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Essays on International Trade and Globalization

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Thesis Introduction

This thesis is composed of three essays on international economics with a particular focus on international trade and the effects of the globalization phenomenon.

The first chapter consists in an empirical paper investigating the effects of international trade on the high skilled workers' wages introducing two new heterogeneities: skill ubiquity and sector complexity. Skill ubiquity describes the degree of specialization of the worker. It expresses the number of her potential employment sectors and their complexity. The complexity of a sector indicates how many skills are required in that sector and how much those skills are specialized. Ubiquity and complexity indexes are constructed based on US workers' university majors and their employment sectors. Thanks to the indexes' construction method I am able to identify which are the most ubiquitous skills, i.e. the skills that are the most common and least specialized at the same time, and which are the most complex sectors, i.e. those which require the greatest number of different and highly specialized skills. Next, using the data on US workers' wages and on US imports and exports volumes, I study the effects of international trade on workers' wages. Introducing those new heterogeneity I find the following results. Increases in exports in more complex sectors are associated with an increase of the wages of all workers and in particular of the wages of highly specialized workers. The overall effect of exports in the least complex sector is negative for the least specialized workers. Increases in imports have an opposite effect than increases in exports on workers' wages. Employment in a more complex sectors increases a worker's wage and owning a less specialized majors increases the worker's wage at a decreasing rate with respect to her employment sector complexity.

The second chapter of the thesis consists in a theoretical model explaining the dynamics behind the empirical results found in the first chapter. I build a general equilibrium monopolistic competition model with multiple manufacturing heterogeneous sectors each needing a different number, and type, of specialized workers. Sectors differ in the number and the type of specializations they require for production and workers differ by their skill ubiquity. The sectors needing more, and at the same time more specialized, workers will be more complex than the others, the specializations required by more, and at the same time less complex, sectors will be more ubiquitous. I allow only for partial mobility of workers across sectors according to the sectors' complexity and the workers' specialization. By means of the model I study globalization impact on wages and most importantly, how this effect would change according to the each worker's specialization. The model suggests that when globalization shocks sectors differing in complexity, it induces differential effects for skilled workers. When the least complex sector is the only sector which is open to trade it would lead to a rise of the wage of high specialized workers and a fall of the least specialized ones' in highly specialized workers abundant country and, when the ratio of low specialized-high specialized workers is high enough, the model results suggest that such decrease will affect negatively also the most specialized workers. In contrast, when the most complex sector is open to trade, it has a positive effect on both the most and the least specialized workers. Therefore, the results of the model are in line with the empirical results of the previous chapter.

The focus of the third chapter of the thesis is on firm's production location decision in a globalized world. In this paper we provide theoretical explanation of the recent phenomenon of reshoring, i.e.: moving previously offshored business activities back to origin country. Thanks to access to a unique survey of American reshoring firms, we provide evidence for the importance of quality and access to technology innovation as main drivers of reshoring decision. Based on this evidence we build a dynamic heterogenous firm model in which firms decide where to locate prodution and choose the quality of produced variety. Apart from pioneering theoretical explanation of reshoring, this paper's contribution is the introduction of the quality choice into a dynamic offshoring model. If a firm decides to offshore its production, it will face lower payroll costs yet higher quality production costs, thus, in a dynamic setting, quality plays an additional role into the firm's location decision since possible cost savings from offshoring can be offset by quality-related mark-ups decreases. We find that the most productive firms will choose to produce in the developed domestic country in each period, the second most productive firms will instead offshore in the first period, exploit the rise in profits due to low wages and return in the next period in the domestic country in order to further increase the quality of their product. Finally the model predicts that the least productive firms will remain abroad both the periods. This paper is joint work with Marta Paczos (University of Bologna).

Part I

Globalization and Wages: The role of Sector Complexity and Skill Ubiquity

Introduction

From Ricardo (1817) passing through the Heckscher-Ohlin model (1991) and for all the past decades, the economists tried to understand the effects of trade on workers. A lot has been said and studied but still, our knowledge on the effects of trade on workers and on their wage is far from complete. What we know, is that we don't know enough.

The international trade literature has addressed this issue distinguishing between high skilled and low skilled workers and searching in the data the regularities which would have proven the rightfulness of the theoretical models. Unfortunately the results were mixed, and the international trade literature still has not been able to properly address the question to whether the classical models work and to fully uncover the effects of globalization on workers.

More specifically, there are mixed evidences on the effects of trade in the developing countries, with a tendency to assess that they go in the opposite direction with respect to the standard theory (for a full review of this literature see Goldberg and Pavcnik (2007)), meanwhile, there are just few and mixed evidences that international trade played a role in the developed countries (see Haskel et al. (2012) and Han et al. (2012)).

While the great majority of the literature has always focused on the contrapposition between high skilled and low skilled workers and has tried to find the regularities using those two groups, my aim is to go beyond this division introducing new forms of heterogeneity which I prove to have an important role in this problem.

Hence, what I want to tackle with the first two chapters of my thesis is this tendency of the literature to underestimate the heterogeneity of workers within those two groups and, more specifically, the heterogeneity of the effects of international trade within high skilled workers.

If we look at the labour literature, the wage determinants have been at the center of the attention for long, one of the most interesting finding for the purpose of my analysis, is that the variation of wage appears to be the highest within the high skilled workers group and, in the latest forty years, there has been an increase in residual unexplained wage inequality in this group (Lemieux and Johnson (2006), Juhn et al. (1993)). Furthermore this literature finds that different university degrees imply different wages for the workers (Lemieux (2014)) but it is not proposing a theory to explain those differences.

In addition to that, we know that sectors are connected together in complex ways not only by the simple material inputs used, but also by the different knowledges, hence workers, that are used and we know that within the same sector there is a big unexplained wage inequality among workers (see Helpman et al. (2010a,b) and Hidalgo et al. (2007)).

Hence, just like connecting all the pieces of a puzzle, the first two chapters of the thesis aim to disclose the, until now unknown, elements that affects the effects of international trade on workers. I do so introducing new heterogeneities at the sector's and at the worker's level, which are able to embody all the mentioned information.
Differently from the literature, the number of years of schooling is not the most important attribute that matters when studying the effects of trade on the workers, instead, also which type of knowledge the worker acquires and how she can use it inside the economy matters. Thus, I introduce a new horizontal heterogenity among high skilled workers, each worker possesses a knowledge which is then used by those sectors in the economy which require that particular knowledge. Hence, introducing this heterogeneity among high skilled workers allows to introduce also a new heterogeneity among the sectors in the economy. Sectors using different types of knowledge differ from one another and differ on how they react to international trade.
More in particular, each worker possesses a knowledge which could be more or less specific, this specificity, here onwards specialization, will affect the number of the different sectors in which he is able to work and the types of each of these sectors. This implies that, when facing a shock such as an increase in international trade, those workers will react differently. For example a worker highly specialized will not be able to be hired in a lot of different sectors and at the same time she is difficultly replaceable, hence, the way in which she will face an increase in trade will differ from a worker lowly specialized who is able to be hired anywhere but has to compete with a higher number of workers. Contemporaneusly, firms in each sector require different number and different types of knowledges in order to be able to produce. Some of the sectors require a higher number of different knowledges and, at the same time, more specialized ones, those sectors are therefore more complex and there is no reason why they should react to external shocks as the less complex ones. Hence, the complexity of each sector will matter when studying the effects of international trade. More specifically, when a shock affects a sector in which several types of workers are hired, it will affect the wage of those workers and it will also affect all those sectors sharing some of the types of workers with the shocked sector. Following this reasoning, a positive shock in one complex sector will induce a rise of the wage of the several types of workers hired in that sector, this rise will also negatively affect all those sectors sharing some of the types of workers with the more complex sector. While the former sector will exploit the positive effect of the shock, the latter will not benefit from the shock but it will experience a rise in wage of those "shared" workers in order to prevent them to leave for the higher payed sector. In the end this positive shock will affect differently the workers and the sectors according to respectively how much

specialized and how much complex they are.

Summarizing, the first two chapters of my thesis study the effect of Globalization on the high skilled workers' wages taking into consideration the role of Sector Complexity and Skill Ubiquity respectively through an empirical analysis and a develop of a new theoretical model. I introduce these new sources of heterogenity among sectors and among workers and I study how they impact both the determination of wage and the effects of globalization. The complexity of one good reflects both how many specific knowledges that good requires in order to be produced, and how much specialized those knowledges are, while the ubiquity of the skills of one worker reflects the capability of that worker's knowledge to be used in different sectors taking also into consideration how much complex those sectors are. From the empirical investigation I find that increases in exports in more complex sectors are associated with an increase of the wages of all workers and in particular of the wages of highly specialized workers. The overall effect of exports in the least complex sector is negative for the least specialized workers. Increases in imports have an opposite effect than increases in exports on workers' wages. Employment in a more complex sectors increases a worker's wage and owning a less specialized majors increases the worker's wage at a decreasing rate with respect to her employment sector complexity. The theoretical model in the second chapter suggests that when globalization shocks sectors differing in complexity, it induces differential effects for skilled workers. When the least complex sector is the only sector which is open to trade it would lead to a rise of the wage of high specialized workers and a fall of the least specialized ones' in highly specialized workers abundant country and, when the ratio of low specialized-high specialized workers is high enough, the model results suggest that such decrease will affect negatively also the most specialized workers. In contrast, when the most complex sector is open to trade, it has a positive effect on both the most and the least specialized workers. Therefore, the results of the model are in line with the empirical results of the first chapter.

The first part of the thesis is organized as follow.
The next section describes the literature related to the first two chapters, after that the first chapter will describe the empirical analysis and the second chapter will illustrate the theoretical model

Related Literature

The concept of sector complexity has been firstly introduced by Hidalgo et al. (2007), in their paper they define more complex goods the goods which require a higher number

of “abilities” in order to be produced. In detail, they compute the probability that a country produces a good given that it produces the other goods and from that probability they infer the complexity of that particular good. In order to construct the indexes for sector complexity and for the ubiquity of an ability, they use the exports data for several countries. Using the export information, they are able to identify the goods produced in each country and they construct a network linking all the sectors according to their complexity. Then they use the information about sectors's complexity in order to predict the GDP growth of each country. Differently from that paper and the subsiquent papers such as Hausmann and Hidalgo (2011), my empirical analysis provides a more specific channel through which I can derive a sector complexity, I do not refer to general abilities, instead, I construct the complexity index using the workers' specific skills which I proxy with university majors. Hence, the workers' skill ubiquity is a new concept and by using this novel formulation of complexity, I am analyizing both the wage determinants and globalization impact on the labor market. Moreover, differently from the other papers studying complexity, my focus is on the wage determinants and the effects of globalization on wages and not economic growth.
In particular, in the first chapter of the thesis, I use the American Community Survey (ACS) dataset, for the years 2009-2013, from the United States Census Bureau to obtain measures of skill ubiquity and sector complexity in order to study the effects of those variables on the wages of high skilled workers.

The first two chapters of the thesis are also related with the papers studying the effects of globalization on wage inequality between high skilled and low skilled workers. The literature on this topic is quite vast and not yet conclusive since there is still mixed evidence on this issue. As Haskel et al. (2012) state: “There is only mixed evidence that trade in goods, intermediates, and services has been raising inequality between more- and less-skilled workers”. One possible explaination for those findings is that, when comparing high skilled wages with low skilled ones, we forget that high skilled workers are strongly heterogeneous, hence, we must study more deeply the effect of globalization within the high skilled workers category. For this reason, I focus on the high skilled workers' wages introducing the mentioned new heterogeneities which allow a different approach to the analysis of the effect of international trade on workers' wages.

The empirical analysis is also related with a very recent series of paper which are studying the effect of Globalization on wages taking into consideration the type of task each worker. More specifically Ebenstein et al. (2014) and Baumgarten et al. (2013) focus on the effect of offshoring on workers finding that the type of task each worker performs is relevant for understanding the effect of globalization on her wage. My intention is to analyze the heterogeneous impact of globalization using finer and more detailed indexes of worker skill heterogeneity.

Recently Grossman and Maggi (2000) and Bombardini et al. (2012) have introduced skill dispersion and talent diversity as new determinants of comparative advantage of a country. They prove that the presence of workers with different levels of ability matters in the determination of a country's comparative advantage. Hence, this literature introduces into the trade debate the role of the diversification of abilities and so my study, proposing a novel method to identify the presence of diversified knowledges, attributes a further role to this newly discovered channel.

Furthermore, the first chapter of the thesis is also related to the literature studying the residual wage inequality. More precisely the determinants of wages are still not fully known, even though more and more papers (such as Helpman et al. (2010a,b) Redding et al. (2013)) are trying to study this issue with more attention. Hence, my paper, introducing sector complexity and the ubiquity of the university majors as determinants of wages, delivers a new approach to this issue. The results suggest that those two new heterogeneity are significant in the determination of the wage.

Finally the empirical paper is also related with the literature studying the role of the field of study on wage. More specifically the papers such as Lemieux (2014) and Arcidiacono (2004) find different returns for different university majors. Hence, with this paper, I study the field of graduation linking it with its ubiquity, thus, with the capability of that specific knowledge to be used in several sectors. Hence I observe how this new heterogenity has a role on the effect of globalization on workers' wages and on wages' determinants.

The second chapter of my thesis describes a newly developed theoretical model which is able to explain the empirical results found in the first chapter. The theoretical paper is also related to the recent theoretical papers studying comparative advantages under new perspectives. Costinot et al. (2013) and Costinot and Vogel (2010) focus on the relationships between skilled workers, tasks and comparative advantages. Differently from them I allow for some factors, the specialized workers, not to be substitutes but instead complements to each other. Moreover I consider a monopolistic competition framework allowing only for partial mobility of workers across sectors according to the sectors' complexity and the workers' specialization. I find that some of their results emerge as particular solutions in my setting. My model implies an increase in wage inequality when there is an increase in trade of the least complex good in the country with relatively more workers with the highest specialization. The channel through which I model the complexity of one good is the labor usage in that sector. I introduce a new horizontal heterogeneity among the high skilled workers, i.e. the specialization, and I compute the complexity using the number of *different* types of specializations required for the production.

Finally the second chapter of the thesis could be related to the specific factor model and to the H-O model but differs from them in some crucial elements. In particular my theoretical model differs from those models both by the type of competition considered and also by the definition of the characteristics of the factors. In detail, my model is able to distinguish, and to rank, the different factors used in the economy according to the complexity of the sectors in which they are used. More in detail, the specific factor model considers a perfect competition scenario in which each specific factor is used by one sector only, thus, there is not any difference between these factors in terms of the number of sectors in which they are used. Instead, my model is able to add a further dimension to differentiate the factors used. Introducing the skill specialization and sector complexity I am able to study the issue with a different approach. In the H-O model goods differ in the intensity of the usage of the different production factors, but, assessing that one good requires more of a particular factor than another one does not tell anything about the relationship between those factors, they are in fact “equal” in the sense that their role in the market will only depend on the overall endowments and not on the characteristics of each of them. Instead my model is able to add a new source of heterogeneity making it possible to understand how the different factors differ intrinsicaly from one another. Moreover while the H-O model predicts changes in wages due to changes in prices, my model does not consider this channel also because there is scarce evidence that the changes in the ratio of high skilled goods’ prices-low skilled goods’ prices did actually happen and that they are able to explain the increased inequality between high skilled and low skilled workers. Finally, my model assumes monompolistic competition instead of perfect competition setting. This difference leads to another important difference in the determination of the wages. In fact, in my model, the wages of the high skilled workers are not associated with their marginal productivity in the sectors, but, instead, they are the outcome of the equilibrium between demand and supply of specialized workers. This implies that, workers with different degree of specialization will have a different “bargaining power” since they can move across different number and different types of sectors according to their specialization.

Chapter 1

Globalization and Wages: The role of Sector Complexity and Skill Ubiquity

The Empirical Analysis

1.1 Dataset Description

I use the American Community Survey dataset from 2009 to 2013. The dataset contains information about each individual such as age sex race years of schooling, wage, sector in which she is employed and university major. I use only the observations of workers for which we have information on university major since I am interested in wages of high skilled workers. Sectors are expressed using the NAICS classification, in particular, in order to avoid dealing with differently defined sectors, I use the four digit naics classification for each sector.

Each year the number of observations then amount to about 300'000, with a total of 173 different university majors, 166 different sectors and 1,542,989 observations. The dataset is a repeated cross section. I report the distribution of both sectors and majors in the appendix A1.

I combine this dataset with the information about Exports and Imports from the Census Bureau Database - Foreign Trade Division, in particular I use the data from 2008 to 2013. Finally I combine the cited datasets with the Annual Survey of Manufactures (ASM) and the Economic Census from which I obtain the information about total output of sectors which is proxied by the total value of shipments from 2008 to 2012.

1.2 Complexity-Ubiquity Variables

I use the ACS data in order to compute the complexity indexes for each sector and the ubiquity ones for each university major applying the reflection method developed by Hidalgo et al. (2007).

Given S, the number of sectors, and M, the number of university majors, I define the $(S \times M)$ matrix M_{sm} whose elements are equal to 1 if sector s uses more than one worker[1] with the major m and 0 otherwise. I define the ubiquity index for each major m as $k_{m,0} = \sum_s M_{sm}$ which represents the number of sectors in which the major m is used, notice that in the paper I will both use the term ubiquity and specialzation where the latter is the inverse of the former (more ubiquitous workers are also less specialzied since they can be used in a lot of sectors). At the same time I compute $k_{s,0} = \sum_m M_{sm}$ which is a complexity index for the sector s and it represents how many different types of majors are used in the sector s. Moreover, from those two indexes I compute the iterative indexes $(k_{m,1}, k_{m,2}, k_{m,3}, ...)$ and $(k_{s,1}, k_{s,2}, k_{s,3}, ...)$ according to the following formulation.

$$\begin{aligned} k_{m,N} &= \frac{1}{k_{m,0}} \sum_s M_{sm} k_{s,N-1} \\ k_{s,N} &= \frac{1}{k_{s,0}} \sum_m M_{sm} k_{m,N-1} \end{aligned} \tag{1.1}$$

Therefore each sector s is identified by a vector $\mathbf{k_s} = (k_{s,0}, k_{s,1}, k_{s,2}, k_{s,3}, ...)$ and each major m is described by the vector $\mathbf{k_m} = (k_{m,0}, k_{m,1}, k_{m,2}, k_{m,3}, ...)$. For the sectors' indexes it is easy to show that the even indicators $(k_{s,0}, k_{s,2}, k_{s,4}...)$ identify the complexity of the sector s, while the odd ones $(k_{s,1}, k_{s,3}, k_{s,5}...)$ represent the ubiquity of the majors used in that sector. The opposite is true for the major indexes, in fact, the even indicators show the ubiquity of that major while the odd ones indicate the complexity of the sectors in which that major is used. I compute the $k_{s,i}$ indexes with $i = 0, ..., 20$ for all the 166 NAICS-four digits sectors and the $k_{m,i}$ indexes with $i = 0, ..., 20$ for the 173 majors.

While it is clear to show that $k_{s,1}$ is the average ubiquity of the majors used in sector s, I retain useful to explain why $k_{s,2}$ is the average complexity of the sectors which are similar to sector s.

Since $k_{s,2}$ is computed using the $k_{m,1}$ indexes (from equation (1.1)), it has at the numer-

[1]notice that the results hold also when considering at least one worker, but I retain more accurate to exclude from the matrix the majors which are used only once in a sector, thus I exclude majors which are connected to the sector only by chance.

ator the sum of the $k_{m,1}$ indexes i.e. the sum of the average complexity of the sectors which use major m, but notice that the sum is for all the m which are used in the sector considered. This implies that, for the generic sector s, it will be the sum of the average complexity of only those sectors which uses the majors used in the sector s, in this sense I compute the average complexity of sectors which are similar to s, similar because they share the usage of those majors. The same reasoning works for $k_{m,2}$ index but for the ubiquity instead of complexity.
The iterative nature of the indexes' formation requires a particular focus on the meaning of each of them, in particular, in the table 1.1, I list some of the indexes with their descriptions both for the sectors and for the majors.

Table 1.1

Index	Meaning
$k_{s,0}$	Number of different types of majors the s sector uses (*complexity* of sector s)
$k_{m,0}$	Number of Sectors in which the major m is used (*ubiquity* of major m)
$k_{s,1}$	Average *ubiquity* of the majors used in sector s
$k_{m,1}$	Average *complexity* of the sectors which use major m
$k_{s,2}$	Average *complexity* of the sectors which are similar to sector s
$k_{m,2}$	Average *ubiquity* of majors which are similar to major m

It is fundamental to understand the reasoning behind the usage of the iterated indexes. More specifically, using both the information on ubiquity and complexity when computing the indexes, I am able to classify properly the role of both each worker and each sector in the society. In order to understand this concept, the next paragraph aims to be an explicative example of how the index works and why it is needed in the analysis.

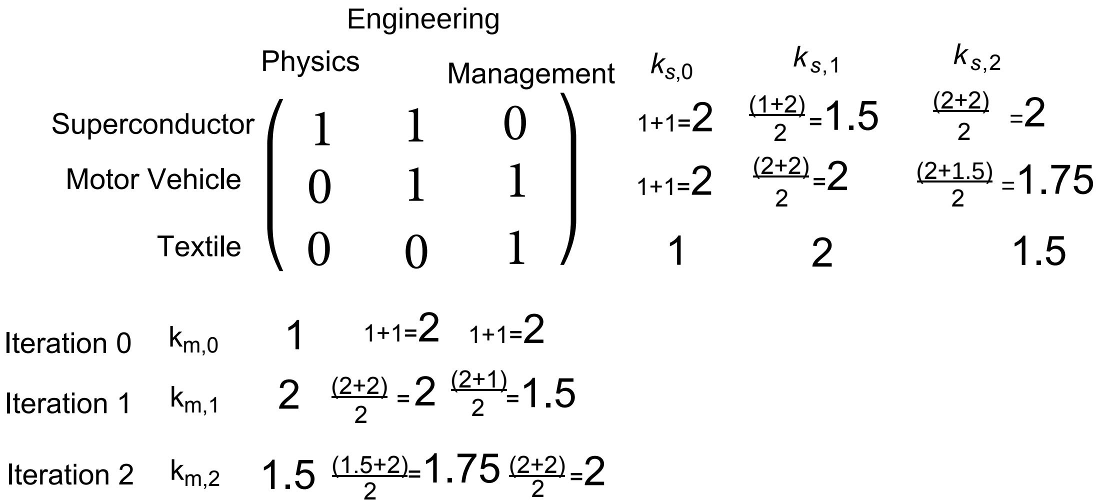
1.2.1 How the indexes work: An explicative example

Consider an economy made by 3 sectors (Superconductor, Motor Vehicle and Textile sector) and 3 university majors (Physics, Engineering and Management) connected together according to the matrix described in figure 1.1. From the Matrix it is possible to identify the connections between sectors and workers, more specifically it tells that workers with a major in Physics are hired in the Superconductor sector, while the Engineers are hired both in the Superconductor and the Motor Vehicle sector and finally the workers with a major in Management are hired both in the Motor Vehicle and in the Textile sector. Since I know in which sector each worker is used, I can classify the workers not only according to the *number* of sectors which need them, but also to the *type* of sectors in which they could be hired. From the point of view of the sector, it is optimal to build an index which is able to distinguish sectors according to the *number* of skills they use and their *types*. It is important, in order to have a complete understanding of the effects of a phenomenon such as the Globalization on the workers, to be able to use as much information as possible, with the aim to distinguish the role of each worker and each sector in the society.

The first step to do is to count, for each sector, the number of majors which are used and, for each major, the number of sectors which use that major. This correspond to the zero iteration of the index used in this paper. More specifically, it is easy to observe, from fig.1.1, that both the Superconductor and the Motor Vehicle sector use 2 different majors, instead, the Textile sector uses only 1 major. Hence the value of $k_{s,0}$ for each of the sector will be, respectively, 2, 2 and 1. I apply the same logic for the majors, hence I count the number of sectors which use each specific major. It follows that the value of $k_{m,0}$ will be 1,2 and 2 respectively for Physics, Engineering and Management.
The indexes constructed in such a way (at the zero iteration) identify the number of skills used in each sector and the numer of sectors in which each worker can be used. It is now important to notice that $k_{s,0}$ is not able to distinguish between Superconductor and Motor Vehicle sectors and contemporaneously, $k_{m,0}$ is not able to distinguish between Engineering and Management, nevertheless we all know that they are different. Hence, I would like to build an index which goes further and is able to distinguish different sectors and different majors using all the information available. For this purpose, I build the $k_{s,1}$ and $k_{m,1}$ indexes which are, respectively, the average $k_{m,0}$ of the majors used in sector s and the average $k_{s,0}$ of the sectors which use major m, i.e. respectively, the average ubiquity at the zero iteration of the majors used in sector s and the average complexity, at the zero iteration, of the sectors using major m . More specifically, $k_{Superconductor,1}$ is the average of $k_{Physics,0}$ and $k_{Engineering,0}$, hence 1.5; instead $k_{MotorVehicle,1}$ is the aver-

age of $k_{Engineering,0}$ and $k_{Management,0}$, hence it is equal to 2; finally $k_{Textile,1}$ is equal to $k_{Management,0}$. The same reasoning is applied to construct the $k_{m,1}$ indexes for the majors. In particular $k_{Management,1}$ is the average of $k_{MotorVehicle,0}$ and $k_{Textile,0}$, $k_{Engineering,1}$ is the average of $k_{Superconductor,0}$ and $k_{MotorVehicle,0}$, while $k_{Physics,1}$ is equal to $k_{Superconductor,0}$.
From this first iteration, it is easy to notice that the index is still not able to distinguish all the sectors and all the majors since Motor Vehicle and Textile have the same value and also Physics and Engineering appears to have the same value. For this purpose, it is necessary to go further and to build the second iteration of this index, i.e. to compute $k_{s,2}$ and $k_{m,2}$ respectively for each sector and each major.
Applying the same algorithm of before, I compute, for each sector s, $k_{s,2}$ as is the average $k_{m,1}$ of the majors used in that sector, and, for each major m, $k_{m,2}$ as the average $k_{s,1}$ of the sectors which use that particular major. More specifically, $k_{Superconductor,2}$ is the average of $k_{Physics,1}$ and $k_{Engineering,1}$, while $k_{MotorVehicle,2}$ is the average of $k_{Engineering,1}$ and $k_{Management,1}$ and finally $k_{Textile,2}$ is equal to $k_{Management,1}$. Again, applying the same logic for the majors, I find that $k_{Physics,2}$ is equal to $k_{Superconductor,1}$, $k_{Engineering,2}$ is equal to the average of $k_{Superconductor,1}$ and $k_{MotorVehicle,1}$, while $k_{Management,2}$ is the average of $k_{MotorVehicle,1}$ and $k_{Textile,1}$.
The (second iterated) indexes built in such a way, are able to classify each sector and each major distinguishing each one of them. More specifically, they are able to understand that Textile is the least complex sector, Motor Vehicle is the second most complex and that the Superconductor sector is the most complex one. In fact, looking at the matrix, it can be noticed that, even though both Superconductor and Motor Vehicle use the same number of workers, the type of those workers is different. Motor Vehicle sector uses Management, while Superconductor uses Physics, the two majors are different because they are differently specialized, hence provide different skills, and are used differently in the economy.
The same reasoning works for the majors. More specifically, $k_{m,2}$ is able to distinguish between Physics, Engineering and Management. Physics appears to be the most specialized major (the least ubiquitous one) while Management is the least specialized one. Again, if I wanted to use the 0 iteration, the index $k_{m,0}$ would have not been able to distinguish between Management and Engineering since they are both used in two sectors, but I know that, being hired in Textile is different than being hired in the Motor Vehicle sector.
Hence, both $k_{s,2}$ and $k_{m,2}$ are the best indexes that I can use to distinguish each sector's and each major's characteristics and role into the economy.

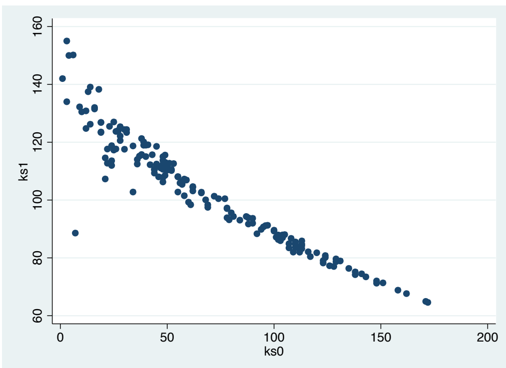
Figure 1.1



1.2.2 Indexes Correlations and Null Models

Now I focus on the relationship between $k_{s,1}$ and $k_{s,0}$ in fig.1.2.

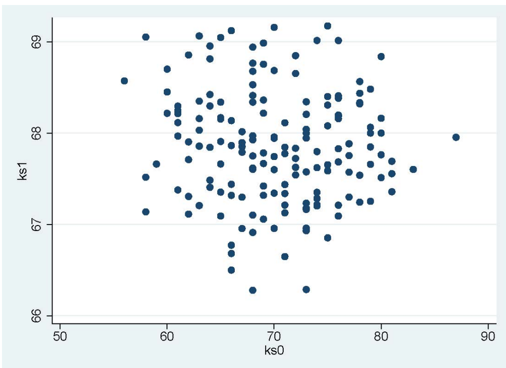
Figure 1.2: 2012 $k_{s,1}$-$k_{s,0}$



From the fig. 1.2 it is possible to observe the negative correlation between the number of different majors used in a sector and the average ubiquity of that majors. The relationship is negative, thus implying that considering two sectors, if one becomes more complex increasing the number of majors it uses, it will not add a high ubiquitous major but it will add a low ubiquitous one. This relationship is not obtained by construction because, even if it is correct to say that, from equation 1.1, $k_{s,1}$ tends to decrease when $k_{s,0}$ increases, an increase in the number of majors used will also increase the numerator in that equation, which of course will increase $k_{s,1}$. Hence the overall effect of an increase in the number of majors in one sector on $k_{s,1}$ will depend on how much ubiquitous are the majors which are added. Finding a negative correlation, I observe that in more complex sectors we will observe more and more specialized workers. Moreover, I prove that this relationship is not driven by how I construct the index in the following paragraph.

Following Hidalgo and Hausmann (2009), I test the relationship in figure 1.2. In order to test wether the relationship between the complexity of a sector and the average ubiquity of the majors used in that sector delivers some information, it must be verified wether this information has been driven only by the way in which I construct the index. More specifically, if random assigments between majors and sector deliver the same results as the ones I found, then, the construction of the index is by construction delivering the results hence the negative relationship of the two will not provide any information.
The first null model I construct consists in a matrix with the same number of sectors and majors and with the same number of ties between them (of 1s). In figure 1.3 I report the relationship between complexity and average ubiquity in the null model 1[2]. It is clear that there is no correlation between the two, thus implying that the negative relationship found in the data delivers some information about the connections between majors and sectors in real life.

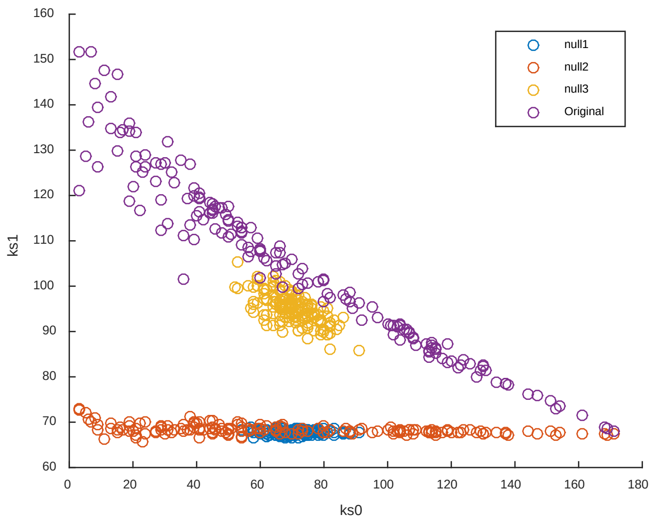
Figure 1.3: $k_{s,1}$-$k_{s,0}$ Null Model 1



[2]for simplicity just in 2013, but the same of course is true for the other years

I go further constructing other null models, more similar to the data but with randomly assigned connections between sectors and majors. I construct a second null model where the number of sectors and majors are as the original, the number of the ties is the same but randomly assigned, and at the same time the degree sequence of the sectors is fixed. The degree sequence is the sequence of the vertex degrees, where the vertices in this second null model are the sectors and the degree is the number of links each sector has with a different major. Moreover I construct the third null model with the same number of nodes and edges as the original but with the same degree sequence for the major nodes[3].
I report the Null models and the Original data in the figure 1.4 . It is clearly shown that the negative relationship observed in the data is not driven by the construction of the indexes and cannot be due to randomness. Hence it is able to deliver more information about the inner relationship between majors and sectors.
I retain useful, in order to understand if the index of complexity is reasonably proxying

Figure 1.4: $k_{s,1}$-$k_{s,0}$



the knowledge complexity of a sector, to observe which are, according to the indexes, the most "knowledge complex" sectors and which are the most specialized workers [4]. In table 1.2 the first in the ranking is the most complex sector and the last is the least complex

[3]From the original Network (Matrix) of Majors and Sectors, I create a random network with the same number of nodes and edges between nodes (Null 1). Then I construct a network where, in addition to that, the distribution of the edges to each sector node is the same (Null 2). Moreover I construct a further random network with the same number of nodes and edges as the original but with the same distribution of the degrees possessed by each major node (Null 3)

[4]for the ranking I use the $k_{s,2}$ and $k_{m,2}$ indexes

sector. In table 1.3 the first in the ranking is the most specialized major (least ubiquitus one) and the last is the least specialized one.

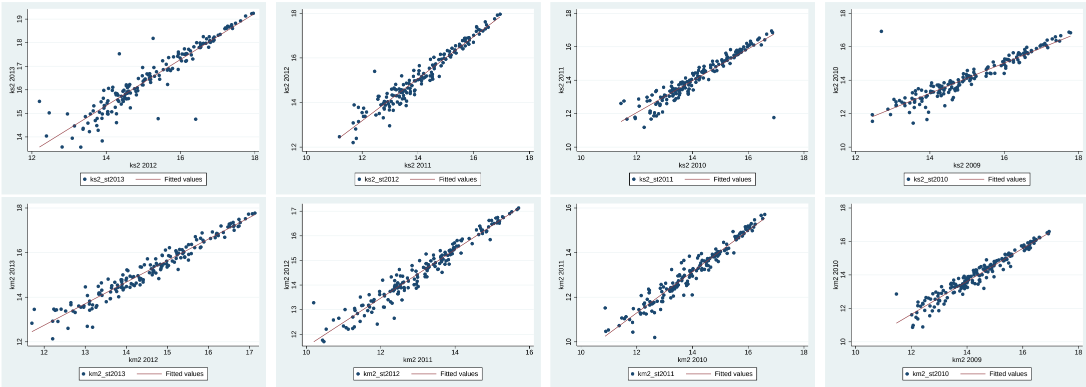
Table 1.2: Complexity ranking

Ranking	NAICS 4digit	Description
1	6113	Colleges, Universities, and Professional Schools
2	6111	Secondary Schools
3	5416	Scientific and Technical Consulting services
4	5415	Computer Systems Design and Related Services
5	5417	Scientific Research and Development Services
⋮	⋮	⋮
162	3271	Clay Product and Refractory Manufacturing
163	3131	Fiber, Yarn, and Thread Mills
164	3151	Apparel Knitting Mills
165	3169	Leather and Allied Product Manufacturing
166	3159	Apparel Accessories and Other Apparel Manufacturing

Table 1.3: Specialization ranking

Ranking	University Major
1	Astronomy and Astrophysics
2	Military Technologies
3	Actuarial Science
4	Genetics
⋮	⋮
170	Marketing and Marketing Research
171	Accounting
172	General Business
173	Business Management and Administration

Figure 1.5: $k_{s,2}$ and $k_{m,2}$ over time



It is interesting to observe wether the indexes are changing over time or are robust. From fig.1.5 it is clear to show that both the complexity index and the ubiquity index are robust over time. This is a good property of the indexes because I would like the indexes to identify some inner characteristics of both the complexity of the sectors and the ubiquity of the majors which, by definition, do not change so much over time.

Moreover I study the relationship between the size of a sector (i.e. the number of workers working in that sector) and its complexity and the relationship between the size of a major (i.e. the number of workers with that major) and its ubiquity. Hence I compute the correlation between the "size" of a sector and the complexity of that sector and between the "size" of a major and its ubiquity. In order to do so I count the number of workers in each sector, for each of this sector I confront this number with the complexity of that sector. Doing so I find that the $Corr(\text{size}, ks2) \in [0.4502, 0.4645]$ [5]. Hence it is possible to asses that since the correlation between the two variables is not too strong, the two measures are not exchangable with each other, thus implying that my index is able to deliver some information which are not obtained using just size.

Furthermore I study the correlation between the number of workers with a specific major and the ubiquity of that majors and I find that the $Corr(\text{size}, km2) \in [0.6635, 0.6801]$ [6]. Again the correlation between those two measures, albeit bigger than before, is till not enough to assess that the index could be substituted by just the size, thus, using my ubiquity index, I am able to grasp more information than just size.

[5] it is 0.4556 in 2009, 0.4502 in 2010, 0.4515 in 2011, 0.4645 in 2012 and 0.4577 in 2013

[6] it is 0.6635 in 2009, 0.6667 in 2010, 0.6732 in 2011, 0.6731 in 2012 and 0.6801 in 2013

1.3 Empirical Analysis

1.3.1 Wages Complexity and Ubiquity

Before focusing on the role of complexity and ubiquity on the effects of Globalization on the high skilled workers' wages, it is useful to study which is the connection between the wage of a worker, the complexity of the sector in which she is hired and the ubiquity of the major she possesses. Hence, in this section, I propose the complexity and the ubiquity as further and relevant determinants of wages.

I combine the cross sections datasets on wages for the years from 2009 to 2013. I adjust the wages each year with the inflation rate with respect to 2013. Thus I obtain a repeated cross section dataset. Since I am combining the indexes of ubiquity and complexity across the years, in order to avoid changes in the index only due to changes in the number of available majors or sectors (even though the number does not actually differs almost at all) I use the standardize version of the indexes[7].

Complexity and ubiquity could matter through several channels on the determination of wages. If we consider the wage determination as the outcome, among others, of wage negotiation between the workers and the firms, higher ubiquity could give to the worker a higher bargaining power since she could decide to work elsewhere if the wage is too low. At the same time, being more specialized, could give to the worker higher negotiation power since she possesses the specific knowledge which is possessed only by few other workers. Hence, ex ante, it is not clear the overall direction of the effect of ubiquity on wages.

The general identification strategy for the wage of worker i, working in sector s having the major m at time t is the one reported in equation (1.2).

$$ln(w_{ismt}) = \beta_0 + \beta\mathbf{X} + \gamma_1 Complex_{s,t} + \gamma_2 Ubiquity_{m,t} + \gamma_3 Complex_{s,t} * Ubiquity_{m,t} + \epsilon_{ismt} \tag{1.2}$$

In table 1.4 I report the regressions results. In particular I control for a series of observable workers characterstics such as age sex race state languages spoken etc[8] moreover I study also the non linear effect of complexity and ubiquity using an interaction term of the two. In addition to the control variables and to the year fixed effects, I repeat

[7]the value of the index divided by its standard deviation

[8]The control variables are: age, sex, state, citizien status, class of worker, ability to speak english, marital status, educational attainment, hours worked per week, week worked during the past year and black dummy

the regression, as robustness checks, using clustered standards error at the naics 4- digits level, I also use sector fixed effects at 4 digits level and major fixed effects.

Table 1.4: Complexity, Ubiquity and wage

VARIABLES	$Wage$	$Wage$	$Wage$	$Wage$
Complexity	0.03308***	0.13574***	0.10566***	0.10566**
	(0.00073)	(0.00665)	(0.00813)	(0.04665)
Ubiquity	0.01183***	0.12130***	0.07788***	0.07788**
	(0.00061)	(0.00707)	(0.00868)	(0.03553)
Complexity*Ubiquity		-0.00645***	-0.00364***	-0.00364**
		(0.00041)	(0.00041)	(0.00179)
Year FE	✓	✓	✓	✓
Sector FE 4d			✓	✓
Major FE			✓	✓
Cluster 4d				✓
Observations	1,542,989	1,542,989	1,542,989	1,542,989
R-squared	0.57986	0.57993	0.61702	0.61702

Standard errors in parentheses

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

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,t,2}$ index for sector s at time t standardized over the period t. Ubiquity represents the $k_{m,t,2}$ index for major m at time t standardized over the period t. Robust standard errors clustered at sector (four digits) level are reported in parentheses in the last column. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

From table 1.4, when allowing for all possible fixed effects and for clustered standard errors, we observe that an increase in one standard deviation of the index $k_{s,2}$ induces an increase of 4.8% of the wage, at the same time, an increase of one standard deviation in $k_{m,2}$ produces a rise of 1.6% of the wages. When considering the interaction of complexity and ubiquity, I find that the increase in wage due to an increase in ubiquity is decreasing with respect to the complexity, i.e. when a worker works in a very complex sector, it is less important to have a high ubiquitous major.

This result would suggest that, the increase of bargaining power due to high ubiquity has a stronger effect than the increase in bargaining power due to high specialization, but, at the same time, when considering highly complex sector, this ubiquity premium is not so strong. One possible explaination for that, is that in more complex sectors the importance of the lower level of specialized workers (the highly ubiquitous ones) is low because their knowledge is not so important when compared with all the knowledges required in that particular sector.

1.3.2 Complexity, Ubiquity and Globalization

In the next section I study if and how, the complexity of the sectors and the ubiquity of the majors have a role in the effect of globalization on domestic workers' wages. More specifically I combine the dataset from the american economic survey with the trade data from the US Census Bureau Database - Foreign Trade Division from which I use the value of Exports from US to the rest of the world and the value of Imports from the rest of the world.

When I introduce data on trade, the only sectors which remain are mainly the manufacturing sectors, hence, it is useful to report the new ranking for the most complex sectors and the most specialized majors when I introduce the trade data. In table 1.5 I report the most complex sectors and the most specialized ones[9]

This section is organized as follow: I will first study the effect of Exports on the wages of the least specialized and most specialized workers considering only the most complex and least complex sectors, then I go from this dichotomous vision, to the analysis of the effects of export intensity on all workers considering their level of ubiquity and the complexity of their sector. After that I will introduce also Imports into the analysis.

[9] In the sectors' table the first sector is the most complex and the last sector is the least complex. In the majors' table the first major is the most specialized and the last is the least specialized. In the tables the k_{s2} and k_{m2} reported are standardized for each year.

Table 1.5: Complex-Ubiquity Ranking

naics4	Sector Description	$ks_{2_{st}}$
3254	Pharmaceutical and Medicine Manufacturing	19.043726
3391	Medical Equipment and Supplies Manufacturing	19.017021
3344	Semiconductor and Other Electronic Component Manufacturing	18.827576
3364	Aerospace Product and Parts Manufacturing	18.816758
3259	Other Chemical Product and Preparation Manufacturing	18.526658
3321	Forging and Stamping	11.830463
3169	Other Leather and Allied Product Manufacturing	11.75657
3131	Fiber, Yarn, and Thread Mills	11.737089
3122	Tobacco Manufacturing	11.681647
3159	Apparel Accessories and Other Apparel Manufacturing	11.643073

Major	Major Description	$km_{2_{st}}$
2411	Geological and Geophysical Engineering	11.055806
3801	Military Technologies	11.314193
5001	Astronomy and Astrophysics	11.35235
6202	Actuarial Science	11.418827
3201	Court Reporting	11.595324
5200	Psychology	18.949993
6206	Marketing and Marketing Research	18.992877
6201	Accounting	19.203665
6200	General Business	19.221224
6203	Business Management and Administration	19.255351

Exports on Most Specialized and Least Specialized workers

This section focuses on the effects of exports on the most specialized and the least specialized workers if the sector in which they work is the most or the least complex one.

It is important to identify, in the regression, which are the most specialized and least specialized workers, in order to do so I take into consideration, for each naics 3 digits sector, the distribution of ubiquity of the workers working in that sector and I compare the ubiquity of each worker with this distribution. Hence I define the most and the least specialized workers. I follow the same method for sector complexity, thus, I compare the $k_{s,2}$ of each sector with the distribution of $k_{s,2}$ in its macrosector in the year considered. Therefore, I am able to identify which are the most complex sectors and the least complex ones.

Following this method, I define the dummy u_{mtq1} which is 1 if the worker's major, m, has an ubiquity measure in the first quartile of the distribution of the ubiquity in that year in the (3 digits) sector in which the worker works. I also define u_{mtq4} equal to one if the ubiquity of the worker's major is in the fourth quartile of the ubiquity distribution in the worker's sector. Therefore if $u_{mtq1} = 1$ we are considering the most specialized workers while if $u_{mtq4} = 1$ the least specialized ones.
Moreover I define the dummy $lc_{st} = 1$ if the sector complexity is below the median of complexity's distribution for the macro sector (3 digits) and 0 otherwise, hence $lc_{st} = 1$ implies least complex sectors and $lc_{st} = 0$ implies most complex ones.
Therefore I study the effect of Exports in the most complex sector and in the least complex sector for the most specialized and the least specialized workers:

$$ln(w_{ismt,e}) = \mathbf{X}\beta + \gamma_1 ln(exp_{st}) + \gamma_2 lc_{st} + \gamma_3 ln(exp_{st}) * lc_{st} + f_s + f_t + \epsilon_{ist} \tag{1.3}$$

Where $\mathbf{X}$ are all the control variables for the observable workers characteristics, $ln(exp_{st})$ is the logarithm of the exports of sector s at time t from US to the rest of the world, f_s is the sector fixed effect at the 3-digits level, and f_t is the time fixed effect.

Table 1.6 shows that an increase of exports in the most complex sectors is associated with an increase in wages, this increase is stronger for the most specialized workers. Moreover the results suggest that when the increase of exports happens in the least

Table 1.6: Effects of Globalization on wages

VARIABLES	$u_{m,q1} = 1$ (Highest Specialization) $Wage$	$u_{m,q4} = 1$ (Lowest Specialization) $Wage$
$Exports$	0.06311**	0.03633**
	(0.02477)	(0.01763)
lc_{st}	1.34179**	0.81748**
	(0.56036)	(0.40300)
$Exports * lc_{st}$	-0.05940**	-0.03662**
	(0.02371)	(0.01717)
Constant	8.42684***	8.74469***
	(0.51134)	(0.37641)
Year FE	✓	✓
Sector FE 3d	✓	✓
Observations	43,319	52,546
R-squared	0.53038	0.45423

Robust standard errors in parentheses

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

$Notes$: The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. The variable Exports represents the natural logarithm of the exports of sector s at time t. The dummy $lc_{st} = 1$ if the s sector (4 digits) is among the least complex sectors in the macro aggregate of sector identified with 3 digits, $lc_{st} = 0$ implies that s is among the most complex ones. The dummy $u_{mtq1} = 1$ if the major of the worker i is among the most specialized majors used in the sector in which the worker is hired, $u_{mtq4} = 1$ if the major is among the least specialized ones. Robust standard errors clustered at sector (four digits) level are reported in parentheses. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

complex sector instead, the effect is different, more specifically it has a negative effect on wages if we compare it with the most complex sector's Export scenario, and it has an overall positive effect[10] for the most specialized workers and it has an overall negative[11] effect for the least specialized ones. In contrast, a high complex globalization induces[12] an increase in wages of both the most specialized worker and the least specialized ones[13].

Summarizing these first results, increases of Exports have a greater positve effect if they happen to be in the most complex sectors, the most specialized workers are the ones who benefit the most from the increase in exports. Exports in the least complex sectors are instead associated with a deterioration of the least specialized workers' conditions and a small increase of the wages of the most specialized workers' wage. All the type of workers are better off if the increase of exports happens in the most complex sector than in the least complex one.

Complexity, Ubiquity and Export Intensity

After having studied the effect of the value of exports on wages, I must make a step forward in the direction of identifying the effect of exports and imports on wages after considering the complex-ubiquity effects. One possible problem I must avoid is to include the effect of the sectors' total output in the coefficient of exports and imports. In particular, instead of observing the effect of exports, I could have just observed the effect of the size of the sectors in which workers work[14]. In order to avoid this issue, I use the data from the Annual Survey of Manufactures (ASM). From this dataset I take the information of the total output of each sector (which has been identified by the literature using the total value of shipments) for the years from 2008 to 2011. I use the economic census (EC)[15] for 2012. More precisely, using the ASM and the EC data, I construct a database having the information on total output (O_{st}) for each sector defined at four digit level from 2008 to 2012. I then combine this dataset with the dataset which has information on workers characteristics, sectors' complexity, majors' ubiquity, exports and imports by sector. Hence I construct the variables of export intensity ($\frac{E_{st}}{O_{st}}$) and import intensity ($\frac{I_{st}}{O_{st}}$) for each sector s at time t.

I study the effect of export intensity in one sector on the wages of workers in that sec-

[10] 0.06311-0.05940=0.00371

[11] 0.03633-0.03662=-0.00029

[12] I cannot prove causality at this stage, I am instead suggesting a strong correlation

[13] respectively of 0.06311 and 0.03633

[14] This problem is partially solved introducing sector fixed effect, but this solution does not take into account changes in total output over time for different sectors, hence it is better to introduce the share of exports (or imports) over the total output.

[15] The economic census substitutes the ASM every 5 years (for the years ending with 2 and 7).

tor, taking into consideration how the effect of exports can influence in different ways workers with different level of specialization and workers working in sector with different complexity. I control for workers characteristics, and for time, sector and majors fixed effects.

$$ln(w_{ismt}) = \mathbf{X}\beta + \gamma_1 k_{s2,t} + \gamma_2 k_{m2,t} + \gamma_3 k_{s2,t} k_{m2,t} + \\ + \gamma_4 ln(\frac{E_{st-1}}{O_{st-1}}) + \gamma_5 ln(\frac{E_{st-1}}{O_{st-1}}) k_{s2,t} + \gamma_6 ln(\frac{E_{st-1}}{O_{st-1}}) k_{m2,t} + f_s + f_m + f_t + \epsilon_{ist} \tag{1.4}$$

Table 1.7 reports the results of regression (1.4).

Notice that the interaction of export both with complexity and ubiquity is significant and it is positive for the former and negative for the latter. Thus implying that, an increase in export in more complex sectors is associated with an increase of wages, this increase is bigger the more the worker is specialized[16].

The average effect of an increase of 1% of exports intensity implies an increase of 0.063% of wage. If we consider the most complex sector (Pharmaceutical and Medicine Manufacturing) and the Least complex one (Apparel Accessories), the average effect of a 1% increase of export intensity in the former induces an increase of 0.11% of wage while the same increase in the latter implies a decrease of 0.0035% of wage.
From the point of view of the workers, being among the most specialized workers (geophysical engineers), the effect of an increase of 1% of exports intensity is an increase of 0.15% of wage, instead being among the least specialized workers (with a degree in business management and adminitration) the same increase in exports implies an Increase of 0.035% of wage. Moreover being the least specialized worker in the least complex sector implies a negative effect of export (-0.033%) while the most specialized workers in the least complex sector have a positve effect from the increase in export (+0.083%). Finally, increases of exports in the most complex sector induce a rise of wage for both the most specialized and the least specialized workers with greater effect for the former (+0.2% for the most specialized against a +0.077% for the least specialized).

[16] Not using an instrumental variable approach we cannot be completely sure of the presence of a causality linkage but, throughout the chapter, I will prove that the correlation is strong, persistence and does not present relevant endogeneity problems.

Table 1.7: ComplexUbiquity Exports Intensity and wage

VARIABLES	$Wage$
Complexity	-0.04699
	(0.04858)
Ubiquity	0.08985***
	(0.03170)
Exports	0.06801
	(0.04507)
Exports*Complexity	0.01475*
	(0.00762)
Exports*Ubiquity	-0.01414***
	(0.00523)
Sector 3d FE	✓
Year FE	✓
Major FE	✓
Observations	171,110
R^2	0.51510

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,t,2}$ index for sector s at time t standardized over the period t. Ubiquity represents the $k_{m,t,2}$ index for major m at time t standardized over the period t. The variable Exports represents the natural logarithm of the exports share of sector s at $t-1$. The export share is computed dividing the export value with the total value of shipment of the sector considered. Robust standard errors clustered at sector (four digits) level are reported in parentheses. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Complexity, Ubiquity, Export and Import Intensity

Now I introduce in the analysis also the import intensity in order to study the broader effect of Complex-Ubiquity on Globalization's effects, both in terms of Exports and Imports. Thus, I estimate the following regression.

$$
\begin{aligned}
ln(w_{ismt}) = \mathbf{X}\beta + &\gamma_1 k_{s2,t} + \gamma_2 k_{m2,t} + \gamma_3 k_{s2,t} k_{m2,t} + \\
&+ \gamma_4 ln(\frac{E_{st-1}}{O_{st-1}}) + \gamma_5 ln(\frac{E_{st-1}}{O_{st-1}}) k_{s2,t} + \gamma_6 ln(\frac{E_{st-1}}{O_{st-1}}) k_{m2,t} + \\
&+ \gamma_6 ln(\frac{I_{st-1}}{O_{st-1}}) + \gamma_8 ln(\frac{I_{st-1}}{O_{st-1}}) k_{s2,t} + \gamma_9 ln(\frac{I_{st-1}}{O_{st-1}}) k_{m2,t} + f_s + f_m + f_t + \epsilon_{ist}
\end{aligned}
\tag{1.5}
$$

The results of the regression (1.5) are reported in the first column of the table 1.8. The second and the third column are instead reporting, as robustness checks, the results when controlling for sectors' trend (using sector time fixed effects) finding that, also in these case, the results hold.

The results in table 1.8 show that, when considering the exports, not only the previous findings are confirmed, but also, when including imports, the results are even bigger and more significant. This is due to the fact that the effect of imports on wages goes in the opposite direction of exports, thus, without controlling for imports I were underestimating the exports' results.

More specifically an increase of 1% of export intensity is associated, on average with an increase of wages of 0.081%, while the same increase of import induces to a decrease of 0.025%.

In the most complex sector, an increase of 1% of export intensity produces an average increase of 0.16% of wage, while an increase of Import of the same amount in the same sector implies a decrease of 0.032% of wage.

If we consider instead the least complex sector, an increase of export induces, on average, to a decrease of wage of 0.044% while a rise in imports implies an increase of wage equal to 0.047%.

From the point of view of the workers, the least specialized workers experience, on average, an increase of wages equal to 0.032% due to export and a decrease of 0.0007% due to imports. Instead the most specialized workers observe a rise of their wage of 0.23% due to an increase in export and a decrease of 0.1% due to imports.

Moreover being the least specialized worker in the least complex sector implies a nega-

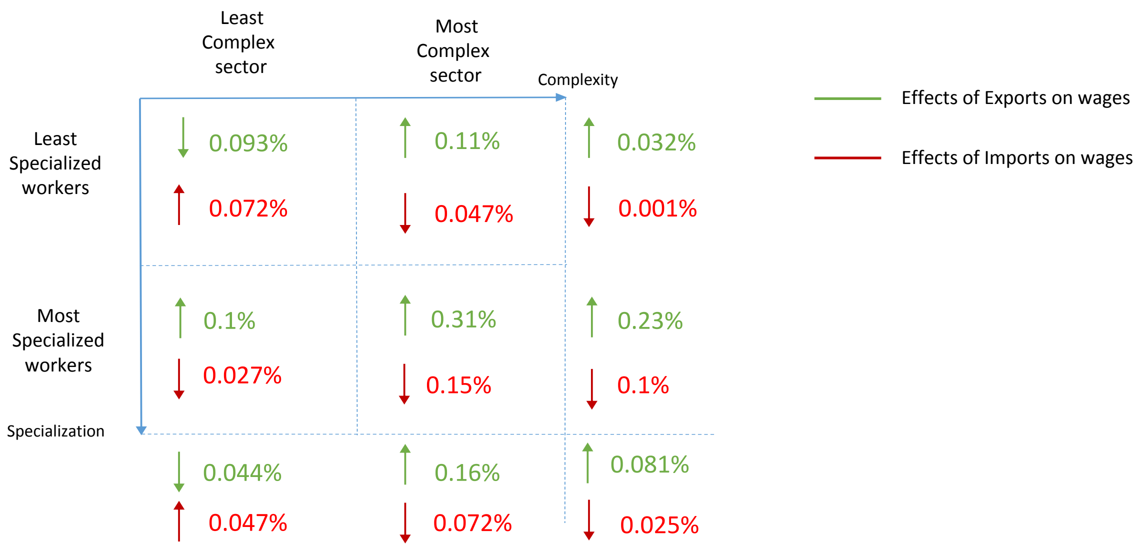
Table 1.8: ComplexUbiquity Export and Import Intensity

VARIABLES	Wage	Wage	Wage	Wage
Complexity	-0.02911	-0.02794	-0.02614	-0.06059***
	(0.04757)	(0.07031)	(0.05262)	(0.01746)
Ubiquity	0.07476**	0.06426**	0.06815**	0.05684***
	(0.03100)	(0.02519)	(0.03007)	(0.01913)
Exports	0.04487	-0.04397	0.02714	0.06832
	(0.07945)	(0.14862)	(0.09555)	(0.04819)
Exports*Complexity	0.02762***	0.02856***	0.02672***	0.01186***
	(0.00628)	(0.00988)	(0.00742)	(0.00318)
Exports*Ubiquity	-0.02387***	-0.01950***	-0.02198***	-0.01505***
	(0.00422)	(0.00397)	(0.00385)	(0.00385)
Imports	0.02761	0.06726	0.02760	-0.01008
	(0.06111)	(0.10869)	(0.06060)	(0.04604)
Imports*Complexity	-0.01613**	-0.01663*	-0.01566**	-0.00632**
	(0.00668)	(0.00910)	(0.00647)	(0.00299)
Imports*Ubiquity	0.01207**	0.01022**	0.01162**	0.00640*
	(0.00454)	(0.00428)	(0.00463)	(0.00351)
Sector 3d FE	✓		✓	
Year FE	✓			✓
Major FE	✓	✓	✓	✓
Year#Sector 3d FE		✓		
Sector 4d FE				✓
Year#Sector 2d FE			✓	
Observations	171,110	171,110	171,110	171,110
R^2	0.51548	0.51601	0.51557	0.52069

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,t,2}$ index for sector s at time t standardized over the period t. Ubiquity represents the $k_{m,t,2}$ index for major m at time t standardized over the period t. The variable Exports represents the natural logarithm of the exports share of sector s at $t-1$. The export share is computed dividing the export value with the total value of shipment of the sector considered. The variable Imports represents the natural logarithm of the imports share of sector s at $t-1$. The import share is computed dividing the import value with the total value of shipment of the sector considered. Robust standard errors clustered at sector (four digits) level are reported in parentheses. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

tive effect of export (-0.093%) and a positive effect of import (+0.072%), while the most specialized workers in the least complex sector have a positve effect from the increase in export (+0.1%) and a negative effect from the increase in import (-0.027%).
Finally, increases of exports in the most complex sector induce a rise of wage for both the most specialized and the least specialized workers with greater effect for the former (+0.31% for the most specialized against a +0.11% for the least specialized) and increases of imports induce reductions of wage of both the most and least specialized workers with greater effect for the most specialized workers (-0.15% for the most specialized against a -0.047% for the least specialized). The mentioned percentages which represent the effect of an increase of 1% of exports or imports on wages are summarized graphically in the figure 1.6

Figure 1.6: Effects of an increase of 1% of export (or import) intensity on wages



It is then possible to summarize the results obtained in this section in the following way.
Exports in more complex sectors have higher positive effect on wages of workers and higher specialization implies higher benefit from exports. Imports in more complex sectors have higher negative effect on the wages of workers and being more specialized implies bigger

negative effect from imports. Regarding the Residual wage inequality, working in a more complex sector increases a worker's wage while owning a more ubiquitous major increases one's wage. This high-ubiquity premium is decreasing with the complexity of the sector in which the worker works.

In the next section I report relevant robustness checks. The results are robust and persistent to all of them.

Robustness checks

Time Invariant complexity and ubiquity indexes

As robustness check I compute the complexity and the ubiquity indexes unique for all the 5 years in our data. More specifically, I continue to use the thereshold of two workers as a lower bound when computing the connections between workers and sectors. The table 1.9 shows that the results on the interacted effect of complexity and ubiquity on exports is robust to all the specifications both using the full interacted model and the one with only the interacted terms and both allowing trend (sector-time) fixed effects or sector fixed effects.

Capital Intensive control

Now I introduce into the analysis the capital investment control at sector level in order to prove that the indexes are not just proxy for sector capital intensity. More specifically I interact the investment in capital by sector with the export share. I use the 2009 data on capital investment from the NBER-CES Manufacturing Industry Database which is commonly used in the literature to identify capital intensity for each sector. I use the latest information for each sector (2009) and I argue that, since we are interested in controlling for the inner characteristic of a sector usage of capital we should not be concerned too much about the time invariancy of this variable.
From the table 1.10 I show that the results are still robust to this further control, both using 3 digits and 4 digits sector fixed effects.

Moreover, also when considering a time invariant index of complexity and ubiquity, controlling for capital intensity does not change the robustness of my results (see table 1.11).
Furthermore, in order to exclude that my results are capturing some other effects, I interact both exports and imports with other observable characteristics of the workers such as age, sex, class of worker and schooling. Hence I find that, both using annual

Table 1.9: Robustness Check: Time Invariant Indexes

VARIABLES	Wage	Wage	Wage	Wage
Complexity	-0.11246	-0.12026		
	(0.10485)	(0.10265)		
Ubiquity	0.05634**	0.05694**		
	(0.02676)	(0.02655)		
Exports	-2.06384***	-2.19045***	-1.34879	-1.41396
	(0.76502)	(0.78479)	(0.86419)	(0.89821)
Exports*Complexity	0.06388***	0.06644***	0.04752***	0.04864***
	(0.01562)	(0.01602)	(0.01714)	(0.01797)
Exports*Ubiquity	-0.01099***	-0.01070***	-0.01106***	-0.01074***
	(0.00361)	(0.00356)	(0.00366)	(0.00361)
Imports	1.39934*	1.45015*	1.55421**	1.60417**
	(0.80866)	(0.83456)	(0.74809)	(0.78209)
Imports*Complexity	-0.03839**	-0.03947**	-0.04193**	-0.04297**
	(0.01782)	(0.01843)	(0.01612)	(0.01695)
Imports*Ubiquity	0.00457	0.00451	0.00452	0.00443
	(0.00345)	(0.00341)	(0.00344)	(0.00341)
Sector FE (3d)	✓		✓	
Year FE	✓		✓	
Major FE	✓	✓	✓	✓
Year#Sector FE (3d)		✓		✓
Observations	170,656	170,656	170,656	170,656
R^2	0.51543	0.51602	0.51526	0.51583

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,2}$ index for sector s standardized over the whole period of five years. Ubiquity represents the $k_{m,2}$ index for major m standardized over the whole period. The variable Exports represents the natural logarithm of the exports share of sector s at $t-1$. The export share is computed dividing the export value with the total value of shipment of the sector considered. The variable Imports represents the natural logarithm of the imports share of sector s at $t-1$. The import share is computed dividing the import value with the total value of shipment of the sector considered. Robust standard errors clustered at sector (four digits) level are reported in parentheses. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Table 1.10: Robustness Check: Sector's capital intesity

VARIABLES	Wage	Wage	Wage	Wage
Complexity	-0.03581	-0.07376	-0.04017	-0.06084***
	(0.04952)	(0.06673)	(0.05374)	(0.01745)
Ubiquity	0.07445**	0.07112***	0.06880**	0.05599***
	(0.02972)	(0.02321)	(0.02847)	(0.01924)
Exports	0.05950	-0.12706	0.01717	0.06612
	(0.08730)	(0.18238)	(0.09755)	(0.05077)
Exports * Complexity	0.03442***	0.05365***	0.03548***	0.01139***
	(0.00727)	(0.01324)	(0.00819)	(0.00308)
Exports * Ubiquity	-0.02713***	-0.02755***	-0.02541***	-0.01465***
	(0.00467)	(0.00472)	(0.00441)	(0.00389)
Imports	0.02947	0.07867	0.03317	-0.03710
	(0.06511)	(0.13690)	(0.06392)	(0.04355)
Imports * Complexity	-0.02325***	-0.03439***	-0.02325***	-0.00584**
	(0.00703)	(0.01139)	(0.00686)	(0.00279)
Imports * Ubiquity	0.01519***	0.01706***	0.01481***	0.00631*
	(0.00429)	(0.00443)	(0.00435)	(0.00351)
Exports * Capital Intensity	-0.00002	-0.00007***	-0.00003	0.00000
	(0.00002)	(0.00002)	(0.00002)	(0.00000)
Imports * Capital Intensity	0.00002	0.00006***	0.00003	0.00001
	(0.00002)	(0.00002)	(0.00002)	(0.00001)
Sector 3d FE	✓		✓	
Year FE	✓			✓
Major FE	✓	✓	✓	✓
Year#Sector 3d FE		✓		
Sector 4d FE				✓
Year#Sector 2d ✓			✓	
Observations	170,835	170,835	170,835	170,835
R^2	0.51585	0.51676	0.51594	0.52078

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,t,2}$ index for sector s at time t standardized over the period t. Ubiquityrepresents the $k_{m,t,2}$ index for major m at time t standardized over the period t. The variable Exports represents the natural logarithm of the exports share of sector s at $t-1$. The export share is computed dividing the export value with the total value of shipment of the sector considered. The variable Imports represents the natural logarithm of the imports share of sector s at $t-1$. The import share is computed dividing the import value with the total value of shipment of the sector considered. Robust standard errors clustered at sector (four digits) level are reported in parentheses. Capital Intensity represent the total capital expenditure for the sector s in 2009. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

indexes for complexity and ubiquity or one index for all the years, my results are robust and even bigger when controlling for those interactions.

Worker's Occupation

I go further with the robustness checks introducing the occupation type into the analysis. More specifically, in order to be sure that the results on ubiquity are not identifying other effects, I introduce as control the type of occupation of the worker. In particular I use the SOC occupation code in order to control for the effect of the type of occupation of the worker (manager, engineers, technicians, etc.). I both control using the SOC index alone and interacting it with Exports and Imports. I find that my results are still robust when controlling for the occupation type thus implying that my results are able to identify an effect which is different from the simple type of occupation often taken into consideration in the literature. In the table 1.12 I report the regression results[17].

Separating the effect of Export from the effect of output

As further robustness check, I distinguish now the role of export from the role of output. More specifically, in order to be sure that the coefficient of Export Share is not driven by the changes in the output level, I use the Export variable instead of export share, and I control for the sector output. In table 1.13 I report the results. The results on Exports are still significant for this further robustness check.

[17]For simplicity I report only the regression table where the indexes of ubiquity and complexity are determined yearly. Moreover this table does not consider also the interaction term of Exports with the type of workers, but my results are robust also when allowing the interaction terms of exports and SOC and when considering those interaction in the specification with time invariant indexes.

Table 1.11: Robustness Check: Sector's capital intesity

VARIABLES	Wage	Wage
Complexity	-0.15703*	-0.24664***
	(0.09329)	(0.06281)
Ubiquity	0.05250**	0.04824*
	(0.02614)	(0.02557)
Exports	-3.64517***	-7.15608***
	(1.09024)	(1.10710)
Exports*Complexity	0.10186***	0.18677***
	(0.02591)	(0.02620)
Exports*Ubiquity	-0.01070***	-0.00991***
	(0.00353)	(0.00346)
Imports	2.74237**	5.49440***
	(1.04229)	(1.12876)
Imports*Complexity	-0.07119***	-0.13874***
	(0.02411)	(0.02720)
Imports*Ubiquity	0.00472	0.00452
	(0.00341)	(0.00336)
Exports * Capital Intensity	-0.00004	-0.00015***
	(0.00003)	(0.00003)
Imports * Capital Intensity	0.00004	0.00015***
	(0.00003)	(0.00003)
Sector 3d FE	✓	
Year FE	✓	
Major FE	✓	✓
Year#Sector 3d FE		✓
Observations	170,381	170,381
R^2	0.51635	0.51849

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,2}$ index for sector s standardized over the whole period of five years. Ubiquity represents the $k_{m,2}$ index for major m standardized over the whole period. The variable Exports represents the natural logarithm of the exports share of sector s at $t-1$. The export share is computed dividing the export value with the total value of shipment of the sector considered. The variable Imports represents the natural logarithm of the imports share of sector s at $t-1$. The import share is computed dividing the import value with the total value of shipment of the sector considered. Robust standard errors clustered at sector (four digits) level are reported in parentheses. Capital Intensity represent the total capital expenditure for the sector s in 2009. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 1.12: Robustness Check: Worker's Occupation

VARIABLES	Wage	Wage	Wage	Wage
Complexity	0.00244	0.00912	0.00534	-0.04609***
	(0.04108)	(0.06265)	(0.04627)	(0.01475)
Ubiquity	0.04033	0.03423	0.03551	0.03519**
	(0.02685)	(0.02126)	(0.02591)	(0.01681)
Exports	-0.00422	-0.07100	-0.01548	0.02655
	(0.05723)	(0.11557)	(0.07304)	(0.04027)
Exports*Complexity	0.01911***	0.01940**	0.01831***	0.00762***
	(0.00510)	(0.00822)	(0.00610)	(0.00286)
Exports*Ubiquity	-0.01501***	-0.01137***	-0.01359***	-0.00913***
	(0.00361)	(0.00327)	(0.00323)	(0.00329)
Imports	0.01592	0.06136	0.01485	-0.02588
	(0.04725)	(0.08128)	(0.04771)	(0.04317)
Imports*Complexity	-0.01309**	-0.01387**	-0.01270**	-0.00451*
	(0.00505)	(0.00685)	(0.00480)	(0.00269)
Imports*Ubiquity	0.01045***	0.00852**	0.01013**	0.00551*
	(0.00382)	(0.00353)	(0.00382)	(0.00328)
Sector 3d FE	✓		✓	
Year FE	✓			✓
Major FE	✓	✓	✓	✓
Year#Sector 3d FE		✓		
Sector 4d FE				✓
Year#Sector 2d FE			✓	
Observations	171,110	171,110	171,110	171,110
R-squared	0.57855	0.57900	0.57862	0.58199

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,t,2}$ index for sector s at time t standardized over the period t. Ubiquityrepresents the $k_{m,t,2}$ index for major m at time t standardized over the period t. The variable Exports represents the natural logarithm of the exports share of sector s at $t-1$. The export share is computed dividing the export value with the total value of shipment of the sector considered. The variable Imports represents the natural logarithm of the imports share of sector s at $t-1$. The import share is computed dividing the import value with the total value of shipment of the sector considered. Robust standard errors clustered at sector (four digits) level are reported in parentheses. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity and type of occupation.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 1.13: Robustness Check: Exports and Output as separate variables

VARIABLES	Wage	Wage	Wage	Wage
Complexity	-0.29782**	-0.38483**	-0.30144**	-0.14466***
	(0.12034)	(0.16982)	(0.13055)	(0.04676)
Ubiquity	0.35193***	0.30054***	0.33399***	0.23527***
	(0.08043)	(0.06896)	(0.08144)	(0.05377)
Exports	0.02100	-0.12562	0.00661	0.05820
	(0.06643)	(0.10855)	(0.06282)	(0.04181)
Exports*Complexity	0.02716***	0.03272***	0.02704***	0.00948***
	(0.00580)	(0.00694)	(0.00581)	(0.00275)
Exports*Ubiquity	-0.02230***	-0.01881***	-0.02131***	-0.01215***
	(0.00369)	(0.00410)	(0.00391)	(0.00287)
Imports	0.06565	0.11568	0.06409	0.03680
	(0.06033)	(0.10916)	(0.05986)	(0.04535)
Imports*Complexity	-0.01391**	-0.01561*	-0.01361**	-0.00453
	(0.00686)	(0.00890)	(0.00669)	(0.00321)
Imports*Ubiquity	0.00806*	0.00682	0.00787	0.00274
	(0.00460)	(0.00496)	(0.00479)	(0.00336)
Output	-0.00000	-0.00000	-0.00000	-0.00000
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Constant	7.34985***	9.21077***	7.58208***	7.85688***
	(0.89929)	(1.58690)	(1.10905)	(1.04302)
Major FE	✓	✓	✓	✓
Sector 3d FE	✓		✓	
Year FE	✓			✓
Year#Sector 3d FE		✓		
Sector 4d FE				✓
Year#Sector 2d FE			✓	
Observations	171,110	171,110	171,110	171,110
R-squared	0.51577	0.51630	0.51583	0.52077

Robust standard errors in parentheses

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

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,t,2}$ index for sector s at time t standardized over the period t. Ubiquity represents the $k_{m,t,2}$ index for major m at time t standardized over the period t. The variable Exports represents the natural logarithm of the exports of sector s at $t-1$. The variable Imports represents the natural logarithm of the imports of sector s at $t-1$. The variable Output represent the total value of shipment of the sector considered at time $t-1$. Robust standard errors clustered at sector (four digits) level are reported in parentheses. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken and nativity.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

Endogeneity checks

Now I will focus on eventual endogeneity issues which could bias my results.

First of all I study the case in which the fact that more complex sectors export more could bias my results.
Firstly I report the correlation between complexity of a sector and export intensity which is equal to 0.31. Hence, at a first glance, they do not appear to be as much correlated to bias the result. Still I must check if, introducing the square of complexity or the square of Export intensity instead of the intraction of export and complexity, I obtain the same result. In particular obtaining the same results would mean that, when I use the interaction term, I just proxy this non linearity. Moreover, when I consider in the same regression the square term and the interaction term, I must check that the last is still significant and the former is not.
In table 1.14 I report the regression results. I find that, when introducing the square terms alone, the results are very different, thus implying that it is not the same to write k_{s2}^2 or $(k_{s2} * Exp_{intensity})$. Moreover, when I consider both the interaction term and the square term, the first is significant and the latter becomes insignificant. Thus, I can assess that my results are not biased by the fact that more complex sectors could export more.

My results could be biased if the wage of worker i in sector s could influence the overall exports of sector s (Reverse Causality Problem). First of all, it is possible to exclude that the wage of one worker can actually affect the total exports of the sector in which she works. Moreover the export intensity measure is lagged, hence this would imply that a single worker today have to affect the last year exports of the sector in which she is working.
It can be indeed true that workers in the same sector could have a correlated wage, but, this problem is solved with the use of clustered standard errors and sector fixed effects. Moreover, if we want to examine the issue that the sectors with higher wages have lower (or higher) exports due to some productivity effect, then, this is not a reverse causality problem but it is an omitted variable one which I discuss in the next paragraph. Hence I don't retain the reverse causality issue to matter for my results.

Consider now a variable which is actually affecting both Export and wages (Omitted Variable Problem), indeed it is very likely that such a variable exists and, even though I am controlling for major, sector and time fixed effects, there could still be a residual part which affects still Exports and wages. My analysis is interested into the interaction between the exports and complexity (and ubiquity). Hence the results would be bias if this unobservable variable could affect how exports effect differs among more and less

Table 1.14: ComplexUbiquity Export and Import Intensity

VARIABLES	Wage	Wage	Wage	Wage
Complexity	0.03585	-0.03135	-0.06570	-0.06155
	(0.04804)	(0.05033)	(0.05625)	(0.05171)
Ubiquity	0.04157	0.07558**	0.04738	0.07491**
	(0.03030)	(0.03203)	(0.02906)	(0.03085)
Exports	0.17047	0.05120	0.25598***	0.06610
	(0.13169)	(0.12637)	(0.07196)	(0.08883)
$Exports^2$	0.00524	-0.00098		
	(0.01061)	(0.01079)		
Exports*Complexity		0.02802***		0.02648***
		(0.00687)		(0.00680)
Exports*Ubiquity	-0.00870***	-0.02404***	-0.01063***	-0.02406***
	(0.00240)	(0.00463)	(0.00338)	(0.00417)
Imports	-0.08122	0.02789	-0.08816	0.02309
	(0.05975)	(0.06035)	(0.05837)	(0.06369)
Imports*Complexity	-0.00016	-0.01616**	-0.00049	-0.01599**
	(0.00732)	(0.00666)	(0.00694)	(0.00664)
Imports*Ubiquity	0.00320	0.01210**	0.00401	0.01221***
	(0.00490)	(0.00455)	(0.00522)	(0.00455)
$Complexity^2$			0.00323**	0.00119
			(0.00138)	(0.00144)
Sector 3d FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Observations	171,110	171,110	171,110	171,110
R^2	0.51509	0.51548	0.51514	0.51549

Notes : The dependent variable is the natural logarithm of annual wage of worker i with major m working in sector s at time t, the wages are adjusted to the inflation having 2013 as reference year. Complexity represents the $k_{s,t,2}$ index for sector s at time t standardized over the period t. Ubiquityrepresents the $k_{m,t,2}$ index for major m at time t standardized over the period t. The variable Exports represents the natural logarithm of the exports share of sector s at $t-1$. The export share is computed dividing the export value with the total value of shipment of the sector considered. The variable Imports represents the natural logarithm of the imports share of sector s at $t-1$. The import share is computed dividing the import value with the total value of shipment of the sector considered. Robust standard errors clustered at sector (four digits) level are reported in parentheses. The control variables used in the specifications are age, sex, educational attainment, state, citizenship status, class of worker, marital status, hours worker per week, weeks worked during the year, black dummy, language other than english spoken, nativity.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

complex sectors (more or less specialized workers). Hence, for the endogenity issue to be a problem, it is not enough to consider an effect which affects linearly exports and wages, but it is instead required it to be affecting the way in which exports effect changes according to complexity and wages. Such an event indeed could exist but, as far as I know, it is not clear what it could be. Furthermore it has been recently proved by Bun and Harrison (2014) that, under reasonable assumptions[18] the use of OLS estimation gives an exogenous and consistent coefficient of the interaction term even when one of the variable of the interaction is endogenous. The OLS results appear to be as good as the IV results for the interaction term coefficient. For these reasons, I retain this endogeneity issue not to be very worriying for my results.

Now I consider a reverse causality problem. In particular it is reasonable to say that, when wages in one sector are higher, more people would like to be hired in that sector hence increasing the number of different majors and then complexity of the sector. In order to understand why this problem is not a serious issue for my project, I must take a step back and consider how I construct the complexity index. Sectors are more complex not only if the number of workers with different majors is higher, but also if more specialized workers work in that sector. Hence, at a first glance, it is not clear that an increase in the number of workers will actually increase the complexity of the sector, because it will depend, in the end, on their level of specialization. Moreover we can make a step forward, in particular, it is reasonable to assume that majors with a high average wage are those majors that will on average attract more people. This will imply that sectors which on average pay more, attract more people but at the same time those people would be more ubiquitous. Hence, there is one force pushing for the increase in complexity, through an increase in the number of workers, and another force pushing down the complexity through the increase of the ubiquity of those new workers. Hence the overall results is not clear, therefore it is possible to say that my results are not strongly biased in one direction. It is still indeed true that the overall effect could be partially bias the results, but, due to the mentioned reasons, I retain this effect not to be too much worrying for the results to hold.

[18] if x is endogenous and w is not, then the coefficient for $x*w$ will be exogenous if $E(x_i) = 0, E(w_i) = 0$, $E(x_i + u_i|w_i) = E(x_i u_i)$ where u_i is the error term of our regression. Moreover if u_i, w_i and x_i are jointly normally distributed with mean zero and variance matrix, the OLS coefficient of the interaction term is consistent

1.4 Discussion

In this section I explain one possible channel through which complex-ubiquity could affect the effects of globalization on high skilled workers wage. In doing so I describe the main elements of my theoretical model, extensively discussed in the next chapter of the thesis, whose aim is to study how sector complexity and skill ubiquity have a role on the effects of Globalization on workers' wage. This section's aim is to summarize briefly the results of the theory linking them to the empirical results found in this first chapter.

Consider a monopolistic competition model with two manufacturing sectors[19]. Each firm produces one variety of one of the two sectors and uses blue collar workers (low skilled) and specialized (high skilled) workers in the production.

Sector one is assumed to be less complex than sector two, thus implying that, while sector one requires, apart from the low skilled workers, just one type of specific knowledge, sector two will also need a more specific one. More complex sectors are then the ones which use a higher number of knowledges in their pruduction and at the same time more specialized knowledges. Those knowledges are represented in the model by the horizontally heterogenous high skilled workers.

There are two types of high skilled workers, workers with specialization one and workers with specialization two, the former are the ones whose knowledge is more common, or less specialized, and the latter are the most specialized ones. Hence, workers with specialization one will be used in both sectors while workers with specialization two will be used only in the most complex one (sector two).

Workers can move across sectors but only in the position for which they have a specialization for, thus, the wage of the workers with the same specialization is the same. Hence, workers of type one will earn w_1 and workers of type two will earn w_2, both the two wages are endogenously determined in the model.

The overall demand for the varieties of the two sector is equal to the total earnings of the workers and the total supply of each type of workers is exogenously given.

After having obtained the equilibrium in closed economy, I introduce a country which differs from the domestic one either in total endowments or in preferences. Hence I open to trade either sector one or sector two and I compare the newly obtained wages with the autarky ones. The choice of which sector to open to trade is exogenous since I am only interested into the effect of this choice. Indeed I retain it would be interesting adding the

[19] and one agricultural (numeraire) sector

endogenous decision in the future research agenda.

I find that, when the economy has a higher share of workers with specialization two over workers with specialization one, then the effects of opening to trade of the most complex sector are the following.
The availability of a bigger market induces a rise in profit of firms in the open sector (sector two), but, due to the zero profit condition, the firms must pay more the workers they use. In particular, since sector two is the most complex, it will use all the two types of workers, hence, both w_1 and w_2 should increase. At the same time, firms in sector one, which did not experience the positive effect of trade, must now pay more the workers they use since w_1 has increased, but, this is not possible since they cannot experience negative profit, therefore they must drag down the wage of workers one. The new level of w_1 will be anyway higher than before because since w_2 increased, this led to an increase of the overall demand of all goods, thus implying higher profits for firms in sector one too. The overall effect of the forces described is positive for all types of workers with greater positive effect for the most specialized ones.

When, instead, the least complex sector is open to trade, firms in this sector will suffer because we assumed the domestic country to have a comparative advantage on the most complex sector. This implies that firms in sector one must now decrease the wages of those specialized workers they use, hence w_1 must decline (again for the zero profit condition to hold). This decrease of the wage of workers with specialization one could have two effects on the wages of the most specialized workers.
More specifically, if the share of low specialized over high specialized workers is low enough, then firms in sector two will now pay more the workers with specialization two since they cannot experience the positive profit coming from the decrease of w_1. Therefore we would observe that the least complex globalization leads to an increase of the wages of the most specialized workers and a decrease of the wage of the least specialized ones.
If instead the share of the low specialized over high specialized workers is high enough, then the decrease of w_1 will have a strong effect on the overall demand of all types of goods, thus, also the profit for the firms in sector two will decrease, hence this will force the firms to decrease the wage of the most specialized workers too. Therefore, this implies that globalization in the least complex sector can produce a decrease of all types of workers' wage.

In order to summarize the results, the model predict that opening to trade the most complex sector produces a positive effect on the wages of all types of high skilled workers with a stronger effect for the most specialized ones. Instead, the least complex globalization can induce either an overall decrease of the wages of all types of workers or, at the best, an increase of the high specialized workers' wage and a decrease of the low specialized ones'.

Going back to the empirical findings of the paper, the results are in line with the prediction of the model when we observe exports effect. More specifically, I find that an increase of exports in the most complex sector produces positive effect for the high skilled workers with a stronger effect for the most specialized ones. Moreover I find that when there is an increase in exports in the least complex sector, the average effect on the high skilled workers is negative but, if we observe this effect more deeply, we find it is positive for the most specialized workers and negative for the least specialized ones.

The empirical results on imports are also in line with the model. More specifically it is reasonable to assume that increases in import in one sector reflect that, for that sector, the domestic country does not have a comparitve advantage, in particular the share of the most specialized workers over the least specialized ones in that sector is lower than the rest of the world. This implies that, when opening to trade, according to my model, the effects must be opposite than the ones observed before. This is exactly what happens when you look at the results on imports.

1.5 Conclusions

This paper has examined the effects of Globalization, proxied by international trade, on high skilled workers' wage introducing two new sources of heterogenity among workers and sectors.

I found that introducing sector complexity and skill ubiquity is relevant when studying the effects of globalization on high skilled workers' wages, moreover it appears to be relevant also among the determinants of the wages.

An increase in exports of a sector has a positive effect on the wages of all types of high skilled workers if that sector is highly complex, moreover this increase benefits more the most specialized workers. Instead, an increase in exports of a low complex sector implies a small increase of the wages of the most specialized workers and a decrease of the least specialized ones' wages, the average effect is a reduction of the workers' wages. The effects of an increase of import are the opposite of the ones found for an increase of exports.

Moreover, my paper suggests that working in more complex sectors implies higher wage, being less specialized implies higher wage and this "low specialization" premium is decreasing with the complexity of the sector in which the worker works.

I believe that going further into the study of the role of sector complexity and skill ubiquity on different international trade phenomena and on the determinants of wages could be a new and interesting strand of research.

Chapter 2

Globalization and Wages: The role of Sector Complexity and Skill Ubiquity

The Theoretical Model

2.1 Model's introduction

This model is a variant of Martin and Rogers (1995) with more than one manufacturing sectors which are differentiated according to their complexity.
Differently from the paper, where the fixed costs are related to the capital necessary for the production, I link the fixed cost required to produce a good with the good's complexity. As mentioned in the part I 's introduction and in the first chapter of the thesis, this paper introduce a theoretical background to the newly introduced heterogeneities among workers and sectors. More specifically, not only this model considers the classic vertical heterogeneity among workers (high skilled-low skilled) but it also allows the high skilled workers to be horizontally differentiated through each worker's specialization.

I model the complexity of a good using the number of different types of specialized workers necessary for the production of that good.
Each individual can be either a blue collar or a specialized worker. If she is a specialized worker, then she can hold only one specialization.
Since, as mentioned, each good differs for the number and for the types of specialized workers required for its production, then, some specializations will be used in more than one production process. Even though the model is analytically solvable for K sector and K specializations, for simplicity of the analysis, this chapter describes the model with 2

manufacturing sectors and 2 specializations.

The chapter is organized as follow, first I will focus on the closed economy and, after that, I will open the border of the economy allowing different sectors to open to the globalization, then I will study the effects of trade on the high skilled workers' wages.

2.2 Closed Economy

Consumer Problem

In the country there are 2 manufacturing sectors and an agricultural (numeraire) sector. Different varieties of the same good are produced in each of the two manufacturing sectors, while the agricultural good is an homogenous one.
Each individual consumes the goods from the two manufacturing sectors and the agricultural good in order to maximize the following utility function.

$$U = \left(U_1^{\beta_1} U_2^{\beta_2}\right)^{\alpha} U_A^{1-\alpha} \qquad \text{with} \quad \alpha \in (0,1) \quad \text{and} \quad \beta_1 + \beta_2 = 1 \tag{2.1}$$

Where U_1 is the Utility derived by the consumption of the goods in sector 1, U_2 is the utility from sector 2 and U_A is the utility from the Agricultural Sector.
The overall utility function is then a Cobb Douglas function, hence the parameter α is the fraction of total earnings the consumers are willing to use for the manufacturing sectors while β_i represents how much the consumers benefit from consuming the manufacturing goods in the i sector with respect to all the manufacturing sectors.
Each consumer enjoys the consumption of a differentiated basket of varieties in each manufacturing sector (love for variety) and her utility function for each differentiated sector is a standard CES. The utility experienced by the consumers from the agricultural good is instead linear in the consumption of the homogenous good.

$$\begin{aligned} U_1 =& \left(\int_0^{n_1} c_{1,k}^{\frac{\sigma-1}{\sigma}} dk \right)^{\frac{\sigma}{\sigma-1}} \\ U_2 =& \left(\int_0^{n_2} c_{2,k}^{\frac{\sigma-1}{\sigma}} dk \right)^{\frac{\sigma}{\sigma-1}} \\ U_A =& c_A \end{aligned} \tag{2.2}$$

Where n_i is the number of varieties in sector i, $c_{i,k}$ is the consumption of variety k of the

i sector and σ is the elasticity of substitution among varieties in each sector ($\sigma > 1$). Each consumer maximizes her utility function, subject to her budget constraint, choosing the optimal consumption level for each variety in each sector.
Thus the demand function for each variety k in sector i is the following:

$$
\begin{aligned}
c_{1,k} &= \left(\frac{p_{1,k}}{P_1}\right)^{-\sigma} \frac{\alpha E_1}{P_1} \\
c_{2,k} &= \left(\frac{p_{2,k}}{P_2}\right)^{-\sigma} \frac{\alpha E_2}{P_2}
\end{aligned}
\tag{2.3}
$$

Where $p_{i,k}$ is the price of the variety k in sector i, E_i is the share of the earnings the consumers spend for sector i, which can be easily proved to be equal to $E_i = \beta_i E$, where E is the total earnings, and P_i is the price index for sector i with $P_i = \left(\int_0^{n_i} p_{i,k}^{1-\sigma} dk\right)^{\frac{1}{1-\sigma}}$.
In the agricultural sector, the consumers spend a residual $(1-\alpha)$ amount of earnings to buy the homogeneous good, thus, since the price of the numeraire good is equal to one[1], we can rewrite the demand function of the representative consumer for the agricultural good as the following.

$$c_A = (1-\alpha)E \tag{2.4}$$

This is true since the amount of earnings available to the consumer that she wants to spend in the agricultural good is exactly the residual of the earning spent in the manufacturing goods.

Firm Problem

Two types of workers are present in the country, the blue collar workers (L) and the specialized one (R), among the specialized workers there are workers with specialization one (R_1) and workers with specialization two (R_2).

The agricultural sector is perfectly competitive. The production of the agricultural

[1] because the agricultural sector is perfectly competitive with marginal cost of production equal to one

good requires only blue collar workers whose productivity is normalized to one. Since the agricultural sector is perfectly competitive and the blue collars' productivity is equal to one, also the wages of the blue collars are equal to one in equilibrium.

The manufacturing sectors are monopolistic competitive markets. Each firm in each manufacturing sector must pay a fixed cost in order to hire (and mantain) the workers with the specific knowledges required for the production of the manufacturing goods and a variable cost for producing each unit of it.

. Each firm produces one variety in one sector and each unit of the variety is produced using one blue collar worker.

In order to be able to produce one variety, the firm must hire specialized workers necessary for the production, each sector has different needs and therefore requires a different number of specialized workers.

The complexity of a good consists on the number of different types of specific knowledges and therefore of specialized workers necessary for the production.

In the model, sector one is the least complex sector and sector two is the most complex one, the former requires workers with specialization one and the latter requires both the workers with specialization one and workers with specialization two. In particular, for simplicity purpose, we assume each firm requires one unit of each of the specialized workers necessary for the production in the sector.

The profits of the firms in sector one and two are the following[2]:

$$\begin{aligned} \pi_1 &= p_1 q_1 - q_1 - w_1 \\ \pi_2 &= p_1 q_1 - q_1 - (w_1 + w_2) \end{aligned} \tag{2.5}$$

Where p_i is the price of the goods in sector i, q_i is the quantity of each variety produced by each firm in sector i and w_i is the wage of workers with specialization i.

Now we consider the firm maximization problem. Each firm maximizes her profit choosing the optimal price level given the demand function of the consumers. The maximization problem is then the following.

[2]Each firm produces only one variety, since the firms in a sector are homogeneous I drop the variety index

$$\begin{aligned} &\max_{p_i} \pi_i \\ s.t.\ \ c_i = &\left(\frac{p_i}{P_i}\right)^{-\sigma} \frac{\alpha E_i}{P_i} \end{aligned} \tag{2.6}$$

Therefore the optimal price level is

$$p_1 = p_2 = \frac{\sigma}{\sigma - 1}$$

And the optimized profit functions for the firms in the two sectors are the following.

$$\begin{aligned} \pi_1 &= \frac{\alpha \beta_1 E}{n_1} \frac{1}{\sigma} - w_1 \\ \pi_2 &= \frac{\alpha \beta_2 E}{n_2} \frac{1}{\sigma} - w_1 - w_2 \end{aligned} \tag{2.7}$$

Now we characterize the equilibrium. In equilibrium the free entry conditions, the labor market conditions and the earning conditions must be satisfied.
The free entry conditions require the profit for the firms both in sector one and in two to be equal to zero.

$$\begin{aligned} \frac{\alpha \beta_1 E}{n_1} \frac{1}{\sigma} - w_1 &= 0 \\ \frac{\alpha \beta_2 E}{n_2} \frac{1}{\sigma} - w_1 - w_2 &= 0 \end{aligned} \tag{2.8}$$

Then the labor market clearing conditions for both the labor markets for the specialized workers and for the blue collars must be satisfied. In particular this implies that the overall demand of workers must be equal to the overall fixed supply of them.
For the specialized workers we know that each firm in the manufacture sectors requires one specialized workers of each type necessary in the specific sector. Thus, in sector one, each firm need one worker with specialization one, while, in sector two, each firm demand one worker with specialization one and one worker with specialization two.
This implies that, for the labor market of specialized workers to be cleared, the sum of the demand of workers with specialization one in both the first and the second sector must be equal to the fixed supply of workers of type one (R_1) and at the same time, the total demand of workers specialized in two must be equal to R_2.

$$\begin{cases} n_1 + n_2 = R_1 \\ n_2 = R_2 \end{cases} \tag{2.9}$$

$$\Rightarrow$$

$$\begin{aligned} n_1 =& R_1 - R_2 \\ n_2 =& R_2 \end{aligned} \tag{2.10}$$

The demand of blue collars is obtained summing up the demand of unskilled workers in all the two manufacturing sectors ($L_1 + L_2$) and the agricultural one (L_A). As before, the total demand must be equal to the total fixed supply L.

$$L_1 + L_2 + L_A = L \tag{2.11}$$

We know that, in each manufacturing sector, the productivity of the blue collars is equal to one, thus, in order to produce one unit of the variety produced by the firm, one unskilled worker must be hired. This implies that the total number of blue collars workers employed in one sector is given by the demand of each variety multiplied by the number of different varieties in the sector. The demand of blue collar workers in the agricultural sector depends on the demand of the numeraire good that is equal to $(1 - \alpha)E$. Therefore we can rewrite eq.2.11 in the following form.

$$n_1 c_1 + n_2 c_2 + (1 - \alpha)E = L \tag{2.12}$$

Thus, applying (2.10) and (2.3) we can rewrite (2.12).

$$(\frac{\sigma - \alpha}{\sigma})E = L \tag{2.13}$$

Another condition that must be satisfied is the earning one. In particular, the total earning is not exogenous but it is instead determined by the sum of the earnings of all the population.

$$E = w_1 R_1 + w_2 R_2 + L \tag{2.14}$$

Therefore, in closed economy, the equilibrium wages, i.e. the wages that satisfy the free entry conditions, the labor market conditions and the earning conditions, are the following.

$$\begin{aligned} w_1 &= \frac{\alpha\beta_1 L}{(R_1 - R_2)(\sigma - \alpha)} \\ w_2 &= \frac{\alpha L(\beta_2 R_1 - R_2)}{R_2(R_1 - R_2)(\sigma - \alpha)} \end{aligned} \tag{2.15}$$

Since I am interested in the scenario in which both the two sectors are active, i.e. when there are firms producing in sector 1 and firms producing in sector 2, the values for which both the two wages are non negative must be studied. Thus, I find that the condition to satisfy is the following:

$$\beta_1 \leq \frac{R_1 - R_2}{R_1} \tag{2.16}$$

We can rewrite the "non-negativity condition" also in terms of the number of firms in each sector in equilibrium. In particular the condition can be rewritten as $\beta_1 \leq \frac{n_1}{n_1+n_2}$[3]. The preference of the population for the goods in sector 1 must be lower, in equilibrium, than the share of the firms in that sector over the total number of firms.
From now on, the results taken into considerations satisfy the non-negativity condition.

Now I study the comparative statics, in particular, it is possible to rewrite the wages as functions of the exogenous variables in the following form.

$$\begin{aligned} w_1 &= f(\overset{-}{R_1}, \overset{+}{R_2}, \overset{+}{L}, \overset{+}{\alpha}, \overset{+}{\beta_1}, \overset{-}{\sigma}) \\ w_2 &= g(\overset{+}{R_1}, \overset{-}{R_2}, \overset{+}{L}, \overset{+}{\alpha}, \overset{-}{\beta_1}, \overset{-}{\sigma}) \end{aligned} \tag{2.17}$$

The formulation above implies that, while, as usual, the increase in the supply of one particular type of workers decreases her wage, the increase in supply of the other type of worker has a different effect. In particular, if R_2 (R_1) increases, then the wages of workers specialized in one (two) increase. This happens because the increase in supply of the workers with specialization two decreases the wage for those workers. This decrease

[3]or it is equivalent to write it as $\frac{R_1}{R_2} \geq \frac{1}{\beta_2}$

in their wage allow the firms in sector two to pay more the workers with specialization one and this the reason why we observe an increase in their wage. Instead, an increase in the number of workers with specialization one, reducing the wage of those workers, allow the firms in sector two to pay now more the workers with specialization two.

From the comparative statics we notice moreover that both the wages increase when the number of unskilled workers increase. This happens because the increase in L produces a further increase in the number of the numeraire goods sold and increases the available total earnings that can be spent in the two sectors, thus allowing for an increase in both the two wages. This could be thought as a market size effect driven by the unskilled labor market.

The two wages are increasing function of their preferences parameter, in particular an increase in β_1 (β_2) induces an increase in the wages for the workers with specialization one (two) because it allows higher earnings to be used for the sector one (two).

An increase in α induces an increase in both the two wages because it implies that a larger share of total earnings is now used for the manufacturing goods, i.e. for sector one and two.

Finally the two wages decrease in σ. Since σ is the elasticity of substitution between two varieties in the same sector, if σ goes to infinity, the varieties tends to be perfect substitute, while as σ goes to one they tends to become perfect complements. This implies that, if the varieties are more and more substitutes to each other, i.e. if σ increases, the market power of each firm producing one variety decreases and so does also her profit. Therefore, the decrease in the profit induces the equilibrium wages to be lower because of the impossibility for the firms to pay the workers more.

2.3 Open Economy

Now it is possibile to open the economy and to study the effects of globalization in sector one or in sector two. In order for the normalization of the wages of blue collar workers to hold in both the countries, we assume that the numeraire good is always tradable between the countries without any frictional cost of trade. The manufacturing goods can be traded between the countries, but the trade incurs in standard iceberg costs.
When a good is traded between two countries, the firm must pay a cost for the movement of this good and this cost is modelled as an iceberg cost, i.e. in order to sell one unit of good abroad, a firm has to produce $\tau > 1$ units because $\tau - 1$ units are "lost" during transportation. Thus, the firm can now decide the price of her variety both in the domestic (p_i) and in the foreign market (p_i^*), hence it is possible to rewrite the firm maximization problem in the following way.

$$\begin{aligned}\max_{p_i,p_i^*} \pi_i =& p_i q_i + p_i^* q_i^* - q_i - \tau_i q_i^* - F_i \\ s.t.\ \ q_i =& \Big(\frac{p_i}{P_i}\Big)^{-\sigma} \frac{\alpha\beta_i E}{P_i} \\ q_i^* =& \Big(\frac{p_i^*}{P_i^*}\Big)^{-\sigma} \frac{\alpha^*\beta_i^* E^*}{P_i^*}\end{aligned} \tag{2.18}$$

Where F_i are the fixed costs payed by the firms in the i sector and are equal to w_1 in sector one and $w_1 + w_2$ in sector two. The perfect price indexes (P_i and P_i^*) are different and must be rewritten in the following way:

$$\begin{aligned}P_i = \Big(\int_0^{n_i} p_i^{1-\sigma} + \int_0^{n_i^*} p_i^{*1-\sigma}\Big)^{\frac{1}{1-\sigma}} =& p_i(n_i + n_i^*\tau_i^{1-\sigma})^{\frac{1}{1-\sigma}} \\ P_i^* = p_i(n_i\tau_i^{1-\sigma} + & n_i^*)^{\frac{1}{1-\sigma}}\end{aligned} \tag{2.19}$$

Therefore the optimal prices set by the firms in sector i are:

$$\begin{aligned}p_i =& \frac{\sigma}{\sigma - 1} \\ p_i^* =& \frac{\sigma}{\sigma - 1}\tau_i = \tau_i p_i\end{aligned} \tag{2.20}$$

Thus, the optimized profit for the firms in sector i, when the sector is open to trade, (respectively in the domestic and foreign country) is the following[4].

$$\begin{aligned}\pi_i =& \frac{\alpha\beta_i E}{n_i + n_i^*\tau_i^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha^*\beta_i^* E^*\tau^{1-\sigma}}{n_i^* + n_i\tau_i^{1-\sigma}}\frac{1}{\sigma} - F_i \\ \pi_i^* =& \frac{\alpha^*\beta_i^* E^*}{n_i^* + n_i\tau_i^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_i E\tau^{1-\sigma}}{n_i + n_i^*\tau_i^{1-\sigma}}\frac{1}{\sigma} - F_i^*\end{aligned} \tag{2.21}$$

Since specialized workers are immobile across countries, the fixed costs payed by two firms producing in the same sector and in different countries could be different since it is related to the wage of each specialized workers in each country.

$$\begin{aligned}F_i &= \sum_{j=1}^{i} w_j \\ F_i^* &= \sum_{j=1}^{i} w_j^*\end{aligned} \tag{2.22}$$

The last element to consider before completing the characterization of the open economy equilibrium is the agricultural sector. Since the agricultural good can be traded without incurring in any trade costs and since the sector is perfectly competitive in both the countries, we observe that $p_A = p_A^* = 1$ and that the normalization of the wages of blue collar workers to 1 holds.

Therefore now I have all the elements to study the conditions required to characterize the equilibrium in the open economy case. The conditions that must hold are the labor market clearings conditions, the free entry conditions and the earning conditions.
In my model, specialized workers cannot move between the two countries, thus, the number of firms depends on the number of specialized workers, in particular:

$$\begin{aligned}n_i &= R_i - R_{i+1} \\ n_i^* &= R_i^* - R_{i+1}^*\end{aligned} \tag{2.23}$$

[4]we can write them also as domestic (D) and foreign (F) countries profits: $\pi_D = \frac{\alpha_D\beta_{iD}E_D}{n_{iD}+n_{iF}\tau_i^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha_F\beta_{iF}E_F\tau^{1-\sigma}}{n_{iF}+n_{iD}\tau_i^{1-\sigma}}\frac{1}{\sigma} - F_{iD}$ and $\pi_{iF} = \frac{\alpha_F\beta_{iF}E_F}{n_{iF}+n_{iD}\tau_i^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_{iD}E_D\tau^{1-\sigma}}{n_{iD}+n_{iF}\tau_i^{1-\sigma}}\frac{1}{\sigma} - F_{iF}$

Notice that, the workers in the agricultural sectors will clear the blue collar market since they are defined as the residual of blue collar workers not used in the manufacturing sectors.
Finally the earning conditions can be written as the following.

$$\begin{aligned} \sum_{i=1}^{2} w_i R_i + L = E \\ \sum_{i=1}^{2} w_i^* R_i^* + L^* = E^* \end{aligned} \tag{2.24}$$

It is then possible to focus on the effects of opening a particular sector between the two countries.
The paper will first focus on the identical countries scenario first opening the border of the least complex sector (one) and then of the most complex sector (two), after that I will analyze the case in which the countries differ in some characteristics and I wil study the effects of trade on workers' wages in these scenarios.

2.3.1 Identical Countries

Globalization in Sector 1

The profit for the firms in sector one and two in the two countries are:

$$\begin{aligned}\pi_1 =& \frac{\alpha\beta_1 E}{n_1 + n_1^*\tau_1^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha^*\beta_1^* E^*\tau_1^{1-\sigma}}{n_1^* + n_1\tau_1^{1-\sigma}}\frac{1}{\sigma} - F_1 \\ \pi_1^* =& \frac{\alpha^*\beta_1^* E^*}{n_1^* + n_1\tau_1^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_1 E\tau_1^{1-\sigma}}{n_1 + n_1^*\tau_1^{1-\sigma}}\frac{1}{\sigma} - F_1^*\end{aligned} \tag{2.25}$$

$$\begin{aligned}\pi_2 =& \frac{\alpha\beta_2 E}{n_2}\frac{1}{\sigma} - F_2 \\ \pi_2^* =& \frac{\alpha^*\beta_2^* E^*}{n_2^*}\frac{1}{\sigma} - F_2^*\end{aligned} \tag{2.26}$$

Since the two countries are identical[5], the profit are:

$$\begin{aligned}\pi_1 =& \frac{\alpha\beta_1 E}{n_1}\frac{1}{\sigma} - w_1 \\ \pi_1^* =& \frac{\alpha\beta_1 E}{n_1}\frac{1}{\sigma} - w_1\end{aligned} \tag{2.27}$$

$$\begin{aligned}\pi_2 =& \frac{\alpha\beta_2 E}{n_2}\frac{1}{\sigma} - (w_1 + w_2) \\ \pi_2^* =& \frac{\alpha\beta_2 E}{n_2}\frac{1}{\sigma} - (w_1 + w_2)\end{aligned} \tag{2.28}$$

The labor market clearing conditions are then:

$$\begin{aligned}n_1 =& R_1 - R_2 \\ n_2 =& R_2\end{aligned} \tag{2.29}$$

Since in the open economy scenario, the agricultural good is freely tradable without any trade costs, it it not needed to impose the total demand of the agricultural sector to be completely satisfied by the production in the countries. This implies that, the total number of blue collar workers in the agricultural sector (L_A) will be the residual number of workers not employed in the two manufacturing sectors, thus, allowing the blue collar labor market condition to be always cleared.
Therefore it is then possible to study the equilibrium wages in the case of identical coun-

[5] $\alpha = \alpha^*$, $\beta_i = \beta_i^*$ $R_i = R_i^* \Rightarrow n_i = n_i^*$ and $w_i = w_i^* \Rightarrow E = E^*$

tries and globalization in sector one[6].

$$
\begin{aligned}
w_1 &= \frac{\alpha\beta_1 L}{(R_1 - R_2)(\sigma - \alpha)} \\
w_2 &= \frac{\alpha L(R_1(1-\beta_1) - R_2)}{R_2(R_1 - R_2)(\sigma - \alpha)}
\end{aligned}
\tag{2.30}
$$

In the very basic case in which $R_1 = R_1^*$ $R_2 = R_2^*$ $L = L^*$ $\beta_1 = \beta_1^*$ ($\Rightarrow$ $\beta_2 = \beta_2^*$) it is straightforward that the equilibrium wages will be identical for the two countries. Moreover we find that in this scenario, the wages are not affected by trade, this implies that they don't change with or without the globalization.

If two countries, identical in every aspect, engage into trade, they will not observe any change in the workers wages.

Different countries

The more interesting case is the one in which the two countries differ in one characteristic. More specifically in the next sections I will discuss the effects of trade in each of the two sectors if the countries differ either in their preferences or in the number of each type of specialized workers.

2.3.2 Differences in Preferences

In this section the two countries are completely identical except for their preferences over the two manufacturing sectors, i.e. they are different in β. More specifically the paper will cover the case in which trade is available in the first sector and then it will focus on the opening to trade of the second sector.

[6] it would happen the same if the sector opened to trade were sector two

Globalization in sector 1

Allowing firms in sector one to trade between the countries will lead to the following free entry conditions.

$$\begin{aligned}
\pi_1 =& \frac{\alpha}{n_1 + n_1\tau^{1-\sigma}}\frac{1}{\sigma}(\beta_1 E + \beta_1^* E^* \tau^{1-\sigma}) - w_1 = 0 \\
\pi_1^* =& \frac{\alpha}{n_1 + n_1\tau^{1-\sigma}}\frac{1}{\sigma}(\beta_1^* E^* + \beta_1 E \tau^{1-\sigma}) - w_1^* = 0 \\
\pi_2 =& \frac{\alpha(1-\beta_1)E}{n_2}\frac{1}{\sigma} - (w_1 + w_2) = 0 \\
\pi_2^* =& \frac{\alpha(1-\beta_1^*)E^*}{n_2}\frac{1}{\sigma} - (w_1^* + w_2^*) = 0
\end{aligned} \tag{2.31}$$

Finding the equilibrium wages for two specialized workers in the two countries allows to study how they change with respect to their autarky level.
More specifically workers with specialization one (the least specialized workers) will benefit from globalization if the following condition is satisfied.

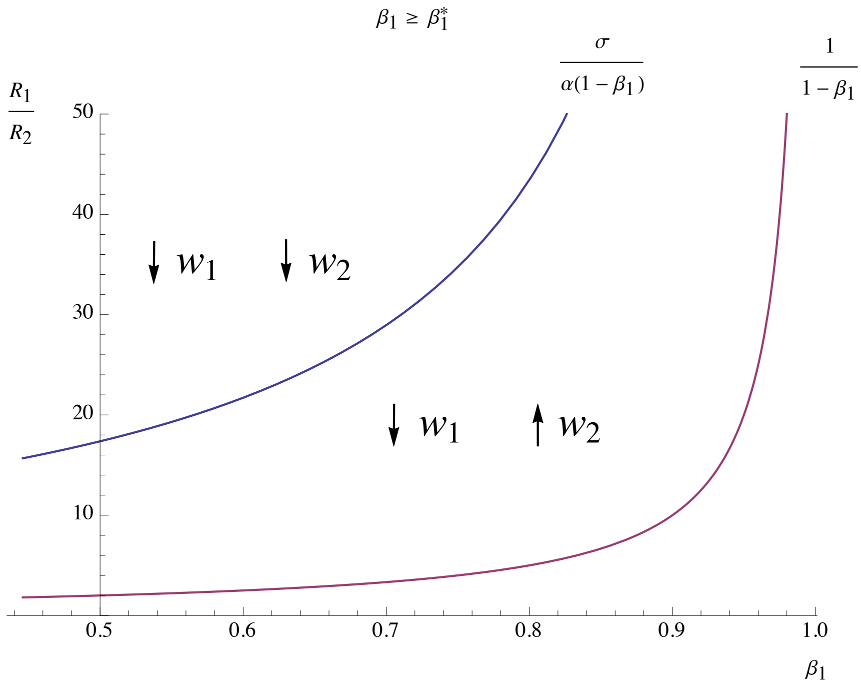
$$\beta_1 \leq \beta_1^* \tag{2.32}$$

Meanwhile the wages of workers with specialization two (the most specialized workers) will increase if the following conditions are met.

$$\begin{aligned}
&\text{if } \beta_1 < \beta_1^* \text{ and } \frac{R_1}{R_2} \geq \frac{\sigma}{\alpha(1-\beta_1)} \\
&\text{or if } \beta_1 > \beta_1^* \text{ and } \frac{R_1}{R_2} \leq \frac{\sigma}{\alpha(1-\beta_1)}
\end{aligned} \tag{2.33}$$

Therefore we can represent the effects of globalization in sector one on the wages of the two specialized workers in fig. 2.1 and in fig. 2.2:

Figure 2.1: Effects of Globalization in sector 1



Effects of Globalization in sector 1 for the wages of workers with specialization one and two in the domestic country if $\beta_1 \geq \beta_1^*$ considering the case in which all the sectors are active. For further analysis see Appendix B.1

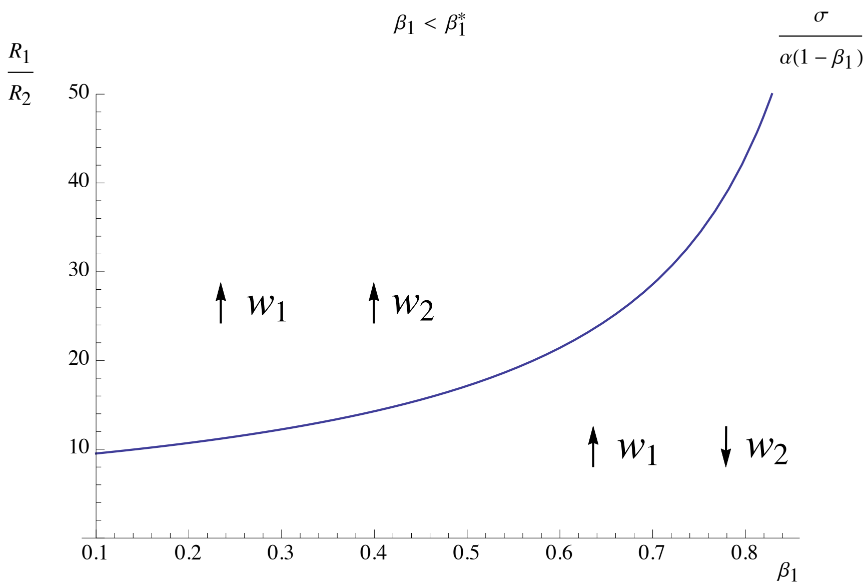
Let's study one by one all the possible cases and the related effects of globalization.

In the case in which $\beta_1 \geq \beta_1^*$ (fig.2.1), the workers with specialization one will suffer from globalization. This happens because the opening to the foreign consumers has affected the domestic firms in two different ways, there has been an increase in competition and an increase in the market size. Since the foreign consumers are less incline to spend in sector one than the domestic consumers because $\beta_1 \geq \beta_1^*$, then the increase in market size is overcome by the increase in competition and so the firms in sector one will end up having lower profits. The free entry conditions imply that the firms have to pay less the workers with specialization one and therefore this leads to a decrease in their wages.
At the same time, the decrease in the wages of workers with specialization one benefits firms in sector two. This is true because those firms, which, because of autarky, don't experience the increase in competition, can now pay less the workers with specialization one. The free entry condition of sector two implies that firms in sector two must pay more the workers with specialization two, this is the reason why we observe an increase in the wage of workers specialized in two in the fig.2.1.

Notice that after a certain threshold of the ratio of the least specialized over the most specialized workers, the wages of workers specialized in two start decreasing. This "economic crisis effect" happens because of the effects of the reduction in wages on the total earnings available to sector two.
In particular, the reduction of the wages of workers specialized in one produces a reduction of the total earnings available for both sector one and sector two, this implies that, not only the firms in sector one will experience a reduction in their profits, but also will do so the firms in sector two. Therefore, for the free entry conditions to hold, the workers with specialization two must be payed less too.
In order to understand when this crisis effect takes place we must study the threshold level. In particular when the ratio $\frac{R_1}{R_2}$ is high enough this second effect takes place, this happens because, if the number of workers specialized in one is high, then the reduction in their wages affects more the overall economy and thus the sector two too.
Moreover, studying the threshold level we notice that an increase in β_1 increases the threshold over which the wages of workers two are negatively affected by globalization in sector one. This happens because if β_1 is high, this means that the part of the earnings used for sector two $(1-\beta_1)$ is low, in turns this implies that the greatest effect of the reduction of total earnings is on sector one rather than on sector two, therefore this implies that it is required an higher ratio $\frac{R_1}{R_2}$ to trigger this crisis effect.

Now I study the effects of globalization on the domestic country when $\beta_1 < \beta_1^*$ (fig.2.2). When foreign consumers are more incline to spend their earnings in sector one, it is easy to observe an increase of the wages of workers specialized in one in the domestic country. This happens because, as I clarified before, the competition effect and the market size effect take place and thus, when $\beta_1 < \beta_1^*$ the market size effect overcome the competition one allowing the firms in sector one to pay more their workers.
As before, the effect of globalization in sector one on the wages of workers specialized in one has an impact on the workers specialized in two. In particular, since now firms in sector two must pay more the workers in sector one, they must pay less the workers with specialization two.
Again, above a certain threshold of $\frac{R_1}{R_2}$, the effect on the wages of workers two changes, in particular now workers with specialization two experience an increase in their wages if $\frac{R_1}{R_2}$ is high enough. This "economic boom" effect happens because the increase in wages of workers one produces an increase in total earnings and thus and increase in the profits for firms in sector two which in turns are able to pay more the workers in sector two.
As before, the threshold is higher for higher values of β_1 because, in order to trigger this effect, a higher $\frac{R_1}{R_2}$ is required since the sector mostly affected by the increase in earnings

Figure 2.2: Effects of Globalization in sector 1



Effects of Globalization in sector 1 for the wages of workers with specialization one and two in the domestic country if $\beta_1 < \beta_1^*$ considering the case in which all the sectors are active. For further analysis see Appendix B.1.

is sector one (due to the higher β_1).

It is also useful to make the comparative static analysis on the effect of globalization, i.e. on the effect of an infinitesimal increase in trade costs on the difference of the wages before and after globalization.

Studying the effect of an increase in τ on the difference between the wages of workers with specialization one before and after the globalization, we find the following effect[7].

$$\begin{aligned} &\frac{\partial(w_{1,after} - w_{1,before})}{\partial\tau} \geq 0 \text{ if } \beta_1^* \leq \beta_1 \\ &\frac{\partial(w_{1,after} - w_{1,before})}{\partial\tau} < 0 \text{ if } \beta_1^* > \beta_1 \end{aligned} \tag{2.34}$$

[7]Studying the partial derivative of the difference between the wages after and before globalization is the same as to study the effect of τ on the wages after globalization since the formulation of the wages before globalization is not a function of τ

Meanwhile the wages of workers with specialization two are affected by an increase in the trade costs in the globalization one scenario in the following way:

$$\begin{gathered}\text{if } \beta_1 < \beta_1^* \text{ then} \\ \frac{\partial(w_{2,after} - w_{2,before})}{\partial\tau} \geq 0 \text{ if } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \\ \text{if } \beta_1 > \beta_1^* \text{ then} \\ \frac{\partial(w_{2,after} - w_{2,before})}{\partial\tau} \geq 0 \text{ if } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)}\end{gathered} \tag{2.35}$$

From the above findings we observe that when $\beta_1 \geq \beta_1^*$ the increase in τ, which implies a reduction of the globalization of sector one between the two countries, produces an increase in the wages of workers with specialization one. This happens because globalization induces those workers to be worse off due to the already mentioned effects and therefore, a reduction in globalization would benefit them.
At the same time, the effect of the increase in τ on the wages of workers with specialization two depends upon the level of $\frac{R_1}{R_2}$. As I already mentioned, if $\beta_1 < \beta_1^*$ the wages of workers specialized in two increase only after the threshold level of $\frac{R_1}{R_2}$ due to the economic boom effect, thus, I find that an increase in τ induces a decrease in the wages of workers with specialization two only if $\frac{R_1}{R_2}$ is above that threshold, otherwise a reduction in globalization induces an increase of the wages of workers specialized in two.
Applying the same reasoning, if $\beta_1 \geq \beta_1^*$ an increase in τ increases wages of workers with specialization two only if $\frac{R_1}{R_2}$ is above the mentioned threshold.

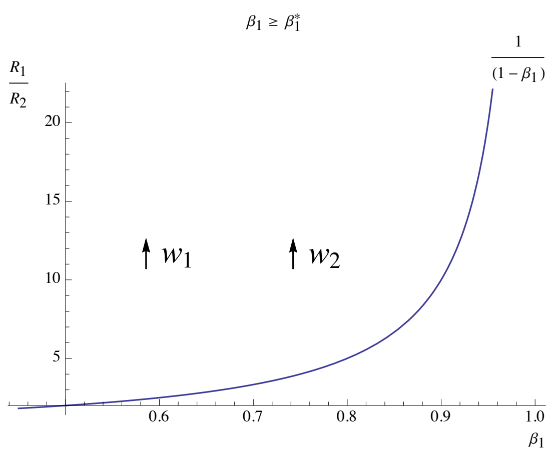
Globalization in Sector 2

This section focuses on the effects of allowing international trade in the second (most complex) sector. As before, imposing the free entry conditions in the two sectors we get what follows.

$$\begin{aligned}
\pi_1 =& \frac{\alpha\beta_1 E}{n_1}\frac{1}{\sigma} - w_1 = 0 \\
\pi_1^* =& \frac{\alpha\beta_1^* E^*}{n_1}\frac{1}{\sigma} - w_1^* = 0 \\
\pi_2 =& \frac{\alpha}{n_2 + n_2\tau^{1-\sigma}}\frac{1}{\sigma}(\beta_2 E + \beta_2^* E^* \tau^{1-\sigma}) - (w_1 + w_2) = 0 \\
\pi_2^* =& \frac{\alpha}{n_2 + n_2\tau^{1-\sigma}}\frac{1}{\sigma}(\beta_2^* E^* + \beta_2 E \tau^{1-\sigma}) - (w_1^* + w_2^*) = 0
\end{aligned} \tag{2.36}$$

Therefore, finding the equilibrium wages of the two types of specialized workers and comparing the results with the previous (closed economy) level of them, I find that, if all sectors are active[8] then, the effects of globalization in sector two are represented in the fig.2.3 and in fig.2.4

Figure 2.3: Effects of Globalization in sector 2

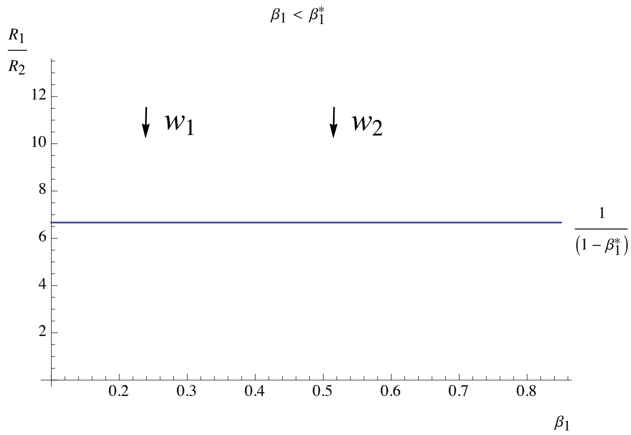


Effects of Globalization in sector 2 for the wages of workers with specialization one and two in the domestic country if $\beta_1 \geq \beta_1^*$ considering the case in which all the sectors are active. For further analysis see Appendix B.2

.

[8]see B.2 for calculations

Figure 2.4: Effects of Globalization in sector 2



Effects of Globalization in sector 2 for the wages of workers with specialization one and two in the domestic country if $\beta_1 < \beta_1^*$ considering the case in which all the sectors are active. $\frac{1}{1-\beta_1}$ and $\frac{1}{1-\beta_1^*}$ are the threshold levels under which we do not observe all the sectors to be active. For further analysis see Appendix B.2.

In fig.2.3 the effect of globalization in sector two if $\beta_1 \geq \beta_1^*$ is positive for both the two types of specialized workers.
Since $\beta_1 \geq \beta_1^*$, this implies that $\beta_2 \leq \beta_2^*$, thus, the market size effect of globalization is stronger than the competition effect for the domestic firms.
The increase in the market size for the domestic firms producing in sector two, induces an increase in the profits of those firms and in turns, due to the free entry conditions, both the wages of the two types of workers must increase. Here I don't observe a different effect for the two type of workers because they are both used in the most complex sector which is the one that has been globalized.

Moving to fig.2.4 I find that for $\beta_1 < \beta_1^*$ the wages of both the two types of workers decrease. This is due to the increase in competition in sector two for the domestic firms which has not been overcome by an increase in the market size since $\beta_1 < \beta_1^*$. Again here, since the firms in sector two employ both the two specialized workers, they must reduce their salary for the free entry condition to hold.

Now I study the effects of an increase in trade costs on the wages of the two type of specialized workers in this scenario.

$$\begin{aligned}\frac{\partial(w_{1,after}-w_{1,before})}{\partial\tau} &\geq 0 \text{ if } \beta_1 \leq \beta_1^* \\ \frac{\partial(w_{1,after}-w_{1,before})}{\partial\tau} &< 0 \text{ if } \beta_1 > \beta_1^*\end{aligned} \tag{2.37}$$

$$\begin{aligned}\frac{\partial(w_{2,after}-w_{2,before})}{\partial\tau} &\geq 0 \text{ if } \beta_1 < \beta_1^* \\ \frac{\partial(w_{2,after}-w_{2,before})}{\partial\tau} &< 0 \text{ if } \beta_1 > \beta_1^*\end{aligned} \tag{2.38}$$

Notice that here again the effect of increasing τ is linearly the opposite of the effect of globalization. In particular when $\beta_1 \leq \beta_1^*$ since globalization produces a decrease in the wages of workers with specialization one and two, a decrease in globalization, through an increase in τ, induces to a rise in both the wages. The opposite happens if instead $\beta_1 > \beta_1^*$.

In fig. 2.5 the results obtained in the already mentioned scenarios of the two sectors opened to trade are summarized.

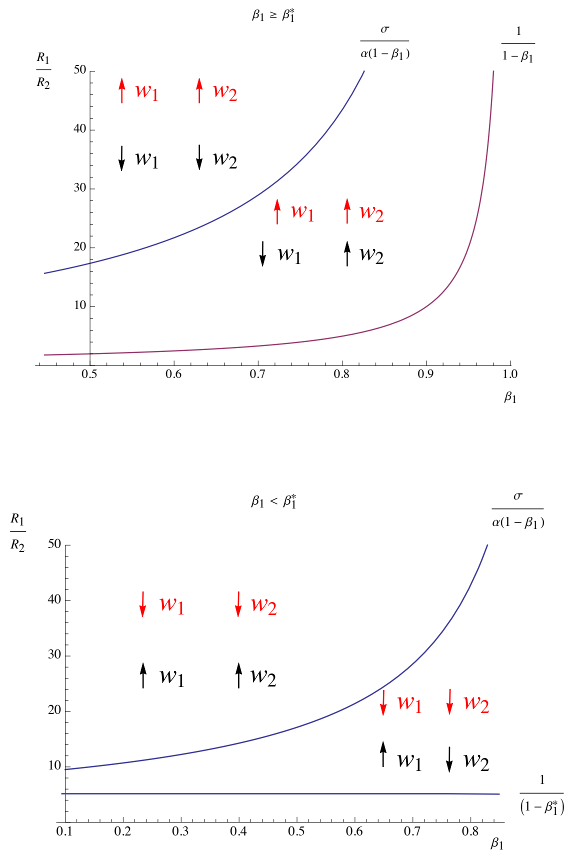
After focusing on the effects of globalization on the wages of the two type of workers separately, it is useful to have a look to the ratio of the two wages. In particular, while different papers in the cited literature focus on the "skill premium" meant as the share of the high skilled worker's wage over the low skilled worker's one, I focus on the share of the wages of the two types of skilled workers. Thus I study what happens to the "Specialization Premium" after globalization. For this purpose I compute the specialization premium before and after globalization and then I study under which conditions it increases or decreases.

Considering the scenario of two countries with different preferences over the manufacturing sector, it is easy to prove that both with globalization one and with globalization two the specialization premium in the domestic country increases if $\beta_1 > \beta_1^*$:

$$\frac{w_{2,afterglob}}{w_{1,afterglob}} > \frac{w_{2,closed}}{w_{1,closed}} \quad \text{if} \quad \beta_1 > \beta_1^* \tag{2.39}$$

Even though the model gives a clear condition under which the specialization premium rises, the mechanism behind differ according to the type of globalization and to the different level of $\frac{R_1}{R_2}$.

Figure 2.5: Effects of Globalization in sector 1 and 2



Effects of Globalization in sector 1 (black) and in sector two (red) for the wages of workers with specialization one and two in the domestic country if $\beta_1 \geq \beta_1^*$ and if $\beta_1 < \beta_1^*$ considering the case in which all the sectors are active.

Considering the scenario in which $\beta_1 > \beta_1^*$, if the domestic country opens the border of sector one, this will induce, for low enough level of $\frac{R_1}{R_2}$ a reduction of the wage of workers specialized in one and an increase in wages of workers specialized in two which leads to an increase in the ratio between the two (specialization premium). At the same time, if instead $\frac{R_1}{R_2}$ is high enough, the economic crisis effect is much stronger for those workers which are less specialized because, even though both the two type of workers observe a reduction in wages, the specialization premium increases.

If instead the domestic country decide to open the border of sector two, both the wages of workers specialized in one and two observe an increase in wages, but, this increase, is asymmetric. More specifically the increase in wage of workers with specialization two is higher than the increase of wages of workers with specialization one. Thus, the overall positive effect of globalization two is spread unequally across different types of workers.

If instead we analyze the case in which $\beta_1 < \beta_1^*$, then inequality between the two type of workers decreases. Again here the mechanisms behind this result differ according to the type of globalization and to the level of $\frac{R_1}{R_2}$ and are the opposite of the ones analyzed in the case of $\beta_1 > \beta_1^*$.

2.3.3 Differences in the least specialized workers

This section analyzes the scenario in which the two countries differ only for the endowment of workers with specialization one (the least specialized workers), thus $R_1 \neq R_1^*$.

Globalization in Sector 1

Globalization in sector one implies the following profit functions for the firms in the two sectors in the two countries.

$$\begin{aligned}
\pi_1 =& \frac{\alpha\beta_1 E}{n_1 + n_1^*\tau^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_1 E^*\tau^{1-\sigma}}{n_1^* + n_1\tau^{1-\sigma}}\frac{1}{\sigma} - w_1 \\
\pi_1^* =& \frac{\alpha\beta_1 E^*}{n_1^* + n_1\tau^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_1 E\tau^{1-\sigma}}{n_1 + n_1^*\tau^{1-\sigma}}\frac{1}{\sigma} - w_1^* \\
\pi_2 =& \frac{\alpha\beta_2 E}{n_2}\frac{1}{\sigma} - (w_1 + w_2) \\
\pi_2^* =& \frac{\alpha\beta_2 E^*}{n_2^*}\frac{1}{\sigma} - (w_1^* + w_2^*)
\end{aligned} \tag{2.40}$$

Firstly I study the effect of globalization in sector one on the wages of the two types of workers in the domestic country[9].
The wages of workers specialized in one increase if $R_1 \geq R_1^*$ meanwhile, the wages of the workers with specialization two increase under the following conditions:

$$\begin{aligned}
R_1 \geq R_1^* \text{ and } \frac{R_1}{R_2} \geq \frac{\sigma}{\alpha(1-\beta_1)} \\
R_1 < R_1^* \text{ and } \frac{R_1}{R_2} \leq \frac{\sigma}{\alpha(1-\beta_1)}
\end{aligned} \tag{2.41}$$

Therefore the effects of globalization one on the two wages can be summarized in fig.2.6.

When the number of workers with specialization one is higher in the domestic country than in the foreign country the effect of globalization in sector one for those workers is positive. In particular, when globalization of sector one happens, domestic firms in sector one have the access to a bigger market and, at the same time, face higher competition. Since the workers with specialization one are less in the foreign country than in the domestic one, the firms in sector one are also fewer, this, in turns, implies a small competition effect for the domestic firms.

[9] see B.3 for calculations

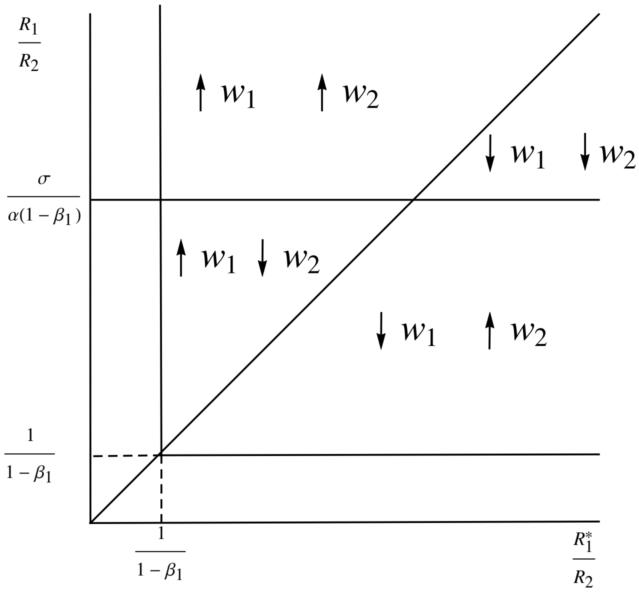


Figure 2.6: Effects of Globalization in sector 1 for the wages of workers with specialization one and two in the domestic country.

While the small competition effect reduces slightly the profits of the domestic firms in sector one, the market size effect allows those firms to increase their profits. The overall effect, in case of $R_1 > R_1^*$, is positive for the domestic firms which have now higher profits. In order for the free entry condition to hold, it is then required an increase in the wages of workers with specialization one and this is the reason why we observe an increase in w_1 if $R_1 > R_1^*$. The opposite reasoning works if $R_1 < R_1^*$, in this case the wages of those specialized workers decrease after globalization.

Globalization in sector one has a different effect on workers with specialization two. If $\frac{R_1}{R_2} \geq \frac{R_1^*}{R_2}$, the increase of the wage of workers with specialization one implies for the firms in sector two a decrease of the wages of workers with specialization two. This happens because the free entry condition must hold in equilibrium and thus, since the increase in wages of workers specialized in one implies a reduction of the profits of the firms in sector two, they must pay less the workers with specialization two in order to compensate this loss.

From the fig.2.6 it can be noticed that, as it happened in the case of countries with different β, the effect of globalization one on the wages of workers specialized in two changes whenever $\frac{R_1}{R_2}$ is above a certain threshold.

In particular, when $\frac{R_1}{R_2} \geq \frac{R_1^*}{R_2}$, and if $\frac{R_1}{R_2}$ is high enough, the increase of the wages of workers with specialization one has a huge effect on the whole economy. In particular, the overall earnings are higher due to the rise of the wages of workers one and due to the high number of workers one with respect to workers specialized in two, therefore this economic boom effect affects also the sector two through an increase in the profits of the firms in this sector allowing them to rise the wages of workers with specialization two.

The same reasoning (but in the opposite direction) works when considering the scenario in which $\frac{R_1}{R_2} < \frac{R_1^*}{R_2}$. For low values of $\frac{R_1}{R_2}$ the reduction in wages of workers specialized in one implies an increase of the wages of the other type of workers, instead, for $\frac{R_1}{R_2}$ high enough, the economic crisis effect induces an overall decrease in total earnings and thus, a decrease of the profits of firms in sector two too. The threshold level is affected positively by β_1 because the increase in the preference of the consumers for sector one implies a delay of the effects of globalization in sector one on the workers with specialization two.

In the following paragraph I study the effect of an increase in trade costs on the wages of the two types of specialized workers.

From the analysis of the partial derivative of the wage of workers with specialization one with respect to τ, it can be noticed that, considering the case in which $R_1 > R_1^*$, even though the wage increases with respect to the closed economy, the effect of the trade costs is non-monotonic, in fact for high values of alpha and beta and/or low values of sigma, the effect is positive, otherwise it is negative.

The opposite is true in the case in which $R_1 < R_1^*$, in particular, for low values of alpha and beta and high values of sigma the effect is positive, otherwise it is negative (see B.3 for further analysis).

The wages of workers with specialization two experience a non-monotonic effect of τ too, but this time, not only will the relative value of R_1 with respect to R_1^* matter , but also the relationship between $\frac{R_1}{R_2}$ and $\frac{\sigma}{\alpha(1-\beta_1)}$ will.

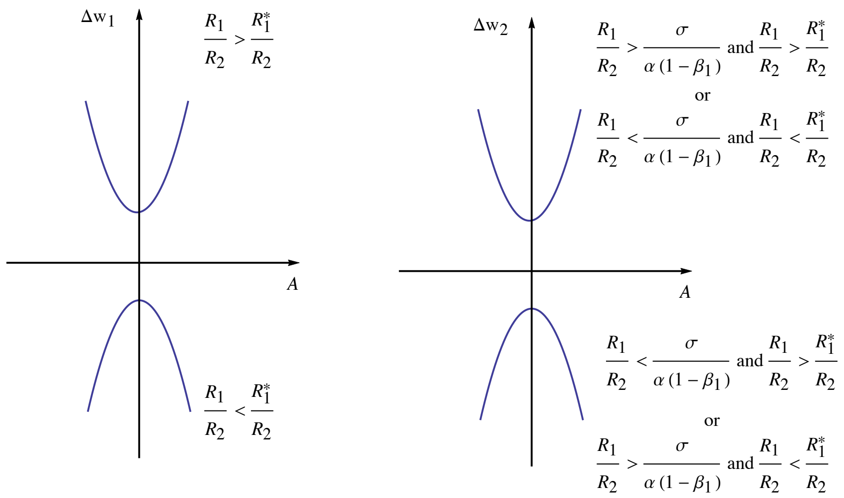
In particular, for low alpha and beta and/or high level of sigma, globalization induces an increase in the wages of workers with specialization two either if $R_1 > R_1^*$ and $\frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)}$ or if $R_1 < R_1^*$ and $\frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)}$. For the same levels of alpha and betas, an increase in globalization induces a decrease in the wages of workers two either if $R_1 > R_1^*$ and $\frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)}$ or if $R_1 < R_1^*$ and $\frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)}$[10].

The reason for these results is that workers with specialization two, when they benefit from globalization, they will experience a u-shaped path of their wages with respect to a function $A(\alpha, \sigma, \beta, \tau) = (\tau^{2\sigma} - \tau^2)(\sigma - \alpha) - 2\alpha\beta_1\tau^2$ which is increasing in σ and decreasing in α and β. Meanwhile, if instead those workers experience a decrease in their wage with respect to the closed economy scenario, the effect of globalization on the wage is inverse

[10] see B.3 for further calculations

u-shaped with respect to the function $A(.)$ (see fig. 2.7).

Figure 2.7: Effects of Globalization in sector 1 and 2



Effects of Globalization in sector 1 for the wages of workers with specialization one (left) and two (right) in the domestic country

As in the previous section, I study also the effect of globalization on inequality among workers. In particular I find that the specialization premium is increasing due to globalization in sector one if $R_1 < R_1^*$

$$\frac{w_{2,afterglob}}{w_{1,afterglob}} > \frac{w_{2,closed}}{w_{1,closed}} \quad \text{if} \quad R_1 < R_1^* \tag{2.42}$$

Studying the mechanisms behind this result it can be noticed that, if $R_1 < R_1^*$, under a certain threshold of $\frac{R_1}{R_2}$, there is an asymmetric effect on the wages of the two types of workers (an increase in the wages of workers with specialization two and a decrease in the wages of workers with specialization one) which leads immediately to an increase in inequality due to globalization. If instead $\frac{R_1}{R_2}$ is high enough, the economic crisis effect affects the workers with the lowest type of specialization with more severity. More specifically, while both the two types of workers observe a decrease in their wages, this downfall is stronger for those workers with specialization one and this is the reason why I observe an increase in inequality after globalization.

Considering the scenario of $R_1 > R_1^*$, the domestic country experiences a decrease in inequality which is due to an asymmetric effect of globalization on the two types of workers when the ratio of high-specialized low-specialized workers is low enough, and which is due to an overall economic boom which benefit the workers with specialization one more than those which specialization two if that ratio is high enough.

Globalization in Sector 2

Now I study the effect of opening the borders of sector two in the two countries if $R_1 \neq R_1^*$. The profits for the firms in the two sectors in the two countries are the following.

$$
\begin{aligned}
\pi_1 =& \frac{\alpha\beta_1 E}{n_1}\frac{1}{\sigma} - w_1 \\
\pi_1^* =& \frac{\alpha\beta_1 E^*}{n_1^*}\frac{1}{\sigma} - w_1^* \\
\pi_2 =& \frac{\alpha\beta_2 E}{n_2 + n_2^*\tau^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_2 E^*\tau^{1-\sigma}}{n_2^* + n_2\tau^{1-\sigma}}\frac{1}{\sigma} - (w_1 + w_2) \\
\pi_2^* =& \frac{\alpha\beta_2 E^*}{n_2^* + n_2\tau^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_2 E\tau^{1-\sigma}}{n_2 + n_2^*\tau^{1-\sigma}}\frac{1}{\sigma} - (w_1^* + w_2^*)
\end{aligned}
\tag{2.43}
$$

The equilibrium wages after the globalization coincide with the wages before it. Globalization in sector two does not affect the wages of the two type of workers which remain equal to their closed economy level if $R_2 = R_2^*$.

This happens because the number of workers with specialization two in each country is the same, this implies that, in equilibrium, the number of firms in sector two are the same in both the two countries. Since now the only sector which is open is the second one, the market size effect and the competition effect have an overall null effect on the wages of workers with specialization two. Since workers specialized in two don't experience any change in their wages, then firms in sector two cannot change the wages of workers with specialization one without breaking the free entry condition. In turn this implies that, since the sector one is closed, workers with specialization one don't experience any change in their wages, therefore the overall effect of globalization appears to be null on the two wages.

Concluding, I find that, either when two countries are identical or when the two countries have the same number of workers with the highest specialization, i.e the specialization used only by the most complex sector in the market, opening the border of the most complex good does not affect the wages of the workers.

2.3.4 Differences in the most specialized workers

Finally this section studies the scenario in which the two countries have a different endowment of the workers with specialization two (the most specialized workers), i.e. $R_2 \neq R_2^*$.

Globalization in Sector 1

The profits of firms in sector one and two in the two countries after the globalization in sector one if $R_2 \neq R_2^*$ are the following.

$$
\begin{aligned}
\pi_1 =& \frac{\alpha\beta_1 E}{n_1 + n_1^* \tau^{1-\sigma}} \frac{1}{\sigma} + \frac{\alpha\beta_1 E^* \tau^{1-\sigma}}{n_1^* + n_1 \tau^{1-\sigma}} \frac{1}{\sigma} - w_1 \\
\pi_1^* =& \frac{\alpha\beta_1 E^*}{n_1^* + n_1 \tau^{1-\sigma}} \frac{1}{\sigma} + \frac{\alpha\beta_1 E \tau^{1-\sigma}}{n_1 + n_1^* \tau^{1-\sigma}} \frac{1}{\sigma} - w_1^* \\
\pi_2 =& \frac{\alpha\beta_2 E}{n_2} \frac{1}{\sigma} - (w_1 + w_2) \\
\pi_2^* =& \frac{\alpha\beta_2 E^*}{n_2^*} \frac{1}{\sigma} - (w_1^* + w_2^*)
\end{aligned}
\tag{2.44}
$$

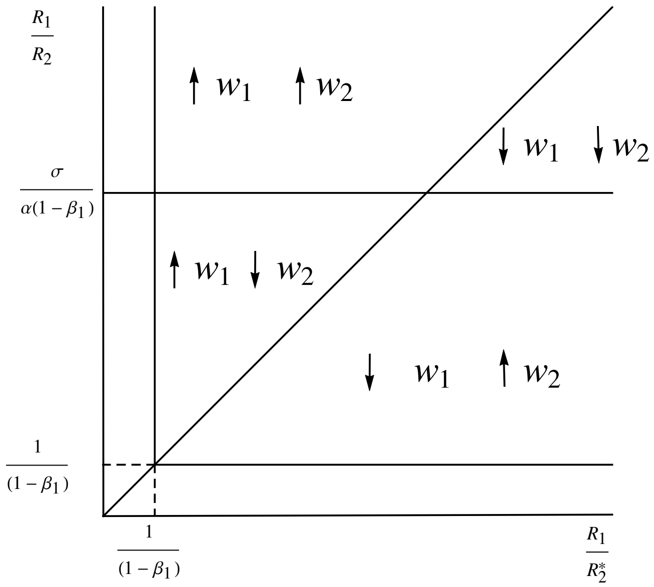
The resulting equilibrium wages for this scenario imply that workers with specialization one observe an increase in their wage if $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$ and workers with specialization two observe an increase in their wage if the following conditions are satisfied.

$$
\begin{gathered}
\frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \\
or \\
\frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)}
\end{gathered}
\tag{2.45}
$$

The effects of globalization in sector one are summarized in fig. 2.8.

When the number of workers with specialization two is lower in the domestic country than in the foreign country, opening sector one produces an increase in the wage of workers with specialization one and a non monotonic effect on the wage of workers with the second specialization. This is due to the fact that the lower number of workers with the highest specialization in the domestic country induces, in equilibrium, through the labor market clearing condition, a higher number of firms in sector one in the domestic country than in the foreign country. When the borders for sector one are open, the domestic firms in sector one have to face a lower competition than the one faced by the foreign firms in the same sector, thus, the market size effect overcomes the competition effect increasing the profits of firms in sector one in the domestic country. The increase in profits of the firms in sector one induces, due to the free entry condition, to an increase in the wages of workers specialized in one. Contemporaneously, firms in sector two must now pay more the workers with specialization one and thus, in order to not experience a negative profit,

Figure 2.8: Effects of Globalization in sector 1



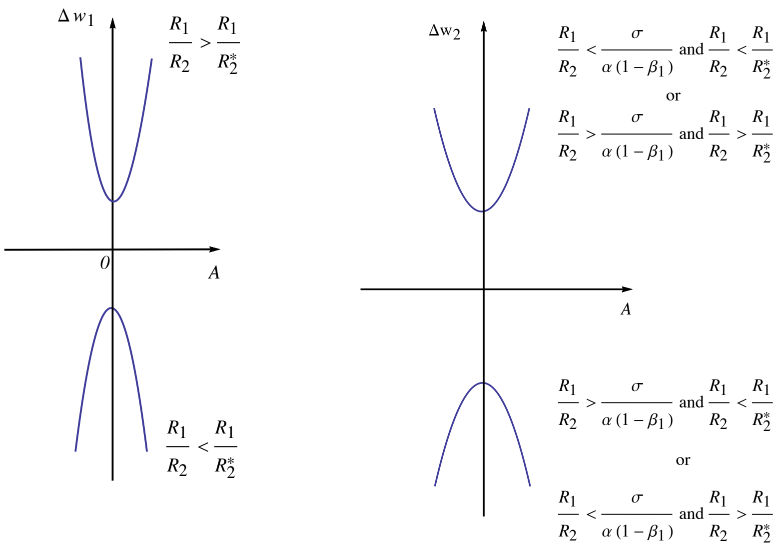
Effects of Globalization in sector 1 for the wages of workers with specialization one and two in the domestic country if $R_2 \neq R_2^*$. For further analysis see Appendix B.4.

they must pay less the workers with specialization two.
This opposite effect of globalization in sector one on the two type of workers holds until the ratio of the two types of workers in the domestic market is under a certain threshold. In particular, for high enough level of $\frac{R_1}{R_2}$, the increase of the wage of workers with specialization one has a positive effect on the total earning so strong that now also the sector two benefits from globalization because it experiences an increase in the available domestic earnings (economic boom effect). The increase in profits of firms in sector two allows those firms to pay more the workers with specialization two and this is the reason why both the two types of workers experience an increase in their wage. If instead the number of workers with specialization two were higher in the domestic country than in the foreign one, we would observe a totally opposite effect than the one described above. More specifically, initially the workers with the highest level of specialization would appear to win from globalization, but, when the ratio of $\frac{R_1}{R_2}$ is high enough the economic crisis effect would pull down also those type of workers and, thus, both the two would be worse off with respect to the closed economy scenario.

It is possible to further analyze the effects of an increase in trade costs on the wages of the two types of workers after the globalization in sector one. If $R_2 > R_2^*$, i.e. if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$, the decrease of wages of workers with specialization one, respectively to the closed economy's level, is non monotonic, in particular, for low levels of β and α and/or high levels of σ, the increase in τ, i.e. a reduction in globalization, induces an increase in the wages, meanwhile for the same parameters level, if $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$ an increase in τ produces a decrease in the wages of workers with specialization one[11].

Then I study the effect of an increase in τ on the wages of workers specialized in two. I notice that the effect will now depend on both the relation between $\frac{R_1}{R_2}$ and $\frac{R_1}{R_2^*}$, and on the relation between $\frac{R_1}{R_2}$ and $\frac{\sigma}{\alpha(1-\beta_1)}$. For low levels of β and α and/or high levels of σ, the increase in τ, i.e. a reduction in globalization, induces an increase of the wages of workers specialized in two either if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$ and $\frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)}$, or if $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$ and $\frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)}$. In the fig. 2.9 the effect of globalization in sector one and sector two are represented with respect to the function $A(\alpha, \sigma, \beta, \tau) = (\tau^{2\sigma} - \tau^2)(\sigma - \alpha) - 2\alpha\beta_1\tau^2$.

Figure 2.9: Effects of Globalization in sector 1 and 2



Effects of Globalization in sector 1 for the wages of workers with specialization one (left) and two (right) in the domestic country

Globalization in Sector 2

Finally this section focuses on the effect of Globalization in sector two if $R_2 \neq R_2^*$. The profit functions of firms in sector one and two in both domestic and foreign countries are the following.

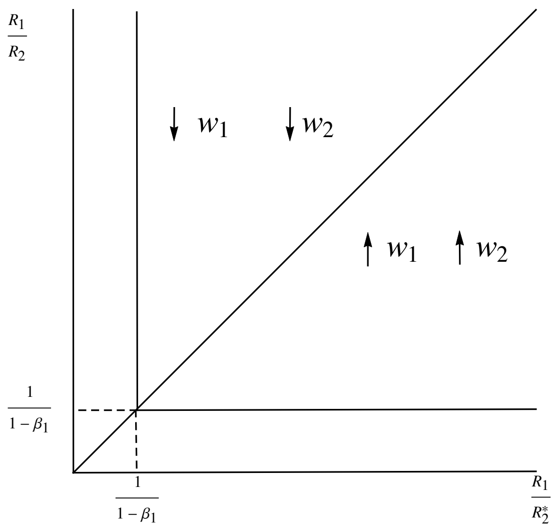
[11] see B.4 for calculations

$$
\begin{aligned}
\pi_1 =& \frac{\alpha\beta_1 E}{n_1}\frac{1}{\sigma} - w_1 \\
\pi_1^* =& \frac{\alpha\beta_1 E^*}{n_1^*}\frac{1}{\sigma} - w_1^* \\
\pi_2 =& \frac{\alpha\beta_2 E}{n_2 + n_2^*\tau^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_2 E^*\tau^{1-\sigma}}{n_2^* + n_2\tau^{1-\sigma}}\frac{1}{\sigma} - (w_1 + w_2) \\
\pi_2^* =& \frac{\alpha\beta_2 E^*}{n_2^* + n_2\tau^{1-\sigma}}\frac{1}{\sigma} + \frac{\alpha\beta_2 E\tau^{1-\sigma}}{n_2 + n_2^*\tau^{1-\sigma}}\frac{1}{\sigma} - (w_1^* + w_2^*)
\end{aligned}
\tag{2.46}
$$

I study the effects of globalization two on the two types of wages in the domestic country and, under the conditions for which the two sectors where active in closed economy I find the following results[12].

Both the wages of workers with specialization one and with specialization two increase if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$, and they decrease otherwise (see fig. 2.10).

Figure 2.10: Effects of Globalization in sector 2

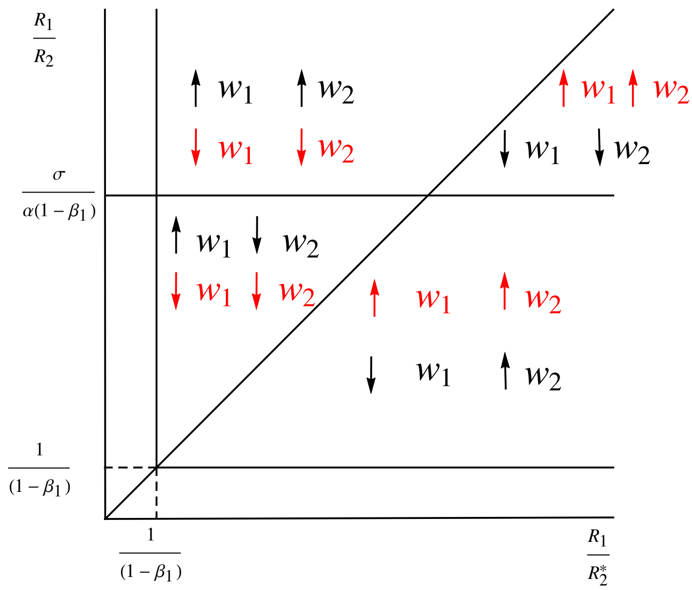


Effects of Globalization in sector 2 for the wages of workers with specialization one and two in the domestic country.

[12]see B.5 for calculations

Globalization in sector two allows domestic firms in sector two to compete with the foreign firms in the same sector, thus, when the number of workers with the highest specialization is lower in the domestic country than in the foreign country, also the number of domestic firms in sector two will be lower than the number of foreign firms in the same sector. Therefore, from the point of view of the domestic firms in sector two, globalization implies a strong increase in competition which overcomes the positive effect of the increase in market size. The decrease of the profits of those firms implies, in turns, that both the workers with specialization one and with specialization two must be payed less than before in order for the free entry condition in sector two to hold.
Thus, the reduction of the profits for the domestic firms in sector two is the reason why both the wages of workers with specialization one and with specialization two decline when $R_2 < R_2^*$.
The results obtained from the analysis of the effects of globalization one and of globalization two on the domestic country's workers are summarized in the following graph:

Figure 2.11: Effects of Globalization in sector 1 and in sector 2



Effects of Globalization in sector one (black) and in sector two (red) for the wages of workers with specialization one and two in the domestic country.

Finally we study the effect of globalization on inequality in this last scenario. Studying the specialization premium it can be easily proven that this premium increases due to globalization if $R_2 > R_2^*$.

$$\frac{w_{2,afterglob}}{w_{1,afterglob}} > \frac{w_{2,closed}}{w_{1,closed}} \quad \text{if} \quad R_2 > R_2^* \tag{2.47}$$

More specifically the mechanisms behind this effect differs according to the type of globalization considered and according to the level of the ratio of the two type of workers ($\frac{R_1}{R_2}$). In the scenario where $R_2 > R_2^*$ ($\Rightarrow \frac{R_1}{R_2} < \frac{R_1}{R_2^*}$), globalization one induces, for low values of $\frac{R_1}{R_2}$, an increase in inequality among workers because of its heterogenous effect on their wages. When instead $\frac{R_1}{R_2}$ is high enough the overall economic crisis effect is more harsh for those workers with the lowest level of specialization and therefore the overall inequality increases due to globalization. Globalization in sector two induces instead to an increase in the wages of all type of workers, but the magnitude of this rise is different according to the specialization level of the workers. In particular those workers with specialization two experience a bigger increase in their wages than the workers with specialization one. Therefore, after globalization, even though we observe an overall increase in all the wages, we also observe an increase in inequality.

Focusing on the scenario in which $R_2 < R_2^*$, it is easy to show that inequality among workers decreases. As before the mechanisms behind this result must be studied taking into consideration the type of globalization and the ratio $\frac{R_1}{R_2}$. Globalization one induces an heterogenous effect among workers which, under a certain threshold of $\frac{R_1}{R_2}$, benefits workers with specialization one and worsens off workers with specialization two, thus, decreasing inequality between the two. Instead, globalization of sector one induces an overall economic boom effect when $\frac{R_1}{R_2}$ is high enough, this economic boom benefits more the workers with specialization one inducing a decrease in inequality. Globalization in sector two decreases both the two types of workers' wages, but, this fall is much worse for workers with specialization two than those with specialization one. This implies that, also in the case of globalization two, inequality between workers decreases.

2.4 Conclusions

The second chapter of the thesis consists in a theoretical model explaining the consequences of introducing complexity and specialization into the analysis of the effects of globalization on high skilled workers' wages. I build a general equilibrium monopolistic competition model with multiple manufacturing heterogeneous sectors each needing a different number, and type, of specialized workers. Sectors differ in the number and the type of specializations they require for production and workers differ by their skill ubiquity. The sectors needing more, and at the same time more specialized, workers will be more complex than the others, the specializations required by more, and at the same time less complex, sectors will be less specialized. I allow only for partial mobility of workers across sectors according to the sectors' complexity and the workers' specialization. By means of the model I study globalization impact on wages and most importantly, how this effect would change according to the each worker's specialization. The model suggests that when globalization shocks sectors differing in complexity, it induces differential effects for skilled workers. When the least complex sector is the only sector which is open to trade it would lead to a rise of the wage of high specialized workers and a fall of the least specialized ones' in highly specialized workers abundant country and, when the ratio of low specialized-high specialized workers is high enough, the model results suggest that such decrease will affect negatively also the most specialized workers. In contrast, when the most complex sector is open to trade, it has a positive effect on both the most and the least specialized workers. The results of the model are in line with the empirical results described in the previous chapter.

Part II

Reshoring

Chapter 3

There and Back Again? Heterogeneous Firms, Product Quality and Reshoring Decision[1]

3.1 Introduction and Related Literature

The reshoring of the manufacturing production has recently gained a lot of publicity in advanced economies. Although the aggregate offshoring trends do not seem to be yet reverted[2], the increasing number of firms choosing to transfer back the manufacturing activities to their home countries caught the attention of both media and the experts. Especially in the United States the public debate on the topic is very lively as the most prominent examples of reshorers include General Electric transferring the production of water heaters from China to Louisville, Kentucky[3], Ford Motor Company shifting its production of the newest EcoBoost engines from China to Cleveland[4] or General Motors moving the production of the next-generation Cadillac SRX from Mexico to Spring Hill, Tennessee[5]. In his 2013 State of the Union speech president Obama stated: *So we have a huge opportunity, at this moment, to bring manufacturing back. But we have to seize it.*[6].

[1]This paper is joint work with Marta Paczos (University of Bologna)

[2]Oldenski (2015)

[3]National Public Radio, *As Overseas Costs Rise, More US Companies Are Reshoring*, January 27, 2014.

[4]Alisa Priddle, *Ford Starts Building Newest Engines in Cleveland*, Detroit Free Press, March 7, 2015

[5]Associated Press, *GM Moving Cadillac SRX Production from Mexico to TN*, August 27, 2014

[6]See State of the Union 2013 and also Economist article

Despite broad public debate the academic discussion of the topic is scarce. Empirical investigation is suffering from lack of representative economy-wide data and relies on surveys conducted within reshoring companies. Kinkel (2014) and Kinkel and Maloca (2009) report the survey data for German firms, Dachs and Zanker (2014) report reshoring surveys for eight European countries, Bailey and Propris (2014) and Pricewaterhouse Coopers (2014) report on the reshoring trends in UK. The trends in US reshoring over recent years are throughly covered by different consultancy companies reports: The Boston Consulting Group (2011, 2013, 2014) and The Hackett Group (2012) with mixed conclusions on the prospects of reshoring. Attempts to measure the importance of reshoring on aggragate economy level are limited. Oldenski (2015) reports that in the period $1999-2012$ imports by US-based multinational (MNE) affiliates were steadily increasing. DeBacker et al. (2016) study MNEs activity for a number of advanced countries and check whether there were any changes in the share of productive resources deployed in the home countries of those companies. In the sample of US MNEs they find no evidence of an increasing home share in employment, however they provide some evidence of a growing concentration of capital investments; they document this pattern also for some other high-income economies.

In spite of the obvious issue of the representativeness, the survey studies provide some interesting insights into drivers of reshoring decision. Kinkel (2014) report that 65% of reshorers in Germany in the period $2010-2012$ quoted quality-related problems as the main reason behind production transfer. Similarly, EEF The Manufacturer's Organization/GFK (2014) reports that the main motivation of UK reshorers surveyed in 2014 was intention to improve quality, mentioned by 49% of interviewed companies. Thanks to the access to a unique survey of American reshoring firms in the period $1995-2015$, we provide preliminary evidence for the importance of quality and technology upgrade as the main drivers behind reshoring decision also for US-based companies. It turns out that also within the group of US reshorers the quality-related problems are the main push factor behind giving up on offshoring activity. Additionally, over 27% of those firms quote innovation possibilities and skilled workforce as main pull factors for locating the production back in US. Moreover, another 12% of firms quote access to skilled workforce as important reshoring driver. In this paper we embrace this quality-related evidence and we develop a novel theory that explains the recent growing reshoring activity.

To our best knowledge there is only one theoretical paper that generates reshoring patterns. Baldwin and Venables (2013) analyze theoretically the location decision of a global firm, separating between a sequential (snake) and a more separated (spider) production processes. Location decision in their model is the outcome of the tradeoff between international differences in the production costs and the production co-location benefits. Reductions in international frictions (trade costs, communication or coordination costs) facilitate the relocation of production but can result in overshooting of offshoring and a subsequent reshoring pattern. They do not consider quality choice in the production process. Therefore, our approach to reshoring is complementary, as we put the quality-related factors at the heart of our analysis. Moreover, we conduct the analysis in heterogeneous firm framework, a margin which is absent in Baldwin and Venables (2013). This paper also contributes to the literature by developing a theory for the offshoring and the quality choice in the heterogeneous firm framework. To our best knowledge, Smeets et al. (2014) is the only one paper that considers this question. However, the model developed there is static and therefore does not admit reshoring possibility, which is in turn the core of our analysis.

In our setting each firm is producing a single good for the domestic country market[7], deciding the quantity and the quality supplied as well as the factory location. We build on Antoniades (2015), a model introducing the quality choice into seminal Melitz and Ottaviano (2008) framework and we enrich it in two steps. First, we add the offshoring possibility. Offshoring is reducing wage costs paid by firms, but it is increasing the quality production costs and entails transportation cost for the components (iceberg type). Introduction of the offshoring possibility into Antoniades (2015) leads to the following findings: i) the most productive firms produce only domestically, ii) the least productive firms offshore, iii) thanks to offshoring possibility some of the least productive firms, who would have to otherwise exit the market, produce. Second, we extend the enriched model into dynamic, two-period setting. High quality varieties yield higher revenues than the low quality ones, yet quality production is costly. Firms would be therefore facing a choice between setting a high quality upfront or smoothing quality upgrade across both periods. Since the fixed costs of quality innovation are convex, firms will find it optimal to set a given level of quality in the first period and upgrade it in the second period. Once we allow for offshoring, some firms in the first period produce abroad. Yet given the second period quality upgrade and increasing quality adaptation costs it entails, they transfer the production back to the domestic country.

We solve the model numerically. The equilibrium delivers a sorting pattern: the most productive firms always produce domestically, the least productive always offshore and the firms with an intermediate productivity reshore. We discuss the crucial parameters

[7]We assume that the domestic and offshore countries are advanced and developing, respectively.

affecting the equilibrium interval of the productivity for which reshoring arises. Comparative statics exercises points the importance of the love for quality parameter. The increase in the consumers' taste for quality increases the intensity of the reshoring activity in the equilibrium.

The reminder of this paper is organized as follows: section 3.2 presents some stylized fact about US reshoring firms. Section 3.3 presents the static model, section 3.4 develops the dynamic model and describes the solution method and the equilibrium outcomes. Section 3.5 concludes.

3.2 US Reshorers: a brief view

Reshoring Initiative (RI)[8] is a non-profit organization assisting US companies in reshoring process. One of the core assets of RI is its reshoring database, in which the organization collects the data on the events of reshoring among US companies from publicly available sources (press releases, companies white papers, media announcements, *etc.*) as well as directly from firms, and verifies their accuracy. In June 2015 RI kindly shared this database with us. Its full content covered 410 reshoring firms and another 231 classified as kept from offshoring. Each record comprises company name, the year of reshoring, the product reshored, industry classification and the main domestic and offshore factors behind the transfer decision.

Table 2 in the Appendix summarizes the timing of the observed reshoring events. Although there were occasional events of reshoring dating back to as early as 1995, the majority of reshoring decisions were taken in post-2010, with a clear concentration in the period $2012 - 2014$.[9]. Figure 13 in the Appendix represents the sectoral composition of reshored companies: it is clearly dominated by manufacturing industry, which coupled with retail and wholesale trade, and professional services account for almost 90% of the sample.

Probably the most important aspect of RI data are survey questions in which reshoring firms quote the main drivers of reshoring, describing both offshore push factors and pull home country incentives. Table 3.1 summarizes this information[10]. Although some firms point to more than one factor (with the single top-scorer quoting 11 factors), the mode for the number of pull and push factors is 1. Similarly to the survey-based reshoring evidence in Germany and UK, the quality-related problems faced by offshore plants seem to be the leading factor behind production transfer also for the American firms. The quality-related factors comprise problems with necessary rework, warranty issues, low product liability and alike. Overall, above 31% of the firms report quality problems followed by lead time and inventory and freight costs (29% and 27%, resp.). Increasing wage costs are quoted by 19% of firms. The prominent role of quality considerations is even more evident once we limit the analysis to the group of firms who quote only one main driver behind their reshoring decision (Figure 3.1): over 40% of firms point to quality issues with lead time

[8] www.reshorenow.org

[9] Observation in year 2016 refers to the firms that declared reshoring scheduled to take place in 2016.

[10] Note that in Table 3.1 the percentage do not sum up to 100 as each firm can quote one or more factors. The percentage is expressed in reference to the total number of factors quoted.

OFFSHORE FACTOR	% of firms quoting	**DOMESTIC FACTOR**	% of firms quoting
Quality Issues	31,63	Technology and innovation difficulties	27,74
Freight costs	29,20	Other	20,19
Lead time, inventory	27,49	Skilled workforce	12,41
Wage costs	19,22	Government Incentives	9,00
Communication & audit	10,46	U.S. price of natural gas	4,38
Intellectual property	6,33	Customer/demand issues	4,38
Loss of control	5,35	Eco-system synergies	3,89
Other	4,87	Infrastructure	2,92
Ethical/green considerations	4,14	Lower real-estate/construction costs	0,97
Difficulty of Innovation	2,92	Supplier issues	0,49
Currency variation	3,89		
Regulatory compliance	1,46		
Political instability	1,46		
Employee turnover	0,97		
Image/Brand	0,24		

Table 3.1: Main offshore and domestic factors behind reshoring decision for US firms

and inventory costs being second factor, mentioned in less than 20% of the answers; wage costs are mentioned by less than 10% of firms. Complimentary to the quality issues domination in the offshore push factors, approximately half of the firms interviewed also point to a limited scope for product innovation to offshore production as the main domestic pull incentive for reshoring (Table 3.1).

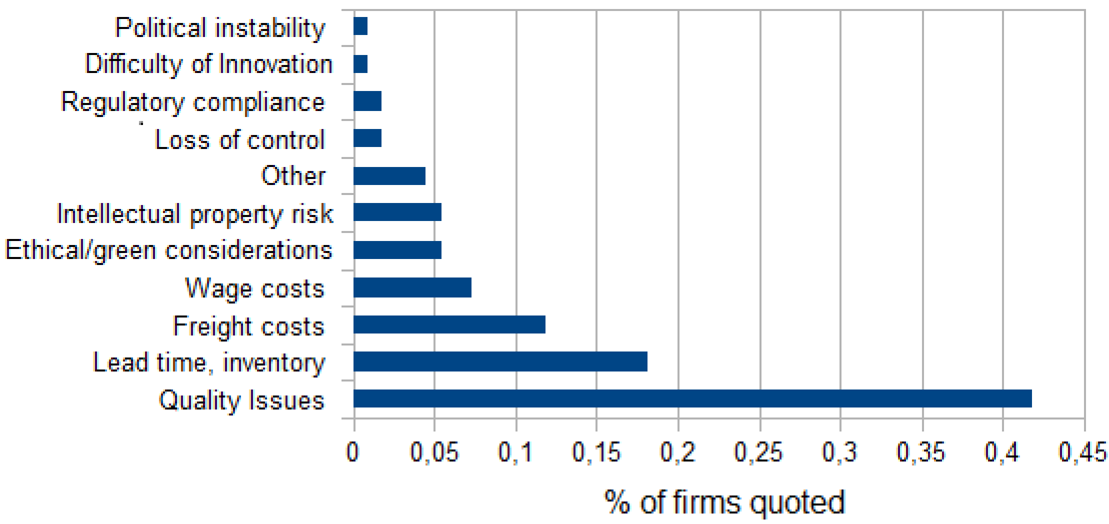


Figure 3.1: Offshore factors behind reshoring in the sample of firms quoting one reason only

3.3 Static Model

Prior to developing a full-blown dynamic model, we begin with a simple static framework in which we can highlight the relationships between the quality choice and offshoring. We base our setting on the closed economy version of Antoniades (2015) which we alter by adding the production location choice.

Preferences The economy is populated with L consumers, each supplying one unit of labor. The utility expression follows closely Antoniades (2015) and reads:

$$U = q_o^c + \alpha \int_{\omega\in\Omega} q_\omega^c d\omega + \beta \int_{\omega\in\Omega} z_\omega q_\omega^c d\omega - \frac{1}{2}\gamma \int_{\omega\in\Omega} (q_\omega^c)^2 d\omega - \frac{1}{2}\eta \Big\{ \int_{\omega\in\Omega} q_\omega^c \Big\}^2 \tag{3.1}$$

where q_ω^c and q_o^c represent the consumption of the numeraire good and the variety ω, and z_ω stands for quality of variety ω. α and η capture the degree of substitution between each variety and the numeraire, γ describes the degree of differentiation among the varieties. Importantly, β is a taste for quality parameter. The inverse demand for each variety is:

$$p_\omega = \alpha - \gamma q_\omega^c + \beta z_\omega - \eta Q^c \tag{3.2}$$

Technology As in Antoniades (2015) a firm produces a given variety ω with inelastically supplied labor input. Homogeneous good and labor markets are competitive. Upon payment of entry cost f_e, a firm draws productivity which determines their marginal cost

c (distributed accordingly to $G(c)$ on the support $[0, c_M]$). Firms that can cover their marginal cost survive and produce, those with the lowest productivity exit the market. The survivors maximize profits based on residual demand curve, taking average prices, average quality level and the number of firms, N, as given. We allow firms to choose the production location: they decide whether to remain and produce at home or whether to offshore. For simplicity, we assume the extreme view of offshoring: once offshored, a firm will offshore all its production.[11] We formulate the total cost structures by closely following Antoniades (2015), but we introduce a difference in total costs due to production location:

$$\begin{aligned} TC^H_\omega &= c_\omega q_\omega + \delta_H z_\omega q_\omega + \theta z^2_\omega \\ TC^O_\omega &= w\tau c_\omega q_\omega + \delta_O z_\omega q_\omega + \theta z^2_\omega \end{aligned} \tag{3.3}$$

TC^H_ω and TC^O_ω stand for total cost of firm ω located in the home country and offshore[12]. The first terms of the total cost functions capture the variable costs of production as in standard Melitz and Ottaviano (2008) setting. The second terms with parameters δ_H and δ_O capture the increases in marginal costs due to quality upgrades. Those quality adaptation costs are brought about by the implementation of quality innovations. We assume that the quality-related production costs are always greater for the offshoring firm ($\delta_H \leq \delta_O$), *i.e.* the greater the geographical distance between the plants and the headquarters, the more costly is quality adaptation. Those variable costs entail for instance machines fine-tuning for the new technology processes, new materials, workers retraining, *etc.* The third terms, involving θ's account for fixed cost of quality innovation, invariant to quantity produced. They describe firms' R&D investments, product re-design, invention of the new technology processes and so on. Following Antoniades (2015) we assume this cost to be convex. In principle, we could allow for differences in θ's across production locations. However, firms R&D activities are predominantly located in the headquarters, in particular if the main destination market is the domestic one, therefore we assume θ's to be equal across production locations[13]. Additionally, we assume that the total wage costs are always lower offshore: $w\tau < 1$.

[11] The model can be easily extended to a version where a firm combines a range of potentially offshorable tasks in the spirit of Grossman and Rossi-Hansberg (2008). Each firm would then decide on the fraction of tasks offshored. However, this complication would not qualitatively change the results of the model.

[12] Wage in the domestic country is normalized to 1.

[13] The earlier version of this paper assumed $\theta_H \leq \theta_O$. The qualitative results of both the static and the dynamic model are identical. The results are available upon request.

In such a setting, the problem for a firm producing domestically is identical to the closed economy solution in Antoniades (2015). Therefore, we solve the problem only for the offshoring firm and present the equilibrium outcome.
Denote by $c_{D,O}$ the marginal cost value for which the offshoring firm's demand is driven to zero, $q_\omega(c_{D,O}) = 0$ and $z_{D,O}$ stands for quality level relative to $z_{D,O}$. We can now express prices and quantities as functions of $c_{D,O}$, c_ω and qualities z_ω and $z_{D,O}$:

$$p_\omega = \frac{1}{2}(w\tau)(c_{D,O} + c_\omega) + \frac{1}{2}\Big(z_\omega(\beta + \delta_O) - z_{D,O}(\beta - \delta_O)\Big) \tag{3.4}$$
$$q_\omega = \frac{L}{2\gamma}(w\tau)(c_{D,O} - c_\omega) + \frac{L}{2\gamma}(\beta - \delta_O)(z_\omega - z_{D,O}) \tag{3.5}$$
$$\pi_\omega = \frac{L}{4\gamma}\Big((w\tau)(c_{D,O} - c_\omega) + (\beta - \delta_O)(z_\omega - z_{D,O})\Big)^2 - \theta(z_\omega)^2 \tag{3.6}$$

Next, we find the optimal quality level, $z^\star_\omega$, which is maximizing profit (3.6)[14].

$$z^\star_\omega = \lambda_O\Big((c_{D,O} - c_\omega)(w\tau) - z_{D,O}(\beta - \delta_O)\Big) = \lambda_O(c_{D,O} - c_\omega)(w\tau) \tag{3.7}$$
$$\lambda_O = \frac{L(\beta - \delta_O)}{4\gamma\theta - L(\beta - \delta_O)^2}$$

The last passage in (3.7) follows from the fact that for $c_\omega = c_{D,O} \Rightarrow z_{D,O} = \lambda_O((c_{D,O} - c_{D,O})(w\tau) - z_{D,O}(\beta - \delta_O)) \Rightarrow z_{D,O} = -z_{D,O}\lambda_O(\beta - \delta_O) \Rightarrow z_{D,O} = 0$. Given the optimal quality, we can express (3.4), (3.5) and (3.6) dependent on c_ω and cost cutoff $c_{D,O}$:

$$p_\omega = \frac{1}{2}(w\tau)(c_{D,O} + c_\omega) + \frac{1}{2}(w\tau)\lambda_O(\beta + \delta_O)(c_{D,O} - c_\omega) \tag{3.8}$$
$$q_\omega = \frac{L}{2\gamma}(w\tau)(c_{D,O} - c_\omega)(1 + \lambda_O(\beta - \delta_O)) \tag{3.9}$$
$$\pi_\omega = (w\tau)^2(c_{D,O} - c_\omega)^2\frac{L}{4\gamma}(1 + \lambda_O(\beta - \delta)) \tag{3.10}$$

This results lead to two parametric assumptions. First, to assure concavity of profit π_ω in quality z_ω it is required that $L(\beta - \delta_O)^2 - 4\gamma\theta < 0$. Second, in order to impose non-negative z_ω we must assume that $\beta > \delta_O$. Each firm, given its marginal cost c_ω, will be choosing the location of its production by comparing the maximized profits under each

[14] As in Antoniades (2015) firms here choose simultaneously price and quality for a given output level. Given linearity and separability of the model, we first solve for the optimal price and next, we find the optimal quality level.

of the scenarios:

$$\pi_\omega^H = \frac{L}{4\gamma}(c_{D,H} - c_\omega)^2(1 + \lambda_H(\beta - \delta_H)) \tag{3.11}$$

$$\pi_\omega^O = \frac{L}{4\gamma}(w\tau)^2(c_{D,O} - c_\omega)^2(1 + \lambda_O(\beta - \delta_O)) \tag{3.12}$$

As long as $\pi_\omega^H \geq \pi_\omega^O$ a given firm with marginal cost c_ω would prefer to produce domestically instead of offshoring. We find that the pivotal firm that is indifferent between producing domestically and offshoring is characterized by the following marginal cost c_1:

$$c_1 = c_{D,O} w\tau \Big(\frac{\Gamma_H + \Gamma_O w\tau + (1 - w\tau)\sqrt{\Gamma_H \Gamma_O}}{\Gamma_H + \Gamma_O w\tau^2} \Big) \tag{3.13}$$

where $\Gamma_H = \frac{\theta(\beta+4\gamma-\delta\mathrm{h})+L(\delta\mathrm{h}-\beta)}{L(\beta-\delta\mathrm{h})-4\gamma\theta}$ and $\Gamma_O = \frac{\theta(\beta+4\gamma-\delta\mathrm{o})+L(\delta\mathrm{o}-\beta)}{L(\beta-\delta\mathrm{o})-4\gamma\theta}$. It is easy to show that under model parametric restrictions, it is always the case that $c_1 < c_{D,H} < c_{D,O}$. Figure 3.2 represents the equilibrium location choices. Firms with the marginal costs below the cost

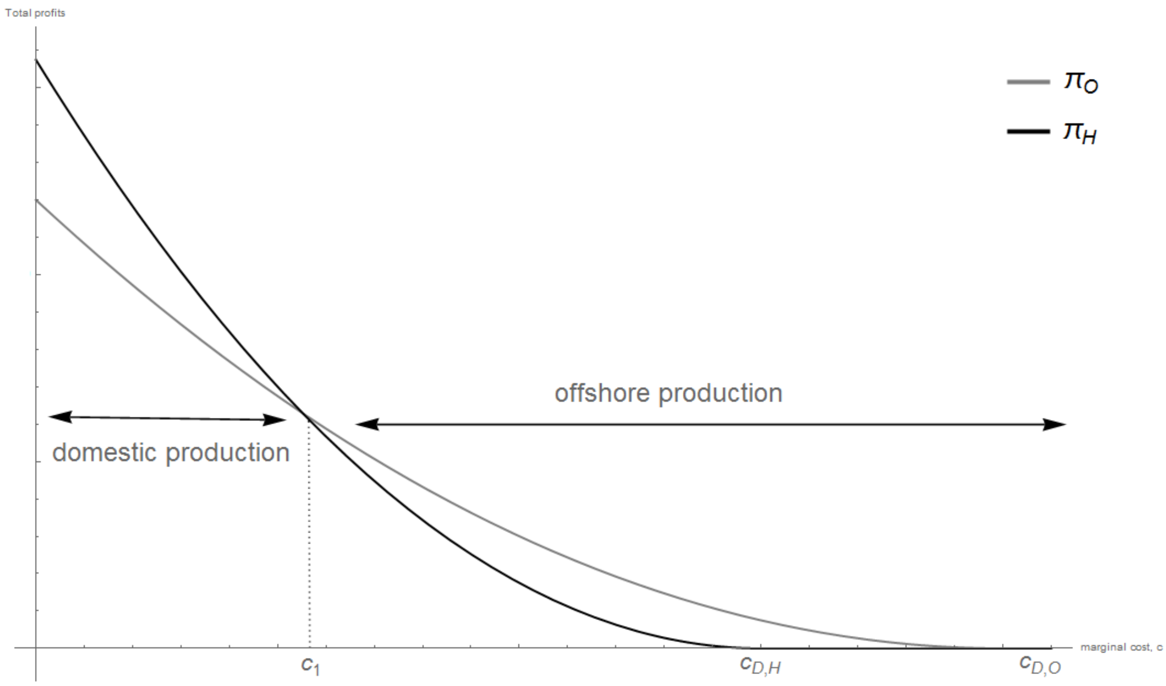


Figure 3.2: Static model equlibrium.

cutoff c_1 produce in the home country, whereas firms with the marginal costs above this threshold produce offshore. $c_{D,H}$ is the critical cost cutoff originating from the closed economy model of Antoniades (2015), where firms with marginal costs above $c_{D,H}$ exit the market. Introduction of the offshoring possibility results in a new critical cost cutoff,

$c_{D,O}$, $c_{D,O} > c_{D,H}$. This implies that thanks to offshoring we observe in equilibrium some firms with very low productivity (with their marginal costs falling into $[c_{D,H}, c_{D,O}]$ interval) that without offshoring option would not be able to survive. Moreover, for the firms whose marginal cost lays between c_1 and $c_{D,H}$ offshore leads to higher profits.

The model is closed by free entry condition as firms *ex ante* expect zero profits:

$$\int_0^{c_1} \pi_\omega^H dG(c) + \int_{c_1}^{c_{D,O}} \pi_\omega^O dG(c) = f_e \tag{3.14}$$

This condition determines the cost cutoff $c_{D,O}$. Following Melitz (2003), Melitz and Ottaviano (2008) and Antoniades (2015) we assume that the firm cost draws are Pareto distributed on the support $[0, c_M]$ with $G(c) = \left(\frac{c}{c_M}\right)^k$. The cost cutoff in this economy is:

$$c_{D,O} = \left(\frac{4\gamma f_e(k+1)(k+2){c_M}^k}{Lw\tau((\lambda_H(\beta-\delta_H)-\lambda_O(\beta-\delta_O))\psi + ((4k^2+8k+2)(1+\lambda_O(\beta-\delta_O))))}\right)^{\frac{1}{k+2}} \tag{3.15}$$

$$\tag{3.16}$$

where $\psi = \Big((k+1)(k+2)(\chi w\tau)^k + 2(k+2)k(\chi w\tau)^{k+1} + (k+1)k(\chi w\tau)^{k+2}\Big)$, χ is the constant multiplying cutoff c_1 (equation (3.13)) and $\lambda_H = \frac{L(\beta-\delta_H)}{4\gamma\theta - L(\beta-\delta_H)^2}$ and $\lambda_O = \frac{L(\beta-\delta_O)}{4\gamma\theta - L(\beta-\delta_O)^2}$.

3.4 Dynamic Model

Let us now analyze firm location decision in the two-period setting. Analogously to the static formulation, offshoring comprises a tradeoff between lower wages costs and higher quality-related production costs. The timing of the events is as follows: firstly all firms pay the entry cost, f_e and draw the marginal cost c_ω from the common distribution $G(c)$. Firm productivity is invariant across the periods. Next, given the realized value of c_ω firms decide the quantities produced, the quality upgrades and the production location in both periods. Finally production takes place. Each firm can choose to always produce in the home country, always offshore, reshore in the second period or offshore in the second period. Given the realized marginal cost, c_ω and the location choice firms experience different marginal costs of production. They choose the profit maximizing scenario.
Denote by $i \in \{Home(H), Offshore(O)\}$ a firm's location decision in the fist period and by j analogous decision in the second period. The joint profit for the ω firm reads:

$$\Pi^{i,j}_{\omega} = \Pi^{i,j}_{\omega,1}+\Pi^{i,j}_{\omega,2} = q^{i,j}_{\omega,1}(p^{i,j}_{\omega,1}-c_\omega T^i-\delta_i z^{i,j}_{\omega,1})-\theta_i(z^{i,j}_{\omega,1})^2+q^{i,j}_{\omega,2}(p^{i,j}_{\omega,2}-c_\omega T^j-\delta_i(z^{i,j}_{\omega,1}+\Delta^{i,j}_{\omega}))-\theta_j(\Delta^{i,j}_{\omega})^2 \tag{3.17}$$

where $q^{i,j}_{\omega,1}$ and $q^{i,j}_{\omega,2}$ stand for the quantity in the first and second period, $z^{i,j}_{\omega,1}$ is the quality level in the first period and $\Delta^{i,j}_{\omega}$ is the second period quality upgrade. The fixed costs of quality innovation are convex and paid only on the *per period* quality upgrade (*i.e.* the first period innovation cost is $\theta_i(z^{i,j}_{\omega,1})^2$, whereas in the second period it equals $\theta_j(\Delta^{i,j}_{\omega})^2$)[15]. T^i and T^j are the payroll costs, conditional on location choice. For home production the wages are normalized to 1, $T^H = 1$. On the other hand, the offshore labor costs include offshore wages (assumed to be lower than the home wages, $w < 1$) and iceberg cost of shipping the goods back to home country ($\tau > 1$) $T^O = w\tau$. Denoting the period by $t \in \{1, 2\}$, the inverse demand function is expressed in the standard way:

$$p^{i,j}_{\omega,t} = \alpha - \gamma q^{c,i,j}_{\omega,t} + \beta z^{i,j}_{\omega,t} - \eta Q^c_t \qquad \text{with} \qquad Q^c_t = \int_{i\in\Omega_t} q^{c,i,j}_{\omega,t} d\omega \tag{3.18}$$

As before, we can express the optimal quantities and prices, and the maximized profit as

[15] In principle the innovation costs are symmetric for both quality upgrades and downgrades, however, in equilibrium the latter choice is absent.

the functions of per period cost cutoffs, quality choices and the marginal cost, c_ω:

$$q^{i,j}_{\omega,1} = \frac{L}{2\gamma}T^i(c^{i,j}_{D,1} - c_\omega) + \frac{L}{2\gamma}(\beta - \delta_i)(z^{i,j}_{\omega,1} - z^{i,j}_{D,1}) \tag{3.19}$$

$$q^{i,j}_{\omega,2} = \frac{L}{2\gamma}T^j(c^{i,j}_{D,2} - c_\omega) + \frac{L}{2\gamma}(\beta - \delta_j)(z^{i,j}_{\omega,1} + \Delta^{i,j}_\omega - z^{i,j}_{D,2}) \tag{3.20}$$

$$p^{i,j}_{\omega,1} = \frac{1}{2}T^i(c^{i,j}_{D,1} + c_\omega) + \frac{1}{2}\Big((\beta + \delta_i)z^{i,j}_{\omega,1} - (\beta - \delta_i)z^{i,j}_{D,1}\Big) \tag{3.21}$$

$$p^{i,j}_{\omega,2} = \frac{1}{2}T^j(c^{i,j}_{D,2} + c_\omega) + \frac{1}{2}\Big((\beta + \delta_j)(z^{i,j}_{\omega,1} + \Delta^{i,j}_\omega) - (\beta - \delta_j)z^{i,j}_{D,2}\Big) \tag{3.22}$$

$$\begin{aligned}\Pi^{i,j}_\omega =& \frac{L}{4\gamma}\Big(T^i(c^{i,j}_{D,1} - c_\omega) + (\beta - \delta_i)(z^{i,j}_{\omega,1} - z^{i,j}_{D,1})\Big)^2 + \\ & \frac{L}{4\gamma}\Big(T^i(c^{i,j}_{D,2} - c_\omega) + (\beta - \delta_j)(z^{i,j}_{\omega,1} + \Delta^{i,j}_\omega - z^{i,j}_{D,2})\Big)^2 + \\ & - \Big(\theta_i(z^{i,j}_{\omega,1})^2 + \theta_j(\Delta^{i,j}_\omega)^2\Big)\end{aligned} \tag{3.23}$$

In equations (3.19) - (3.23) $c^{i,j}_{D,1}$ and $c^{i,j}_{D,2}$ are the marginal cost cutoff values for a firm making a location decision $\{i, j\}$ in period 1 and 2, respectively. A firm with a marginal cost c_ω, $c_\omega > c^{i,j}_{D,1}$ ($c_\omega > c^{i,j}_{D,2}$) will not be producing in period 1 (period 2). $z^{i,j}_{D,1}$ and $z^{i,j}_{D,2}$ are the quality levels that are associated with marginal cost cutoffs $c^{i,j}_{D,1}$ and $c^{i,j}_{D,2}$, respectively. While in the static model z_D is zero in the equilibrium, in the dynamic model it is not necessarily the case. This is the dynamic feature due to two period horizon combined with the convexity of quality innovation costs. Consider a firm's with marginal cost c_ω such that it is equal to $c^{i,j}_{D,1}$ and lower than $c^{i,j}_{D,2}$: it does not produce in the first period, but it produces in the second one. However, despite no production in the first period, it engages in quality enhancing investments, as it would allow for the highest quality upgrade at the lowest possible cost in the following period. As in the static formulation, the optimal quality choice in every period can be found by maximizing (3.23) with respect to $z^{i,j}_{\omega,1}$ and $\Delta^{i,j}_\omega$:

$$z^{i,j}_{\omega,1} = \Phi_{i,j}(\beta - \delta_j)\left(\frac{L(\beta - \delta_i)}{\lambda_j}\Big((c^{i,j}_{D,1} - c)T^i - z^{i,j}_{D,1}(\beta - \delta_i)\Big) + 4\gamma\theta_j\Big(T^j(c^{i,j}_{D,2} - c) - z^{i,j}_{D,2}(\beta - \delta_j)\Big)\right) \tag{3.24}$$

$$\Delta^{i,j}_\omega = \Phi_{i,j}(\beta - \delta_i)(\beta - \delta_j)L\left((\beta - \delta_j)\Big((c^{i,j}_{D,1} - c)T^i - z^{i,j}_{D,1}(\beta - \delta_i)\Big) + \frac{1}{\lambda_i}\Big((c^{i,j}_{D,2} - c)T^j - z^{i,j}_{D,2}(\beta - \delta_j)\Big)\right) \tag{3.25}$$

$$
\begin{aligned}
z_{\omega,2}^{i,j} &= z_{\omega,1}^{i,j} + \Delta_{\omega}^{i,j} \\
\Phi_{i,j} \equiv & \frac{\lambda_i \lambda_j}{(\beta - \delta_j)(L(\beta - \delta_i) - 4\gamma\theta_j \lambda_i \lambda_j (\beta - \delta_j))} \\
\lambda_j &\equiv \frac{L(\beta - \delta_j)}{4\gamma\theta_j - L(\beta - \delta_j)^2} \\
\lambda_i &\equiv \frac{L(\beta - \delta_i)}{4\gamma\theta_i - L(\beta - \delta_i)^2}
\end{aligned}
$$

By imposing $c = c_{D,1}^{i,j}$ and $c = c_{D,2}^{i,j}$ in equations (3.24) and (3.25). We are left with a system of two equations which enables us to express $z_{D,1}^{i,j}$ and $z_{D,2}^{i,j}$ as functions of $c_{D,1}^{i,j}$, $c_{D,2}^{i,j}$ and parameters. Therefore, we can rewrite equations (3.19) -(3.25) as follows:

$$q_{\omega,1}^{i,j} = 2\Phi_{i,j}(c_{D,1}^{i,j} - c_\omega)L(\beta - \delta_j)\left(T^j\theta_j(\beta - \delta_i) + T^i\frac{\theta_i}{\lambda_j} - (\beta - \delta_j)\theta_j T^i\right) \tag{3.26}$$

$$q_{\omega,2}^{i,j} = 2\Phi_{i,j}(c_{D,2}^{i,j} - c_\omega)L\theta_j(\beta - \delta_i)\left(\frac{T^j}{\lambda_i} + T^i(\beta - \delta_j)\right) \tag{3.27}$$

$$\begin{aligned} p_{\omega,1}^{i,j} = \frac{\Phi_{i,j}(\beta - \delta_j)}{\theta_i}&\left(c_{D,2}^{i,j}\delta_i L(\beta - \delta_i)\theta_j\left(\frac{T^j}{\lambda_i} + T^i(\beta - \delta_j)\right) + \right. \\ &+ c\theta_i\left(\frac{T^i}{\lambda_j}(2\gamma\theta_i - L\beta(\beta - \delta_i)) - 2\gamma\theta_j(T^i(\beta - \delta_j) + T^j(\beta + \delta_i))\right) + \\ &\left. + c_{D,1}^{i,j}\left((2\gamma\theta_i + L(\beta - \delta_i)\delta_i)\Big(\frac{T^i\theta_i}{\lambda_j} - \theta_j(T^i(\beta - \delta_j) - T_j(\beta - \delta_i))\Big)\right)\right) \end{aligned} \tag{3.28}$$

$$\begin{aligned} p_{\omega,2}^{i,j} = \frac{\Phi_{i,j}}{\theta_i}&\left(c_{D,2}^{i,j}(\beta - \delta_i)\Big(\frac{T^j}{\lambda_i} + T^i(\beta - \delta_j)\Big)(2\gamma\theta_i\theta_j + L(\beta - \delta_j)\delta_j(\theta_i + \theta_j)) + \right. \\ &+ c\theta_i\left(2\gamma\theta_j(\beta - \delta_i)\Big(\frac{T^j}{\lambda_i} - T^i(\beta + \delta_j)\Big) - \beta T^j(\beta - \delta_j)\Big(4\gamma\theta_j + \frac{L(\beta - \delta_i)}{\lambda_i}\Big)\right) + \\ &\left. + c_{D,1}^{i,j}(\beta - \delta_i)L(\beta - \delta_j)\delta_j\Big(\frac{T^i\theta_i}{\lambda_j} - \theta_j(T^i(\beta - \delta_j) - T^j(\beta - \delta_i))\Big)\right) \end{aligned} \tag{3.29}$$

$$\begin{aligned} z_{\omega,1}^{i,j} = \frac{\Phi_{i,j}(\beta - \delta_j)}{\theta_i}&\left(c_{D,1}^{i,j}L(\beta - \delta_i)\Big(\frac{T^i\theta_i}{\lambda_j} + \theta_j(T^j(\beta - \delta_i) - T_i(\beta - \delta_j))\Big) + \right. \\ &\left. + c_{D,2}^{i,j}L(\beta - \delta_i)\Big(\frac{T^j\theta_j}{\lambda_i} + \theta_j T^i(\beta - \delta_j)\Big) - c\theta_i\Big(\frac{T^j L(\beta - \delta_i)}{\lambda_j} + 4\gamma\theta_j T^j\Big)\right) \end{aligned} \tag{3.30}$$

$$\Delta_\omega^{i,j} = \Phi_{i,j}(c_{D,2}^{i,j} - c)L(\beta - \delta_j)(\beta - \delta_i)\Big(\frac{T^j}{\lambda_i} + (\beta - \delta_j)T^i\Big) \tag{3.31}$$

$$\begin{aligned} z_{\omega,2}^{i,j} = \frac{\Phi_{i,j}}{\theta_i}&\left(c_{D,1}^{i,j}L(\beta - \delta_j)(\beta - \delta_i)\Big(\frac{T^i\theta_i}{\lambda_j} - \theta_j(T^i(\beta - \delta_j) - T^j(\beta - \delta_i))\Big) + \right. \\ &+ c_{D,2}^{i,j}L(\beta - \delta_j)(\beta - \delta_i)\Big(\frac{T_j}{\lambda_i} + T_i(\beta - \delta_j)\Big)(\theta_i + \theta_j) + \\ &\left. - c\theta_i\Big(\frac{T^j L(\beta - \delta_j)(\beta - \delta_i)}{\lambda_i} + 4\gamma\theta_j(T^i(\beta - \delta_i) + T^j(\beta - \delta_j))\Big)\right) \end{aligned} \tag{3.32}$$

In each period t firms with marginal cost c_ω above cost cutoff value $c_{D,t}$ will not produce. They exit the market (*i.e.* neither engage in any production, nor in any quality investments) if $c_\omega > max\{c_{D,1}^{i,j}, c_{D,2}^{i,j}\}$. For the sake of clarity of the exposition from now onwards we restrict attention only to the firms that are producing in both periods, *i.e.* $c_\omega \leq min\{c_{D,1}^{i,j}, c_{D,2}^{i,j}\}$, for given $\{i, j\}$ location choice. The entry of firms is unrestricted

and firms enter until the expected profit is driven to zero.
Note that the maximum price a firm can quote is bounded and it is associated with zero quantity produced. It also must equal the marginal cost, thus we can write the following regularities:

$$\begin{aligned} c^{i,j}_{D,1} &= \frac{1}{T^i}\Big(\alpha - \eta Q_1 + (\beta - \delta_i)\Big) z^{i,j}_{D,1}(c^{i,j}_{D,1}, c^{i,j}_{D,2}) \\ c^{i,j}_{D,2} &= \frac{1}{T^j}\Big(\alpha - \eta Q_2 + (\beta - \delta_j)\Big) z^{i,j}_{D,2}(c^{i,j}_{D,1}, c^{i,j}_{D,2}) \end{aligned} \tag{3.33}$$

where $Q_t = \int_{i\in\Omega_t} q^{c,i,j}_{\omega,t} d\omega, t \in \{1,2\}$ and it stands for the consumption level over all varieties in period t. As in our setup the only destination market is the home country market, in equilibrium Q_1 and Q_2 are unique and common for all production location scenarios. Considering all possible location choices, the equations (3.33) generate a system. Once the system is solved, we can express all performance measures (3.19) -(3.25) and the maximized profits as the functions of model parameters and Q_1 and Q_2[16]. We can write the conditions that fully specify the equilibrium as:

$$\Pi^{i^\star,j^\star}_{\omega} = \max_{i,j\in\{H,O\}} \Big\{\Pi^{i,j}_{\omega}(c_\omega, Q_1, Q_2; \Theta)\Big\} \tag{3.34}$$

$$\int_0^{\widetilde{c_1}} \Pi^{i^\star,j^\star}_{1,\omega}(c_\omega)dG(c_\omega) + \int_{\widetilde{c_1}}^{\widetilde{c_2}} \Pi^{i^\star,j^\star}_{2,\omega}(c_\omega)dG(c_\omega) + \int_{\widetilde{c_2}}^{\widetilde{c_3}} \Pi^{i^\star,j^\star}_{3,\omega}(c_\omega)dG(c_\omega) + \int_{\widetilde{c_3}}^{\widetilde{c_M}} \Pi^{i^\star,j^\star}_{4,\omega}(c_\omega)dG(c_\omega) = f_e \tag{3.35}$$

$$Q_t = \int_0^{\widetilde{c_1}} q^{i^\star,j^\star}_t dG(c_\omega) + \int_{\widetilde{c_1}}^{\widetilde{c_2}} q^{i^\star,j^\star}_t dG(c_\omega) + \int_{\widetilde{c_2}}^{\widetilde{c_3}} q^{i^\star,j^\star}_t dG(c_\omega) + \int_{\widetilde{c_3}}^{\widetilde{c_M}} q^{i^\star,j^\star}_t dG(c_\omega) \tag{3.36}$$

$$\text{s.t. } \widetilde{c_k} \le min\Bigg\{ min\Big\{c^{i^\star,j^\star}_{D,1}(Q_1,Q_2), c^{i^\star,j^\star}_{D,2}(Q_1,Q_2)\Big\}, c_M\Bigg\}, k \in \{1,2,3,M\}$$

where $i^\star, j^\star$ are the optimal location choices. $\widetilde{c_k}$ for $k \in \{1,2,3\}$ are the profit cutoffs between 4 potential location scenarios. $\widetilde{c_M}$ is maximum value for the marginal cost. As profit functions are convex, there are at most 3 cutoffs, however in equilibrium we do not necessarily observe all of them. $\Pi^{i^\star,j^\star}_{k,\omega}(c_\omega)$ for $k \in \{1,2,3,4\}$ stand for the maximal profit for a given interval of marginal cost and Θ stands for the model parameter set. $G(c)$ is the common cost distribution, assumed to be Pareto for productivity $\frac{1}{c}$, *i.e.* $G(c) = \left(\frac{c}{c_M}\right)^k$

[16] To be found in the Appendix.

. Equation (3.34) describes each firm's optimal location decision $\{i, j\}$ as the choice of the scenario under which the maximized joint two period profit is the greatest. Equation (3.35) is the standard Free Entry condition, bounded by the restriction to the firms producing in the two periods (thus restrictions on $\widetilde{c}$). (3.36) is the condition closing the model, stating the aggregate equilibrium consumption levels of Q_1 and Q_2.

Because of the complex analytical form of the profit functions $\Pi_{\omega}^{i,j}(c_{\omega}, c_{D,1}^{i,j}, c_{D,2}^{i,j}; \Theta)$ and the large set of model parameters[17] the model cannot be solved analytically. Instead, we solve it by means of the numeric methods. The numerical solution procedure is based on fixed point theorem. We proceed as follows: given a set of parameter values, we initially guess the values of Q_1 and Q_2 and we find the relative profit-maximizing location choices $\{i^{\star}, j^{\star}\}$ for each $c_{\omega} \in [0, c_M]$. Next, we compute the Free Entry condition (3.35) and verify whether the guessed values of Q_1 and Q_2 overlap with their model-based counterparts, i.e. whether (3.36) holds. If not, the guess on Q_1 and Q_2 is updated. We repeat this procedure by iterating over the combinations of the parameter values.

We would assume, similarly to the formulation in the static model in the previous section that a firm's fixed cost of quality innovation is invariant both to production location and timing, *i.e.* $\theta_i = \theta_j = \theta$. As argued before, θ's stand for the R&D-related quality investments, that are most likely to take place in the headquarters. Moreover, the reshoring phenomenon does not address the re-location of R&D activities, but it is concentrated in the component manufacturing business. Modeling the choice of R&D location is beyond the scope of this model. Moreover, it is easy to show that in the dynamic setting firm's quality choice in the first period is always greater than the subsequent quality upgrade in the following period. Therefore, if θ's would differ accordingly to the production location, firms would always choose to remain in the first period in the location offering lower fixed quality costs. As a consequence, if the quality innovation costs are greater offshore, the firms initially choose to produce domestically, build-up the quality stock in the first period and finally offshore. We would not observe any reshoring activity whatsoever, which is at odds with the data.

3.4.1 Equilibrium Results

The numerical solution delivers reshoring in the equilibrium. The equilibrium is characterized by a sorting pattern into production location choices according to the individual

[17] $\Theta \equiv \{\alpha, \beta, \delta_H, \delta_O, \eta, \gamma, \theta_H, \theta_O, w, \tau, L\}$

firm productivity: the most productive firms (with the lowest marginal cost draws, c_ω) always decide to produce in the home country, whereas the least productive (with the highest marginal cost draws) always offshore. Reshoring arises for the intermediate values of productivity. For illustration, in Figure 3.3 we present one parametrization that delivers a reshoring equilibrium. Firms within the area A choose production at home, firms from the region C choose production offshore, whereas the intermediate productivity firms (region B) are the reshorers. For the reshoring firms the first period benefits from lower offshore wages outweigh higher offshore quality adaptations costs. However, when the quality upgrade in the second period materializes, the quality adaptations costs abroad rise as well and those firms prefer to transfer the production back to the domestic country[18].

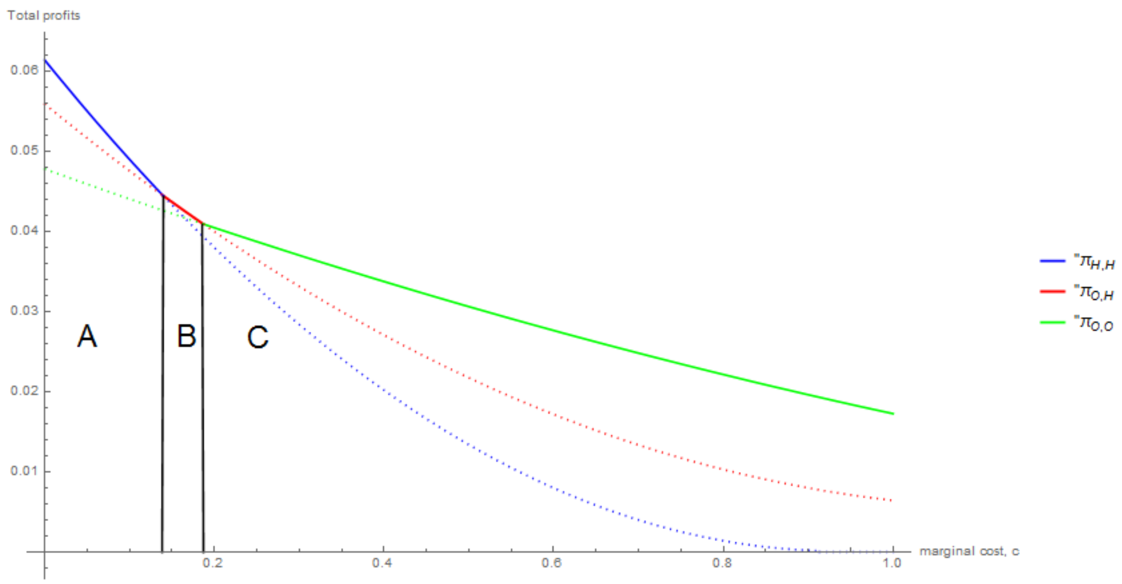
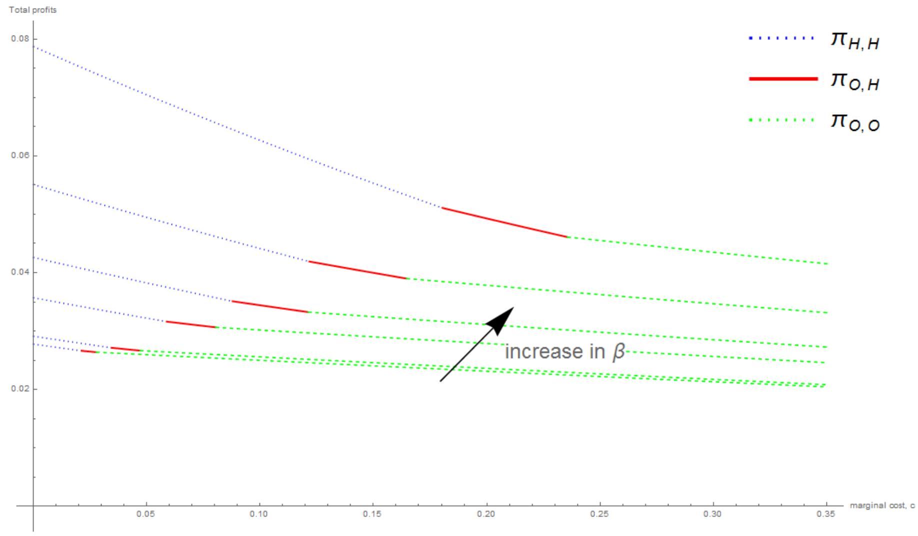


Figure 3.3: Reshoring equilibrium illustration.

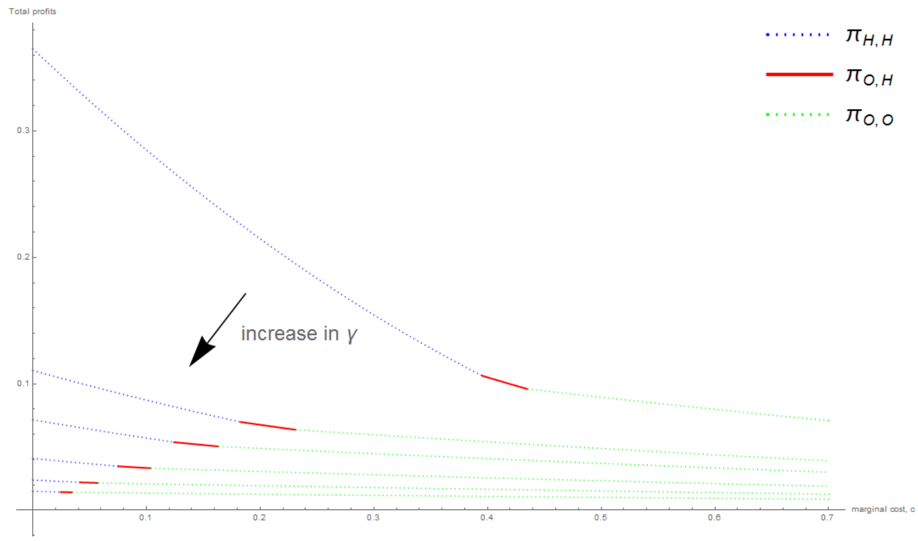
In Figure 3.4 we present the reshoring equilibrium sensitivity to the variations in the taste for quality parameter (β) and to the degree of product differentiation (γ). When the consumer's love for quality increases two things happen (panel 3.4a). First, there is an increase of the interval of productivity where reshoring is an equilibrium outcome, *ceteris paribus*. Secondly, the equilibrium reshoring takes place for lower productivity firms, *ceteris paribus*. Intuitively, as the consumers in the home country value quality more and more, the scope for reshoring is also growing. The opposite effects happen for an increase

[18] Arguably, production transfer across countries can entail important fixed costs, from which our framework abstracts. However, an introduction of fixed offshore or/and fixed reshoring costs would not alter qualitatively the main results of the model.

Figure 3.4: Reshoring equilibria. Comparative statics (I).



(a) taste for quality, β

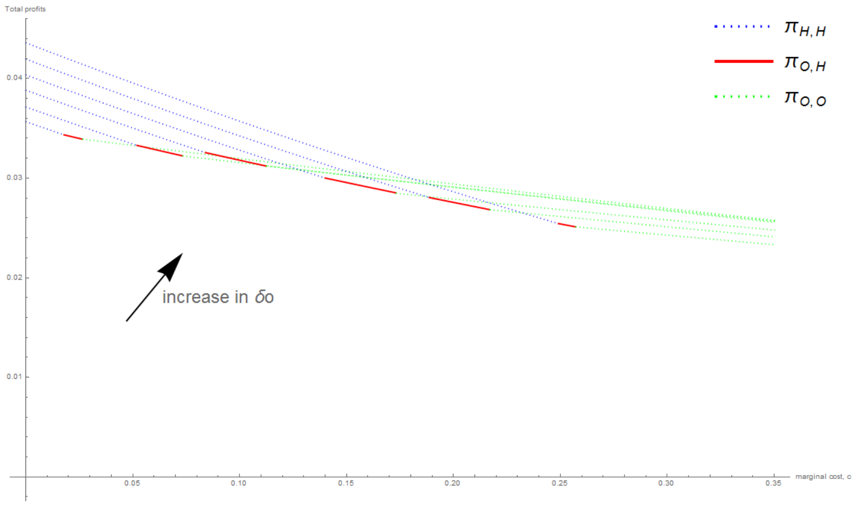


(b) degree of product differentiation, γ

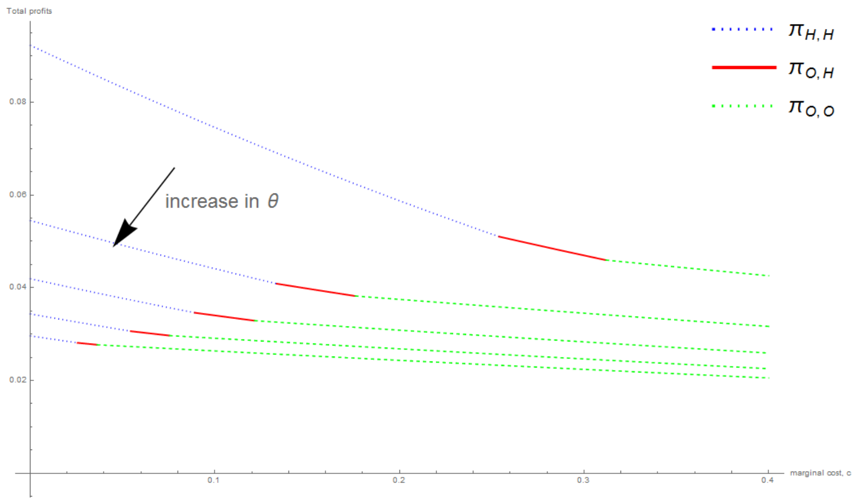
in the degree of product differentiation, γ (panel 3.4b). First, in the more differentiated sectors reshoring is less likely to occur and more and more firms choose to offshore the production in both periods. Secondly, in the more differentiated sectors, reshoring takes place for more productive firms. Increase in the degree pf product differentiation depresses all firms' profits and as a consequence the firms invest less in the quality. Summing up, the model predicts that reshoring should be more prevalent in the sectors characterized by a lower degree of product differentiation and a higher taste for quality.

In Figure 3.5 we present equilibrium sensitivity to the variations in the quality cost structure. In the panel 3.5a there are plotted reshoring equilibrium changes due to an increase

Figure 3.5: Reshoring equilibria. Comparative statics (II).



(a) offshore quality adaptation cost, δ_O

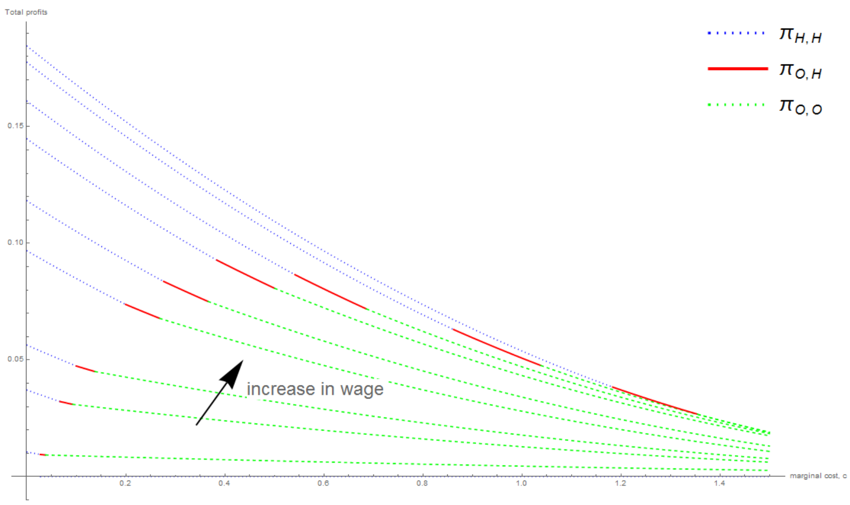


(b) quality innovation cost, θ

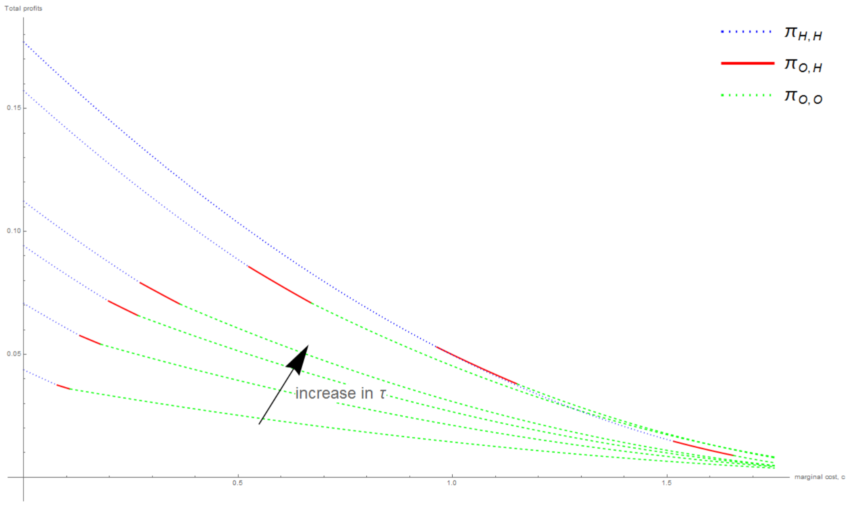
in the variable costs of producing quality, δ_O The reaction pattern is non-monotonic. Initially, for low values of δ_O (when δ_H is close in value to δ_O) the reshoring activity is more likely to occur, and it takes place for lower productivity firms. However, when the quality production becomes very costly (for δ_O sufficiently higher than δ_H), the reshoring interval starts to shrink and eventually it vanishes. Increasing the quality adaptation costs decrease the net benefits from the offshore production, *ceteris paribus*. In the limiting case, when the quality production is prohibitively expensive, we would observe only the home producing firms. On the other hand, in the panel 3.5b there are plotted the equilibrium changes due to variations in θ. It describes the cost of quality innovation, *i.e.* the new design expenses, R&D outlays, the machinery replacement costs, *etc.* Increase in θ results in the reshoring activity being less and less likely to occur and taking place for more and more productive firms. This is because rising θ reduces the net benefits from the investments in the quality and depresses the profits for all the firms, but most prominently for the home producers. In the limiting case, when the quality innovation is very costly we would observe all the firms producing only offshore.

In Figure 3.6 we present the comparative statics exercise for wages, w (panel 3.6a) and transport cost parameter, τ (panel 3.6b). Qualitatively, the impact of an increase in wages or a rise in the transportation cost is similar, as those parameters jointly describe the effective unit labor cost of the offshore labor. Increase in w or in τ initially increases the probability of reshoring. Also, alongside increasing w and τ, we observe less and less productive firms transferring their offshored production back. However, when transportation costs continue to rise, *ceteris paribus* the reshoring activity starts to decrease. Intuitively, for very high values of transport costs and/or very high levels of offshore wages we would observe neither reshoring, nor offshore production.

Figure 3.6: Reshoring equilibria. Comparative statics (III).



(a) offshore wage, w

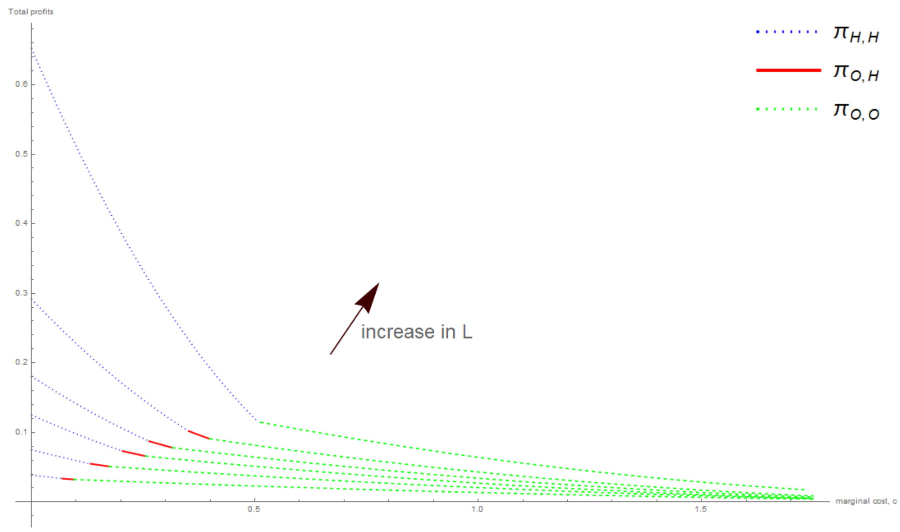


(b) transportation costs, τ

Finally, in Figure 3.7 we report how the reshoring equilibrium reacts to the changes in the market size, L. Similarly to the impact of an increasing offshore wages and a rise in the transportation costs, an increase in the market size results in the reshoring activity taking place for less and less productive firms. As the market size grows, the scope for quality differentiation increases[19] and firms invest more in quality. These gains from quality production are the greatest for the home producers (and their profit curve, the blue dotted line in Figure 3.7, shifts the most). For large enough market size L the reshoring activity disappears. In the limiting case, for very large values of L, we observe all the firms producing domestically.

[19]The increase in the scope for quality differentiation leading to a higher optimal quality choice by firms is one of the main findings in Antoniades (2015).

Figure 3.7: Reshoring equilibria. Comparative statics (IV): market size, L



3.5 Conclusions

We present a dynamic model of heterogeneous firms choosing both the quantity and the quality of the good and making a production location decision. Quality production is attractive as consumers are willing to pay higher price for the higher quality good, yet quality production is costly. Offshoring offers a way for reducing payroll costs, however it comprises quality production costs greater than the domestic manufacturing. The model generates the equilibrium reshoring of production and yields an equilibrium sorting pattern with reshoring arising for the intermediate values of productivity. The most productive firms will always produce in the developed domestic country, while the least productive ones will offshore. The second most productive firms will initially offshore, exploiting the advantages of low quality - low cost production, coming back in the next period producing, domestically, higher quality goods. We find that the region of equilibrium reshoring is particularly sensitive to taste parameter for quality, β. The greater the taste for quality, the greater the chance for observing reshoring in equilibrium.

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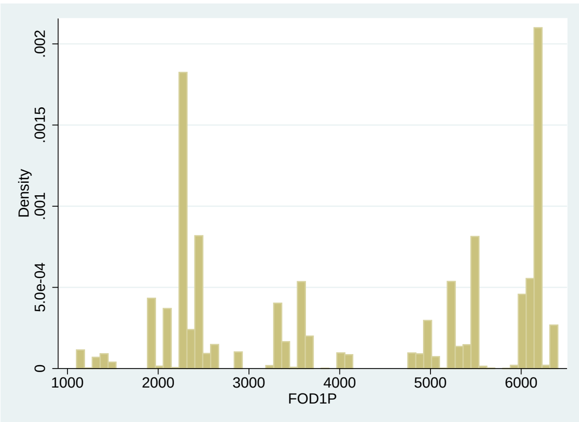
Appendices

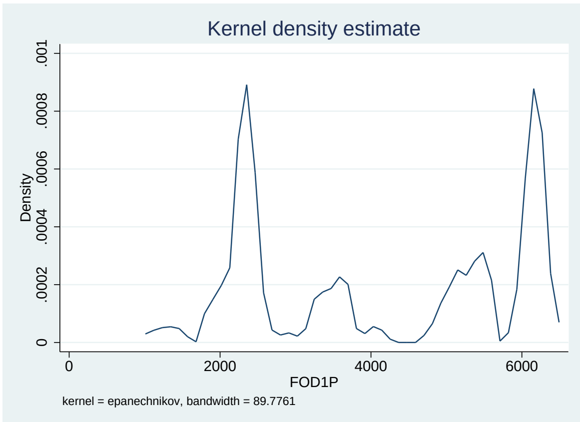
Appendix A

A.1 - Data Info

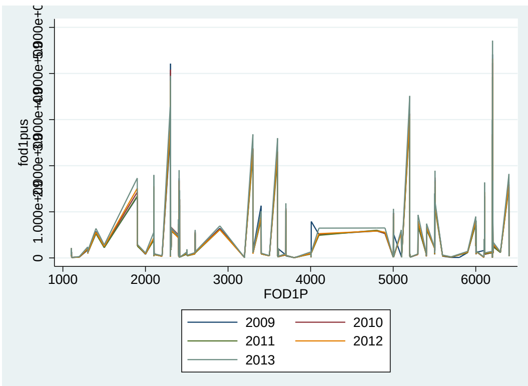
In this section I report the distributions of sectors and majors over the years in our dataset.

The database contains 1542989 observations of workers from 2009 to 2013. It is a Pooled Cross section database.
The following plots describe the density of the field of graduation.

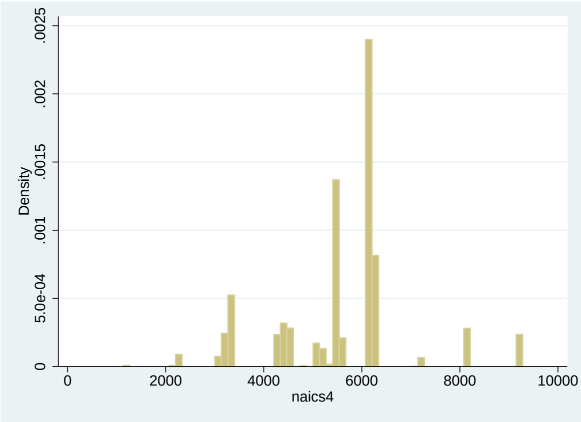


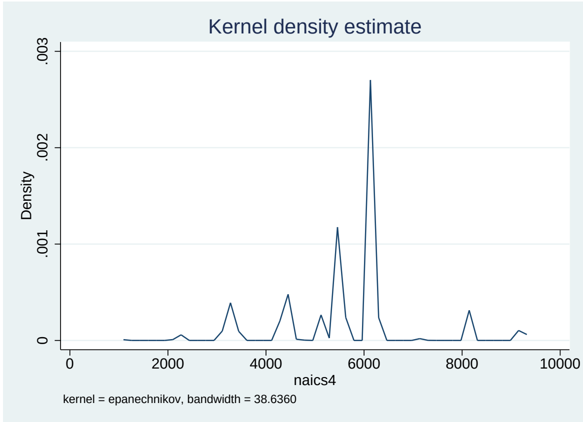


The number of workers with each major in the years did not change a lot, as it can be seen from the graph below

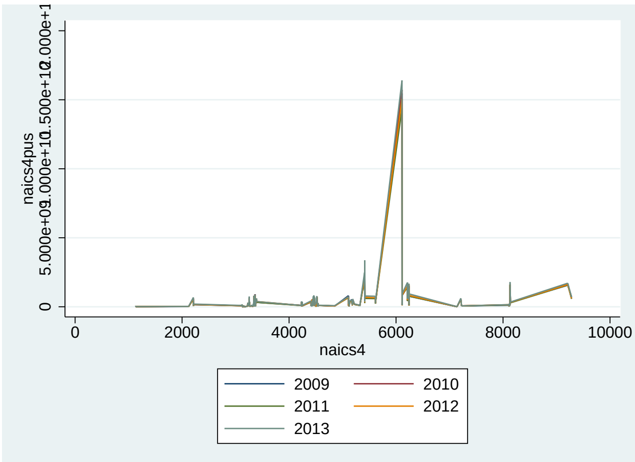


The next graphs describe the distribution of the sectors in the data.





The number of workers with each sector in the years did not change a lot, as it can be seen from the graph below



Appendix B

Different countries

Different preferences

B.1 - Globalization in Sector 1

The conditions under which both the sectors were active in closed economy and are still active after globalization are the following:

If $\beta_1 \geq \beta_1^*$ then the conditions that must hold are $\frac{R_1}{R_2} \geq \frac{1}{1-\beta_1}$ and $\frac{R_1}{R_2} \geq A(\beta_1, \beta_1^*, \sigma, \alpha, T)$, if instead $\beta_1 < \beta_1^*$ then the conditions that must hold are $\frac{R_1}{R_2} \geq \frac{1}{1-\beta_1^*}$ and $\frac{R_1}{R_2} \geq B(\beta_1, \beta_1^*, \sigma, \alpha, T)$ where

$A(\beta_1, \beta_1^*, \sigma, \alpha, T) \equiv \frac{\alpha - \alpha(\beta_1 + \beta_1^* - 1)\tau^{1-\sigma} + \sigma(-1 + (\beta_1 - \beta_1^* - 1)\tau^{1-\sigma})}{(-1+\beta_1)(-\alpha + \sigma + (\alpha(-1+2\beta_1^*) + \sigma)\tau^{1-\sigma})}$ and

$B(\beta_1, \beta_1^*, \sigma, \alpha, T) \equiv \frac{\alpha-\alpha(\beta_1+\beta_1^*-1)\tau^{1-\sigma}-\sigma(1+(\beta_1-\beta_1^*+1)\tau^{1-\sigma})}{(-1+\beta_1^*)(-\alpha+\sigma+(\alpha(-1+2\beta_1)+\sigma)\tau^{1-\sigma})}$.
Notice that if $\beta_1 \geq \beta_1^*$, then $A(.) \leq \frac{1}{1-\beta_1}$ and if $\beta_1 < \beta_1^*$ then $B(.) < \frac{1}{1-\beta_1^*}$, thus, the conditions can be rewritten in the following equations:

$$\begin{aligned} \text{if } \beta_1 < \beta_1^* &: \frac{R_1}{R_2} > \frac{1}{(1-\beta_1^*)} \\ \text{if } \beta_1 \geq \beta_1^* &: \frac{R_1}{R_2} \geq \frac{1}{(1-\beta_1)} \end{aligned} \tag{37}$$

In the figure 2.1 the values of the parameters are the following (but could be chosen any other values, the results do not change) $\alpha = 0.35$, $\beta_1^* = 0.45$, $\sigma = 3$.
In the figure 2.2 the values of the parameters are the following (but could be chosen any other values, the results do not change) $\alpha = 0.35$, $\beta_1^* = 0.85$, $\sigma = 3$.

B.2 - Globalization in Sector 2

If globalization in sector two happens, then, in order for all the sector to be active it is required that $\frac{R_1}{R_2} \geq \frac{1}{1-\beta_1}$ and $\frac{R_1}{R_2} \geq \frac{1}{1-\beta_1^*}$ $\frac{R_1}{R_2} \geq A_2(\beta_1, \beta_1^*, \sigma, \alpha, T)$ and $\frac{R_1}{R_2} \geq B_2(\beta_1, \beta_1^*, \sigma, \alpha, T)$ where
$A_2(\beta_1, \beta_1^*, \sigma, \alpha, T) \equiv \frac{\alpha+\alpha(\beta_1+\beta_1^*-1)\tau^{1-\sigma}-\sigma(1+(\beta_1-\beta_1^*+1)\tau^{1-\sigma})}{(-1+\beta_1)(-\alpha+\sigma)+(\beta_1^*-1)(\alpha-2\alpha\beta_1+\sigma)\tau^{1-\sigma})}$ and
$B_2(\beta_1, \beta_1^*, \sigma, \alpha, T) \equiv \frac{\alpha+\alpha(\beta_1+\beta_1^*-1)\tau^{1-\sigma}+\sigma(-1+(\beta_1-\beta_1^*-1)\tau^{1-\sigma})}{(-1+\beta_1^*)(-\alpha+\sigma)+(-1+\beta_1)(\alpha-2\alpha\beta_1^*+\sigma)\tau^{1-\sigma})}$.
However notice that, if $\beta_1 \geq \beta_1^*$, then $A_2(.) \leq \frac{1}{1-\beta_1}$, $A_2(.) \geq B_2(.)$ and $\frac{1}{1-\beta_1} \geq \frac{1}{1-\beta_1^*}$ and if $\beta_1 < \beta_1^*$ then $A_2(.) < B_2(.)$ and $\frac{1}{1-\beta_1} < \frac{1}{1-\beta_1^*}$ and $B_2(.) < \frac{1}{1-\beta_1^*}$, , thus, the non negative conditions can be rewritten in the following equations:

$$\begin{aligned} \text{if } \beta_1 < \beta_1^* &: \frac{R_1}{R_2} > \frac{1}{(1-\beta_1^*)} \\ \text{if } \beta_1 \geq \beta_1^* &: \frac{R_1}{R_2} \geq \frac{1}{(1-\beta_1)} \end{aligned} \tag{38}$$

Moreover, when I study the effects of globalization in sector two on the wages of the specialized workers, I find that workers with specialization two will be affected differently from globalization whether the ratio of workers with specialization one over workers with specialization two is smaller or greater than $\frac{\sigma}{\sigma-\alpha\beta_1}$. Studying this threshold level it can be noticed that it is always smaller than $\frac{1}{1-\beta_1}$ and moreover, if $\beta_1 < \beta_1^*$ it is also smaller than $\frac{1}{1-\beta_1^*}$, thus, I find that this threshold is always excluded by the non-negativity conditions and this is the reason why it is not present it into the analysis of the effects of globalization.

In the analysis of the effects of an increase in trade costs on the two type of wages, I find the following.

$$\begin{aligned}\frac{\partial(w_{1,after}-w_{1,before})}{\partial\tau} &\geq 0 \text{ if } \beta_1 \leq \beta_1^* \\ \frac{\partial(w_{1,after}-w_{1,before})}{\partial\tau} &< 0 \text{ if } \beta_1 > \beta_1^*\end{aligned} \tag{39}$$

$$\begin{aligned}&\text{if } \beta_1 < \beta_1^* \\ \frac{\partial(w_{2,after}-w_{2,before})}{\partial\tau} \geq 0 \text{ if } &\frac{R_1}{R_2} > \frac{\sigma}{\sigma-\alpha\beta_1} \\ &\text{if } \beta_1 > \beta_1^* \\ \frac{\partial(w_{2,after}-w_{2,before})}{\partial\tau} \geq 0 \text{ if } &\frac{R_1}{R_2} < \frac{\sigma}{\sigma-\alpha\beta_1}\end{aligned} \tag{40}$$

However, it is easy to show that if $\beta_1 < \beta_1^*$, then $\frac{\sigma}{\sigma-\alpha\beta_1} < \frac{1}{1-\beta_1^*}$, thus, since for both the sectors to be active it is required that $\frac{R_1}{R_2} > \frac{1}{1-\beta_1^*}$, then I must substitute $\frac{R_1}{R_2} > \frac{\sigma}{\sigma-\alpha\beta_1}$ with $\frac{R_1}{R_2} > \frac{1}{1-\beta_1^*}$, i.e. it is always true for all the admissible parameters.
Moreover it could be noticed that it is always true that $\frac{\sigma}{\sigma-\alpha\beta_1} < \frac{1}{1-\beta_1}$, thus, since the "non-negativity" conditions require $\frac{R_1}{R_2} > \frac{1}{1-\beta_1}$ if $\beta_1 > \beta_1^*$, thus, the condition $\frac{R_1}{R_2} < \frac{\sigma}{\sigma-\alpha\beta_1}$ can never hold and therefore, the effect of τ on the wages of workers with specialization two is always negative if $\beta_1 > \beta_1^*$.
It is possible to rewrite the conditions for the wages of workers with specialization two in the following way.

$$\begin{aligned}\frac{\partial(w_{2,after}-w_{2,before})}{\partial\tau} &\geq 0 \text{ if } \beta_1 < \beta_1^* \\ \frac{\partial(w_{2,after}-w_{2,before})}{\partial\tau} &< 0 \text{ if } \beta_1 > \beta_1^*\end{aligned} \tag{41}$$

Differences in $\mathbf{R_1}$

B.3 - Globalization in Sector 1

The wages of workers with specialization one increase after the globalization in sector one simply if $R_1 \geq R_1^*$, instead the workers with specialization two observe an increase in their wage if $R_1 \geq R_1^*$, $\frac{R_1}{R_2} > \sigma$, $\frac{R_1}{R_2} > \frac{\sigma}{\alpha}$ and $\frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)}$, if instead $R_1 < R_1^*$ then it increases if either $\frac{R_1}{R_2} > \sigma$ and $\frac{R_1}{R_2} \leq \frac{\sigma}{\alpha}$, or if $\frac{R_1}{R_2} > \frac{\sigma}{\alpha}$ and $\frac{R_1}{R_2} \leq \frac{\sigma}{\alpha(1-\beta_1)}$ or if $\frac{R_1}{R_2} \leq \sigma$.

From those restrictions it is easy to proof that since $\sigma < \frac{\sigma}{\alpha} < \frac{\sigma}{\alpha(1-\beta_1)}$, they can be rewritten in the following way:

$$\begin{aligned} R_1 \geq R_1^* &\text{ and } \frac{R_1}{R_2} \geq \frac{\sigma}{\alpha(1-\beta_1)} \\ R_1 < R_1^* &\text{ and } \frac{R_1}{R_2} \leq \frac{\sigma}{\alpha(1-\beta_1)} \end{aligned} \tag{42}$$

Now I consider also the conditions under which the two sectors were both active before globalization happened, in particular this is true either if $\frac{R_1}{R_2} < \frac{R_1^*}{R_2}$ and $\frac{R_1}{R_2} > \frac{1}{1-\beta_1}$, or if $\frac{R_1}{R_2} > \frac{R_1^*}{R_2}$ and $\frac{R_1^*}{R_2} > \frac{1}{1-\beta_1}$.
Moreover it is easy to show that $\frac{1}{1-\beta_1} < \frac{\sigma}{\alpha(1-\beta_1)}$.
Therefore we must only exclude our results below the area limited by the coordinates $(\frac{1}{1-\beta_1}, \frac{1}{1-\beta_1})$[20].

When studying the partial derivative of the wages of workers specialized in one with respect to τ I find that the sign will depend on two terms, $(R_1 - R_1^*)$ and $(\alpha - 2\alpha\beta_1 - \sigma)\tau^2 + (\sigma - \alpha)\tau^{2\sigma}$ which for simplicity it's called term $A(\alpha, \beta, \sigma, \tau)$.
A$(\alpha, \beta, \sigma, \tau)$ can be rewritten also as $(\tau^{2\sigma} - \tau^2)(\sigma - \alpha) - 2\alpha\beta_1\tau^2$, therefore since it is easy to prove that $(t^{2\sigma} - t^2) > 0$, the function appears to be increasing in σ and decreasing in α and β_1.

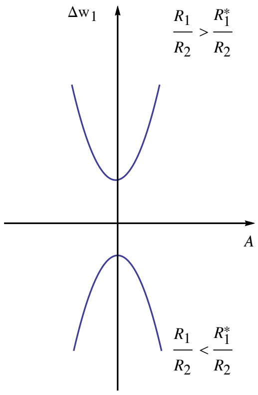
$$\frac{\partial w_{1,after}}{\partial \tau} = -\kappa(R_1 - R_1^*)((\tau^{2\sigma} - \tau^2)(\sigma - \alpha) - 2\alpha\beta_1\tau^2) \tag{43}$$

Since $\kappa \geq 0$ and $(\tau^{2(\sigma-1)} - 1) > 0$, then if $R_1 > R_1^*$ and $A > 0$, i.e. for low values of alpha and beta and/or high value of σ, then the partial derivative is negative, otherwise if $A < 0$ it will be positive. The opposite is then true for the case in which $R_1 < R_1^*$.
Since an increase in τ represent the reduction of the effect of globalization, then this implies that, if being in the case of $R_1 > R_1^*$ then, for negative values of A, the globalization produces a decrease in the wages of workers specialized in one (still the wages are higher than the closed economy case) because a reduction in the globalization allows for an increase in those wages. The opposite is true for values of A greater than zero in which globalization appears to increase the wages of workers with specialization one.
In the fig. B.8 and fig. B.9, are represented the effects of globalization on the difference between the wage before and after opening the borders for workers with specialization

[20] in this framework $\beta_1 = \beta_1^*$

one both when $R_1 > R_1^*$ and when $R_1 < R_1^*$.

Figure 8: Effects of Globalization in sector 1



Effects of Globalization in sector 1 for the wages of workers with specialization one in the domestic country

Now I study the effect of τ on the wages of workers specialized in two.

$$\frac{\partial w_{2,after}}{\partial \tau} = -\kappa_2(R_1 - R_1^*)(-A)(R_2\sigma - \alpha(1-\beta_1)R_1) \tag{44}$$

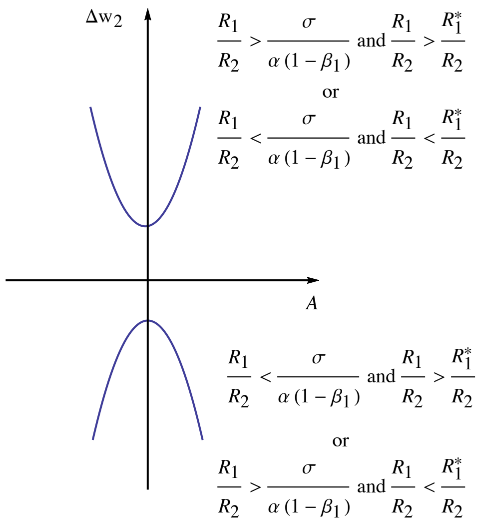
Since $\kappa_2 > 0$, as before the sign of the partial derivative depends upon the term $(R_1 - R_1^*)$ and A(.) but now it will also depend upon the new term on the righthand side of the partial derivative above.

Thus, studying the sign of the effect of τ I get the following conditions.

$$
\begin{aligned}
&\text{if } \frac{R_1}{R_2} > \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0 \\
&\text{if } \frac{R_1}{R_2} > \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0 \\
&\text{if } \frac{R_1}{R_2} > \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0 \\
&\text{if } \frac{R_1}{R_2} > \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0 \\
&\text{if } \frac{R_1}{R_2} < \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0 \\
&\text{if } \frac{R_1}{R_2} < \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0 \\
&\text{if } \frac{R_1}{R_2} < \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0 \\
&\text{if } \frac{R_1}{R_2} < \frac{R_1^*}{R_2} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0
\end{aligned}
\tag{45}
$$

Thus, applying the same reasoning we can represent the difference of the wages before and after the globalization ($w_{2,after} - w_{2,before}$) in the following graph.

Figure 9: Effects of Globalization in sector 1



Effects of Globalization in sector 1 for the wages of workers with specialization two in the domestic country.

Different in $\mathbf{R}_2$

B.4 - Globalization in Sector 1

After globalization one the wages of workers with specialization one increase if $R_2 < R_2^*$ and thus if $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$, while the wages of workers with specialization two rise if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$, $\frac{R_1}{R_2} > \sigma$ and $\frac{R_1}{R_2} \leq \frac{\sigma}{\alpha}$ or if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$, $\frac{R_1}{R_2} > \sigma$, $\frac{R_1}{R_2} > \frac{\sigma}{\alpha}$ and $\frac{R_1}{R_2} \leq \frac{\sigma}{\alpha(1-\beta_1)}$ or if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$ and $\frac{R_1}{R_2} \leq \sigma$ or if $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$, $\frac{R_1}{R_2} > \sigma$, $\frac{R_1}{R_2} > \frac{\sigma}{\alpha}$ and $\frac{R_1}{R_2} \geq \frac{\sigma}{\alpha(1-\beta_1)}$.
Since $\sigma < \frac{\sigma}{\alpha} < \frac{\sigma}{\alpha(1-\beta_1)}$, I can rewrite the above conditions under which the wages of the workers with specialization two increase, in the following way.

$$\begin{aligned} &\frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \\ &\frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \end{aligned} \tag{46}$$

The conditions under which the two sectors were active before the globalization must be added into the analysis, thus, either $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$, and $\frac{R_1}{R_2^*} > \frac{1}{1-\beta_1}$ or $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$ and $\frac{R_1}{R_2} > \frac{1}{1-\beta_1}$. Moreover, since $\frac{1}{1-\beta_1} < \frac{\sigma}{\alpha(1-\beta_1)}$, then the analysis remain invariant, but in the graphical analysis we must focus on the portion of the graph limited by $\frac{1}{1-\beta_1}$.

Now I study the sign of the partial derivative of the wages of the two types of workers with respect to τ.

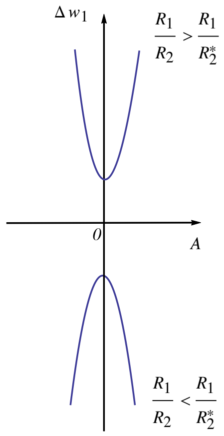
$$\frac{\partial w_{1,after}}{\partial \tau} = \kappa_3(R_2 - R_2^*)A \tag{47}$$

Thus, since $\kappa_3 > 0$, I study the sign of A and $(R_2 - R_2^*)$ in order to discuss the sign of the partial derivative.

$$\begin{aligned} &\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } A > 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} < 0 \\ &\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } A < 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} > 0 \\ &\text{if } \frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } A > 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} > 0 \\ &\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } A < 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} < 0 \end{aligned} \tag{48}$$

Thus, reminding that the increase of τ implies a reduction of the effects of globalization, the difference between the wages after and before globalization could be represent in the following graph.

Figure 10: Effects of Globalization in sector 1 on w_1



Effects of Globalization in sector 1 for the wages of workers with specialization one in the domestic country.

Moreover I study the effect of an increase in τ on the wages of workers specialized in two.

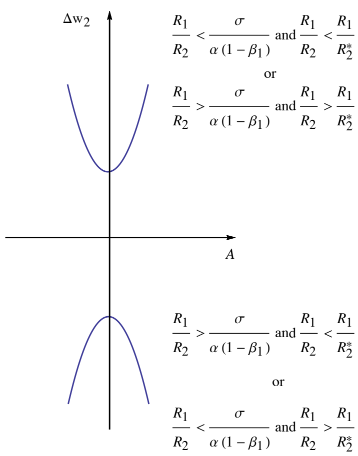
$$\frac{\partial w_{2,after}}{\partial \tau} = -\kappa_4(R_2 - R_2^*)(A)(R_2\sigma - \alpha(1-\beta_1)R_1) \tag{49}$$

Thus, since $\kappa_4 > 0$ and $(R_2\sigma - \alpha(1-\beta_1)R_1) > 0$ if $\frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)}$, we can write the sign study in the following way.

$$\begin{aligned}
&\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0\\
&\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0\\
&\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0\\
&\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0\\
&\text{if } \frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0\\
&\text{if } \frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} < \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0\\
&\text{if } \frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A > 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} > 0\\
&\text{if } \frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } \frac{R_1}{R_2} > \frac{\sigma}{\alpha(1-\beta_1)} \text{ and } A < 0 \Rightarrow \frac{\partial w_{2,after}}{\partial \tau} < 0
\end{aligned} \tag{50}$$

As before we can represent the changes of the wages of workers two after the globalization with respect to before it in the following graph.

Figure 11: Effects of Globalization in sector 1 on w_2



Effects of Globalization in sector 1 for the wages of workers with specialization two in the domestic country.

B.5-Globalization in Sector 2

While the wages of workers with specialization one increase whenever $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$, for the wages of workers specialized in two the conditions that must hold are the following.
If $1 < \sigma < 2$ and $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$, it is required that $\frac{R_1}{R_2} < \frac{\sigma}{\sigma-\alpha\beta_1}$ and at the same time it is also required that $\frac{R_1}{R_2} < min\{\frac{R_1}{R_2^*}\frac{1}{\sigma-1}, \frac{R_1}{R_2^*}\frac{\sigma}{\sigma-\alpha}\}$[21], if instead $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$ it is required that $\frac{R_1}{R_2} > \frac{\sigma}{\sigma-\alpha\beta_1}$.
Meanwhile if $\sigma > 2$, then the wages of workers with specialization two increase only if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$ and $\frac{R_1}{R_2} > \frac{\sigma}{\sigma-\alpha\beta_1}$.
When I study all the admissible values for which both the two sectors are active in both the countries, the equilibrium solutions must satisfy also the following conditions.
If $\frac{R_1}{R_2} > \frac{R_1}{R_2^*}$, then $\frac{R_1}{R_2^*} > \frac{1}{1-\beta_1}$, if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$ then $\frac{R_1}{R_2} > \frac{1}{1-\beta_1}$.
Therefore it can be noticed that, since $\frac{1}{1-\beta_1} > \frac{\sigma}{\sigma-\alpha\beta_1}$, the conditions above can be rewritten the following way: Both the wages of workers with specialization one and with specialization two increase if $\frac{R_1}{R_2} < \frac{R_1}{R_2^*}$, and they decrease otherwise.

Now I study the impact of a change in τ on the effect of globalization in sector two on both the wages of workers with specialization one and two.
Notice that now the partial derivative of w_1 with respect to τ is the following:

$$\frac{\partial w_{1,after}}{\partial \tau} = \kappa_5(R_2 - R_2^*)(\alpha(\tau^2 + t^{2\sigma}) - \sigma(\tau^{2\sigma} - t^2) - 2\alpha)\beta_1\tau^2) \tag{51}$$

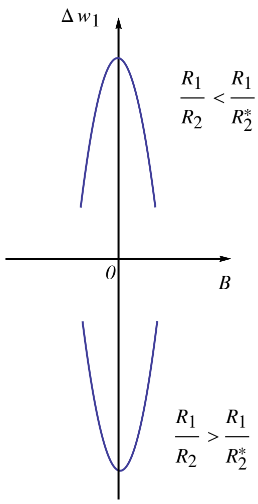
Thus, defining $B(\alpha, \beta_1, \sigma, \tau) \equiv (\alpha(\tau^2 + t^{2\sigma}) - \sigma(\tau^{2\sigma} - t^2) - 2\alpha)$ I study the sign of the effect of an increase in τ and I get the following.

$$\begin{aligned}
&\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } B(.) > 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} < 0 \\
&\text{if } \frac{R_1}{R_2} > \frac{R_1}{R_2^*} \text{ and } B(.) < 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} > 0 \\
&\text{if } \frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } B(.) > 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} > 0 \\
&\text{if } \frac{R_1}{R_2} < \frac{R_1}{R_2^*} \text{ and } B(.) < 0 \Rightarrow \frac{\partial w_{1,after}}{\partial \tau} < 0
\end{aligned} \tag{52}$$

Therefore, the effect of globalization on wage of workers with specialization one can be summarized in the following graph.

[21] if $\alpha < \sigma(2-\sigma)$, then $\frac{R_1}{R_2^*}\frac{1}{\sigma-1} > \frac{R_1}{R_2^*}\frac{\sigma}{\sigma-\alpha}$, otherwise if $\alpha > \sigma(2-\sigma)$, then $\frac{R_1}{R_2^*}\frac{1}{\sigma-1} < \frac{R_1}{R_2^*}\frac{\sigma}{\sigma-\alpha}$

Figure 12: Effects of Globalization in sector 2 on w_1



Effects of Globalization in sector 2 for the wages of workers with specialization one in the domestic country.

Appendix C

C.1 - Information on the Reshoring Initiative Data

	Full Sample		Reshorers		KFO	
	No.	%	No.	%	No.	%
1995	1	0,16	.	.	1	0,44
1997	1	0,16	1	0,24	.	.
1999	1	0,16	.	.	1	0,44
2001	2	0,31	1	0,24	1	0,44
2002	1	0,16	.	.	1	0,44
2003	2	0,31	2	0,49	.	.
2005	1	0,16	.	.	1	0,44
2006	3	0,47	2	0,49	1	0,44
2007	6	0,94	4	0,98	2	0,88
2008	19	2,98	11	2,69	8	3,51
2009	32	5,02	19	4,65	13	5,70
2010	34	5,34	27	6,6	7	3,07
2011	76	11,93	41	10,02	35	15,35
2012	101	15,86	76	18,58	25	10,96
2013	185	29,04	108	26,41	77	33,77
2014	140	21,98	95	23,23	45	19,74
2015	30	4,71	20	4,89	10	4,39
2016	2	0,31	2	0,49	.	.
Total	637	100	409	100	228	100,00
Observations	637		409		228	

Table 2: The year of reshoring, different samples

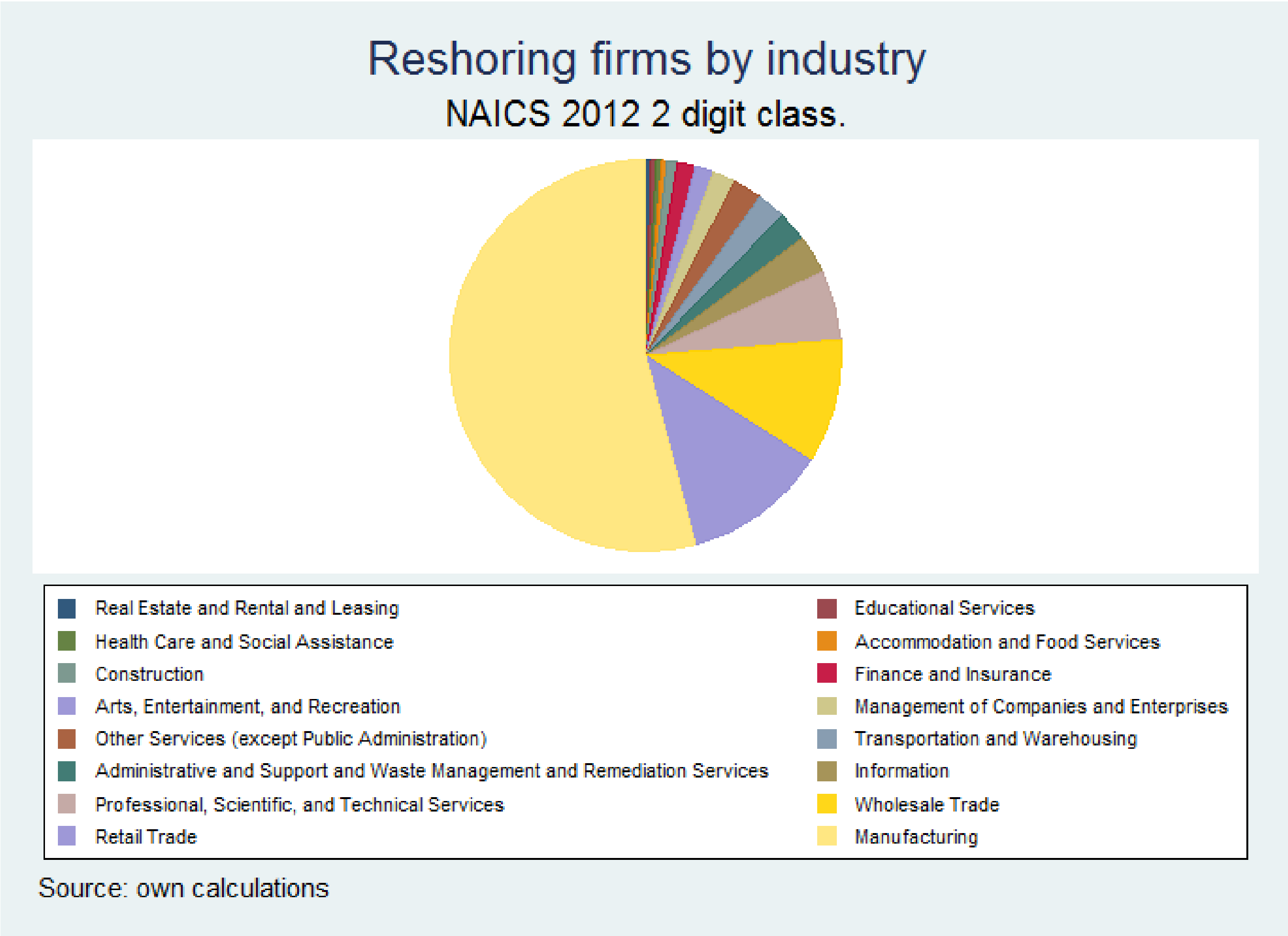


Figure 13: Reshoring firms by industry

Domestic factor	% of companies
Technology and/or innovation difficulties	27,74
Other	20,19
Skilled workforce	12,41
Government Incentives	9,00
U.S. price of natural	4,38
Customer/demand issues	4,38
Eco-system synergies	3,89
Infrastructure	2,92
Lower real-estate/construction costs	0,97
Supplier issues	0,49

Table 3: Main domestic factors behind reshoring decision for US firms

C.2 - Static Model Equilibrium derivation

Noticing that $\lambda_k(\beta-\delta_k) = \frac{L(\beta-\delta_k)^2}{4\gamma\theta_k - L(\beta-\delta_k)^2}$ for $k \in \{H, O\}$ and $c_{D,O} = \frac{c_{D,H}}{w\tau}$:

$$\frac{L}{4\gamma}(c_{D,H}-c_\omega)^2(1+\lambda_H(\beta-\delta_H)) > \frac{L}{4\gamma}(w\tau)^2(c_{D,O}-c_\omega)^2(1+\lambda_O(\beta-\delta_O))$$

$$(c_{D,O}^2 - 2c_{D,O}c_\omega + c_\omega^2)(\frac{4\theta_O\gamma}{4\theta_O\gamma - L(\beta-\delta_O)^2}) > (c_{D,O}^2 - 2c_{D,O}c_\omega(w\tau) + c_\omega^2(w\tau)^2)(\frac{4\theta_O\gamma}{4\theta_O\gamma - L(\beta-\delta_O)^2})$$

$$(c_{D,H}^2 - 2c_{D,H}c_\omega + c_\omega^2)(\frac{\theta_H}{4\theta_H\gamma - L(\beta-\delta_H)^2}) > (c_{D,H}^2 - 2c_{D,H}c_\omega(w\tau) + c_\omega^2(w\tau)^2)(\frac{\theta_O}{4\theta_O\gamma - L(\beta-\delta_O)^2})$$

$$(c_{D,H}^2 - 2c_{D,H}c_\omega + c_\omega^2)(\Gamma_H) > (c_{D,H}^2 - 2c_{D,H}c_\omega(w\tau) + c_\omega^2(w\tau)^2)(\Gamma_O)$$

$$\text{where } \Gamma_H \equiv \frac{\theta_H}{4\theta_H\gamma - L(\beta-\delta_H)^2},\ \Gamma_O \equiv \frac{\theta_O}{4\theta_O\gamma - L(\beta-\delta_O)^2}$$

$$\Leftrightarrow c_\omega^2(\Gamma_H - (w\tau)^2\Gamma_O) - 2c_\omega c_{D,H}(\Gamma_H - (w\tau)\Gamma_O) + c_{D,H}^2(\Gamma_H - \Gamma_O) > 0 \qquad (53)$$