transformation of the ratio of the corresponding type of imports to GDP. Standard errors are in parentheses, the R^2 reported is the adjusted one and * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

1.A.4 First Stages F-Statistics

Table 1.A9: First Stages F-Statistics, Complementarities and Economic Growth, IV Results

	1	2	3	4
Ln Total Good Imports	12.44	13.82		
Ln Capital Good Imports			10.77	17.21
Ln Consumer Good Imports			17.60	17.67
Ln Intermediate Good Imports			7.03	6.23
Ln Raw Material Imports			11.60	10.26
Ln Total Good Imports (ratio of GDP)× Ln Average Years of Total Secondary Schooling		22.24		
Ln Capital Good Imports (ratio of GDP)× Ln Average Years of Total Secondary Schooling				72.62
Ln Consumer Good Imports (ratio of GDP)× Ln Average Years of Total Secondary Schooling				28.13
Ln Intermediate Good Imports (ratio of GDP)× Ln Average Years of Total Secondary Schooling				95.32
Ln Raw Material Imports (ratio of GDP)× Ln Average Years of Total Secondary Schooling				61.53

The table reports the corresponding F-Statistics for each first stage regression

Chapter 2

Complementarities Between Imports and Absorptive Capacity in European Manufacturing*

Technologies embedded in imports have long been suspected of boosting domestic productivity but the evidence gathered so far is rather mixed. In this chapter we investigate the role of complementarities between absorptive capacity and imports in solving this empirical puzzle. More specifically, we test for a variety of complementarities by combining different import categories with different proxies for absorptive capacity. The investigation is based on a panel of 18 manufacturing industries across 16 European countries covering the 2008-2014 period. Our findings suggest that complementarities do exist but are limited to certain types of imports and certain proxies of absorptive capacity. They provide evidence in favor of a positive and statistically significant impact of complementarities between capital imports and education-related absorptive capacity proxies on labor productivity. These findings are robust to altering specifications and controlling for endogeneity.

Keywords: Capital Imports, Intermediate Imports, Absorptive Capacity, Labor Productivity

*This chapter is based on a paper written in collaboration with Prof. Jean-Marie Grether (University of Neuchâtel, Switzerland).

2.1 Introduction

The impact of trade openness on economic growth has been widely studied. Early macro-level research suggested a positive relationship, but methodological limitations were identified (e.g. Rodriguez and Rodrik, 2000), calling for further research. One such avenue of reseach is the technology spillovers approach, which emphasizes learning by importing. Technology embedded in imports may positively impact domestic productivity either directly from the more advanced exporter as originally suggested by Coe and Helpman (1995) or indirectly from a re-exporting country as further proposed by Lumenga-Neso et al. (2005). However, empirical results have been mixed. Some studies show a positive impact (e.g. Smeets and Warzynski, 2013) while others do not (e.g. Conti et al., 2014). The aim of this chapter is to investigate if these mixed results are due to the lack of consideration of complementarities between absorptive capacity and imports.

Absorptive capacity acts as a catalyst, enhancing the utilization of technologies embedded in imports, and potentially leading to a positive impact on productivity through the complementarity between these variables. Estimating this complementarity empirically comes with its challenges. Previous research has investigated the relevance of complementarities at the firm level (e.g. Abreha, 2019). We suspect, however, that absorptive capacity may not be confined to the firm itself, as this same firm could delegate the task of absorbing knowledge to another firm within the same industry or even to another firm of another industry within the manufacturing sector. Besides, firm-level studies do not differentiate between different types of imports, such as intermediate and capital goods. Still, the differentiation between these types of imports may be crucial, as noted by Caselli (2018), to gain a deeper understanding on the complementarity between imports and absorptive capacity and its impact on productivity. Last but not least, even if absorptive capacity clearly relates to the competence level of the workforce, it is unclear which indicator is best suited to capture this ability.

This study aims to contribute in several ways to the current literature on the impact of complementarities between imports and absorptive capacity on productivity. The investigation focuses on testing the significance of these complementarities by differentiating between capital and intermediate imports and by using different proxies for absorptive capacity related to workers' education or occupational types. The goal is to test whether the importance of the complementarity between imports and absorptive capacity depends on the type of imports and on the absorptive capacity proxy considered. Moreover, the analysis is conducted at the industry level for imports and productivity, and at the manufacturing sector level for absorptive capacity proxies.

We believe that this intermediate level of aggregation presents a number of important advantages to address our empirical issues. Plant-level data can offer interesting insights on within-industry heterogeneity but lack generality as they are often confined to a single country. At the other extreme, cross-country studies may present a substantial global coverage, but national-level variables are contaminated by composition effects. Industry-level data offer an interesting compromise between these two extremes. Moreover, by measuring productivity at a more disaggregated level than absorption capacity (i.e. at the (sub-)industry level rather than the level of the overall manufacturing sector), we can address the cases where competences required to master new technologies in a specific industry (e.g. food-processing) have to be found in other industries (e.g. machines). This type of cross-industry dependencies may be quite frequent in practice, making our specification more relevant.

The analysis is performed using a panel including 18 manufacturing industries across 16 European countries during the 2008-2014 time period. The database is obtained by merging three different data sources. Productivity estimates at the industry level needed are obtained from the 8th Vintage CompNet database. Information on different types of imports, specifically capital and intermediate imports at the industry level, are inferred from the World Input-Output tables (WIOT) database. Finally, proxies for absorptive capacity at the manufacturing sector level, related to workers' education and occupational types, are collected from the Eurostat database.

Fixed effects results suggest that the positive and significant impact of complementarities depends on the type of imports and absorptive capacity proxies utilized. Specifically, complementarities related to capital imports turn out significant when using absorptive capacity proxies related to education, but it is intermediate imports, not capital imports that seem to matter when the absorptive capacity proxy is based on occupational types. However, this latter result disappears when controlling for endogeneity on the basis of instrumental variable (IV) regressions. Further robustness tests are conducted with different specifications and proxies. The robustness findings support the IV ones with positive and significant complementarities being found for capital imports and education-related absorptive capacity proxies while no significant complementarities emerge for other combinations.

The following section presents the relevant literature which influenced the research question. Next, the methodology used for the empirical estimation is explained. The chapter's main results are then presented and discussed, followed by the robustness section. We finish with a conclusion summarizing the chapter's results and suggesting possible avenues for further research.

2.2 Literature Review

The adoption of more open trade regimes in the last two decades of the previous century coincided with a flurry of empirical investigations attempting to identify the effect of trade openness on opening countries. The macro-level studies conducted during this period (e.g. Dollar, 1992, Sachs et al., 1995, Edwards, 1998) concluded that trade liberalization had a positive impact on economic growth, supporting an optimistic perspective on open trade regimes during the nineties. However, the paper by Rodriguez and Rodrik (2000) raised doubts about this early optimistic view. It revealed that all the previous studies had methodological limitations which impacted their results, implying that additional research on this topic was still required[1].

[1] See Irwin (2024) for a recent survey of the literature that followed the Rodriguez and Rodrik (2000)'s critics. An average positive impact of trade openness on countries' economic growth emerges form this survey with,

An imports perspective is one of the research approaches available for examining the significance of trade openness on national performance. There are various research avenues to investigate the role of imports, including imports variety (Broda and Weinstein, 2006, Hsieh et al., 2020)[2], imports competition (Berthou et al., 2019, Chen and Steinwender, 2021)[3], and learning by importing. Our chapter adopts a perspective rooted in the technology spillovers nexus, which is related to the learning by importing approach.

The seminal work of Coe and Helpman (1995) introduced the technology spillovers research avenue. They defined the concept of direct technology spillovers and presented evidence supporting a positive impact of imports on countries' total factor productivity. It is true that Keller (1998) raised criticisms on Coe and Helpman (1995)'s results. However, the original findings and the criticisms were later reconciled by Lumenga-Neso et al. (2005) by introducing the concept of indirect technology spillovers. This concept suggests that the benefits of technology spillovers through imports do not depend on the development stages of partner countries. In other words, countries can benefit from technology spillovers even when trading with partners at lower stages of development.

Following Melitz (2003)[4] the international trade literature has increasingly shifted its focus to firm level analyses. As could be expected, various studies investigating the impact of imports on productivity have been conducted at the firm level. However, the results of these studies do not converge, some finding a positive effect (e.g. Smeets and Warzynski, 2013, Halpern et al., 2015), while others report no significant effect (e.g. Vogel and Wagner, 2010, Conti et al., 2014). A potential missing element in these studies is the concept of complementarity between imports

however, heterogeneities across countries.

[2] Broda and Weinstein (2006) provided evidence in favor of imports variety, which has recently been contested by Hsieh et al. (2020).

[3] Two recent papers provided new insights into imports competition. Berthou et al. (2019) used the CompNet database to show that gains from imports competition are enhanced when importing countries have efficient institutions, while Chen and Steinwender (2021) found that imports competition benefits initially unproductive family-owned Spanish firms through an increase in productivity.

[4] The author developed a model analyzing the relationship between trade openness and productivity through a firm's perspective. In this model, the exporting process allows for inter-firm reallocation towards the most productive firms and is therefore considered beneficial.

and absorptive capacity.

The relevance of complementarities between imports and absorptive capacity in explaining firms' performance has been investigated by Augier et al. (2013), Yasar (2013), and Abreha (2019). However, we suspect that absorptive capacity at the sectoral level might be more relevant than absorptive capacity within a firm. Indeed, a firm could outsource the task of absorbing knowledge to another firm within the whole manufacturing sector rather than absorbing it itself.

Furthermore, due to data limitation, the firm-level investigations mentioned above lack distinction between different types of imports. Indeed, in a study analysing the impact of complementarities on Chinese firms' output, Yasar (2013) only included machinery imports in the analysis. On the other hand, Abreha (2019) only included intermediate imports in a study focusing on the productivity of Ethiopian firms. Augier et al. (2013), in an empirical investigation analysing the relevance of complementarities in explaining Spanish firms' productivity, included capital and intermediate imports but could not differentiate between the two.

This lack of distinction between intermediate and capital imports is regrettable given the importance of technology embodied in capital imports revealed by previous studies. Indeed, a the turn of the century Caselli and Wilson (2004) had already shown that the composition of imported capital may explain part the observed cross-country heterogeneity in total factor productivity. More recently, the plant-level analysis of Mexican manufacturing by Caselli (2018) has found that capital good imports are more likely to embody technological improvements than intermediate inputs.

The objective of this chapter is to provide a contribution to the literature that analyses the impact of the complementarity between imports and absorptive capacity on productivity. The empirical investigation is performed at the industry level[5] for imports and productivity related variables

[5] Industry level analysis is also performed by Bournakis et al. (2018), but their focus is on the development of indices of R&D-based international knowledge spillovers rather than on the complementaries between imports and absorptive capacity.

and at the overall manufacturing sector level for absorptive capacity proxies, to account for absorptive capacity not necessarily occurring within the firm or the industry. Moreover, our study aims to test the significance of different complementarities by differentiating between capital and intermediate imports and by using either educational or occupational workers' characteristics as alternative absorptive capacity proxies. This empirical setting allows testing if the significance of complementarities depends on the type of imports and on the type of absorptive capacity proxies considered.

2.3 Methodology

2.3.1 Data

The analysis is constructed by merging data from three different sources: CompNet, WIOT, and Eurostat databases. The CompNet database is used to collect data on productivity, the WIOT database to obtain information on different types of imports and the Eurostat one to gather absorptive capacity proxies. The merging of these databases provides us with a panel of 18 manufacturing industries for 16 European countries covering the 2008-2014 time period. This constitutes our basis to empirically investigate the impact of different complementarities on the productivity of European manufacturing industries[6].

The CompNet institute collects firm-level data from multiple European national statistical centers[7]. Data are made consistent and reaggregated at the industry level before being made available for researchers. The industry-level variables in the database contain various information related to the distribution of firm-level variables within the industry. For instance, in our study, the dependent variable is the mean labor productivity calculated at the industry level.[8]

The World Input Output Tables (WIOT) offers consistent information on inter-industry flows

[6]Tables describing the industries/countries and the variables used are respectively available in Appendix sections 2.A.1 and 2.A.2.

[7]See the User Guide for the 8th Vintage CompNet Dataset.

[8]Other distribution information, such as values for selected percentiles, are also available.

for a large panel of countries[9]. Critically for us, the database provides data on raw material and intermediate imports at the industry level, but capital and consumption imports are originally available only at the country level. To overcome this limitation, we use simple proportionality rules to construct capital and consumption imports at the industry level by exploiting the information contained in the WIOT database. A detailed description of the implemented procedure is available in the Appendix section 2.A.2.

The Eurostat database[10] contains the information on worker's education and occupational types which we use to construct our proxies for absorptive capacity. Our core set of results is based on four simple ratios depending on the persons considered at the numerator (either manufacturing workers with tertiary education or manufacturing workers employed in science and technology activities) and the comparative benchmark at the denominator (either the overall number of people at the national level sharing the same characteristic or the whole manufacturing workforce irrespective of its characteristics).

2.3.2 Econometric Strategy

Our study uses a double ln econometric specification to test the impact of complementarities between imports and absorptive capacity on productivity. The model includes labor productivity as the dependent variable and capital and intermediate imports interacted with absorptive capacity as independent variables. We also include some control variables in addition to time and industry-country effects.

[9] See Dietzenbacher et al. (2013) and Timmer et al. (2015)'s for a deeper explanation on how the WIOT database is constructed.

[10] Database from the Statistical Office of the European Union, Brussels.

Baseline Specification

The econometric specification is the following:

$$\begin{aligned}\ln(PROD)_{i,j,t} = {} & \alpha_1 \ln(ABS)_{i,t} + \alpha_2 \ln(KIMP)_{i,j,t} + \alpha_3 \ln(IIMP)_{i,j,t} \\ & + \alpha_4 \ln(ABS)_{i,t} \times \ln(KIMP)_{i,j,t} + \alpha_5 \ln(ABS)_{i,t} \times \ln(IIMP)_{i,j,t} + \\ & + CV_{i,j,t} + \mu_{i,j} + \gamma_t + \varepsilon_{i,j,t}\end{aligned} \tag{2.1}$$

In Equation (2.1), the subscripts i, j, and t respectively represent the country, industry, and year. The model includes industry-country effects denoted by $\mu_{i,j}$, a time effect represented by γ_t, and the error term denoted by $\varepsilon_{i,j,t}$. The dependent variable is the natural logarithm (ln) of the average of labor productivity, in terms of real value-added, for firms in industry j in country i at time t ($PROD_{i,j,t}$). The variables $KIMP_{i,j,t}$ and $IIMP_{i,j,t}$ respectively represent the capital and intermediate imports of industry j divided by its output in country i at time t. Additional control variables are included in the analysis, represented by $CV_{i,j,t}$, which consist of (ln of) consumption imports over output ($CIMP_{i,j,t}$)[11], raw imports over output ($RIMP_{i,j,t}$), as well as capital intensity i.e. real capital over labor ratio ($KINT_{i,j,t}$).

The interaction terms $\ln(ABS)_{i,t} \times \ln(KIMP)_{i,j,t}$ and $\ln(ABS)_{i,t} \times \ln(IIMP)_{i,j,t}$ are included to investigate the impact of complementarities between the two different types of imports (*KIMP* and *IIMP*) and the absorptive capacity proxy (*ABS*) on productivity (*PROD*). The proxies for *ABS* are derived from indicators of the skill level of the manufacturing workforce. The two skill indicators used are the number of persons with tertiary education (TER) and the number of persons engaged in science and technology activities (TEC). These numbers are converted into shares using two possible denominators: either total national employment of the corresponding skill category (n) or total manufacturing employment over all skill categories (m).

This leads to four absorptive capacity proxies, two of them capturing how the manufacturing sector manages to attract highly skilled employees (TER_n and TEC_n) and the other two captur-

[11] The consumption imports are included to control for competition effects.

ing the share of skilled employees in the composition of the manufacturing workforce (TER_m and TEC_m). As can be appreciated in the Appendix section 2.A.2, over the whole sample, even if the dispersion across countries is quite large, the manufacturing sector captures on average 10% of the corresponding skill shares, while those skill shares account for close to 20% of manufacturing employment. At first glance, each indicator qualifies as a proxy for manufacturing absorptive capacity, and will be used as such in separate regressions. We conduct these investigations to test if the significance of complementarities depends not only on the type of imports but also on the absorptive capacity proxy that is used.

Instrumental Variables

To further control for the robustness of our findings, we need to address endogeneity issues. Indeed, our setting may be affected by a self-selection pattern (Vogel and Wagner, 2010, Caselli, 2018), under which the most productive industries might be the ones more involved in the importing process. Besides, measurement errors may affect productivity estimates, and unobserved variables may confound both imports and productivity. In such cases, the import variables will be correlated with the error term leading to biased fixed effects coefficients. To account for this potential bias, instrumental variables (IV) regressions are performed.

The constructed instruments used in this research are inspired by the procedure followed by Autor et al. (2013), who instrumented *US* imports from China by *European* imports from China. In our case, we instrumented the four types of import ratios for a given country i ($KIMP_i$, $IIMP_i$, $RIMP_i$ and $CIMP_i$) by the average import ratios of groups of "*kindred*" countries considered as most similar to country i.

The degree of similarity is based on the production and import structure. More precisely, for each country and each year, we calculate the cross-industry correlation between this country and all other countries in the sample, for both imports and output. Then we calculate the average of import and output correlations over all years to identify single average correlation coefficients per country pair for each criterion. We rank these average numbers to identify the three kindred countries according to the import and output criteria. For each group of kindred countries (i.e. for each criterion) we calculate our variables by dividing the sum of the imports (for each type of imports) over the sum of the outputs of the corresponding countries. Finally, we calculate the average between the variable based on the production structure and the variable base on the import structure.

This procedure generates instruments for capital, intermediate, consumption and raw imports for each industry in each country for every year during the 2008-2014 time period. The interaction between the instrument for capital and intermediate imports with absorptive capacity are also used as instruments for the original interactions[12].

2.4 Results

2.4.1 Fixed effects

The fixed-effect results derived from the estimation of Equation (2.1) are reported in Table (2.1). Each column presents the findings obtained using one of the four absorptive capacity proxies. All remaining explanatory variables, as well as the dependent one, remain the same across all columns. The structure of this table facilitates a comparative analysis of results using the different absorptive capacity proxies. Although our main focus will be on the coefficients of imports and absorptive capacity, we first provide general comments on all other coefficients.

The estimated coefficients for control variables are quite stable across columns. The coefficient for real capital intensity variable remains positive and statistically significant across all specifications. Coefficients for consumption and raw imports are respectively positive and negative although not always significant depending on the specification.

[12]The IV regressions are performed using the natural logarithm of the instruments.

Considered in isolation, coefficients for all absorptive capacity proxies are always positive, even if only statistically significant for TEC_n and TEC_m. The signs and significance of import ratios coefficients are more contrasted. Reading the table from left to right, the coefficient for capital imports starts positive (significantly so for TER_n) and then switches sign (significantly so for TEC_m). For intermediate imports, the reverse happens: the coefficient starts negative and then becomes positive and strongly significant. This contrasted pattern is replicated identically for the interaction terms, which are aimed to capture the complementarities between imports and absorptive capacity.

The above results cast doubts about the fixed effects specification. It is one thing to admit that different absorptive capacity proxies may uncover different dimensions of the relationship between capital imports and productivity. But it is more difficult to explain why this relationship would turn negative, and significantly so in the last column of Table (2.1). This may be an indication of collinearity between capital imports and intermediate imports. Indeed, foreign-produced machines and equipments may require specific inputs which are also imported. However, it is unclear how this collinearity is linked to absorptive capacity and why it may lead to a sign reversal.

Another potential explanation of this puzzling pattern of fixed effects results is endogeneity. This could arise from self-selection or because imports and labor productivity are affected by confounding factors. In fact, as intermediate imports are closely associated with yearly operations, and probably more so than capital imports, which are linked to longer-term prospects, it could be argued that *IIMP* is probably more prone to endogeneity problems than *KIMP*. This is what is investigated in the next section.

Table 2.1: Complementarities and Labor Productivity, Fixed Effect Results

	Absorption: TER_n	Absorption: TEC_n	Absorption: TER_m	Absorption: TEC_m
Ln (Absorption Capacity)	0.308	0.302*	0.096	0.197*
	(0.197)	(0.171)	(0.127)	(0.114)
Ln (Capital Imports / Output)	0.378**	0.121	−0.070	−0.114*
	(0.155)	(0.135)	(0.068)	(0.061)
Ln (Intermediate Imports / Output)	−0.138	0.126	0.280***	0.353***
	(0.232)	(0.242)	(0.094)	(0.091)
Ln (Capital Imports / Output)×	0.163***	0.055	−0.036	−0.068**
Ln (Absorption Capacity)	(0.062)	(0.058)	(−0.036)	(0.032)
Ln (Intermediate Imports / Output)×	−0.090	0.023	0.119**	0.187***
Ln (Absorption Capacity)	(0.088)	(0.102)	(0.052)	(0.055)
Ln (Consumption Imports / Output)	0.103*	0.084	0.083	0.093*
	(0.056)	(0.056)	(0.056)	(0.054)
Ln (Raw Imports / Output)	−0.017	−0.022*	−0.017	−0.012
	(0.013)	(0.013)	(0.013)	(0.013)
Ln (Real Capital Intensity)	0.191***	0.188***	0.189***	0.189***
	(0.058)	(0.058)	(0.059)	(0.058)
Constant	3.895***	3.775***	3.210***	3.484***
	(0.568)	(0.520)	(0.362)	(0.342)
Country-Industry Effect	*Yes*	*Yes*	*Yes*	*Yes*
Time Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	1947	1947	1947	1947
R^2	0.081	0.083	0.148	0.245

Notes: Absorption capacity is defined either as the share of manufacturing in national employment of the skill category (n) or as the share of the skill category in total manufacturing employment (m). The skill categories are either persons with tertiary education (TER) or persons employed in science and technology (TEC). FE regressions with clustered standard errors in parenthesis. Fixed effects not reported but available upon request. The dependent variable in each regression is the natural logarithm of labor productivity.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

2.4.2 IV Regressions

The results of the IV approach are presented in Table (2.2), for the same set of variables and under a similar presentation as for the fixed effects regressions[13]. The difference lies in the instrumentalization of the import variables as described in section 2.3.2.

Globally speaking, apart from capital intensity, which remains positive and strongly significant, a number of explanatory variables loose significance in IV regressions. This is particularly true of intermediate imports, which become non-significant whatever the specification. The absorptive capacity proxies based on skill shares within the manufacturing sector (TER_m and TEC_m) also lead to non-significant results in the last two columns of Table (2.2). Oppositely, the coefficient of capital imports remains positive and significant in the first two columns, and also when interacted with the share of manufacturing in national employment of people with tertiary education (TER_n).

From the above, we can infer that endogeneity issues affect more seriously intermediate imports than capital imports. As suggested above, this is probably due to the fact that intermediate imports are determined jointly with productivity, and the more specialized the manufacturing workforce (in the sense of higher TER_m and TEC_m values), the more acute the link with unobserved factors. As a consequence, the highly significant coefficients of the last two columns of Table (2.1) must be considered with suspicion. By contrast, the sign and significance of the coefficients for capital imports remain fairly stable when controlling for endogeneity.

We interpret this stability of the interaction term coefficient as evidence of the complementarity between capital imports and the manufacturing share of tertiary educated people (TER_n). This finding is in line with the argument that technology is embodied in capital imports (as stressed by Caselli and Wilson, 2004), which suggests that absorptive capacity may be essential

[13]The first stages F statistics are reported in the corresponding appendix section for all the IV regressions presented in the chapter (including also the regressions in the appendix). The reported F-Statistics provide no evidence in favour of weak instruments. The detailed results for all the first stages remain also available upon request.

to benefit from it. However, as the degree of significance of this variable also decreases with instrumentalization, we must remain cautious in interpretation. This is why a number of robustness exercises are performed in the next section.

Table 2.2: Complementarities and Labor Productivity, IV Results

	Absorption: TER_n	Absorption: TEC_n	Absorption:TER_m	Absorption:TEC_m
Ln (Absorption Capacity)	1.718	1.148*	−0.215	0.238
	(1.174)	(0.653)	(0.769)	(0.444)
Ln (Capital Imports / Output)	2.031*	0.982*	0.737	0.592
	(1.175)	(0.587)	(1.257)	(1.145)
Ln (Intermediate Imports / Output)	−1.791	−0.699	−1.797	−1.226
	(1.583)	(1.225)	(2.903)	(2.325)
Ln (Capital Imports / Output)× Ln (Absorption Capacity)	0.574*	0.215	0.011	−0.005
	(0.305)	(0.141)	(0.202)	(0.214)
Ln (Intermediate Imports / Output)× Ln (Absorption Capacity)	−0.269	0.073	−0.318	−0.098
	(0.441)	(0.384)	(0.855)	(0.787)
Ln (Consumption Imports / Output)	0.578	0.333	0.742	0.316
	(0.680)	(0.555)	(0.848)	(0.611)
Ln (Raw Imports / Output)	0.038	0.050	0.042	0.054
	(0.253)	(0.216)	(0.318)	(0.316)
Ln (Real Capital Intensity)	0.181***	0.180***	0.176***	0.180***
	(0.063)	(0.061)	(0.066)	(0.063)
Constant	9.388**	7.113**	5.531**	5.004**
	(4.740)	(2.872)	(2.547)	(2.154)
Country-Industry Effect	*Yes*	*Yes*	*Yes*	*Yes*
Time Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	1947	1947	1947	1947
R^2	0.027	0.021	0.016	0.0001

Notes: Absorption capacity is defined either as the share of manufacturing in national employment of the skill category (n) or as the share of the skill category in total manufacturing employment (m). The skill categories are either persons with tertiary education (TER) or persons employed in science and technology (TEC). FE regressions with clustered standard errors in parenthesis. Fixed effects not reported but available upon request. The dependent variable in each regression is the natural logarithm of labor productivity.

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

2.5 Robustness Checks

2.5.1 Stepwise Regressions and Grid Search

This section investigates the robustness of the IV results in two different ways. We start by introducing control variables one at a time. The different specifications and their results appear in section 2.A.3 of the Appendix. Four tables are reported, corresponding to the four proxies of absorptive capacity used in this study. The last column of each column reports the same results as those appearing in each column of Table (2.2).

Results broadly confirm previous findings. It is true that for one specification of the TER_n table, the coefficient of the interaction term with intermediate imports becomes negative and significant. But in all other specifications and in all other tables this coefficient remains non significant. In contrast, the interaction term involving capital imports remains positive and significant in all specifications of the TER_n table, and in three out of five specifications of the TEC_n table. None of the interaction terms in the last two tables (for TER_m and TEC_m) turns out to be significant.

Another way to check for the robustness of results is to introduce a cutoff of the absorptive capacity proxy below which complementarity effects are supposed to vanish altogether. Instead of defining an arbitrary cutoff level, we identify it by grid search, selecting the cutoff value which minimizes the sum of square residuals of the IV regression. We apply this technique only to the most significant absorptive capacity proxy identified by this study i.e. the manufacturing share of tertiary educated people (TER_n). More precisely, we convert all values below the cutoff into the minimum of all reported TER_n values. The original sample values of TER_n range from 5.4% to 14.3%. The optimal cutoff value obtained is 12.5%. Results are reported in the Appendix section 2.A.3. As can be appreciated, all interaction terms involving capital imports turn out positive and with an increased significance level.[14]

[14] We thank Marcelo Olarreaga very much for suggesting this alternative specification.

In sum, whether by introducing explanatory variables one by one or by redefining absorptive capacity values below a certain cutoff, all the above-reported robustness exercises strengthen the results obtained from the baseline specification. Positive and statistically significant complementarities do appear when capital imports are associated with the manufacturing share of tertiary educated people (TER_n).

2.5.2 Additional Robustness Tests

A number of alternative specifications and different variable definitions have been tested. We briefly describe them below without reporting detailed results, which are kept available upon request.

Running regressions where absorptive capacity is defined by combining educational attainment with occupational type did not lead to major changes. Defining instruments based on alternative criteria (e.g. averages between variables based on a common border criterion and imports or output criterion) or splitting the sample between euro and non-euro countries neither lead to major changes, essentially leading to a drop in significance without altering the signs. This remains true when output is replaced by value-added when calculating imports ratios.

Overall, our empirical investigation of complementarities between imports and absorptive capacity leads to two major conclusions. First, complementarities do emerge, but they depend on the type of imports, and how absorptive capacity is measured. Second, taking the best out of the available sample, the most robust and positive link is obtained for capital imports and when absorptive capacity is defined as the share of manufacturing in national employment of persons with tertiary education level.

2.6 Conclusion

Do complementarities between imports and absorptive capacity contribute to enhance the productivity of domestic manufacturing industries? The empirical evidence reported in this chapter suggests that this is the case, but only provided the considered imports are capital imports (not intermediate) and the manufacturing sector captures a sufficiently high share of people with tertiary education (rather than alternative measures of absorptive capacity). Based on a panel of 18 manufacturing industries for 16 European countries and covering the 2008-2014 period, our study tests for the significance of complementarities between different types of imports and absorptive capacity proxies. The results confirm the relevance of the approach. After controlling for endogeneity, we find that complementarities between capital imports and education related absorptive capacity proxies are positive and significant while no such evidence is found for intermediate imports. These findings are robust to the utilization of different specifications or altenative measures.

Further research questions on the impact of complementarities on domestic productivity still need to be explored. In this study, we focus on European countries. However, performing this empirical analysis for countries at different stages of development, such as Latin American or African countries, would be of particular interest. Indeed, testing whether the types of complementarities impacting productivity are similar or differ to the ones in Europe in less developed countries could enhance a more global understanding of the phenomenon and sustain better-informed development policies. Moreover, while this study is performed at the industry level, further research could be conducted at the firm level to identify the mechanisms that might be hidden at a more aggregated level. This could lead to findings on additional conditions under which complementarities between different types of imports and absorptive capacity proxies might positively and significantly impact productivity.

The most promising research avenue is probably to combine the two above-mentioned points. Thus, a firm level investigation on the impact of complementarities between different types of imports and absorptive capacity proxies on productivity in a Latin American or an African context would be most welcome in the future.

Chapter 2 Appendix

2.A Appendix

2.A.1 Sample Structure

Countries and Periods

Table 2.A1: Countries (2008-2014)

Belgium	Croatia	Czech Republic	Denmark
Finland	France	Hungary	Italy
Lithuania	Netherlands	Poland	Portugal
Slovenia	Spain	Sweden	Switzerland*

* For Switzerland, the time period is 2009-2014.

Manufacturing Industries

Table 2.A2: Manufacturing Industries

Industry	Industry-Description
C10 & C11 & C12	Manufacture of food products, beveradges and tobacco products
C13 & C14 & C15	Manufacturing of textiles, wearing apparel and leather and related products
C16	Manufacture of wood and of products of wood and cork except furniture
C17	Manufacture of paper and paper product
C18	Printed and reproduction of recorded media
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computerelectronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment
C29	Manufacture of motor vehicles, trailers and semitrailers
C30	Manufacture of other transport equipment
C31 & C32	Manufacture of furniture, other manufacturing

Continued on next page

Table 2.A2 – *Continued from previous page*

Industry	**Industry-Description**
C33	Repair and installation of machinery and equipment

2.A.2 Variables

Description

Table 2.A3: Variables Description

Variable	Description	Source
Core Variables		
Labor Productivity ($PROD$)	Real value added per worker	CompNet Database 8^{th} Vintage
Tertiary Education - national share (TER_n)	Employees with tertiary education in the manufacturing sector over employees with tertiary education at the national level	Eurostat database
Science and Technology - national share (TEC_n)	Employees in science and technology in the manufacturing sector over employees in science and technology at the national level	Eurostat database
Tertiary Education - manufacturing share (TER_m)	Employees with tertiary education in the manufacturing sector over total employees in the manufacturing sector	Eurostat database
Science and Technology - manufacturing share (TEC_m)	Employees in science and technology in the manufacturing sector over total employees in the manufacturing sector	Eurostat database
Capital Imports ($KIMP$)	Imports of capital goods over output	World Input-Output Tables
Intermediate Imports ($IIMP$)	Imports of intermediate goods over output	World Input-Output Tables
Control Variables		
Raw Imports ($RIMP$)	Imports of raw material over output	World Input-Output Tables
Consumption Imports ($CIMP$)	Imports of consumption goods over output	World Input-Output Tables
Real Capital Intensity ($KINT$)	Value of real capital over labor	CompNet Database 8^{th} Vintage

Notes: Imports are summed up across all partners to account for indirect technology spillovers as argued by Lumenga-Neso et al. (2005). In the original WIOT capital and consumption imports are available at the country level only, so we implement a procedure based on simple proportionality rules to infer their value at the industry level.

Summary Statistics

Table 2.A4: Summary Statistics

	count	mean	sd	min	max
Core Variables					
Labor Productivity	1983	3.479	0.722	0.721	5.339
Tertiary Education - national share	1989	0.099	0.021	0.054	0.143
Science and Technology - national share	1989	0.110	0.028	0.056	0.179
Tertiary Education - manufacturing share	1989	0.196	0.086	0.054	0.375
Science and Technology - manufacturing share	1989	0.210	0.079	0.064	0.375
Capital Imports	1989	0.042	0.044	0.003	0.398
Intermediate Imports	1989	0.250	0.115	0.025	0.743
Control Variables					
Consumption Imports	1989	0.067	0.048	0.014	0.363
Raw Imports	1989	0.012	0.023	0.000	0.175
Real Capital Intensity	1951	3.378	0.618	1.282	4.929

Capital and Consumption Imports

In the original WIOT database the capital/consumption imports are only available at the country level. We implement a procedure to impute the imports at the industry level using information available in the original database. In order to illustrate the procedure, let us consider an importer country X and an exporter country Y. In a first step, we construct the following coefficients:

$$\begin{aligned}
\alpha_{j_1,Y_{j_2}} &= \frac{X \text{ imports in industry } j_1 \text{ from Y's industry } j_2}{X \text{ imports in all 56 industries (not only manufacturing) from Y's industry } j_2} \\
\beta_{j_1} &= \frac{\text{Industry } j_1 \text{ value added in X}}{\text{Value added of all 56 industries in X}} \\
\gamma_{j_1,Y_{j_2}} &= \frac{1}{2}\left(\alpha_{j_1,Y_{j_2}} + \beta_{j_1}\right)
\end{aligned} \tag{2.A1}$$

In a second step we impute the capital/consumption imports of X in industry j_1 coming form Y's j_2 industry by multiplying the capital/consumption imports of X coming from Y's j_2 industry times $\gamma_{j_1,Y_{j_2}}$.

2.A.3 Stepwise IV Results

National Shares as Absorption Capacity Proxies

Table 2.A5: Complementarities and Labor Productivity, Stepwise IV Results for Tertiary Education - national share (TER_n)

	1	2	3	4	5
Ln (Tertiary Education - national share)	1.161	1.146	1.084	1.579	1.718
	(0.917)	(0.800)	(0.753)	(1.511)	(1.174)
Ln (Capital Imports / Output)	1.649	1.641*	1.397	1.855	2.031*
	(1.031)	(0.906)	(0.879)	(1.271)	(1.175)
Ln (Intermediate Imports / Output)	-2.063*	-1.862*	-1.577	-2.107*	-1.791
	(1.217)	(1.073)	(1.158)	(1.247)	(1.583)
Ln (Capital Imports / Output)* ×	0.447**	0.461**	0.387**	0.509*	0.574*
Ln (Tertiary Education - national share)	(0.219)	(0.202)	(0.190)	(0.265)	(0.305)
Ln (Intermediate Imports / Output) ×	-0.408	-0.430*	-0.332	-0.255	-0.269
Ln (Tertiary Education - national share)	(0.271)	(0.239)	(0.277)	(0.462)	(0.441)
Ln (Consumption Imports / Output)		0.227			0.578
		(0.594)			(0.680)
Ln (Raw Imports / Output)			-0.070		0.038
			(0.161)		(0.253)
Ln (Real Capital Intensity)				0.187***	0.181***
				(0.070)	(0.063)
Constant	6.534**	7.424**	6.042**	6.482	9.388**
	(3.027)	(3.078)	(2.649)	(4.710)	(4.740)
Country-Industry Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	1983	1983	1983	1947	1947
R^2	0.018	0.030	0.009	0.005	0.027

Notes: FE IV regressions with clustered standard errors in parenthesis. Fixed effects not reported but available upon request. The dependent variable in each regression is the natural logarithm of labor productivity.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.A6: Complementarities and Labor Productivity, Stepwise IV Results for Science and Technology - national share (TEC_n)

	1	2	3	4	5
Ln (Science and Technology - national share)	0.980*	0.989*	0.969**	1.151	1.148*
	(0.505)	(0.542)	(0.466)	(0.741)	(0.653)
Ln (Capital Imports / Output)	0.912	0.920	0.885	0.960	0.982*
	(0.570)	(0.681)	(0.568)	(0.642)	(0.587)
Ln (Intermediate Imports / Output)	-0.643	-0.664	-0.572	-0.859	-0.699
	(0.687)	(0.889)	(0.888)	(0.768)	(1.225)
Ln (Capital Imports / Output) ×	0.214*	0.215	0.209*	0.222*	0.215
Ln (Science and Technology - national share)	(0.122)	(0.133)	(0.121)	(0.130)	(0.141)
Ln (Intermediate Imports / Output) ×	-0.022	-0.022	-0.012	0.047	0.073
Ln (Science and Technology - national share)	(0.205)	(0.206)	(0.244)	(0.336)	(0.384)
Ln (Consumption Imports / Output)		-0.018			0.333
		(0.590)			(0.555)
Ln (Raw Imports / Output)			-0.014		0.050
			(0.167)		(0.216)
Ln (Real Capital Intensity)				0.184***	0.180***
				(0.064)	(0.061)
Constant	6.244***	6.193***	6.153***	5.553**	7.113**
	(1.729)	(1.886)	(1.837)	(2.433)	(2.872)
Country-Industry Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	1983	1983	1983	1947	1947
R^2	0.018	0.016	0.015	0.001	0.021

Notes: FE IV regressions with clustered standard errors in parenthesis. Fixed effects not reported but available upon request. The dependent variable in each regression is the natural logarithm of labor productivity.

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

Manufacturing Shares as Absorption Capacity Proxies

Table 2.A7: Complementarities and Labor Productivity, Stepwise IV Results for Tertiary Education - manufacturing share (TER_m)

	1	2	3	4	5
Ln (Tertiary Education - manufacturing share)	-0.323	0.022	0.140	-0.666	-0.215
	(2.490)	(0.741)	(0.453)	(2.935)	(0.769)
Ln (Capital Imports / Output)	1.113	0.693	0.701	1.078	0.737
	(4.003)	(1.510)	(1.283)	(3.929)	(1.257)
Ln (Intermediate Imports / Output)	-3.380	-1.455	-1.603	-3.953	-1.797
	(12.936)	(3.750)	(2.785)	(13.091)	(2.903)
Ln (Capital Imports / Output) ×	0.081	0.050	0.069	0.026	0.011
Ln (Tertiary Education - manufacturing share)	(0.431)	(0.196)	(0.229)	(0.341)	(0.202)
Ln (Intermediate Imports / Output) ×	-0.714	-0.313	-0.325	-0.775	-0.318
Ln (Tertiary Education - manufacturing share)	(3.292)	(1.109)	(0.882)	(3.258)	(0.855)
Ln (Consumption Imports / Output)		0.381			0.742
		(0.777)			(0.848)
Ln (Raw Imports / Output)			-0.111		0.042
			(0.339)		(0.318)
Ln (Real Capital Intensity)				0.181**	0.176***
				(0.088)	(0.066)
Constant	3.012	5.359**	3.525*	1.282	5.531**
	(4.860)	(2.516)	(1.825)	(5.683)	(2.547)
Country-Industry Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	1983	1983	1983	1947	1947
R^2	0.002	0.008	0.001	0.001	0.016

Notes: FE IV regressions with clustered standard errors in parenthesis. Fixed effects not reported but available upon request. The dependent variable in each regression is the natural logarithm of labor productivity.

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

Table 2.A8: Complementarities and Labor Productivity, Stepwise IV Results for Science and Technology - manufacturing share (TEC_m)

	1	2	3	4	5
Ln (Science and Technology - manufacturing share)	0.444	0.445	0.462*	0.201	0.238
	(0.383)	(0.364)	(0.242)	(0.869)	(0.444)
Ln (Capital Imports / Output)	0.617	0.609	0.559	0.710	0.592
	(1.629)	(1.669)	(1.005)	(2.128)	(1.145)
Ln (Intermediate Imports / Output)	-0.939	-0.912	-0.750	-1.700	-1.226
	(3.640)	(3.609)	(1.759)	(5.189)	(2.325)
Ln (Capital Imports / Output) ×	0.050	0.049	0.047	0.030	-0.005
Ln (Science and Technology - manufacturing share)	(0.226)	(0.239)	(0.178)	(0.252)	(0.214)
Ln (Intermediate Imports / Output) ×	-0.083	-0.077	-0.044	-0.235	-0.098
Ln (Science and Technology - manufacturing share)	(1.047)	(1.060)	(0.628)	(1.502)	(0.787)
Ln (Consumption Imports / Output)		0.007			0.316
		(0.522)			(0.611)
Ln (Raw Imports / Output)			-0.018		0.054
			(0.215)		(0.316)
Ln (Real Capital Intensity)				0.182***	0.180***
				(0.069)	(0.063)
Constant	4.878***	4.907***	4.811***	3.527**	5.004**
	(1.564)	(1.782)	(1.368)	(1.687)	(2.154)
Country-Industry Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	1983	1983	1983	1947	1947
R^2	0.002	0.002	0.003	0.005	0.0001

Notes: FE IV regressions with clustered standard errors in parenthesis. Fixed effects not reported but available upon request. The dependent variable in each regression is the natural logarithm of labor productivity.

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

Absorption Capacity Proxy with a Grid-Search Cutoff

Table 2.A9: Complementarities and Labor Productivity, Stepwise IV Results for Tertiary Education - national share (TER_n), grid-search cutoff

	1	2	3	4	5
Ln (Tertiary Education - national share, Cutoff)	0.298**	0.294**	0.298**	0.332**	0.359**
	(0.121)	(0.123)	(0.121)	(0.150)	(0.146)
Ln (Capital Imports / Output)	0.839***	0.839***	0.837***	0.839**	0.884***
	(0.288)	(0.297)	(0.300)	(0.363)	(0.318)
Ln (Intermediate Imports / Output)	-0.709	-0.769**	-0.703	-0.956**	-0.855*
	(0.447)	(0.329)	(0.434)	(0.477)	(0.466)
Ln (Capital Imports / Output)×	0.143***	0.140***	0.143***	0.130***	0.134***
Ln (Tertiary Education - national share, Cutoff)	(0.042)	(0.046)	(0.044)	(0.045)	(0.048)
Ln (Intermediate Imports / Output)×	-0.120	-0.112	-0.122	-0.056	-0.053
Ln (Tertiary Education - national share, Cutoff)	(0.103)	(0.120)	(0.119)	(0.137)	(0.141)
Ln (Consumption Imports / Output)		-0.107			0.299
		(0.575)			(0.551)
Ln (Raw Imports / Output)			-0.005		0.042
			(0.197)		(0.233)
Ln (real capital intensity)				0.191***	0.188***
				(0.064)	(0.061)
Constant	5.258***	4.832***	5.232***	4.194***	5.662**
	(1.279)	(1.750)	(1.746)	(1.510)	(2.251)
Country-Industry Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	1983	1983	1983	1947	1947
R^2	0.018	0.011	0.017	0.001	0.017

Notes: FE IV regressions with clustered standard errors in parenthesis. Fixed effects not reported but available upon request. The dependent variable in each regression is the natural logarithm of labor productivity. All absorptive capacity values below a critical cutoff level are converted into the minimal reported value. The critical cutoff level is determined by grid-search to minimize the sum of squared residuals.

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

2.A.4 First Stages F-Statistics

First Stages F-Statistics, Complementarities and Labor Productivity, IV Results

Table 2.A10: First Stages F-Statistics, Complementarities and Labor Productivity, IV Results

	Absorption: TER_n	Absorption: TEC_n	Absorption:TER_m	Absorption:TEC_m
Ln (Capital Imports / Output)	56.22	51.23	45.60	51.29
Ln (Intermediate Imports / Output)	37.81	43.63	48.25	42.60
Ln (Capital Imports / Output)× Ln (Absorption Capacity)	113.59	121.92	347.05	449.12
Ln (Intermediate Imports / Output)× Ln (Absorption Capacity)	52.79	101.15	172.65	212.30
Ln (Consumption Imports / Output)	14.21	13.41	16.39	14.77
Ln (Raw Imports / Output)	42.87	50.75	48.12	47.96

Notes: The table reports the corresponding F-Statistics for each first stage regression

First Stages F-Statistics, Stepwise IV Results

Table 2.A11: First Stages F-Statistics, Complementarities and Labor Productivity, Stepwise IV Results for Tertiary Education - national share (TER_n)

	1	2	3	4	5
Ln (Capital Imports / Output)	49.05	48.46	45.84	59.82	56.22
Ln (Intermediate Imports / Output)	51.26	47.58	46.91	43.56	37.81
Ln (Capital Imports / Output) × Ln (Tertiary Education - national share)	82.76	78.67	76.72	126.36	113.59
Ln (Intermediate Imports / Output) × Ln (Tertiary Education - national share)	69.96	65.70	64.39	59.14	52.79
Ln (Consumption Imports / Output)		16.13			14.21
Ln (Raw Imports / Output)			46.72		42.87

Notes: The table reports the corresponding F-Statistics for each first stage regression

Table 2.A12: First Stages F-Statistics, Complementarities and Labor Productivity, Stepwise IV Results for Science and Technology - national share (TEC_n)

	1	2	3	4	5
Ln (Capital Imports / Output)	52.03	50.22	47.98	54.92	51.23
Ln (Intermediate Imports / Output)	57.78	54.04	53.34	49.72	43.63
Ln (Capital Imports / Output) × Ln (Science and Technology - national share)	85.11	82.05	78.77	132.02	121.92
Ln (Intermediate Imports / Output) × Ln (Science and Technology - national share)	128.32	118.61	118.26	115.27	101.15
Ln (Consumption Imports / Output)		15.25			13.41
Ln (Raw Imports / Output)			56.37		50.75

Notes: The table reports the corresponding F-Statistics for each first stage regression

Table 2.A13: First Stages F-Statistics, Complementarities and Labor Productivity, Stepwise IV Results for Tertiary Education - manufacturing share (TER_m)

	1	2	3	4	5
Ln (Capital Imports / Output)	49.96	52.36	47.38	46.85	45.60
Ln (Intermediate Imports / Output)	60.98	55.77	56.55	56.34	48.25
Ln (Capital Imports / Output) × Ln (Tertiary Education - manufacturing share)	295.82	278.07	276.25	370.46	347.05
Ln (Intermediate Imports / Output) × Ln (Tertiary Education - manufacturing share)	213.27	196.32	197.31	200.60	172.65
Ln (Consumption Imports / Output)		17.05			16.39
Ln (Raw Imports / Output)			55.57		48.12

Notes: The table reports the corresponding F-Statistics for each first stage regression

Table 2.A14: First Stages F-Statistics, Complementarities and Labor Productivity, Stepwise IV Results for Science and Technology - manufacturing share (TEC_m)

	1	2	3	4	5
Ln (Capital Imports / Output)	57.65	58.58	54.00	53.97	51.29
Ln (Intermediate Imports / Output)	55.99	50.97	51.63	50.90	42.60
Ln (Capital Imports / Output) × Ln (Science and Technology - manufacturing share)	390.05	363.66	362.55	479.74	449.12
Ln (Intermediate Imports / Output) × Ln (Science and Technology - manufacturing share)	255.07	232.62	235.60	248.23	212.30
Ln (Consumption Imports / Output)		15.97			14.77
Ln (Raw Imports / Output)			54.86		47.96

Notes: The table reports the corresponding F-Statistics for each first stage regression

First Stages F-Statistics, Absorption Capacity Proxy with a Grid-Search Cutoff

Table 2.A15: First Stages F-Statistics, Complementarities and Labor Productivity, Stepwise IV Results for Tertiary Education - national share (TER_n), grid-search cutoff

	1	2	3	4	5
Ln (Capital Imports / Output)	64.06	61.35	60.05	62.40	57.29
Ln (Intermediate Imports / Output)	49.22	44.72	45.02	41.77	35.45
Ln (Capital Imports / Output)× Ln (Tertiary Education - national share, Cutoff)	446.85	413.95	413.06	419.87	370.75
Ln (Intermediate Imports / Output)× Ln (Tertiary Education - national share, Cutoff)	95.99	88.48	87.84	82.05	70.74
Ln (Consumption Imports / Output)		19.39			17.22
Ln (Raw Imports / Output)			62.68		54.46

Notes: The table reports the corresponding F-Statistics for each first stage regression

Chapter 3

The Impact of Complementarities Between Imports and Absorptive Capacity on Plants Productivity*

We investigate the impact of complementarities between imports and absorptive capacity on the productivity of Mexican manufacturing plants from 1994 to 2003. The analysis differentiates between capital and intermediate imports. We also use various indicators for the absorptive capacity of plants corresponding to different workforce types. The proxies relate to worker skills, basic or high, and occupational types, blue or white collar. We test whether the significance of complementarities depends on specific combinations between different import types and absorptive capacity proxies. The empirical findings highlight the importance of analysing different combinations. Indeed, we observe that only the interactions between capital imports and high-skilled workers and between intermediate imports and basic-skilled workers produce complementarities that positively impact productivity. This suggests that the technology embedded in capital imports necessitates, for effective absorption, a workforce with higher skills compared to intermediate imports.

Keywords: Capital Imports, Intermediate Imports, Absorptive Capacity, Plant, Productivity

*This chapter is based on a paper written in collaboration with Prof. Mauro Caselli (University of Trento, Italy).

3.1 Introduction

International trade activities can be an important additional dimension contributing to firms' productivity. Notably, the complementarity between imports and absorptive capacity is of particular interest. Indeed, to fully benefit from the technology spillovers associated with imports (Lumenga-Neso et al., 2005), firms' need to be capable of absorbing these technologies. Moreover, distinguishing between capital and intermediate imports (Caselli, 2018) is crucial to expand our understanding on how the complementarity dimension affects productivity. Indeed, capital imports, given the technology they incorporate (Caselli and Wilson, 2004), may exhibit different relationships with absorptive capacity proxies than intermediate imports.

This study analyses the impact of complementarities on plants' productivity by empirically investigating combinations between different types of imports and absorptive capacity indicators. We differentiate between capital and intermediate imports and use different proxies for the absorptive capacity of plants. The indicators correspond to different workforce types related to the skills, basic or high, and the occupation types, blue or white collar, of the workers. We analyze the interactions between different import types and absorptive capacity proxies to determine whether the technology embedded in certain types of imports need to be combined with certain types of workers for complementarities to be relevant.

We conduct our analysis using a dataset covering Mexican manufacturing plants from 1994 to 2003. Information on production, trade statuses and workers' occupation types is derived from two Mexican Industrial surveys (EIA and EIM). Absorptive capacity proxies linked to workers' skills are imputed from a household survey (ENEU). These variables are used to construct the productivity proxy employing the Woolridge-Levinsohn-Petrin estimator (Wooldridge, 2009).

The constructed productivity variable is used to test the study's hypothesis. This is performed with regressions, where different types of imports, intermediate and capital, are interacted with different proxies for absorptive capacity. This approach is used to empirically test whether the significance of complementarities varies depending on the specific imports' type and absorptive capacity indicator. Furthermore, this study considers the potential self-selection issue arising when the most productive plants are more likely to engage in international trade activities. We differentiate the learning by importing from the self-selection effect by following a procedure similar to the one used by Vogel and Wagner (2010), Castellani et al. (2010) and Caselli (2018). The specification allows identifying the learning by importing phenomenon by explaining productivity differences on the basis of changes in trade statuses.

The empirical findings indicate that the significance of complementarities depends on the combination of import types with absorptive capacity proxies. Positive and significant complementarities related to the learning by importing phenomenon are only observed when capital imports are combined with high-skilled workers and when intermediate imports are combined with basic-skilled workers. None of the other interactions yield significant results.

The chapter contributes to the literature analysing the impact of complementarities between imports and absorptive capacity on firms' productivity by clearly differentiating capital from intermediate imports. This differentiation was not performed in previous research on the topic (Augier et al., 2013, Abreha, 2019) due to data availability. Moreover, in addition to the commonly used high-skilled workforce proxy for firms' absorptive capacity (Augier et al., 2013, Yasar, 2013, Abreha, 2019), we use alternative indicators related to the skills and occupation types of the workers. The results contribute to the literature by providing evidence that interactions between capital imports and high-skilled workers, as well as between intermediate imports and basic-skilled workers, generate complementarities that positively affect productivity. It suggests that the technology embedded in capital imports necessitates, for effective absorption, a higher skilled workforce compared to intermediate imports.

The remainder of the chapter is organized as follows. Initially, the literature that has shaped the research question is introduced. This is followed by an explanation of the data and the procedure followed to construct the productivity variable. Following this, the empirical specifications and results of the analysis are discussed, leading to the conclusion.

3.2 Literature Review

This chapter is rooted in the learning by importing literature, which views imports as a mean of technology diffusion. Coe and Helpman (1995) introduced the concept of direct technology spillovers, occuring through the importing process, showing their positive impact on the receiving countries. Lumenga-Neso et al. (2005) furthered the idea by introducing the concept of indirect technology spillovers, which implies that technology spillovers occur even when trading with less developed countries.

The diffusion of technology through imports may result in a positive impact on firms' productivity due to the learning by importing phenomenon. However, the empirical evidence gathered in the research performed thus far is mixed. Studies by Kasahara and Rodrigue (2008), Paul and Yasar (2009), Smeets and Warzynski (2013), Yu and Li (2014), and Halpern et al. (2015) found positive evidence, while Vogel and Wagner (2010), Van Biesebroeck (2008), and Conti et al. (2014) did not. One suggestive explanation of these mixed results is that to fully benefit from technological transfers firms might need to be able to absorb the technologies embedded in imports.

The importance of absorptive capacity to materialize the potential benefits of technological transfers has been introduced in the seminal work of Borensztein et al. (1998), which analysed the foreign direct investment case[1]. Subsequently, the importance of absorptive capacity was analysed at the firm level for the importing case. Yasar (2013) provided evidence in favor of a positive complementarity between skilled labor and importing machinery on the output of Chinese firms. The impact of complementarities between imports and skilled labor on firms' productivity was analysed by Augier et al. (2013) for Spain and Abreha (2019) for Ethiopia. Augier

[1] Borensztein et al. (1998) found that to fully benefit from foreign direct investments (FDI), another source of technological transfer, countries' absorptive capacity was crucial.

et al. (2013) provided evidence in favor of complementarities between imports and skilled labor on the productivity of Spanish firms. However, due to data availability they could not differentiate between capital and intermediate imports. Abreha (2019), in their study focusing on Ethiopian firms, found some evidence in favor of complementarities between intermediate imports and skilled labor on productivity but, due to data availability, could not include capital imports in their analysis.

To deepen our understanding of the link between imports and firms' productivity, it may be crucial to differentiate between intermediate inputs and capital good imports. Country-level evidence hints at the importance of capital good imports due to the technology they embed (Caselli and Wilson, 2004) and their impact on productivity (Eaton and Kortum, 2001). However, most firm-level studies that focus on the impact of imports on productivity, with a few exceptions (Muendler, 2004, Caselli, 2018), did not differentiate between different types of imports. Caselli (2018) performed an empirical investigation that differentiated between capital and intermediate imports within the context of Mexican manufacturing plants. The results suggested that capital imports played a more significant role than intermediate imports in diffusing technology and positively impacting plants' productivity.

Combining Caselli (2018)'s findings with the Augier et al. (2013) and Abreha (2019)'s papers offers interesting research avenues. Indeed, Caselli (2018)'s results highlight the necessity of differentiating between intermediate and capital imports to achieve a deeper understanding of the interaction between absorptive capacity and imports and its impact on plants' productivity. This differentiation, not performed by Augier et al. (2013) and Abreha (2019), might be crucial as capital imports, which might play a more significant role in diffusing technology than intermediate imports, could have a different relationship with absorptive capacity.

Furthermore, in addition to differentiating between import types, conducting an analysis with different proxies for absorptive capacity might also be crucial. Indeed, in addition to the high-skilled proxy commonly used for absorptive capacity (Augier et al., 2013, Yasar, 2013, Abreha, 2019), differentiating absorptive capacity into different skills and occupation types could offer new insight into the relevance of complementarities between imports and absorptive capacity on firms' productivity. Indeed, specific imports such as capital imports, due to the technology they embody (Caselli and Wilson, 2004, Caselli, 2018), might require a higher skilled workforce than intermediate imports for effective absorption.

This chapter contributes to the existing literature on the influence of complementarities between imports and absorptive capacity on productivity by clearly differentiating capital from intermediate imports and by using different absorptive capacity proxies related to the skills, basic or high, and to the occupation types, blue or white-collar, of the workers. The analysis consists on testing the impact of complementarities between different types of imports with different absorptive capacity proxies on plants' productivity. We conduct the empirical investigation for Mexican manufacturing plants, during the 1994-2003 time period.

3.3 Data

The empirical investigation relies on a database of close to 4000 manufacturing plants. The database relies, as in Caselli (2018), on two surveys, namely the encuesta Industrial Anual (EIA) and the Encuesta industrial Mensual (EIM). These surveys contain plants information on production and trade and represent approximately 85% of the manufacturing output of Mexico. The time period covered in this study is 1994-2003 as information on capital imports is not available after 2003[2].

In this study, international trade information is used to develop binary variables for trade status. Specifically, the export, intermediate imports, and capital imports variables take a value of one if the plants engage in the respective trade activity, and zero otherwise. Plant engagement in the capital imports activity corresponds to the import of machinery and equipment, while engagement in the intermediate imports activity corresponds to the import of materials.

In the database, 36% of the plants do not engage in any of the mentioned international trade activities, while 8% are involved in all of them. To elaborate further, 61% of the plants engage in either capital or materials imports, 53% are involved in materials imports, 31% are involved in capital imports, and 19% of the plants are engaged in export activities. It therefore seems that engagement in the importing process is more frequent than involvement in the exporting one.

The EIA and EIM surveys also include the occupation type of the workers determined by if they are white or blue-collar workers but provide no information on their skills (education levels). We overcome this limitation by imputing the skills of workers using the fourth wave of the Encuesta Nacional de Empleo Urbano (ENEU) household survey for each year. In this survey, the skills can be categorized as basic (primary, lower secondary), and as high (tertiary).

The ENEU dataset provides information on the state and the size of the plant where the workers

[2] See Caselli (2018) and Appendix section 3.A.1 for further information about the surveys.

are employed as well as their occupation (blue or white-collar worker), skills and year of employment[3]. Using this data, we calculate four shares to impute the workers' skills at the plant level. We calculate the average share of white-collar workers with high-skills in all plants of size si in a state e at time t ($shwchs_{si,e,t}$). We obtain this share by dividing the number of white-collar workers with high-skills by the total number of white-collar (WC) workers. Similarly, we calculate the share of blue-collar workers with high-skills ($shbchs_{si,e,t}$), by dividing the number of blue-collar workers with high-skills by the total number of blue-collar (BC) workers. The other two calculated shares are the share of white-collar workers with basic-skills ($shwcbs_{si,e,t}$) and the share of blue-collar workers with basic-skills ($shbcbs_{si,e,t}$).

We subsequently use these shares to impute the number of workers with basic, $BS_{i,si,e,t}$, and high-skills, $HS_{i,si,e,t}$, at the plant level, i, by performing the following calculations:

$$\begin{aligned} HS_{i,si,e,t} &= WC_{i,si,e,t} \times shwchs_{si,e,t} + BC_{i,si,e,t} \times shbchs_{si,e,t} \\ BS_{i,si,e,t} &= WC_{i,si,e,t} \times shwcbs_{si,e,t} + BC_{i,si,e,t} \times shbcbs_{si,e,t} \end{aligned} \tag{3.1}$$

We can then calculate the shares of basic and high-skilled workers, as well as the shares of blue and white-collar workers, by dividing the number of workers with a particular skill or occupation type by the total number of workers in the plant. We therefore have, as proxies for the absorptive capacity of plants, four shares defined as the share of workers with basic-skills, the share of workers with high-skills, the share of blue-collar workers, and the share of white-collar workers[4].

[3]Plants are divided into three size categories. The first corresponds to plants with 0 to 100 workers, the second one to plants with 100 to 250 workers and the third one to plants with more than 250 workers. There are 32 states in Mexico.

[4]Descriptive statistics available in the Appendix section 3.A.1.

3.4 Productivity

The first step for estimating plant productivity consists on modelling a relationship between the output and the inputs of the plant. In line with Caselli (2018), we assume that the output of a plant is characterized by a Cobb-Douglas production function. This production function allows for sectoral variability and is represented by the following equation:

$$Y_{i,t} = A_{i,t} K_{i,t}^{\alpha_1} L_{i,t}^{\alpha_2} M_{i,t}^{\alpha_3} \tag{3.2}$$

Variable $Y_{i,t}$ represents physical output of plant i at time t[5]. The inputs include $K_{i,t}$, $L_{i,t}$, and $M_{i,t}$, representing total quantities of capital, labor, and materials used by the plant i at time t. The variable $A_{i,t}$ represents the productivity, which is unobservable and needs to be estimated. This involves, in the initial phase, estimating the output elasticities (α_1, α_2, α_3). This estimation procedure involves logarithmically transforming Equation (3.2) and subsequently conducting regressions for each sector[6] using the following specification:

$$y_{i,t} = \alpha_1 k_{i,t} + \alpha_2 l_{i,t} + \alpha_3 m_{i,t} + \gamma_t + a_{i,t} + \varepsilon_{i,t} \tag{3.3}$$

The lowercase letters represent the natural logarithms of the variables presented in Equation (3.2). Variable γ_t represents time fixed effect, whereas $\varepsilon_{i,t}$ is the error term. The error term, like the productivity variable, is unobservable to researchers. For estimating the specification presented in Equation (3.3), this study, as in Caselli (2018), uses the Wooldridge-Levinsohn-Petrin (WLP) estimator. This estimator, introduced by Wooldridge (2009) following the work of Levinsohn and Petrin (2003), takes into account the endogeneity of the labor and material variables. It suggests utilizing their lagged values as instrumental variables. Additionally, as

[5]Information on how the production variables used to estimate productivity are constructed is available in Appendix section 3.A.1.

[6]The sectors in this chapter are at the 2 digit disaggregation level. This level of disaggregation corresponds to the industries presented in the second chapter. In this chapter, as in Caselli (2018), the industry level of disaggregation corresponds to the 6 digit one in accordance with the 1994 Mexican System of Classification for Activities and Products.

in Petrin and Levinsohn (2012), we include a proxy for productivity directly in the production function estimation. This proxy consists of a second-order polynomial in the lagged material and capital variables.

This study, in line with De Loecker (2013)'s approach, also includes the plant's international trade status. Specifically, as in Caselli (2018), we include all the possible combinations between the lagged dummy variables for exports, intermediate imports and capital imports. Moreover, the lagged absorptive capacity proxy and the respective lagged interactions with the capital and intermediate imports dummies are also included. Subsequently, this study performs regressions using instrumental variables, where the instruments are the initial two lags of labor variables and the secondary lags of capital and materials variables. Once the regressions are performed, the estimates of α_1, α_2, and α_3 for each sector are obtained. These estimates are then used to compute the estimated physical output $\hat{y}_{i,t}$ and the estimated productivity variable $\hat{a}_{i,t}$ using the following method:

$$\begin{aligned} \hat{y}_{i,t} &= \hat{\alpha}_1 k_{i,t} + \hat{\alpha}_2 l_{i,t} + \hat{\alpha}_3 m_{i,t} \\ \hat{a}_{i,t} &= y_{i,t} - \hat{y}_{i,t} \end{aligned} \tag{3.4}$$

The estimated productivity variable can now be used as the dependent one in order to test for the chapter's hypothesis. Additionally, we control for the fact that the utilization of the productivity estimates as a dependent variable may cause, as explained by Ashraf and Galor (2013), biases in the estimation of standard errors. Therefore, as in Caselli (2018), a two-step block bootstrapping procedure with 500 repetitions is implemented. This procedure is used to obtain consistent standard error estimates in the regressions used to test for the chapter's research question.

3.5 Empirical Specifications and Results

The goal of the analysis consists on empirically estimating the significance of complementarities between imports and absorptive capacity on plants' productivity. In order to conduct the analysis we use specifications, where imports interact with absorptive capacity. These interactions are analysed in the context of differentiating capital and intermediate imports, with inclusion of distinct interaction terms with absorptive capacity. This approach allows to test whether the relevance of complementarities in explaining productivity depends on the considered import type.

Two further refinements are introduced to improve the quality of the empirical analysis. On the one hand, we aim to test whether the significance of complementarities for different import types also depends on the absorptive capacity proxy used. On the other hand, we want to distinguish between the effects of learning by importing and self-selection within the context of complementarity analysis. A more detailed explanation of the specifications used and their respective results is presented below.

3.5.1 Imports and Productivity

In order to test the role of complementarities on productivity, we use the productivity variable obtained from the WLP estimation procedure. The dependent variable is explained by all the possible combinations of lagged import types and exports variables. To analyse the relevance of complementarities, this study also separately includes interaction terms between different import types and absorptive capacity. Years and sectors fixed effects are also included. The specification is as follows:

$$\begin{aligned}\hat{a}_{i,t} &= \alpha_1 exp_{i,t-1} + \alpha_2 kimp_{i,t-1} + \alpha_3 iimp_{i,t-1} + \alpha_4 exp_{i,t-1} \times kimp_{i,t-1} \\ &+ \alpha_5 exp_{i,t-1} \times iimp_{i,t-1} + \alpha_6 kimp_{i,t-1} \times iimp_{i,t-1} + \alpha_7 exp_{i,t-1} \times kimp_{i,t-1} \times iimp_{i,t-1} \\ &+ \alpha_8 abs_{i,fy} + \alpha_9 kimp_{i,t-1} \times abs_{i,fy} + \alpha_{10} iimp_{i,t-1} \times abs_{i,fy} + \gamma_t + \iota_s + \varepsilon_{i,t}\end{aligned} \tag{3.5}$$

In Equation (3.5), the variables related to capital and intermediate imports respectively are represented by $kimp_{i,t-1}$ and $iimp_{i,t-1}$ which take a value of 1 if plant i is engaged in the respective trade activity during year $t-1$, and zero otherwise. Similarly, variable $exp_{i,t-1}$ represents the export dummy variable, with a value of one indicating the engagement of plant i in exports at time $t-1$, and zero otherwise. The variables ι_s and γ_t respectively represent the sector and year fixed effect, introduced in the specification. Variable $abs_{i,fy}$ represents the proxy used for absorptive capacity. We only use the value for the first year (fy) to limit endogeneity issues.

The inclusion of interaction terms between capital imports and absorptive capacity, $kimp_{i,t-1} \times abs_{i,fy}$, and between intermediate imports and absorptive capacity, $iimp_{i,t-1} \times abs_{i,fy}$, aims to test if the significance of complementarities depends on the specific type of imports that is analysed. Furthermore, separate regressions of Equation (3.5) are conducted for each one of the four previously mentioned shares proxying for the absorptive capacity of plants. Two of them relate to the skills of the workers, basic or high, and the other two to their occupation types, blue or white collar. These additional regressions are performed to test whether the significance of complementarities with respect to a given imports' type is contingent on the type of workforce available in the plants.

The findings of the initial specification are presented in Table (3.1), with four columns displaying results obtained using each one of the four absorptive capacity proxies. Most of the coefficients turn out to be non significant, apart from those related to exports. More precisely, when considered in isolation, the export dummy is significantly negative at the 90% level whatever the specification. However, when interacted with the intermediate imports dummy, its effect on productivity is significantly positive at the 95% level. Regarding the other variables, in particular the coefficients relevant to the complementarity hypothesis, the focus of this chapter, most of them are consistently negative and non-significant. These results suggest that, regardless of the import type or absorptive capacity considered, complementarities do not appear to play a role in explaining plants' productivity. Nevertheless, these results should be interpreted cautiously, as this initial specification does not clearly identify the learning by importing phenomenon.

Table 3.1: Imports and Productivity

	Absorption: Workers' Skills		Absorption: Workers' Collar	
	Basic	High	Blue	White
Exports $(t-1)$	$-.296^{*}$	$-.283^{*}$	$-.290^{*}$	$-.290^{*}$
	(.153)	(.160)	(.163)	(.163)
Capital Imports $(t-1)$	$-.094$	$-.064$	.210	$-.247$
	(.246)	(.154)	(.316)	(.183)
Intermediate Imports $(t-1)$	$-.298$	$-.335^{**}$	$-.349$	$-.365^{*}$
	(.262)	(.149)	(.342)	(.194)
Exports $(t-1)\times$ Capital Imports $(t-1)$	.049	.034	.013	.013
	(.314)	(.299)	(.313)	(.313)
Exports $(t-1)\times$ Intermediate Imports $(t-1)$	$.329^{**}$	$.334^{**}$	$.344^{**}$	$.344^{**}$
	(.153)	(.159)	(.167)	(.167)
Capital Imports $(t-1)\times$ Intermediate Imports $(t-1)$	$.237^{*}$	$.241^{*}$	.207	.207
	(.135)	(.141)	(.145)	(.145)
Exports $(t-1)\times$Capital Imports $(t-1)\times$ Intermediate Imports $(t-1)$	.152	.167	.175	.175
	(.303)	(.297)	(.299)	(.300)
Absorption (fy)	$-.049$	$-.214$	.542	$-.542$
	(.353)	(.626)	(.371)	(.371)
Absorption (fy)$\times$ Capital Imports $(t-1)$	$-.108$	$-.578$	$-.457$	.457
	(.473)	(.698)	(.392)	(.391)
Absorption (fy)$\times$ Intermediate Imports $(t-1)$	$-.273$	$-.515$	$-.016$	.016
	(.510)	(.885)	(.453)	(.453)
Time Effect	*Yes*	*Yes*	*Yes*	*Yes*
Sector Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	31,100	31,100	31,100	31,100
R^2	0.520	0.526	0.585	0.585

The trade variables take the value of one if the plant engaged in the respective trade activity at time $t-1$. Absorption (fy) in column (1) corresponds to the basic-skilled workforce share for the first year it is available. Absorption (fy) in column (2) corresponds to the high-skilled workforce share for the first year it is available. Absorption (fy) in column (3) corresponds to the blue-collar workforce share for the first year it is available. Absorption (fy) in column (4) corresponds to the white-collar workforce share for the first year it is available. Bootstrapped standard errors clustered at the plant level and stratified at the sector level are in parentheses. The dependent variable is the productivity (WLP) at time t,

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

3.5.2 Learning by Importing Identification

The specification presented in Equation (3.5) does not account for potential self-selection. The issue may arise in case the most productive plants tend to have a higher probability of engaging in international trade activities. In such instances, the findings derived from Equation (3.5) would not clearly differentiate between the phenomena of self-selection and the learning by importing process.

To control for this issue and isolate the role of learning by importing process we follow a methodology which is in line with previous works, such as Vogel and Wagner (2010), Castellani et al. (2010), and Caselli (2018). This procedure consists of exploiting *changes* in trade status to explain changes in productivity. The specification is as follows[7]:

$$\begin{aligned}\Delta_3 \hat{a}_{i,t} = {} & \alpha_1 nexp_{i,t} + \alpha_2 nkimp_{i,t} + \alpha_3 niimp_{i,t} + \alpha_4 nexp_{i,t} \times nkimp_{i,t} \\ & + \alpha_5 nkimp_{i,t} \times niimp_{i,t} + \alpha_6 nexp_{i,t} \times nkimp_{i,t} \times niimp_{i,t} + \alpha_7 abs_{i,fy} \\ & + \alpha_8 nkimp_{i,t} \times abs_{i,fy} + \alpha_9 niimp_{i,t} \times abs_{i,fy} + \mu_j + \delta_e + \gamma_t + \varepsilon_{i,t}\end{aligned} \quad (3.6)$$

The dependent variable corresponds to the difference in productivity from time $t-3$ to t[8]. The variables related to the international trade status of plants take a value of one if the plant engages in trade activities at time t, while not engaging in such activities from time $t-3$ to $t-1$, and zero otherwise. The trade activities variables in Equation (3.6), $nexp_{i,t}$, $nkimp_{i,t}$ and $niimp_{i,t}$, respectively represent a plant *becoming* an exporter, an importer of capital goods and an importer of intermediate inputs at time t[9].

[7]Using an enriched specification which includes the lagged labor variable does not change the results. See Appendix section 3.A.2.

[8]The selected time period for analyzing differences aims to limit the scenario where a firm intermittently engages in trade activities, a situation that could occur if we considered $t-1$. Additionally, this choice ensures the availability of all explanatory variables, unlike the case of $t-5$ where two trade combinations become unavailable.

[9]In order to analyse the self-selection phenomenon the same explanatory variables used in Equation (3.6) can be used to explain the productivity level at time $t-3$. The analysis has been performed and the results do not provide evidence in favor of self-selection. See Appendix section 3.A.2.

The specification in Equation (3.6) also includes the interaction terms between absorptive capacity and imports related variables as well as all possible combinations between trade statuses. Additionally, industry, μ_j, state, δ_e, and time effects, γ_t, are included. Finally, variable $\varepsilon_{i,t}$ represents the error term. The analysis is again conducted separately using each one of the four absorptive capacity proxy.

The findings of the specification presented in Equation (3.6) are reported in Table (3.2). Similarly to Table (3.1), each column in Table (3.2) presents the results obtained using a specific absorptive capacity proxy. The estimated coefficients for individual variables are only positive and significant for becoming an exporter, while other estimated coefficients exhibit negative signs. The various combinations of different trade statuses are consistently negative and lack significance. These results diverge from those of the first specification, where the export-related variable is negative, and the combinations of trade statuses are positive and significant when combining intermediate imports and exports for any chosen proxy.

The crucial distinctions between Table (3.2) and Table (3.1), which are related to the research question under examination, arise from the interactions between absorptive capacity proxies and different types of imports. Specifically, in Table (3.2), the interaction terms involving capital imports and high-skilled workers in column two, as well as basic-skilled workers and intermediate imports in column one, are positive and significant. This contrasts with Table (3.1), where the interaction terms are negative and lack significance. Conversely, no significant interactions are observed for any combination involving absorptive capacity proxies related to workers' occupation. It appears that only the skills of the workers play a significant role in this context.

These results indicate that the significance of complementarities is contingent on the type of imports being considered and the chosen proxy for absorptive capacity. The findings imply that the technology introduced by capital imports requires, for effective absorption, a higher skilled workforce than the one associated with intermediate imports.

Table 3.2: New Imports and Productivity, Learning by Importing

	Absorption: Workers' Skills		Absorption: Workers' Collar	
	Basic	High	Blue	White
New Exports	.223***	.224***	.221***	.221***
	(.080)	(.079)	(.080)	(.080)
New Capital Imports	−.048	−.178**	.014	−.100
	(.098)	(.083)	(.152)	(.106)
New Intermediate Imports	−.274*	−.002	−.084	.026
	(.153)	(.089)	(.182)	(.113)
New Exports × New Capital Imports	−.201	−.253	−.052	−.052
	(.529)	(.540)	(.514)	(.514)
New Exports × New Intermediate Imports	−.340	−.330	−.291	−.291
	(.226)	(.226)	(.226)	(.226)
New Capital Imports × New Intermediate Imports	−.003	.069	.039	.039
	(.163)	(.154)	(.151)	(.151)
New Exports × New Capital Imports × New Intermediate Imports	−.572	−.488	−.796	−.796
	(.549)	(.551)	(.593)	(.593)
Absorption (fy)	−.117	−.253	.097	−.097
	(.094)	(.166)	(.095)	(.095)
Absorption (fy)× New Capital Imports	−.052	.973**	−.114	.114
	(.241)	(.424)	(.229)	(.229)
Absorption (fy)× New Intermediate Imports	.615*	−.221	.110	−.110
	(.317)	(.608)	(.264)	(.264)
Time Effect	*Yes*	*Yes*	*Yes*	*Yes*
Industry Effect	*Yes*	*Yes*	*Yes*	*Yes*
State Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	5,516	5,516	5,516	5,516
R^2	0.069	0.071	0.067	0.067

New Trade variables take the value of one if the plant engaged in the respective trade activity at time t and did not from time $t-3$ to $t-1$. Absorption (fy) in column (1) corresponds to the basic-skilled workforce share for the first year it is available. Absorption (fy) in column (2) corresponds to the high-skilled workforce share for the first year it is available. Absorption (fy) in column (3) corresponds to the blue-collar workforce share for the first year it is available. Absorption (fy) in column (4) corresponds to the white-collar workforce share for the first year it is available. Bootstrapped standard errors clustered at the plant level and stratified at the sector level are in parentheses. The dependent variable is the difference in productivity (WLP) from time $t-3$ to t , * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.5.3 Additional Findings

Additional analyses, using the learning by importing specification, have been conducted. While we refrain from reporting them in details a brief overview is presented here. The comprehensive results remain available upon request.

The additional analyses consists on lagging the new trade statuses variables, including the differences in the lagged polynomial[10] variables as additional control variables and using a Translog production function to estimate productivity instead of a Cobb-Douglas one. The findings of these additional analyses do not result in major changes. Although a decrease in significance is noticed, the signs of the estimated complementarities align with those in Table (3.2). Furthermore, no evidence supporting positive complementarity is found when alternative absorptive capacity proxies, such as the share of medium-skilled workers, are used or when testing for potential non-linearity in absorptive capacity.

Overall, the results of this study provide evidence supporting the impact of complementarities on plants' productivity. The significance of these complementarities depends on specific combinations. Indeed, only interactions between capital imports and high-skilled workers and between intermediate imports and basic-skilled workers generate complementarities that positively impact productivity. No evidence is found for other combinations and more specifically when absorptive capacity proxies are related to the occupation types of the workers.

[10] The polynomial corresponds to the one presented in the productivity section 3.4.

3.6 Conclusion

This chapter investigates the impact of various complementarities between different types of imports and absorptive capacity indicators on the productivity of Mexican manufacturing plants over the 1994-2003 period. The analysis differentiates between capital and intermediate imports and uses absorptive capacity proxies related to skills, basic or high, and occupational types, blue or white-collar, of the workers. Moreover, we aim at differentiating the learning by importing from the self-selection effect.

When the specification aimed at identifying the learning by importing phenomenon is used, the findings suggest that the relevance of complementarities depends on specific combinations. Indeed, only interactions between capital imports and high-skilled workers or between intermediate imports and basic-skilled workers produce compementarities that positively contribute to productivity. This finding suggests that the technology embedded in capital imports requires, for effective absorption, a workforce with higher skills compared to the intermediate imports case.

These results suggest that for a more comprehensive understanding of the role played by complementarities in explaining productivity, different combinations need to be tested. Our empirical findings illustrate the importance of differentiating between different types of imports and using diverse absorptive capacity proxies.

Future research avenues could involve even more detailed analyses, such as distinguishing absorptive capacity proxies based on the type of diploma. This approach could involve disaggregating high-skilled workers with tertiary education into specific educational paths, exploring different complementarities between capital imports and various tertiary education disciplines. Another potential avenue is extending the plant-level analyses to countries at different development stages to assess whether it affects the impact of complementarities on productivity.

Chapter 3 Appendix

3.A Appendix

3.A.1 Variables

Descriptive Statistics

Table 3.A1: Descriptive Statistics

Sector	Output sh	Number plants	Exp sh	Int imp sh	Cap imp sh	BS sh	HS sh	BC sh	WC sh
Food	0.30	826	0.13	0.41	0.20	0.38	0.10	0.66	0.34
Textiles	0.06	661	0.21	0.38	0.21	0.45	0.09	0.78	0.22
Wood	0.01	148	0.10	0.36	0.17	0.51	0.07	0.81	0.19
Paper	0.04	319	0.13	0.54	0.26	0.32	0.16	0.59	0.41
Chemicals	0.18	789	0.30	0.67	0.28	0.31	0.19	0.61	0.39
Non-metal	0.06	281	0.19	0.20	0.19	0.32	0.18	0.71	0.29
Metal	0.08	99	0.38	0.59	0.31	0.33	0.18	0.71	0.29
Machinery	0.27	800	0.33	0.63	0.26	0.29	0.14	0.72	0.28
All	1.00	3923	0.22	0.47	0.23	0.35	0.14	0.69	0.31

Sector codes are based on the International Industrial Classification, Revision 2: Food, Beverages and Tobacco (31); Textile, Wearing Apparel and Leather Industries (32); Wood and Wood Products, Including Furniture (33); Manufacture of Paper and Paper Products, Printing and Publishing (34); Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products (35); Non-Metallic Mineral Products (36); Basic Metal Industries (37); Fabricated Metal Products, Machinery and Equipment and Other Manufacturing Industries (38–39). The columns report the following information for the year 1994: Column 1 reports the share of total output of each sector; Column 2 reports the total number of plants surveyed in each sector; Column 3 reports the share of exporting plants in each sector; Column 4 reports the share of plants importing materials in each sector; Column 5 reports the share of plants importing machinery and equipment in each sector; Column 6 reports the share of basic-skilled workers in each sector;Column 7 reports the share of high-skilled workers in each sector;Column 8 reports the share of blue-collar workers in each sector;Column 9 reports the share of white-collar workers in each sector.

Production Function Variables

In this section we describe the procedure followed to construct the physical output, capital, labor and materials variables needed to estimate the productivity variable.
A quantity of output approach rather than a revenue-based one is applied to construct a measure of physical output. Indeed, a revenue-based variable may include disparities in prices among distinct plants, which may not be related to disparities in productivity and such biases might prevent a precise estimation of the productivity function.

This study, in line with Caselli (2018), uses the TPD (time product dummy) procedure as introduced by Diewert et al. (2009) and Ivancic et al. (2011) to derive an implicit average unit price. The implementation of this procedure involves constructing the expenditure share of a product in a plant at a time t. Specifically, for a specific product of a particular plant at time t we multiply the total sales quantity by the unit value of total sales and then divide the product by the summation of all such multiplications across all products and plants belonging to the same industry. This computation gives the expenditure share of a product in a plant at a time t.

Subsequently, the observations in the industry-level regression, where the price of a product in a plant "i" is explained by product, plant, and year dummies, are weighted using the previously derived expenditure shares. The industry-level regression can be represented as follows:

$$\ln p_{i,g,t} = \sum_{t=1}^{T} \sum_{i=1}^{I} \beta_{it} D_{it} + \sum_{g=1}^{G} \alpha_g D_g + \varepsilon_{i,g,t} \tag{3.A1}$$

The indices i, g, and t respectively represent the plant, the product, and the time. The dependent variable corresponds to the natural logarithm of the product price, while D_g and $D_{i,t}$ respectively represent product and plant-year dummies. After performing the regressions, the exponential of the estimated parameters for the dummies is computed to derive the estimates of the price variations. Subsequently, the price index can be calculated and used to obtain the quantity index. Specifically, the quantity index is obtained by dividing sales over price, thus providing our measure of physical output, which is explicitly linked to quantity rather than price.

The capital variable corresponds to the total real capital stock, obtained using the perpetual inventory method. This method consists on defining the current real stock of capital as the non depreciated part of the last period one plus real investment. We use different depreciation rates depending on the type of capital under consideration. This study, in line with Caselli (2018), uses 5,5% for construction and installation, 10% for machinery and equipment, 20% for transportation equipment and 21% for office equipment and others. Real investment corresponds to investment value divided by the price index provided by INEGI (Instituto Nacional de Estadistica y Geografia). The labor variable corresponds to the total workforce quantity, obtained by dividing the overall wage bill by the aggregate wage. Regarding the materials variable, its computation is based on dividing the total value of intermediates by the cumulative price index for intermediates.

3.A.2 Results with Lagged Labor

Self-Selection

Table 3.A2: New Imports and Productivity, Self-Selection

	Absorption: Workers' Skills		Absorption: Workers' Collar	
	Basic	High	Blue	White
New Exports	−.156	−.164	−.156	−.156
	(.142)	(.142)	(.144)	(.144)
New Capital Imports	.249	.151	−.101	.255
	(.208)	(.122)	(.254)	(.183)
New Intermediate Imports	.091	−.138	−.054	.032
	(.263)	(.156)	(.354)	(.212)
New Exports × New Capital Imports	.212	.187	.092	.092
	(.669)	(.679)	(.688)	(.687)
New Exports × New Intermediate Imports	.179	.110	.118	.118
	(.598)	(.616)	(.603)	(.603)
New Capital Imports × New Intermediate Imports	−.025	−.085	−.052	−.052
	(.316)	(.324)	(.331)	(.331)
New Exports × New Capital Imports × New Intermediate Imports	1.022	.830	.705	.705
	(.946)	(.900)	(.880)	(.880)
Absorption (fy)	.043	−.346	.102	−.102
	(.298)	(.492)	(.332)	(.332)
Absorption (fy)× New Capital Imports	−.305	−.130	.356	−.356
	(.460)	(.758)	(.399)	(.400)
Absorption (fy)× New Intermediate Imports	−.202	1.535	.086	−.086
	(.568)	(1.097)	(.528)	(.529)
Labor $(t-1)$	*Yes*	*Yes*	*Yes*	*Yes*
Time Effect	*Yes*	*Yes*	*Yes*	*Yes*
Industry Effect	*Yes*	*Yes*	*Yes*	*Yes*
State Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	5,516	5,516	5,516	5,516
R^2	0.855	0.852	0.864	0.864

New Trade variables take the value of one if the plant engaged in the respective trade activity at time t and did not from time $t-3$ to $t-1$. Absorption (fy) in column (1) corresponds to the basic-skilled workforce share for the first year it is available. Absorption (fy) in column (2) corresponds to the high-skilled workforce share for the first year it is available. Absorption (fy) in column (3) corresponds to the blue-collar workforce share for the first year it is available. Absorption (fy) in column (4) corresponds to the white-collar workforce share for the first year it is available. Bootstrapped standard errors clustered at the plant level and stratified at the sector level are in parentheses. The dependent variable is the productivity (WLP) at time $t-3$, * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Learning by Importing

Table 3.A3: New Imports and Productivity, Learning by Importing

	Absorption: Workers' Skills		Absorption: Workers' Collar	
	Basic	High	Blue	White
New Exports	.222***	.222***	.220***	.220***
	(.080)	(.079)	(.080)	(.080)
New Capital Imports	−.049	−.182**	.013	−.102
	(.098)	(.081)	(.151)	(.104)
New Intermediate Imports	−.275*	−.004	−.084	.024
	(.152)	(.088)	(.182)	(.112)
New Exports × New Capital Imports	−.202	−.255	−.053	−.053
	(.530)	(.540)	(.516)	(.517)
New Exports × New Intermediate Imports	−.340	−.329	−.290	−.290
	(.225)	(.226)	(.226)	(.226)
New Capital Imports × New Intermediate Imports	−.004	.066	.038	.038
	(.163)	(.154)	(.151)	(.151)
New Exports × New Capital Imports × New Intermediate Imports	−.568	−.477	−.791	−.791
	(.547)	(.546)	(.590)	(.591)
Absorption (fy)	−.113	−.268*	.094	−.094
	(.095)	(.162)	(.097)	(.097)
Absorption (fy)× New Capital Imports	−.053	.976**	−.115	.115
	(.239)	(.422)	(.228)	(.228)
Absorption (fy)× New Intermediate Imports	.614*	−.222	.109	−.109
	(.316)	(.608)	(.264)	(.264)
Labor $(t-1)$	*Yes*	*Yes*	*Yes*	*Yes*
Time Effect	*Yes*	*Yes*	*Yes*	*Yes*
Industry Effect	*Yes*	*Yes*	*Yes*	*Yes*
State Effect	*Yes*	*Yes*	*Yes*	*Yes*
Observations	5,516	5,516	5,516	5,516
R^2	0.069	0.071	0.067	0.067

New Trade variables take the value of one if the plant engaged in the respective trade activity at time t and did not from time $t-3$ to $t-1$. Absorption (fy) in column (1) corresponds to the basic-skilled workforce share for the first year it is available. Absorption (fy) in column (2) corresponds to the high-skilled workforce share for the first year it is available. Absorption (fy) in column (3) corresponds to the blue-collar workforce share for the first year it is available. Absorption (fy) in column (4) corresponds to the white-collar workforce share for the first year it is available. Bootstrapped standard errors clustered at the plant level and stratified at the sector level are in parentheses. The dependent variable is the difference in productivity (WLP) from time $t-3$ to t , * $p<0.1$, ** $p<0.05$, *** $p<0.01$

General Conclusion

1. Assessing the Complementarity Conjecture

Does the complementarity between imports and absorptive capacity significantly impact countries' performance? The findings of this thesis indicate that the effect depends on both the type of imports and the level at which the analysis is conducted. The macro-level cross-country analysis presented in the first chapter does not provide evidence supporting a positive impact of complementarities between different types of imports, capital and intermediate, and absorptive capacity on the economic growth of recipient nations. In fact, when controlling for endogeneity, none of the estimated interactions are positive and statistically significant. The first chapter's findings suggest that the macro aggregation level may not be the most effective one to conduct the analysis. This level hides firms and sectors' heterogeneities between and within countries, thereby obscuring the underlying mechanisms between imports and absorptive capacity affecting countries' performance.

The results from the second and third chapters, performed respectively at the industry and firm levels, indicate that research conducted at lower aggregation levels is better suited to investigate the mechanisms explaining the role of complementarities in affecting countries' performance. These chapters offer evidence supporting a positive and significant complementarity when capital imports are involved. Specifically, the interaction between capital imports and a highly educated workforce produces a complementarity that positively impact both the labor productivity of European manufacturing industries, in the second chapter, and Mexican manufacturing plants' productivity, in the third chapter. These findings suggest that for effectively absorbing the technology embedded in capital imports, a highly skilled workforce is required.

In the Mexican manufacturing plants study conducted in the third chapter, an additional complementarity turns out. The interaction between intermediate imports and basic-skilled workers produces a complementarity positively impacting plants' productivity. Controlling for the skill level of the workforce adds an additional layer of explanation to solve the complementarity puzzle. Indeed, it suggests that, for effective plants' absorption, capital imports require a higher skilled workforce compared to the intermediate imports case.

The results of this thesis provide evidence that in addition to the relevance of complementarities being contingent on the type of imports and the level of aggregation, the significance of complementarities also depends on the variables used to proxy absorptive capacity. In both the second and third chapters, alternative proxies aiming at identifying the occupation types of workers are included. These proxies consist on being employed in science and technology in the second chapter and the workers' collar type, blue or white, in the third chapter. These occupation type-related proxies do not, however, appear to be relevant, as interactions between these variables and different types of import do not generate positive and significant complementarities. Proxies aiming at identifying the skills of the workers, related to their level of education, appear to be, therefore, more suited to proxy for absorptive capacity.

2. Basic Lessons

A first general contribution of the thesis is that its empirical journey establishes in a coherent way and for the first time a checklist of points of vigilance that any study interested in the complementarity productivity link should in principle address in order to produce meaningful and comparable estimates. The first two points, considered in the first chapter, consist on controlling for import composition (differentiating between different types of imports) as well as endogeneity-related issues. The second chapter checks for two additional points by controlling for the heterogeneity of industries and the appropriateness of different absorptive capacity proxies. The last point added in the third chapter controls for the heterogeneity across plants.

A second contribution of the thesis is to show that once all of these vigilance points are appropriately controlled for, positive and significant complementarities emerge, in particular regarding capital imports. In other words, among the many determinants of productivity, complementarities involving capital imports appear to play a key role which is however conditional to a number of conditions which have been clarified by the thesis (e.g. tertiary education-related absorptive capacity proxies).

Finally, by applying a similar methodology to varying aggregation levels, a third contribution of the thesis is to provide an original and consistent framework for comparisons. Three key empirical recommendations emerge from these comparisons. The first recommendation consists on differentiating import types as lumping them all together into a unique variable is likely to diffuse the positive impact of the complementarity involving capital imports and to lead potentially to non-significant results. The second recommendation we make is to use education-related variables to proxy for absorptive capacity and more specifically related to tertiary education when the proxy is combined with capital imports. Last but not least, we recommend to use industry or firm level data as an analysis at the country level may not really be appropriate because of all the heterogeneity sources it may mask.

3. The Way Ahead

Even if the thesis helps to understand better what the hiding factors of the complementarity-productivity link are, it leaves quite open the question of what the hidden relationships exactly consist of. In other words, the thesis' findings provide evidence that complementarities do matter, but a better understanding of the underlying processes is certainly required. It could take several routes.

First, the quantitative results which emerge from the thesis could be combined with the qualitative findings provided by the literature on innovation management in order to better document the learning-by-importing process. For example, in a first stage, firm-level estimates could be exploited to identify the most salient cases of learning-by-importing effects. In a second stage, a correspondence should be established between these salient cases and the existing case studies of the innovation literature. This could shed more light on the actual processes which are followed by firms to absorb import-embodied technical progress.

Second, efforts could be devoted to better understand which types of specific skills are crucial to benefit from capital imports. The tertiary education proxy masks the heterogeneity existing in higher education training. The relevance of this complementarity might in fact depend on the considered education paths and future investigations could analyse interactions between capital imports and different types of diplomas. This analysis could help identifying which types of educated workers need to be combined with capital imports for effective absorption.

Third, future research could expand the complementarity analysis at the firm level to other countries at different development stages. Ideally, a panel of countries could provide a more global perspective while not hiding firms' heterogeneities between and within countries and industries. These additional analyses would allow to verify whether the conditions under which complementarities are relevant vary depending on the development stage of the country under consideration. This thesis having analysed the case of a Latin American country and a group of similar European countries, an investigation on a Sub-Saharian country would be particularly welcome in the future.

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