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The Impact of Technological Growth on the Labor Market

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Abstract

Nowadays, work is the main source of income to meet subsistence and material needs, which include necessities such as food, water and shelter. However, a person is also looking for a good quality of life, which requires access to new technologies for entertainment reasons. Therefore, the increase in income is the means to improve the "quality" of life and for this reason they invest time and capital for education which can offer a better professional situation and as a consequence, increased wages.

However, in recent years we have experienced many changes in work matters which are mainly summarized in three major categories. Population growth, respect for human rights and changing technological capabilities. In this work, a study will be carried out regarding the rearrangements caused by technological progress.

Technological progress has both positive and negative consequences. On the one hand, it improves people's standard of living and participates in the production process of businesses by expanding their production capabilities. On the other hand, it has entered production, replacing human labor in a multitude of jobs. It is observed that accounting systems have replaced many workers in accounting offices. The same is the case with digging machines that replace long hours of manual work. Thus, questions arise as to whether technology improves our lives or causes us difficulties in the job-finding process.

Keywords: Automation; New Tasks; Innovation; Change in Task Content; Reinstatement Effect; Displacement Effect
JEL Classification: E24; J24; O33

Περίληψη

Στις ημέρες μας η εργασία αποτελεί την κυριότερη πηγή εισοδήματος για την εξυπηρέτηση των βιοποριστικών και υλιστικών αναγκών, στις οποίες συγκαταλέγονται και οι βασικές βιοτικές ανάγκες όπως τροφή νερό και στέγη. Ωστόσο ο άνθρωπος αναζητά και την καλή ποιότητα ζωής η οποία απαιτεί πρόσβαση σε νέες τεχνολογίες για ψυχαγωγικούς λόγους. Επομένως η αύξηση του εισοδήματος αποτελεί το μέσο για τη βελτίωση του τρόπου ζωής του ανθρώπου και για τον λόγο αυτό επενδύει χρόνο και κεφάλαιο για την μόρφωσή του η οποία δύναται να του προσφέρει καλύτερη επαγγελματική αποκατάσταση και κατ' επέκταση, αυξημένους μισθούς.

Ωστόσο κατά τα τελευταία χρόνια βιώνουμε πολλές αλλαγές στα θέματα εργασίας τα οποία συνοψίζονται κατά κύριο λόγο σε τρεις μεγάλες κατηγορίες. Την πληθυσμιακή αύξηση, τον σεβασμό των ανθρωπίνων δικαιωμάτων και την μεταβολή των τεχνολογικών δυνατοτήτων. Στην παρούσα εργασία θα πραγματοποιηθεί μελέτη που αφορά τις αναδιατάξεις που προκαλεί η τεχνολογική πρόοδος.

Η τεχνολογική πρόοδος έχει τόσο θετικές όσο και αρνητικές συνέπειες. Αφενός αναβαθμίζει το βιοτικό επίπεδο των ανθρώπων και συμμετέχει στην παραγωγική διαδικασία των επιχειρήσεων διευρύνοντας τις παραγωγικές τους δυνατότητες. Αφετέρου έχει εισχωρήσει στην παραγωγή αντικαθιστώντας την ανθρώπινη εργασία σε πληθώρα θέσεων εργασίας. Παρατηρείται ότι λογιστικά συστήματα έχουν αντικαταστήσει τους πολλούς εργαζόμενους στα λογιστικά γραφεία. Το ίδιο συμβαίνει και με τα σκαπτικά μηχανήματα που αντικαθιστούν πολύωρη χειρωνακτική εργασία. Έτσι προκύπτουν ερωτήματα για το αν η τεχνολογία βελτιώνει την ζωή μας ή μας προκαλεί δυσχέρειες στη διαδικασία ευρέσεως εργασίας.

Λέξεις Κλειδιά: Αυτοματοποίηση; Νέα Επαγγέλματα; Καινοτομία; Αλλαγή στο Περιεχόμενο της Εργασίας; Επίδραση Αποκατάστασης; Επίδραση Αποκατάστασης

Κατηγοριοποίηση JEL: E24; J24; O33

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Chapter 1. Introduction

For the requirements of the dissertation, a literature review will be carried out to identify the basic concepts of technological progress, then analyses will be presented regarding the correlation of technological progress to labor demand, and finally a study and discussion will be made about the concerns arising from technological progress on the issues of modern economic life.

The development of technology has greatly reshaped the daily life of humans. The "revolution" in technology during the last hundred years is far greater than that which had taken place during the previous 100 years. This is noticeable in our daily lives, on the one hand as our needs, the overall demand for new products and the standard of living have changed, on the other hand because production possibilities have improved making new products easily accessible to more economic classes. So, with a quick glance we can easily claim that access to new technologies has improved our lives. This is easily understood if we ask ourselves how easily someone would go back 30 years, to 1990 when not only did we not have smartphones, but we didn't even have the internet.

1.1. Earlier Thoughts

The rapid development of technology was predicted and preoccupied great economists many years ago, when it was still in its early, by today's standards, stage. At this point a brief description will be done in which the opinions and predictions about the effect of technology on society, the economy and work issues will be mentioned.

John Maynard Keynes in his short article “Economic Possibilities for our Grandchildren", in 1930, refers to the speed at which technology is developing and the potential anomalies that will be caused to society by these repeated and rapid changes. (Keynes, 1930) He also mentioned the unemployment that will be caused by the development of technology. This report was considered unfounded until recently andthat for every position replaced by a production machine, other jobs were created which were necessary for the development of new technologies, their installation and maintenance. However, in the last decade, technology has made leaps to the extent that gives the feeling that robotics in collaboration with artificial intelligence can become autonomous as the systems have the ability of self-diagnosis of damage, and automatic repair by other robots.

At the same time, John Maynard Keynes envisioned a society where production would be technologically advanced and automated by robots and machines. This technological development would offer greater production possibilities, producing an abundance of goods and lowering prices. So, the real wage would increase. Human being as a rational being would choose between work and rest, substituting hours of work for rest, a superior good, to the point where only fifteen hours of work per week were required. This nowadays is not feasible as the social, political and economic conditions have changed. Working conditions bear no relation to what the average worker had in 1930. The entry of women into the labor market after World War II also affected working hours. Globalization and the ever-increasing needs of modern man, who is looking for more and more new products and services in his daily life, have certainly played their role.

In 1982 the Nobel laureate economist Wassily Leontief with the article "The Distribution of Work and Income" returned to his term of technological unemployment (Leontief, 1982) John Maynard Keynes with a slightly more pessimistic approach. He essentially likened man to a horse. Until the 19th century, horses were essential in human life as they were used for the movement of people, the transport of goods and agricultural needs. But when the technology of internal combustion engines was developed, trains and tractors were very quickly replaced by cars. Thus, by likening humans to horses, he sows seeds of concern about the fate of human labor being replaced by more efficient production systems.

1.2. General Concepts

It is known that now the new technological systems are able not only to replace human work but are also more efficient with lower costs for their operation. As a result, concerns arise about the future of work and unemployment levels after humans are replaced by technology. This technology can be distinguished in three categories.

The first category concerns information systems that have improved process capabilities. Such examples are found across the spectrum of work processes, such as economists using special data analysis programs that calculate data more accurately by eliminating time-consuming manual processes, or businesses exchanging e-mails faster by replacing postmen.

The second category concerns robotics. Robots can interact with the natural world. They have automated control, are versatile and can be reprogrammed. Such systems are seen in modern industrial plants where production lines have been replaced by robotic systems.

The third category concerns artificial intelligence. Artificial intelligence consists of complex systems that use data, pattern detection and algorithms to solve problems, at a level that provides the ability to process information and data and interact with humans. This phenomenon in the past had caused fear in people because artificial intelligence capabilities far superior to those of humans were presented. So, it was thought that artificial intelligence tends to replace human thinking as it could do what humans do and thus it was sidelined. Such an example might be a program that has the potential to beat the world's best chess player in a game of chess.

Actually, the goal of artificial intelligence was that man could program machines to act like man. So, the project was approached differently without trying to replace the human mind but was limited to taking on tasks previously performed by humans, also limiting the reasonably existing conflict between humans and machines. Over the past decade, artificial intelligence has fully integrated into our daily lives. It is noteworthy that Open AI's Robot GPT-3 with a question wrote well (arguing correctly and reaching conclusions) for The Guardian newspaper in September 2020. The question was: "Please write a short text about 500 of words. Keep the language simple and concise. Focus on why humans have nothing to fear from Artificial Intelligence." (Fontanella-Khan, 2020)

In addition, significant improvements have been seen in artificial intelligence as it can now replace financial planning, bookkeeping and more. For example, recent work by several academics at Cornell University and Harvard University shows that if artificial intelligence techniques are used to enforce bail decisions, about 25% fairer outcomes are to be achieved than if they were to come from judges. In addition, a 25% reduction in the crime rate is achieved because judges, by simply processing, with no other option, the given information are led to wrong decisions. (Kleinberg, Lakkaraju, Leskovec, Ludwig, & Mullainathan, 2018)

It is important to underline the Raymond Kurzweil's well known quote "Artificial intelligence will reach human levels by around 2029. Follow that out further to, say, 2045, and we will have multiplied the intelligence – the human biological machine intelligence of our civilization – a billion-fold." that is based on his book. (Kurzweil, 2005) Raymond Kurzweil is a well-known futurist and inventor. The above sentence is evidence, that shows us that technology specialists are planning to enhance technology and reach human intelligence levels in near future.

1.3. Technology Categorization

All the above have forced people to worry about the future of work. However, it is necessary, for the needs of studying the effect of technology, in the context of the economics of work, to separate technology into two categories. The technologies will be distinguished into Labor Enabling Technologies and Labor Replacing Technologies. This distinction essentially defines the two ends of the spectrum of technological impact on work issues. In this view we will be able to study which technologies and how they affect wages and the volume of available working hours in the labor market.

Reference will be made to Labor Enabling Technologies when they supplement human capabilities. One such example can be the technology of the microscope, as the human eye cannot by its nature distinguish at this scale. In contrast to this we have Labor Replacing Technologies. Essentially, Labor Replacing Technologies completely replace jobs by freeing up labor. An example of this kind is the production line of Tesla's car factory, which is a fully automated workplace. During this process, the raw material, the sheet metal, is received, and the robots perform all the bodywork and paint work autonomously up to the last stage of assembly. It is a typical example of Labor Replacing Technologies, as robots have replaced human labor without providing additional quality features to the product that could not be provided by human labor. Finally, there are the intermediate stages of technologies which combine the above two extreme cases. As an example of this can be the protection and security systems which cover security needs with thermal camera and alarm systems. These systems have thermal cameras which, on the one hand, belong to the category of Labor Enabling Technologies, as they allow the detection of movements in the dark, something that was not possible before, but on the other hand, they belong to Labor Replacing Technologies, as the alarm systems replace the shift position that were covered by guards.

This distinction between Labor Enabling Technologies and Labor Replacing Technologies is important because they create very different impacts on the labor market.

Labor Enabling Technologies increase productivity. When a technology increases productivity, it also increases wages. In any case, these technologies do not reduce wage levels overall, but they may reduce the wages of a small group of workers or change the way companies are organized in a way that does not benefit everyone. But of course, this loss will be limited to the extent that some people benefit more than others, so overall wage growth will always be a function of this. Because an increase in wages is going to increase the demand for labor and people's willingness to work, employment will follow the trend of wage increases. Thus, Work Assistive Technologies will benefit the whole society,so in conclusion, these technologies tend to act to the benefit of workers and not to their detriment.

Unlike Labor Enabling Technologies, Labor Replacing Technologies directly remove jobs from the workforce. This phenomenon creates direct negative effects on employment and the level of wages, without excluding, indirectly, the effect of chain positive influences. So, as in the example we mentioned earlier, when the Tesla factory uses robots for the car production line, it increases its production capabilities, producing in a shorter time, and reduces the production cost per unit of product. This in turn means that it allows Tesla to price its products lower and people want to consume more cars. However, not all departments have been automated and workers potentially can be employed in other production departments. Thus, lowering the price of cars increases the real wage of workers making them richer. But by consuming cars at lower price, we can consume other goods. The increase in consumption requirements will expand the needs for employment.

Therefore, in this category of technologies the impact on society can be likened to a balance that has on one side productivity and on the other the loss of jobs from the installation of production systems. In the case where productivity is less than the loss of jobs, then society experiences a decrease in wages. It is worth noting that technologies that replace jobs but do not produce at lower costs to allow a reduction in the price of the offered good are socially dangerous.

Chapter 2. Literature Data Research

In this part, reference will be made to data and diagrams that have been collected during the literature review. The data mainly concerns the USA. Afterwards, referencewill be made to some countries of the Organization for Economic Cooperation and Development. The study of data is necessary as it will trace the importance of the concerns arising from the technological development of our time.

2.1. Definitions

At this point it is necessary to summarize some definitions for a better study of the diagrams that will be presented.

“Employment Rate” The Employment Rate is defined as the measure of the degree to which the available labor resources (people who are available to work) are being used. Thus, this percentage is calculated as the ratio of employed persons to the population of persons able to work.

“Distribution of National Income” The distribution of national income is divided into the part produced by labor (man) and the part produced by capital (production machinery). The capital share is complementary to the labor share.

2.2. Chart Study

To test the claim that technological progress replaces labor, it is necessary to find any negative relationship between technological progress and the level of employment. As mentioned earlier, the capital share is complementary to the labor share. Thus, an increase in technological progress also refers to an increase in the share produced by capital over that produced by labor. Therefore, our hypothesis can be transformed into a correlation of the share produced by labor and the employment rate, at a decreasing rate.

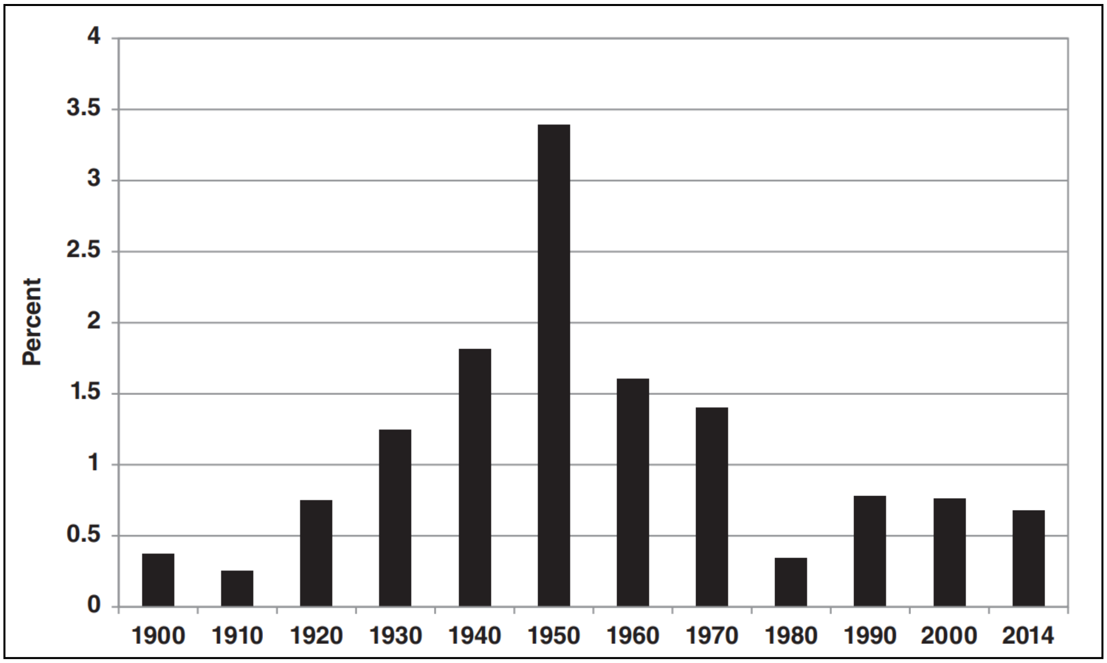

Diagram 2.1. 10-Year Average Annual Growth in Total Factor Productivity, 1900–2014 (Gordon, 2016)

As first evidence on the above we have the following Diagram 2.1. According to Gordon this diagram focuses on total factor productivity (TFP) growth. In the 1940s, 50s, 60s there was a very rapid TFP growth. The TFP explains the annual increase of the Gross Domestic Product (GDP), the total value of goods and services in the economy, by keeping all production factors, the skills and the physical capital, steady.

In this point, there is a need to underline that in the 40s, 60s and 70s there was 2%-3% and during the 50s actually just over 3% increase in TFP growth which means that US economy could achieve a three percent growth per year in GDP, without any significant changes.

On the other side, once we focus on personnel it is worth noting that in periods of staff reduction the, most vulnerable group is that of pre-retirement age. The phenomenon has various interpretations. It is a fact that this group is the staff with the most experience. However, executives with fewer years are equally sufficient experience and development prospects by replacing the positions of older staff, which would happen anyway in the medium term. Another reason why the group of older workers is the vulnerable employment group is the fact that it costs more in terms of wages than a younger employee.

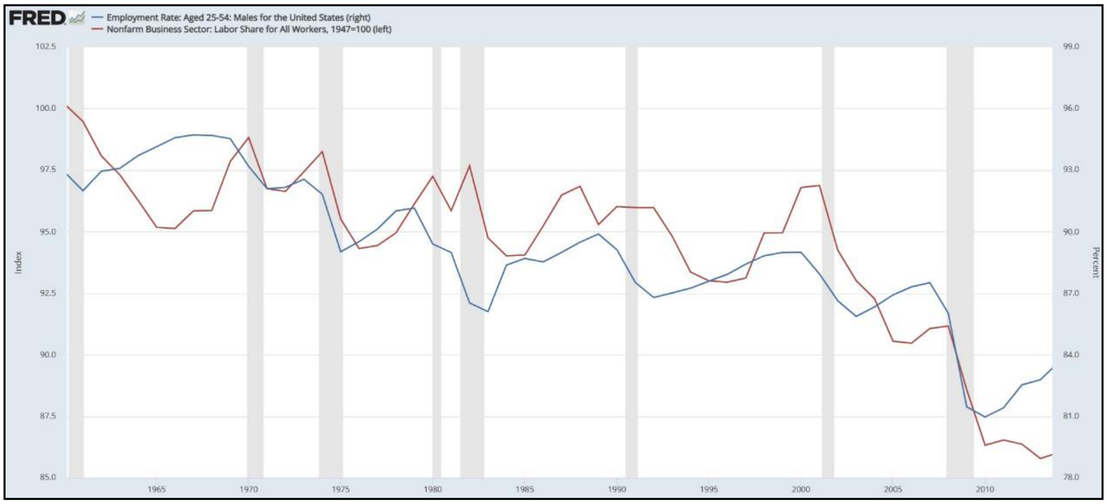

Diagram 2.2. US Employment Rate: Adults Ages 25-54 & Labor Share: Nonfarm Business sector (FRED, 2023)

Reference will be made to the change in the employment rate of the mature men (men that they're able to work) during the years 1960-2015. At the same time, reference will be made to the change in the share of work during the same period. In diagram 2.2. both curves are plotted with decreasing trends. We notice that the Employment rate decreased from about 97.5% to about 84% while the labor share decreased about 14%. The chart has been properly calibrated so that the simultaneous changes of the two percentages over time are clearly visible. It is worth noting that there is a correlation in the movement of these two percentages over time, which suggests that among the oldest employees there may be job replacement due to technological development.

In diagram 2.3. the cumulative difference in log weekly earnings of men aged 16 to 64 is shown. In addition, the data have been categorized into groups of workers according to their educational level. These groups are broken down as follows: men with no secondary education, men with a high school diploma, men with a college education (the lowest level of higher education), men with a bachelor's degree, and men with an education beyond a bachelor's degree.

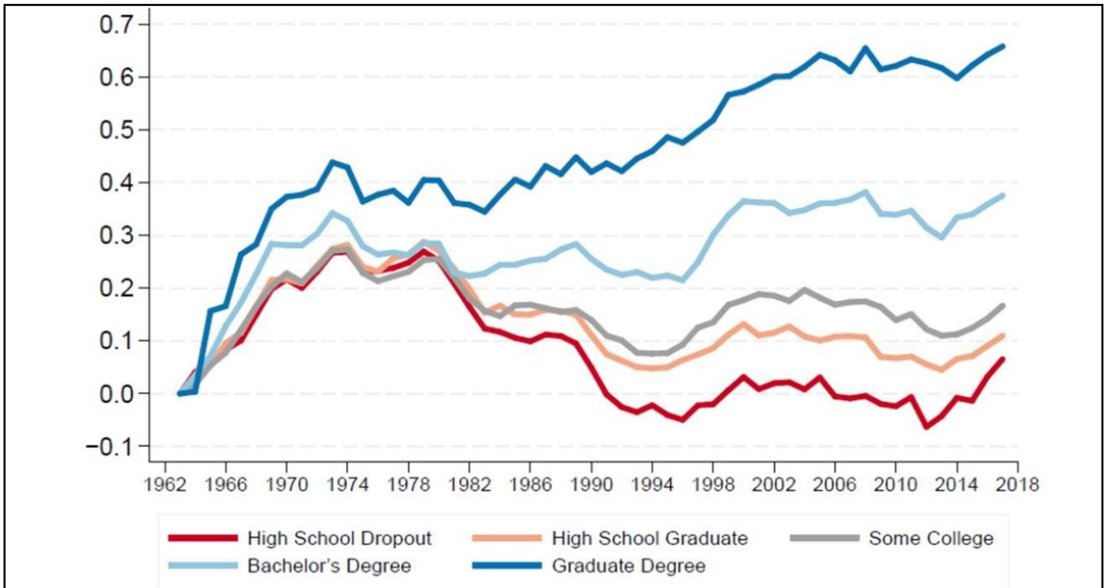

Diagram 2.3. Cumulative Change in Real Weekly Earnings of Working Age Adult Men 18-24, 1963-2017. (Autor, 2019)

This is how we can discern changes in the division of labor. We can distinguish changes in the wages of different groups of men according to the education they have received. In an overall picture we observe that in the first years there is a prosperity of the order of 2% in all groups. This image changes around 1970 as a split is observed in their group course. The two groups with the highest education follow a different path from that of the three groups with the lowest education. An additional point of reference is that from about 1980 to 1995,in addition to the gap between the groups, there is also a rapid decrease in the wages of people with a lower educational level.

In a comparative analysis of diagrams 2.2. and 2.3. we can still draw some conclusions about the effect of technology. In diagram 2.2. we observe a decreasing trend in the division of labor, which is accompanied by an increase in the division of capital. Thus, the increase in capital allocation appears to impart anupward trend to the wages of groups with higher education. On the contrary, the increase in capital allocation accompanies the decrease in wages in the groups with a lower educational level. In addition, it is observed that in short-term periodswhen the level of labor distribution is decreasing, the gap between groups that have received different levels of education increases. Moreover, in short-term periods when the level of work distribution increases, the gap between these groups does not appear to change.

However, education does not always play a decisive role in the level of remuneration of the job. It is usually the trigger for receiving the first salaries. Over time, it has been observed that the salary is formed according to the employee's seniority and abilities. Considering that skill shapes the pay levels ofwork, it would be useful to study how technology has affected work.

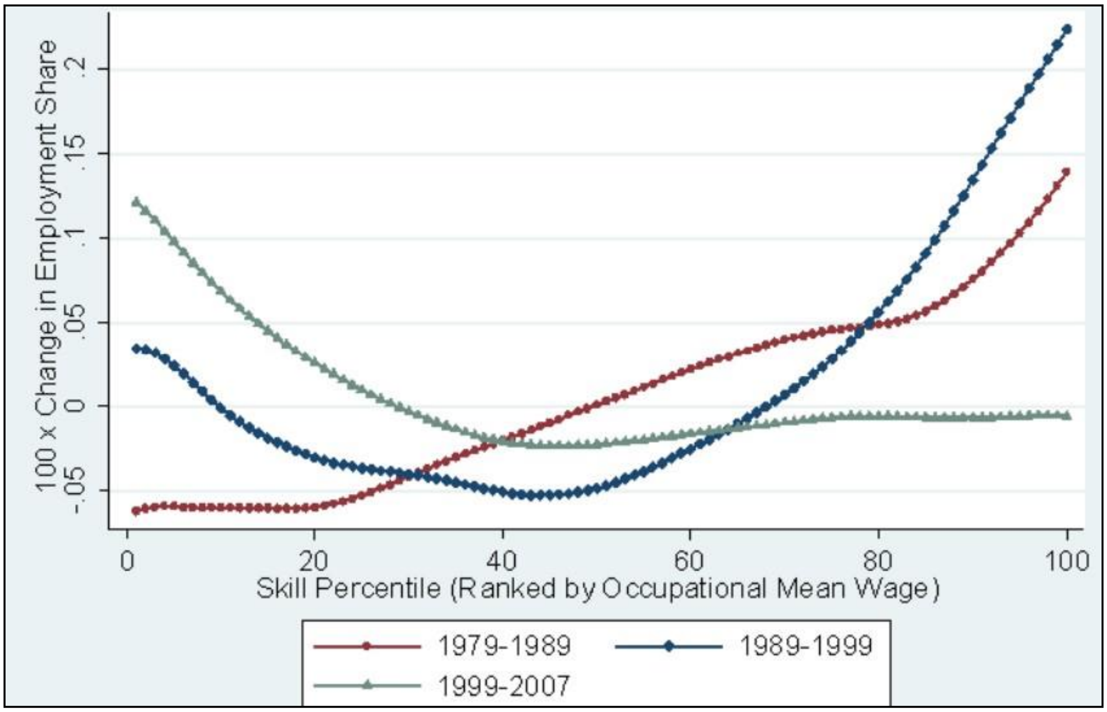

Diagram 2.4. Smoothed Changes in Employment by Occupational Skill Percentile 1979-2007 Work by (Autor & Dorn, 2009) Visualization and further work by (Acemoglu & Autor, 2011)

In diagram 2.4. normalized labor distribution changes at each wage percentile are shown, ranked from lowest to highest wage. That is, on the left side are the workers with the lowest earnings, while on the right are the workers with the highest. In addition, the assumption is made that the remuneration is proportional to the skills of the employee. Thus, we can study the differences in the employment share in each decade. In more detail, we will classify the workers in three categories. First in the low-skilled category in which we find workers with low or no skills. Such workers are those who offer cleaning, custodial and miscellaneous services, and other tasks that do not require prior knowledge. This class is roughly bounded in the range [0.33]. Second is the middle skill category in which we usually find workers in crafts and industries. We limit this category to the range (33,66). Third, the high-skilled category usually includes lawyers, managers, doctors, and teachers. So, we limit this category to the range [67,100]. Additionally, the analysisis sorted into three decades. These decades have been chosen for two reasons. On the one hand because they are the decades in which we have experienced the greatest technological progress and on the other hand because they are easily comparable as they do not contain periods of financial crises which directly affect labor remuneration.

In the first decade (1979 - 1989) we observe an expected reaction of businesses to technological development. For companies to respond to the increase in production, they prefer skilled and qualified workers with the aim of increasing their productivity. Thus, we see a decrease in low-skilled jobs, a neutral situation in middle-skilled jobs (some lose and some gain), and a high absorption in jobs that require high-skilled employees. Essentially, we see businesses tending to accept skilled staff and encourage the workforce to provide companies with more and more skills.

Taking the first decade as the base decade, in the second decade (1989 - 1999) we observe a quite different picture of the curve. Middle-class workers are shown to have a loss in their division of labor. This fact can be justified due to technological progress. Production machines have replaced the production line of factories. This reduces the available market share for middle class people. Therefore, these workers are either absorbed into high-skill jobs or relegated to low-skill jobs. This thought is confirmed as the diagram shows that both the other two categories show an increased share of employment.

Finally, during the last eight years analyzed in diagram 2.3, there is even greater differentiation in the picture of the curve. The middle class persists in reducing the division of labor at a slightly improved rate over the previous decade. The worrying part of this curve is the picture of the third category. This curve not only has a dramatic change in the distribution of work compared to the previous decade, but also takes negative values. This indicates that the labor share of the third category has decreased, and workers in this category have been demoted by one to two categories. The fact is verified by the increase in the employment share of the low-wage category, and it is also amenable to an analogous interpretation. During these eight years there was a flowering of information systems and artificial intelligence, primarily facilitating administrative positions. Now the Computer offers the possibility of replacing working hours in professions such as those of accountants, cashiers in bank branches, or even ERP services that replace administrative positions in companies.

Another piece of information that we can obtain from this diagram is the interpretation of the technological replacement behavior on labor. As we can see each time technology responds to labor groups with the higher labor share. This could be a policy that helps the firm to reduce costs and produce their goods or their services more effectively.

In diagram 2.4. we will also return in the next section in which the trends, expectations and concerns brought about by technological development will beanalyzed. However, unilaterally analyzing the image of the U.S questions arise as to whether this image is also observed in other countries besides the USA.

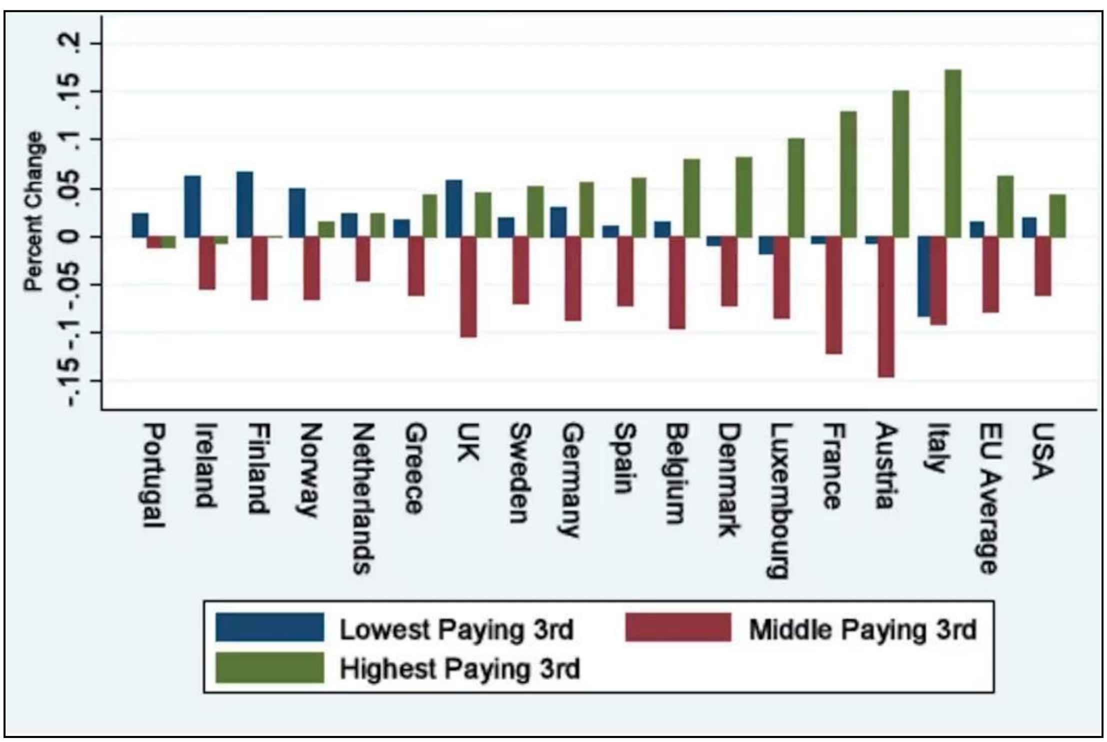

Diagram 2.5. Change in Employment Shares by Occupation 1993-2006 in 16 European Countries (Goos, Maaning, & Salomons, 2009) and USA, Occupations Grouped by Wage Tercile: Low, Middle, High (Acemoglu & Autor, 2011)

In diagram 2.5. the change in employment distribution between the years 1993 and 2006 is shown. The diagram is made up of the analysis of the change in the three categories we studied in diagram 2.4. in a classification of sixteen European countries and the overall picture of the European Union and the USA. At this pointwe can focus on several points. One of them is that the general picture observed in the USA, of the reduction of the division of labor among the workers belonging to the middle class, is also confirmed in all the European countries mentioned in the diagram.

The USA is made up of several states that have heterogeneous elements in terms of work and the distribution of work, something that is also observed in Europe. Thus, the data of the European Union are directly comparable with those of the USA. It is observed that they have approximately the same difference in the distribution of work per category. This phenomenon may not be attributed solely to the change in technology, but also to other social factors. The image of Italy may help our analysis. Italy applies innovative patents, at all levels of the primary and secondary sectors. It is a fact that it has intensified the study of automation of production in agriculture and animal husbandry which belong to the first category. In addition, it also has heavyindustry which it has also automated. This development is illustrated in the diagram as the distribution of work in the first two categories has a strong decreasing trend. At this point there is the opinion that there is a strong increase in the third category and consequently, an absorption of jobs there. The numbers may not be able to reflect the reality as it is difficult, for example, for someone who has been employed for many years in animal husbandry to take up a management position.

The data so far show a change in the division of labor without it being clear that the technology factor is the one causing these changes. Returning to the US data and Diagram 2.6. bubble scatterplot, which studies the change in job availability relative to exposure to robots by US city from 1990 to 2007. The size of each bubble indicates the number of people in its sample each city. Here we observe a strong negative correlation in the change brought about by exposure to robots in labor availability. Especially the coefficient estimation in this regression is (-0.57) with standard error value (0.14). This is yet another indication of the impact of technology on work. However, there is a sense that the outliers, (on the right) that are most strongly exposed to technology, influence the data in the explanatory line of the regression. Therefore, if these cities are removed, the line changes creating a new regression line which is shown in the dotted line diagram with new coefficient estimation in this regression be (-0.51) with standard error value (0.12). What this suggests is an even greater tendency to reduce available jobs in an increase in the participation of robots in the labor market.

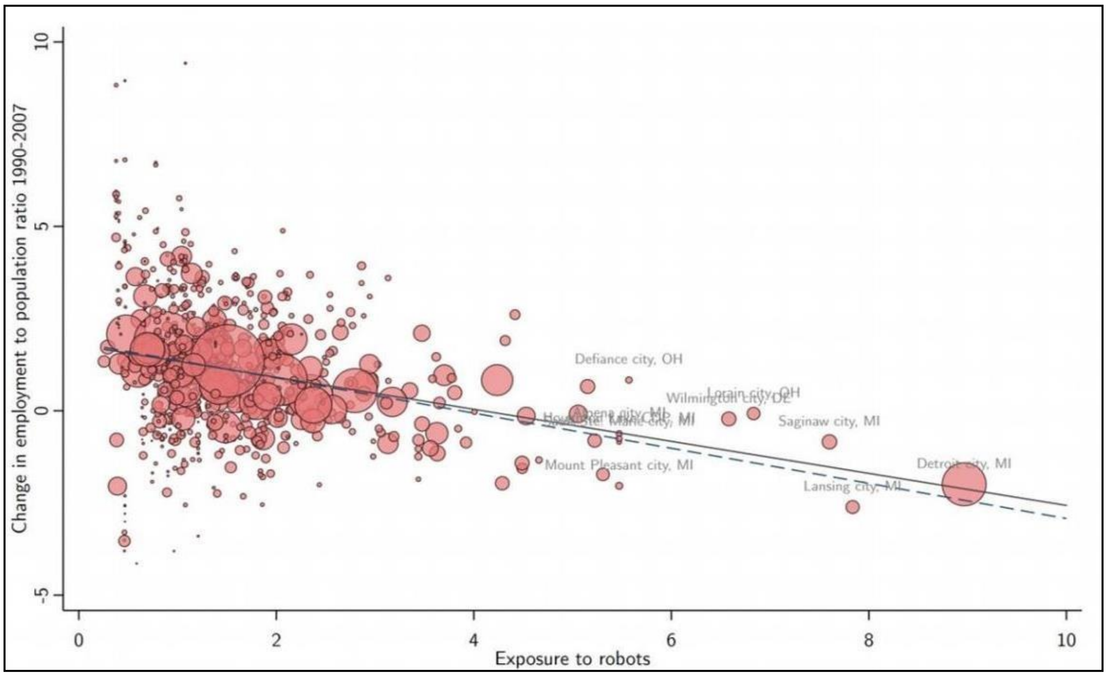

Diagram 2.6. Effects of robots on employment. Long-differences relationship between exposure to robots and changes in the employment to population ratio for 1990–2007 (Acemoglu & Restrepo, 2020)

However, as mentioned in a previous section, the reduction of available jobs may not cause a particular problem in society if more product is produced, as it causes an increase in wages. In this scenario there is a share of Job Replacement Technologies in which the production exceeds the problem caused in the reduction of jobs. There is a problem with technologies that replace jobs with technology, without society benefiting from the reduced costs that technology offers them. Diagram 2.7. graphs the change in wages relative to exposure to robots by US city over the years 1990 to 2007. Here we also observe a negative correlation in hourly labor wages relative to each city's exposure to robots with a coefficient estimation in this regression be (-0.88) with standard error value (0.13). Also important is that if the cities that are more exposed to robots are removed the regression line remains negative. Diagrams 2.6. and 2.7. perhaps are an indication that the development of technology does not push the whole society to a new optimal position but only a subgroup, namely the one that uses the technology.

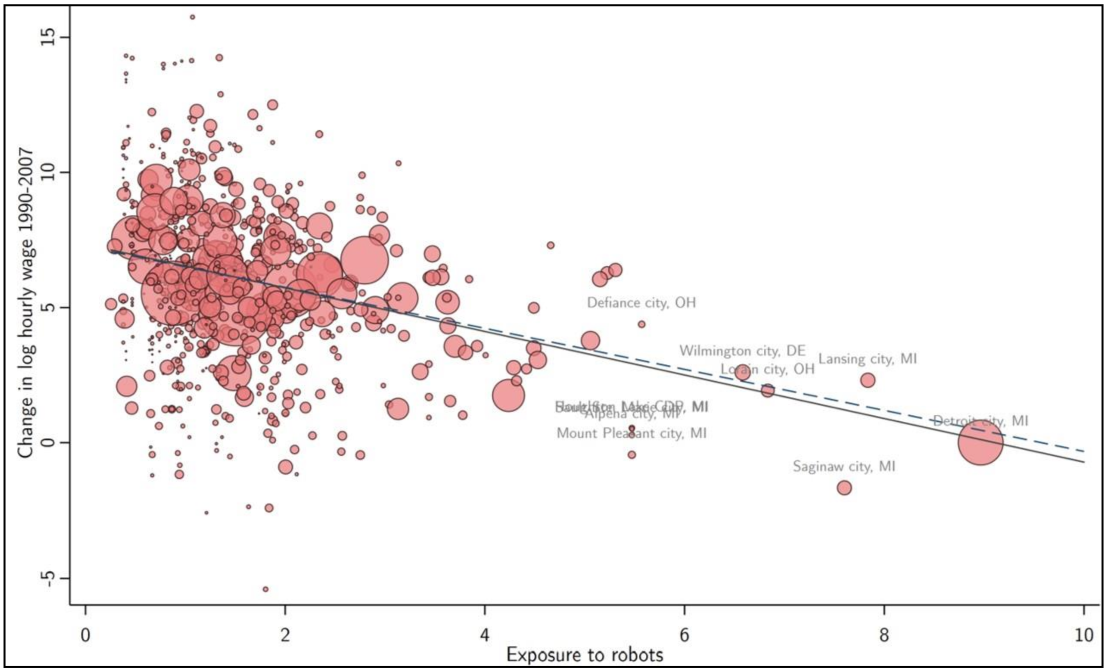

Diagram 2.7. Effects of robots on wages. Long-differences relationship between exposure to robots and log hourly wages for 1990–2007 (Acemoglu & Restrepo, 2020)

Finally, an analysis will be made of the change in employment by sector. In diagram 2.8 the percentage change in employment by industry in US data is analyzed. Each industry is divided into four columns that depict the percent change in each decade from 1979 to 2009. Overall, this chart shows a downward trend in job growth over the first three decades. The last decade has seen either a slight increase in jobs or a sharp decrease in them. The biggest change is in occupations that are most exposed to technology. Throughout the analysis the results are particularly significant when we consider that the US population has increased by approximately 50% in these forty years.

It is worth noting the completely opposite picture presented by personal care services. Even in the last decade when all jobs are experiencing a crisis in available positions, there is more growth than in other occupations. This is probably caused by increased demand for these services. So, this image confirms what John Maynard Keynes mentions about the replacement of labor by production machines and the reduction of total working hours. Plus, John Maynard Keynes predicted that people would use the extra time to evolve, both mentally and for pleasure. This lends an optimism as people appear to have more time to themselves.

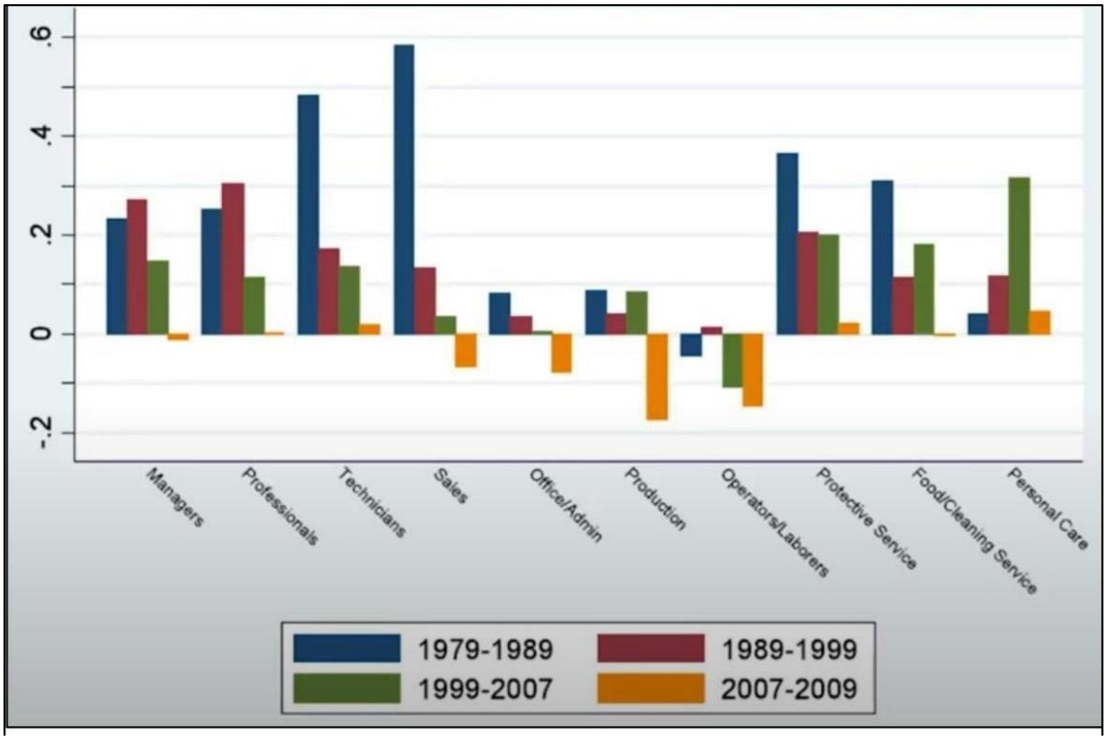

Diagram 2.8. Percent Change in Employment by Occupation, 1979-2009 (Acemoglu & Autor, 2011)

Chapter 3. Models

In this chapter we will present some models that analyse the effect of technology on labor. These models emerged from literature review, and we will present them, analyze how they are working, and we will explain the advantages that they have over the older ones. Finally, we will see how they work on actual data of the US economy. These data are not accessible so we will analyze the features of the data that have been identified by other scientists.

3.1. The Old Model

The usual model that represents technology in the literature is the following one:

$$Y = F(A_L L, A_K K) \qquad (1)$$

In this way this is the most using function in technology measurement. This equation represents a production function "F" that can focus only in capital "K"and labor. "L" As a result we can compute the total output "Y" in a firm or in a whole economic production sector. In this model technology is represented by factor augmenting "A_L and A_K". In this special form A_L represents a labor augmenting technology and A_K represents a capital augmenting technology.

Following the above Jan Tinbergen started transforming the above model with a skilled biased technological change. (Tinbergen, 1974) After that we find models that replace the "K" with "H" which means that "H" now represents high skilled workers and "L" low skilled workers. In this way we should replace "A_K" with "A_H" and once we find out that "A_H" grows faster than "A_L" we are experiencing a skill biased technological change. (León-Ledesma, Mc Adam, & Willman, 2010) But this assumption comes with some errors. One error is that high skilled personnel can't be better in everything. One other problem that comes from the above is that it is not easy to distribute each one in the high or low skill group. We need more information and parameters like if they are working in the field that they are assumed as high skilled etc.

On the other hand, sometimes the above is not realistic. In this model, when we realize a technological progress, we can't distinguish where this progress is coming from and it seems that technology affects all factors and labor is becoming more productive uniformly in all tasks. In this case this approach is not realistic. In science realism is necessary to link theoretical assumptions with empirical results. As a result, to be more accurate we need to change our predictions and changing predictions are followed by changing the models.

After that there were a lot of attempts to transform these models into more realistic ones. In this way scientists were watching the data as in "Diagram 2.1." and they came to the conclusion that technology is always benefits labor. Sometimes technology can create inequalities but in total it helps the whole society. In this view, more productive capital means that individuals are richer, which happens because more productive capital means greater quantity of goods with better quality, then higher supply numbers means lower price and people with the same amount of salary have access to a larger amount of goods. On the other hand, once labor is become more productive individuals being more productive too because they are part of the labor force. The above show us that a picture like diagram 2.3. couldn't happen or it doesn't follow the theoretical assumptions. Once we realize that the labor force experiences real wage reduction and models interpret this in different way, this means that we need to change models.

3.2. New Model

In this part we will analyze one of the most cited models for the output of the tasks and based on it we can decompose several parts of technology. (Acemoglu & Restrepo, 2019) In this way we can measure the different aspects of technology and recognize when technology helps the labor force to produce in a more effective way or displaces it.

$$Y = \left(\int_{N-1}^{N} Y(z)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \qquad (2)$$

$$Y = \begin{cases} A^L\gamma^L(z)l(z) + \ A^K\gamma^K(z)k(z) & if\ z \in \ [N-1, I] \\ A^L\gamma^L(z)l(z) & if\ z\ \in\ (I\ , N] \end{cases} \qquad (3)$$

In this equation Y could be an economic sector or even the whole economy, z represents tasks, Y(z) the output of each task for $z\ \in\ [N\ -\ 1\ ,\ N]$,. To produce each good, we need to combine a set of tasks. N represents the new tasks and finally $\sigma\ \geq\ 0$ is the elasticity of substitution between tasks. In this way we combine these tasks through an aggregate Constant Elasticity of Substitution (CES). In this model every task is independent and, for example, we can sacrifice design for better quality or the opposite. So, the "σ" captures this substitution effect.

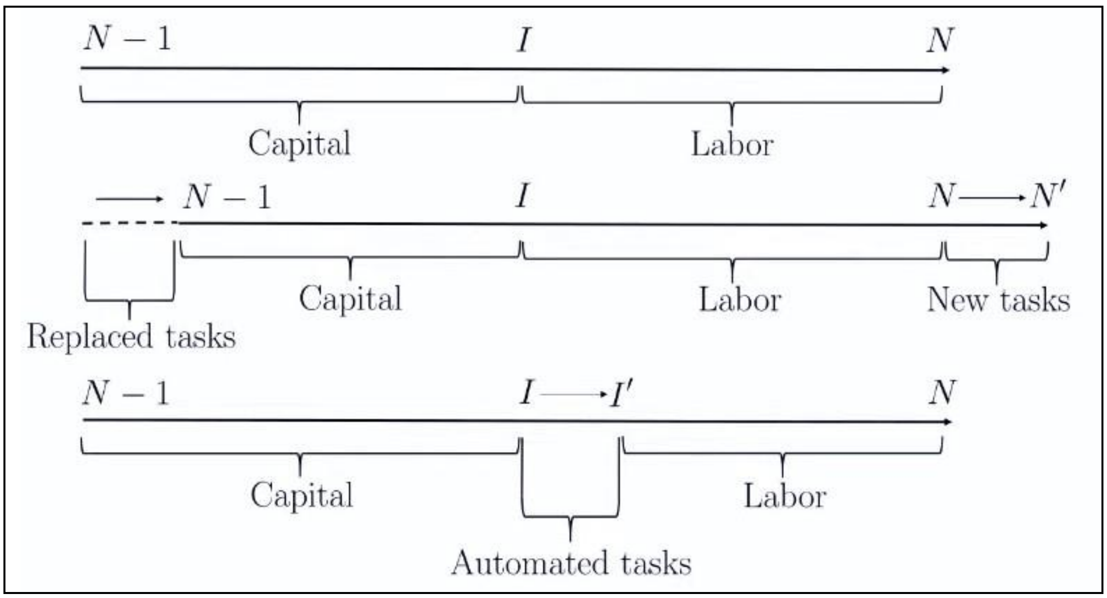

Diagram 3.1. The Task Space and a Representation of the Effect of Introducing New Tasks and Automating Existing Tasks (Acemoglu & Restrepo, 2018)

For the above to be comprehensible, it is required to map and explain the new tasks and innovation. So as a first step tasks are in discrete measurement but, with the assumption that in a sector we can find a large number of tasks, we can transform them into a continuous measurement. Furthermore, to be in a comparable form there is also a transformation that "normalizes" all tasks between zero and one. The "N" measures productivity. As we can see in the first line of "Diagram 3.1." the whole production is equal to one due to the previous "normalization" assumption. The "I" represents the innovation. In this way, we have in the whole process a part that is being produced by capital and another part that is being produced by labor. By enhancing the technology in one sector we experience new tasks vacancies, some tasks that have been automated and some tasks that have been replaced. So in this case all the tasks between N-1 and I are these tasks that have been automated. This means that these tasks can be produced by labor, but we have also the appropriate technology and we can produce them by capital. And consequently, in these tasks capital and labor are highly or perfect substitutes.

To be clearer we will give an example. In previous years power for sowing machinery was provided by horses. After inventing the internal combustion engines, the tractor technology developed with the following response. We had new tasks created such as tractor servicing personnel, tractor production line, tractor designers, driving tractor trainers etc. This is the part from N to N' in the second line. In previous years, the horses needed vets, specialists to produce horseshoes etc. These tasks were removed from the new production line and they can't be counted because they no longer exist. This category is referred to as replaced tasks in the second line. Finally, we have the automated tasks. This category refers to the bundle of tasks that have been automated because of the technology. In our example from a lot of people that were using horses we automated this task by tractors and we need less personnel that is required to use these tractors. It is noticeable that in future this task could be automated more by tractors that using GPS and could perform this task without any personnel.

At this point it is essential to set the cycle of the tasks. Each task has a cycle. First a new technology comes out and makes it necessary. Let's use the example of accountants. When we had an initial large evolution of technology, firms that expanded needed personnel to account for the costs and the revenues. So, the task of an accountant came out. That time was difficult and expensive to try and find how to replace them. After some years that every company needed accountants there were a huge amount of new vacancies in this field. In this case, when firms realized that they were spending a large amount of money for accountants they developed new technologies that receive and make entries with only one person who supervises this procedure. In the future maybe this task could stop being important for companies and disappear. In this way it is essential to explain that every new need of a new task first is being handled by humans. Once it starts to expand, more and more people want to join in this task. When this task collects a lot of personnel then it's cheaper for firms to automate it and put machines instead of personnel because this task could be produced in a cheaper and more efficient way. And finally, it is replaced by a new task.

Now, back to equation (3), $l(z)$ is the amount of allocated labor with $\gamma^L(z)$ being the productivity in task by labor. There is also the factor A^L that represents the augmentation of technological change. Similarly, $k(z)$ is the amount of allocated capital, $\gamma^K(z)$ is the productivity in task by capital and A^K is the factor of capital share augmentation. As we mentioned above here is the mathematical expression of the fact that tasks that are between (I,N] can be produced exclusively by labor force. On the other side, [N-1,I], there are the tasks that can be produced by capital and labor force too. In this case when capital is more profitable for firms, they use capital instead of labor. This could be an allocation between these factors. Following that, when we are experiencing an increase in I, from I to I' means the invention of a new technology that performs tasks that were feasible only by labor. In this way there is a place for new tasks but also some tasks can be automated and produce unemployment by compressing the remaining bunch of tasks. Furthermore, if someone who wants to enter in this narrower set of tasks needs to be specialized more because automation usually replaces tasks that don't need special skills. This is why now, artificial intelligence bring up new concerns. Artificial intelligence, as we referred above is going to simulate the human brain and compete with a new set of tasks.

To sum up all the above, this model expresses three different types of technological change. The first one refers to factors $\{A^L, A^K\}$ augmentation due to technological evolution, in simple words labor and capital are being more productive. The second one refers to automation. Automation can push out labor force. And the third one is about new tasks. New tasks give place to new specialties and new places of work.

Solving the model, we end up with the following equations:

The output is given by:

$$Y(L, K; \theta) = \left[\left(\int_{N-1}^{I} \gamma^K(z)^{\sigma-1}\, dz\right)^{\frac{1}{\sigma}} (A^K K)^{\frac{\sigma-1}{\sigma}} + \left(\int_{I}^{N} \gamma^L(z)^{\sigma-1}\, dz\right)^{\frac{1}{\sigma}} (A^L L)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad (4)$$

The labor share is given by:

$$s^L(W, R; \theta) = \frac{\Gamma(N, I)(W/A^L)^{1-\sigma}}{[1 - \Gamma(N, I)](R/A^K)^{1-\sigma} + \Gamma(N, I)(W/A^L)^{1-\sigma}} \quad (5)$$

$$\Gamma(N, I) = \frac{\int_I^N \gamma^L(z)^{\sigma-1}\, dz}{\int_{N-1}^{I} \gamma^K(z)^{\sigma-1}\, dz + \int_I^N \gamma^L(z)^{\sigma-1}\, dz} \quad (6)$$

The labor share is based on two factors. The $\Gamma(N, I)$, that refers to the task content of production. And the substitution effect that relies on "σ", "W/A^L" and "R/A^K". Here "W" denotes the Labor Factor Price and "R" the Capital Factor Price.

Analyzing the (4) equation looks like a constant elasticity of substitution production function. This function incorporates the tasks and which of them are performed by which workers. In this case when "N" increases, it means that new tasks were added to the economy, and we have reorganization of the labor force in this new environment. In this case we are experiencing a boost in productivity. Furthermore when "N" and "I" are changing, it means that capital is becoming more or less important during the production process because of share parameters. Sometimes distribution between labor and capital share are endogenously changing.

Dismantling the (5) equation we have the following parts. The "s^L" refers to the value-added part that goes to labor share. The rest of this part goes to capital or to the machines. Here the substitution effect (the part in (5) with "σ", "W/A^L" and "R/A^K") is the result when the procedure starts from a standard "CES" production function. The other part is, that what is essential, to include the factor augmented technologies.

In the (5) equation the substitution effect doesn't affect the allocation of tasks. The allocation of tasks doesn't change when labor is being more productive. The allocation of tasks changes when labor is cheaper, or innovation can service a larger set of tasks. In this case the labor force concentrates in tasks that are specialized and is being more effective. At this point we have the substitution between tasks that can be produced both with labor and capital. In the old model everything was depending on the elasticity of substitution. In this case when elasticity "σ" become a little bit more than one the results were completely different than when a little bit less than one. In this case a mismeasurement with a value of "σ" near to one could lead to a faulty interpretation of the actual situation of the economy.

Analyzing automation, automation is the reason which forces tasks to be reallocated between factors. In this case this allocation is computed by the "$\Gamma(N,\ I)$" and has a direct effect on the labor share and further on labor demand. The ability of this factor is to count directly labor share regardless of the elasticity of substitution. Assuming a "σ" that is equal to one, "$\Gamma(N,\ I)$" is increasing in an increase of "N" and decreasing in an increase of "I". In this example, if we experience a period of automation, increase in "I" is happening and "$\Gamma(N,\ I)$" will be reduced without any change of "σ". This happens because this change is taking some tasks away from labor and giving them to capital. Afterwards production is being more capital intensive, increasing the value-added share by labor. In this way we can experience opposite results in an increase of "N".

Once we assume that labor demand is in accordance with the "Wage Bill" WL, we can measure the effect of automation change on the labor demand as following.

$$\frac{\partial\, ln\, WL^{d}\,(L,K;\theta)}{\partial I}=\frac{\partial\, ln\, Y\,(L,K;\theta)}{\partial I}+\frac{1}{\sigma}\frac{1\,-s^{L}}{1-\Gamma(N,I)}\frac{\partial\, ln\,\Gamma\,(N,I)}{\partial I} \qquad (7)$$

The above could be broken down into two parts. The first one refers to the productivity effect, by measuring how the output responds to the automation change and is in the following equation:

$$\frac{\partial\, ln\, Y\,(L,K;\theta)}{\partial I}=\frac{1}{\sigma-1}\left[\left(\frac{R}{A^{K}\gamma^{K}(I)}\right)^{1-\sigma}-\left(\frac{W}{A^{L}\gamma^{L}(I)}\right)^{1-\sigma}\right]>0 \qquad (8)$$

The other part of equation (7) "$\frac{1}{\sigma}\frac{1-s^{L}}{1-\Gamma(N,I)}\frac{\partial\, ln\,\Gamma(N,I)}{\partial I}$" refers to the displacement effect. This equation leads to the outcome that once we are experiencing larger displacement effect than productivity effect, because this case is directly demand for labor with small productivity gains.

Analyzing more the equation (7), once there was a zero displacement effect, the labor demand could increase at the same rate as productivity, keeping labor share constant. Because this isn't realistic, the displacement effect is contained in the equation and this explains the part that is taking away tasks from labor and this is always negative because this can't add tasks in labor. In this equation, the productivity effect doesn't come directly from productivity of labor and capital. It comes from the fact that, when this is profitable, firms prefer to use capital instead of labor, thus reducing their costs. In this case productivity growth could drive firms to a lower demand for labor that leads to lowering the wages because of lower employment. Furthermore, the main problem in the above is when firms replace labor by capital without a remarkable productivity gain. This is a firms' strategy in a micro-environment that affects the macro-environment. To sum up the above, the labor demand comes from a productivity effect plus the displacement effect. The productivity effect is always positive and the displacement effect is always negative, slowing down the labor share.

Once we assume that labor demand is in accordance with the "Wage Bill" WL, we can measure the effect of new tasks change on the labor demand as following.

$$\frac{\partial \ln WL^d\,(L,K;\theta)}{\partial N} = \frac{\partial \ln Y\,(L,K;\theta)}{\partial N} + \frac{1}{\sigma}\frac{1-s^L}{1-\Gamma(N,I)}\frac{\partial \ln \Gamma\,(N,I)}{\partial N} \qquad (9)$$

The above could be broken down into two parts. The first one refers to the productivity effect, by measuring how the output responds to the addition of new tasks and is in the following equation:

$$\frac{\partial \ln Y\,(L,K;\theta)}{\partial N} = \frac{1}{\sigma-1}\left[\left(\frac{W}{A^L\gamma^L(N)}\right)^{1-\sigma} - \left(\frac{R}{A^K\gamma^K(N-1)}\right)^{1-\sigma}\right] > 0 \qquad (10)$$

The other part of equation (9) "$\frac{1}{\sigma}\frac{1-s^L}{1-\Gamma(N,I)}\frac{\partial \ln \Gamma(N,I)}{\partial N}$" refers to the reinstatement effect.

Following the previous explanation, the productivity effect has exactly the same role in the labor share and the reinstatement effect has the opposite effect from the displacement effect. Adding new tasks in the economy, is only helpful to labor share. In this way both productivity effect and reinstatement effect increase labor demand. These new tasks reorganize the production in a more efficient way giving rise to more people to work.

Once we assume that labor demand is in accordance with the "Wage Bill" WL, we can measure the effect on it by augmenting factors of labor and capital respectively $\{A^L, A^K\}$ on the labor demand as following.

$$\frac{\partial\, ln\, WL^d\,(L,K;\theta)}{\partial A^L} = s^L + \frac{\sigma-1}{\sigma}(1-s^L) \qquad (11)$$

$$\frac{\partial\, ln\, WL^d\,(L,K;\theta)}{\partial A^K} = (1-s^L) + \frac{1-\sigma}{\sigma}(1-s^L) \qquad (12)$$

In the equation (11) the "s^L" part and in the equation (12) the "$(1-s^L)$" represents the productivity effect that is imposed on the labor demand by augmenting factors. In (11) the "$\frac{\sigma-1}{\sigma}(1-s^L)$" and in (12) the "$\frac{1-\sigma}{\sigma}(1-s^L)$" represent the substitution across tasks. Here there isn't any evidence of displacement or reinstatement because of this substitution. These equations can just interpret on the one hand the productivity effect that can be produced by the augmenting factors of these technologies and on the other hand how easy it is for firms to substitute between these factors.

All the above are useful, but they are equations that refer only to one sector of the economy or set of firms. In this way we need to check out the whole economy. This is because the labor force can move from one sector to another, and we need to have the whole view of the economy, we need to interpret the effect of capital on labor in total. As a result, the final model of counting the "Wage Bill" in accordance to a multi-sector economy is the following:

$$d\, ln(WL) = d\, ln\, Y + \sum_{i\in f}\left(\frac{s_i^L}{s^L} - 1\right) d\chi_i + \sum_{i\in f} l_i (1-\sigma)(1-s_i^L)\, d\, ln\left(\frac{W_i/A_i^L}{R_i/A_i^K}\right) + \sum_{i\in f} l_i \frac{1-s_i^L}{1-\Gamma_i}\, d\, ln\, \Gamma_i \quad (13)$$

In the above equation "*i*" refers to each different sector of the economy and "*f*" each set of industries. It is important to underline that each of these sectors has its own factor augmenting changes, automation and new tasks that together shape the labor demand. Each factor price come from "W_i" for labor price and "R_i" for capital price in each "i" sector. The share of each sector comes from "χ_i" and "s_i^L" denotes the labor share.

Following the previous equations, the equation (13) can be broken down into four parts. Initially "$d \ \ ln(WL)$" refers to the overall change in labor demand. Therefore, the first part is coming from "$d \, ln \, Y$" that refers to the productivity effect. The second part is "$\sum_{i\in f} (\frac{s_i^L}{s^L} - 1) \, d\chi_i$" and is the compound that refers to composition effect. The third part refers to substitution across tasks and is the "$\sum_{i\in f} l_i (1-\sigma)(1-s_i^L) d \, ln \, (\frac{W_i/A_i^L}{R_i/A_i^K})$". The fourth and last part is the "$\sum_{i\in f} l_i \frac{1-s_i^L}{1-\Gamma_i} \, d \, ln \, \Gamma_i$" and refers to the change in task content component. Change in task content comes from the rate of change in labor share in "i" sector, reduced by the substitution effect of each "i" sector.

As we referred above in multi sector economy, the basic research should be in the composition effect. Research should not be focused on only one sector because simultaneously in some sectors, the composition effect goes up and in some other goes down. In this case we need to analyze the whole economy and find linkages between sectoral transformations. In this way once one sector goes up while the other goes down it is not obvious if this effect helps or not the labor. Furthermore, there is the substitution effect that relies on labor price "W", on capital price "R", and changes in augmenting factors $\{A^L, \ A^K\}$ arbitrated by "σ". As a result the productivity effect and the composition effect comes from sectoral data, following on substitution effect that is computable with an already computed elasticity of substitution. And finally the residuals are the compound of change in task content.

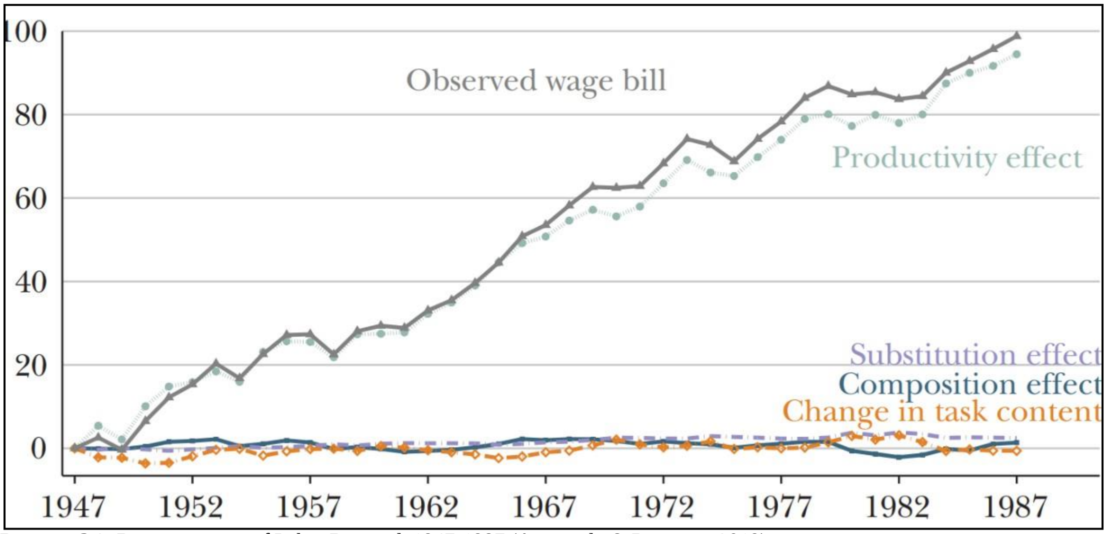

Diagram 3.2. Decomposition of Labor Demand, 1947-1987 (Acemoglu & Restrepo, 2019)

Now some analyzed data will be presented in order to observe how these equations work and how technology affects labor. The diagram 3.2 refers to US data from 1947 to 1987. As shown, the observed "Wage Bill" is increasing at an almost steady rate of 2.5% per year. This indicates that the demand for labor had an increasing behavior for these forty years in the US economy. As we can see, during this period, change in task content, substitution effect and composition effect are in the close region around zero. In this case only productivity expresses the behavior of the "Wage Bill" change. And as it is mentioned before productivity doesn't refer to an increase in productivity of labor. Increase in labor productivity is included in change in task content and this is zero here.

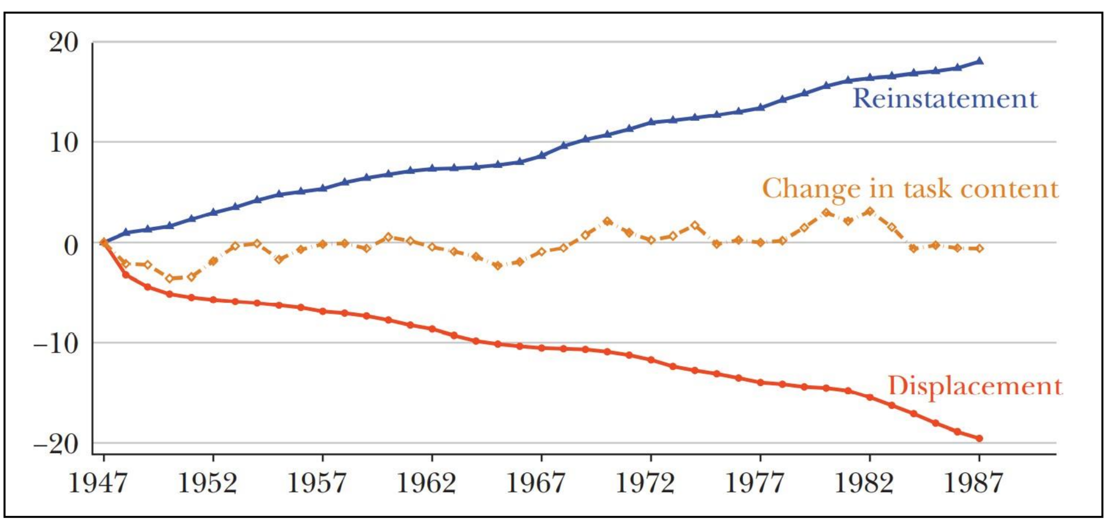

Diagram 3.3. Change in Task Content of Production, 1947-1987 (Acemoglu & Restrepo, 2019)

Diagram 3.3 show the decomposition of the change in task content. As we mentioned before, the basic component that give new tasks in the labor force is the reinstatement effect and the component that takes tasks from labor is the displacement effect. In this way change in task content is the result of these two effects. And as we can see, changes in task content all these years were very close to zero. Even with a large displacement effect, there was a counter balanced reinstatement effect. As a result, in this period, there was a productivity expansion but in a way that did not eliminate labor.

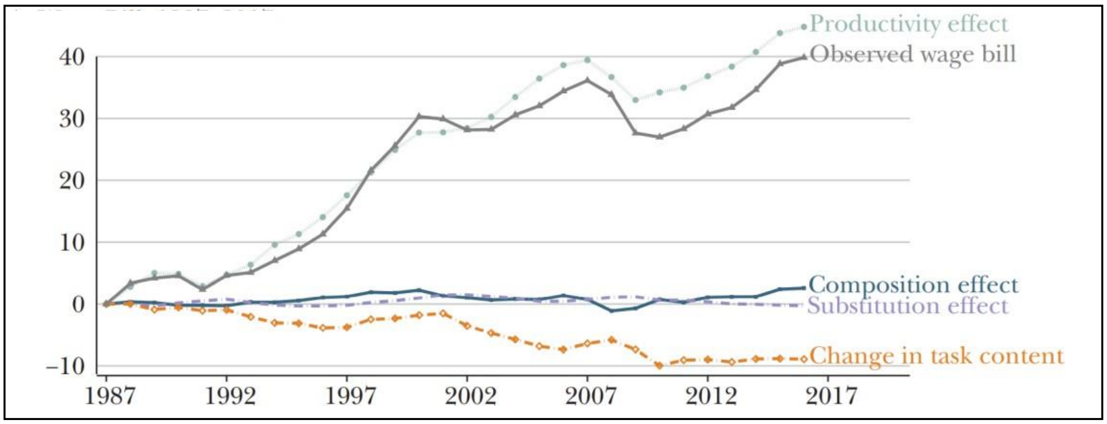

Diagram 3.4. Decomposition of Labor Demand, 1987-2017 (Acemoglu & Restrepo, 2019)

The second period that will be analyzed, will be the next thirty years, from 1987 to 2017. Here again substitution effect and composition effect are close to zero and this means that they don't affect the "Wage Bill". On the other side, as we can see, the "Wage Bill" is still increasing, at a slower rate than in the previous forty years, and goes to a shape like productivity effect. As a consequence, this slowing down comes from productivity effect. Another observation that we could make is that this time there is a decoupling between "Wage Bill" and the productivity effect. As we can observe, this decoupling comes from change in task content. During this time, change in task content is negative, which means that tasks are moving out from labor to capital.

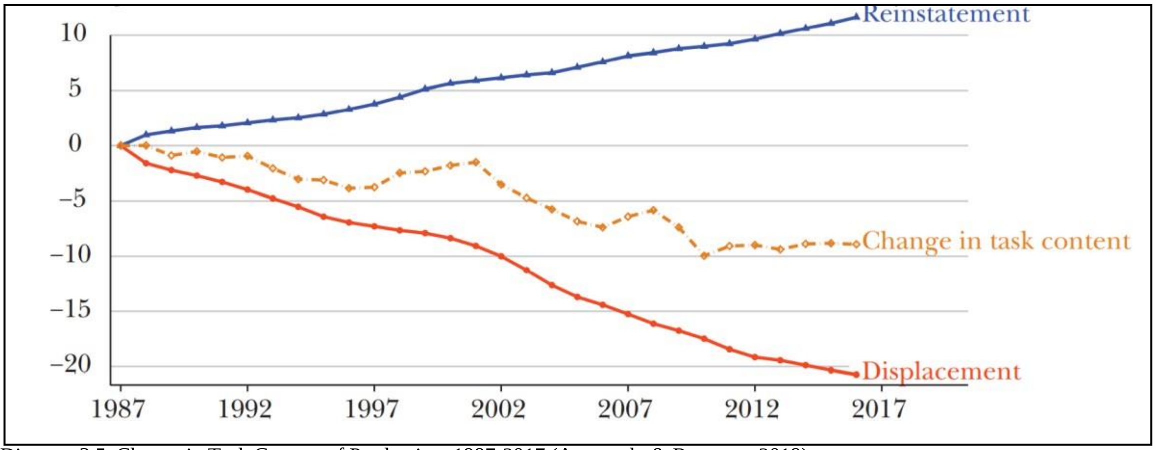

Diagram 3.5. Change in Task Content of Production, 1987-2017 (Acemoglu & Restrepo, 2019)

In diagram 3.5 we can see again the breakdown of change in task content for the last thirty years. And the view is by far more different. This time we can observe a 50% faster replacement effect than the previous time. This could be even worst because the previous time this attitude was counterbalanced by the reinstatement effect, but this time the reinstatement effect instead of rising till catching the same rate with displacement effect, or rising at the previous rate, it slowed down by 50% than the previous forty years. As a result, the combination of these two effects give the mathematical representation of that what we are experiencing this period of rising productivity in a way that is not observable to "Wage Bill".

Chapter 4. Empirical Analysis

Previous chapters presented the history of concerns about the technological impact on labor demand. Therefore, a literature review followed to test if these concerns have any numerical basis. As the findings were indicating a possible confirmation of the above impact in the US economy, we performed research about the best fitting model for this phenomenon. Follow on, the model analyzed in the previous chapter indicated that "Change in Task Content" is the component that indicate us the technological impact on labor demand.

In this chapter the above model will be applied to European data in order to observe the "Wage Bill" in accordance with the components of the new model. The aim is to analyze the "Change in Task Content" component and find out the behavior of the "Wage Bill" in accordance with technological improvement across time.

4.1. The Data

This part refers to the presentation of the data that are used to fit the model and all the transformations that were accomplished in order to fit the equation (13).

First of all, Structural Analysis Database (STAN) from the Organisation for Economic Co-operation and Development (OECD) was used in order to use sectoral data between industries that fit to the model (OECD.Stat, 2023). This database contains the essential data for the industrial activities across countries. The STAN contains a great proportion of European Countries with the most available data on variables in the period between 2000-2017. On the other hand, these data are enough to test the industrial performance of technology on labor and test the trend of "Change in Task Content" component.

The variables that are used for the analysis are the VALK, HRSN, LABR and

CPNK. The VALK variable refers to Value Added volumes of industries, the LABR refers to Labor Costs in Compensation of Employees, the CPNK refers to volumes of Net Capital Stock and HRSN the total engaged Hours of Work. The VALK, LABR and CPNK data are in Euro units of measurement with 2015 year of reference and HRSN is in hours units of measurement. All the above variables are expressed in millions of each unit.

4.2. Industry Specification

In this part we used an industrial sector classification that comes from (Acemoglu & Restrepo, 2019) with some changes to suit as far as possible the model that is described above and not mix sectors with similar characteristics.

Number	**OECD name**	**Class number**	**New name**
1	Agriculture, hunting, forestry and fishing	D01T03	Agriculture
2	Mining and quarrying	D05T09	Mining
3	Manufacturing	D10T33	Manufacturing
4	Electricity, gas and water supply; sewerage, waste management and remediation activities	D35T39	Energy
5	Construction	D41T43	Construction
6	Wholesale and retail trade, repair of motor vehicles and motorcycles	D45T47	Sales
7	Transportation and storage	D49T53	Transportation
8	Accommodation and food service activities	D55T56	Tourism
9	Information and communication	D58T63	Communication
10	Financial and insurance activities	D64T66	Finance
11	Real estate, renting and business activities	D68T82	Real estate

12	Community, social and personal services	D84T99	Services

Table 4.1. Industry Classification

In table 4.1, the "Number" column indicates the index of sector "i" that will be used during the analysis in the following parts. The "OECD name" column indicates the names of referred industry sectors of OECD database as it is in the database. The "Class number" column refers to the industry codes that are included in each sector group. Finally, the "New name" column refers to the new shortened name that will be used in the following analysis to avoid numbering and have clear information.

4.3. Methodology

This part provides a description of the whole data processing, manipulation and regression that was required to reach interpretable results.

First of all. (Eurostat, 2019) indicates countries with low usage of robots and countries with high usage of robots. As a result, three countries from the lowest group and three countries from the highest group were selected for this analysis in order to compare the similarities and differences between them. Furthermore, the selection includes countries that use euro as official currency and have fewer missing values in the tables. Considering the above, the countries for which we extracted data were, Estonia, Greece and Lithuania which belong in the lower group with 3% of shares of industrial and service robots and Spain Finland and Italy that belong in the high group with 11%, 10% and 9% respectively of shares of industrial and service robots.

Secondly the package used for the data processing was the "Excel of Microsoft Office 365". In this package were matched the data with the equation (13) variables, generation of the new variables to be appropriate for the model, diagram generations and the trend regression.

Therefore, used the following operations, while "i" indexes the industry sector and "j" the year of reference.

1. $Y_{i,j} = VALK_{i,j}$
2. $L_{i,j} = HRSN_{i,j}$
3. $W_{i,j} = \frac{LABR_{i,j}}{HRSN_{i,j}}$
4. $K_{i,j} = CPNK_{i,j}$
5. $\sigma_{i,j} = 0{,}7$ [1]
6. $A^L_{i,j} = A^K_{i,j} = 1$ [2]
7. $s^L_{i,j} = \frac{W_{i,j} L_{i,j}}{Y_{i,j}}$
8. $s^K_{i,j} = 1 - s^L_{i,j}$
9. $R_{i,j} = \frac{s^K_{i,j} Y_{i,j}}{K_{i,j}}$
10. $x_{i,j} = \frac{Y_{i,j}}{\sum_{i=1}^{12} Y_{i,j}}$
11. $l_{i,j} = \frac{W_{i,j} L_{i,j}}{\sum_{i=1}^{12} W_{i,j} \sum_{i=1}^{12} L_{i,j}}$
12. $\Gamma(N,I)_{i,j} = \frac{s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma}}{\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma} + s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - s^L_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}}$ [3]

Consequently, by applying the above variables in equation (13) we can derive a time series of each component for each country, as this equation incorporates the sectoral data. In this way this procedure followed by adding the values of previous years to obtain the cumulative results and presented all of them in different diagram for each country.

Finally, regression of the "Change in Task Content" component was carried out to reach the trend line and test and compare its behavior with the other European countries

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[1] This is the most intense value in the range that found in (Knoblach, Roessler, & Zwerschke, 2020) in accordance with (Mućk, 2017)

[2] Under no Labor and Capital augmentation assumption

[3] Solution in Appendix

of our analysis and other countries of other researchers.

4.4. Results

In this part the results will be illustrated by diagrams of "Wage Bill" decomposition into the four components in order to describe their behavior in European economies and find out possible similarities between countries with large usage of robots and low usage.

The presentation of results will start from the countries that have lower share in use of robots.

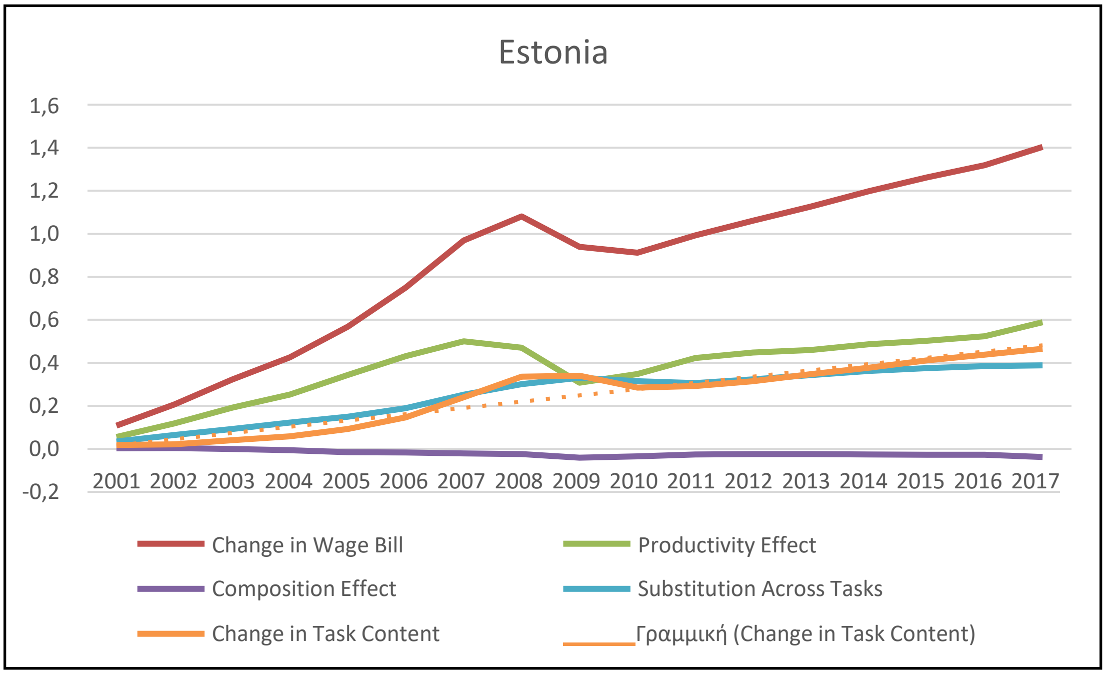

Diagram 4.1. Decomposition of Labor Demand in Estonia, 2000-2017

In this diagram it is obvious that Estonia is experiencing an increase in "Wage Bill" with a rate of 10% per year in period 2000-2007. In period 2007-2010 it experienced a slowdown and a decrease in "Wage Bill". This period was during the Worldwide Great Economic Recession that affected the "Wage Bill" among other economic indexes. This increasing rate in "Wage Bill" returned in period 2010-2017 with a rate of 7%. As we can compare with (Acemoglu & Restrepo, 2019), Estonia presents the same feature as US economy but with greater rate of increases in “Wage Bill” in periods of increasing “Wage Bill”. Estonia entered the European Union in 2004 and in the period 2000-2004 the economy of the country should be in a healthy economic condition in order to meet the Copenhagen criteria that are necessary to be a European Union member. In the period 2004-2007, this attitude is possibly followed on because of its previous years performance and the succor of the European Union.

In Estonia the “Productivity Effect” component seems to keep the same shape as the change in “Wage Bill” as this found in (Acemoglu & Restrepo, 2019) for the US economy. In this paper also US economy presents a common atpattern for “Composition Effect” component with Estonian one. The “Substitution across Tasks” component in Estonia seems to differentiate from the US and this means, because of upslope blue line in diagram 4.1, that the workforce can achieve better salary by moving out, across different industry sectors while in the US economy it seems that this phenomenon occurs as this line is bouncing near to zero area. Finally, the Estonian “Change in Task Content” line also displays a different deportment. In US data it seems to be negative, something that means that the displacement effect is greater than reinstatement effect. According to the Estonian data this component is positive and steadily increasing which means that the reinstatement effect is greater than the displacement effect and technology acts in favor of the workforce.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,957255839
R Square	0,916338741
Adjusted R Square	0,910761324
Standard Error	0,045892683
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,346026854	0,346027	164,2944578	1,74687E-09
Residual	15	0,031592075	0,002106		
Total	16	0,377618929			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Higher 95%*
Intercept	-0,013686423	0,023281342	-0,58787	0,565365086	-0,06330943	0,035936583
year	0,029122243	0,002272026	12,81774	1,74687E-09	0,024279533	0,033964952

Table 4.2. Regression of “Change in Task Content” component trend line in Estonian Data

Because of the significance of the “Change in Task Content” component in our analysis, in this work we computed the trend line with the time series OLS estimation procedure in order to test if this upslope is confirmed by the data as significant. The results of the regression are presented in Table 4.2. The results indicate a highly significat, (<0.001), in coefficient of Year that is unequal to zero. This evidence means that the trend line is strictly increasing at a rate of 2,9% per year. As a result, we can observe a 2,9% increase in “Wage Bill” because of technological improvement.

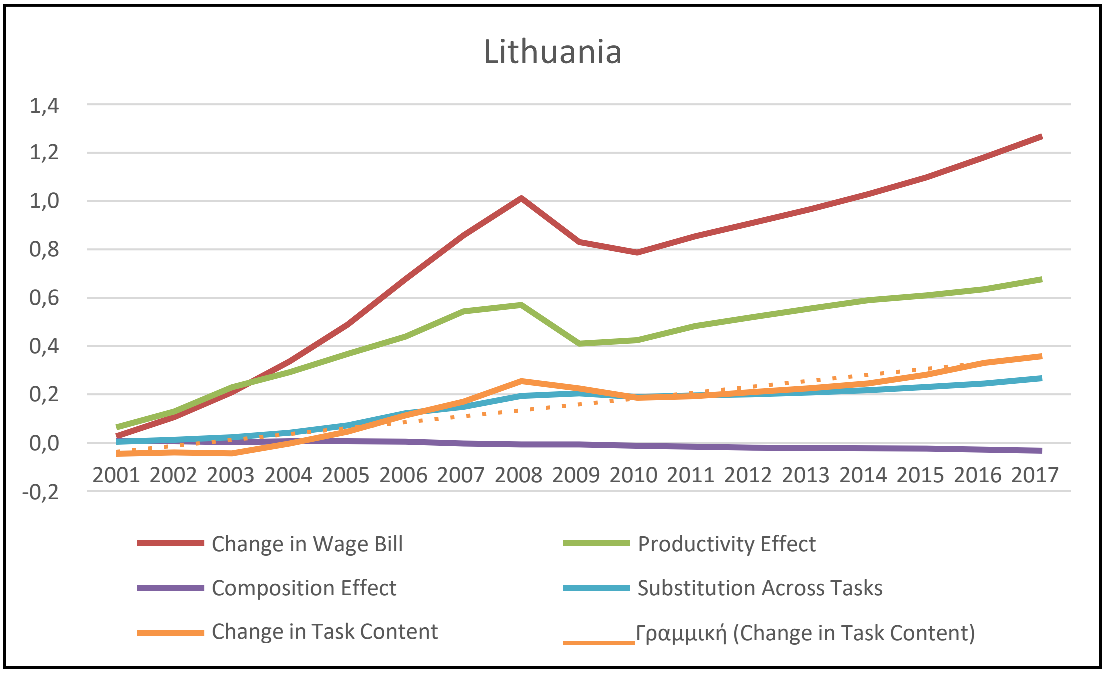

Diagram 4.2. Decomposition of Labor Demand in Lithuania, 2000-2017

Diagram 4.2 indicates that Lithuania is experiencing a similar performance with the Estonian data. In “Wage Bill”, during the Worldwide Great Economic Recession Lithuania seems to experience a greater decrease in “Wage Bill” compared to Estonia. This attitude could be expected, as Lithuania was one of the members, as was Estonia, that became a member of the European Union in 2004.

The Lithuanian “Productivity Effect” component keep the same shape with the change in “Wage Bill” as found for the US economy and Estonian economy above. Similarly, the “Composition Effect” component is similar to the Estonian. The “Substitution across Tasks” component in Lithuania seems to be again similar to that found in Estonia. This means again that it is more profitable for workforce to achieve better salary by moving across industrial sectors. Finally, the “Change in Task Content” line in Lithuania during period 2000-2004 is lower than the zero line, which means that, in that period technology was displacing workforce. Furthermore in 2003 till 2004 observed that this downslope starts to turn into upslope. An upslope that ended up during the period of Economic Recession, but this phenomenon was experienced by Estonia and US too.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,939542187
R Square	0,882739521
Adjusted R Square	0,874922156
Standard Error	0,046637758
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,245610818	0,245611	112,9203375	2,23381E-08
Residual	15	0,032626207	0,002175		
Total	16	0,278237025			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Higher 95%*
Intercept	-0,061880996	0,023659318	-2,6155	0,019487875	-0,112309639	-0,011452352
year	0,024535429	0,002308913	10,6264	2,23381E-08	0,019614098	0,029456761

Table 4.3. Regression of “Change in Task Content” component trend line in Lithuanian Data

As before, in table 4.3 we can find the estimated regression results for the trend line of the “Change in Task Content” component for Lithuania. The results are similar to these that found in Estonia. Testing the hypothesis that coefficient of years is equal to zero again is rejected with significance level (<0.001). This result means that Lithuanian “Change in Task Content” component is increasing at an approximate rate of 2,5% per year. As a result, technological improvement acts in favor of Lithuanian employees too.

The last country that is analyzed as a low share usage of robots is Greece. In diagram 4.3 is observed an increasing rate in the period 2000-2002 at a rate of 10% that is similar to the other two countries that uses robots in lower share. This increasing rate in “Wage Bill” in period (2000-2009) followed by approximately 5%. This pattern is a little bit different than this that found in Estonian and in Lithuanian data. On the other hand, Greece was a European Union member earlier than Estonia and Lithuania. To be more accurate this rate fits to the previous two countries in the period after Recession when they were not the newest members of European Union. Furthermore, we observe a different appearance of “Wage Bill” in Greece during the period 2009-2017. This behavior is similar to US, Estonia and Lithuania in the period of the Economic Recession. On the other hand, this can be explained because the Greek economy was in crisis during the period 2009-2018 (Thomsen, Poul, 2019). Especially the diagram can show us that after each “Economic Adjustment Programme for Greece” the downslope is less steep and after the third one in 2015 changes to an increase.

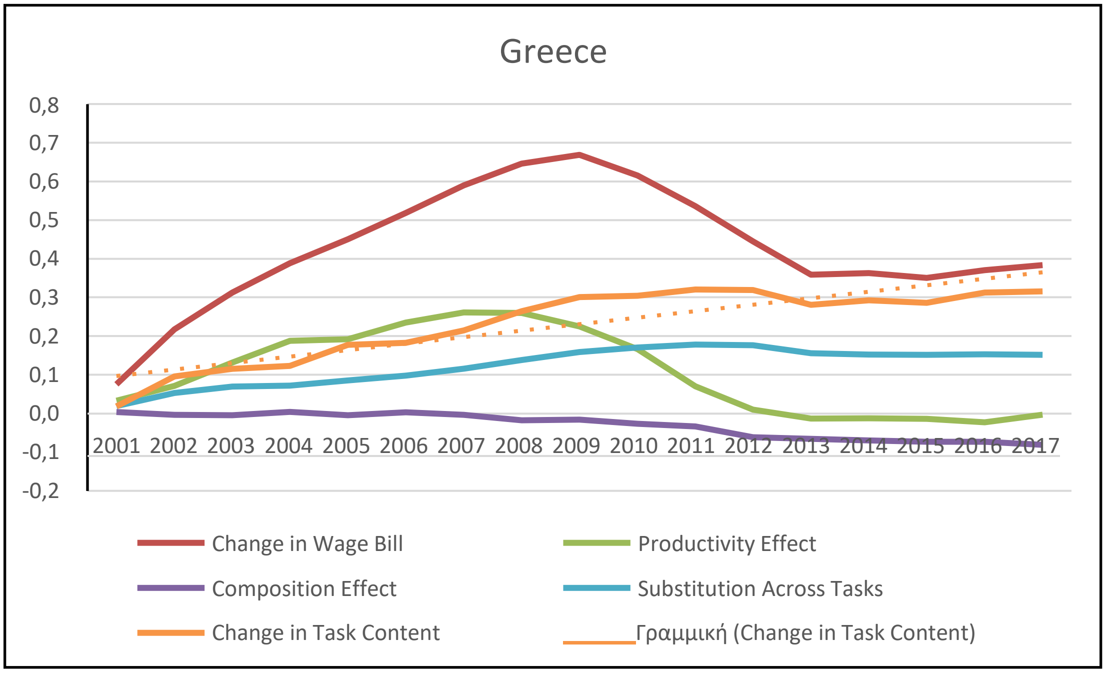

Diagram 4.3. Decomposition of Labor Demand in Greece, 2000-2017

Once more time we can observe in diagram 4.3 that the “Productivity Effect” component in Greece has similar shape as “Wage Bill” but up to now in our analysis this is the first country that meets this component in negative zone, and this may be an impact of a long term crisis in this component. Normally we can find “Composition Effect” component slightly below zero. The “Substitution Across Tasks” component seems to have the same shape as the previous countries with the exception in the crisis period that seems to be stabilized and being constant. Last but not least, the “Change in Task Content” component appears in an increasing rate and being affected by the crisis period. In this way, the line that is above zero in “Change in Task Content” means that the displacement effect is less than the reinstatement effect and in turn technology again in contrast to US data gives place to workforce.

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0,891939591					
R Square	0,795556233					
Adjusted R Square	0,781926649					
Standard Error	0,04432853					
Observations	17					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	0,114697757	0,114698	58,36980837	1,51102E-06	
Residual	15	0,029475278	0,001965			
Total	16	0,144173036				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Higher 95%*
Intercept	0,080297184	0,022487848	3,570692	0,002788327	0,032365471	0,128228898
year	0,016766692	0,002194589	7,640014	1,51102E-06	0,012089036	0,021444348

Table 4.4. Regression of “Change in Task Content” component trend line in Greek Data

Table 4.4 presents the results of the estimated trend line fitted to the Greek “Change in Task Content” component. In these results we can see once more time in European Data that the coefficient of the regression line is not just positive but is also highly significant (<0.001) More accurately Greek data show an approximate rate of 1.7% increase in “Change in Task Content” per year and a positive relationship of new technology and higher wages, because of higher demand. This 1.7% increase is lower than the corresponding 2.9% and 2.5% found in Estonian and Lithuanian data respectively and this possibly could be explained because these two countries are new members of the European Union and the economic shock that experienced by the Greek economy during 2009-2018 crisis.

Having completed the analysis in countries with lower share in use of robots, next will be presented the countries using robots in higher share among the European Union members.

In diagram 4.4 it is found that the shape of “Wage Bill” index in Finland follows the pattern of Estonian and Lithuanian data. Especially in Finland is observed an almost 5% increase in “Wage Bill” per year during period 2000-2008 that is half of the Estonian and Lithuanian one. This period is followed by the recession period 2008-2010 with the loss in “Wage Bill” being almost insignificant because the losses from 2009 seem equal to gains in 2010. After this period the data show that the increase in “Wage Bill” starts to return in increasing pattern of 2% that is again lower than the rate that was found in Estonia and in Lithuania. There is also observed a slowdown during period 2012-2017. It is worth underlining that after the worldwide recession in early 2010 Finland executed the appropriate policies and returned quickly to previous economic conditions. This was followed by a stall in economic growth in 2012 that led Finland to borrow from the IMF (International Monetary Fund) and this is why we can observe this slowdown during the period 2012-2017. (IMF, 2012) The image in Finland that is presented in these data seems like a stable economy with small changes in wages of employees during crisis periods, quick recovery and a steady growth in periods without economic shocks. Furthermore, Finland is an older member of the European Union from 2005. Twelve years as a European Union member are enough to align with economies that have already matured.

Diagram 4.4. Decomposition of Labor Demand in Finland, 2000-2017

On the other hand, analyzing the components, there is the “Composition Effect” component that is slightly downwards all the years but with the exception, that in Finland this increasing rate found from two to four times slower than the other countries. In

Finland is also observed normal behavior of the "Productivity Effect", compared to other European countries, during 2000-2011. During 2012-2017 it seems that the 2012 economic shock affected more the "Composition Effect" component, but it is not observed directly to "Wage Bill" because this is counterbalanced by the abnormal higher increase in "Change in Task Content" component. Furthermore, the "Change in Task Content" component, in the period 2000-2011 keeps the same pattern as the previous European economies. Finally, "Substitution Across Tasks" component seems to be increasing during 2000-2009 followed by a period of stability 2009-2017 with a slight increase in 2012.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,965565319
R Square	0,932316385
Adjusted R Square	0,927804144
Standard Error	0,02303762
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,109659501	0,10966	206,6193689	3,53728E-10
Residual	15	0,007960979	0,000531		
Total	16	0,117620481			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Higher 95%*
Intercept	-0,012226147	0,011686977	-1,04613	0,312064974	-0,037136348	0,012684055
year	0,016394307	0,001140532	14,37426	3,53728E-10	0,01396332	0,018825293

Table 4.5. Regression of "Change in Task Content" component trend line in Finnish Data

Focusing on table 4.5 that presents the trend line estimation of "Change in Task Content" component in Finnish data, we obtain once more time a positive coefficient value that is highly significant (<0.001). This table indicates that there is roughly a 1.6% increase in "Change in Task Content" component per year, a value which show that technology implies a higher "Reinstatement Effect" than "Displacement Effect".

Diagram 4.5 presents "Wage Bill" and its components of Italian data. As we can observe in the 2000-2008 period, there is a steady increase with almost the same rate as we found in Finnish data during the same period. This period was succeeded by a stability period during 2008-2014. Finally, during period 2015-2017 Italian "Wage Bill" returns to the increasing rate. This abnormal behavior, compared to the other European countries, comes from the different trend of “Productivity Effect” component that is not counterbalanced by other components as we found in Finnish data. Italy also is one of the founding members of European Union with the appropriate time to be a mature member.

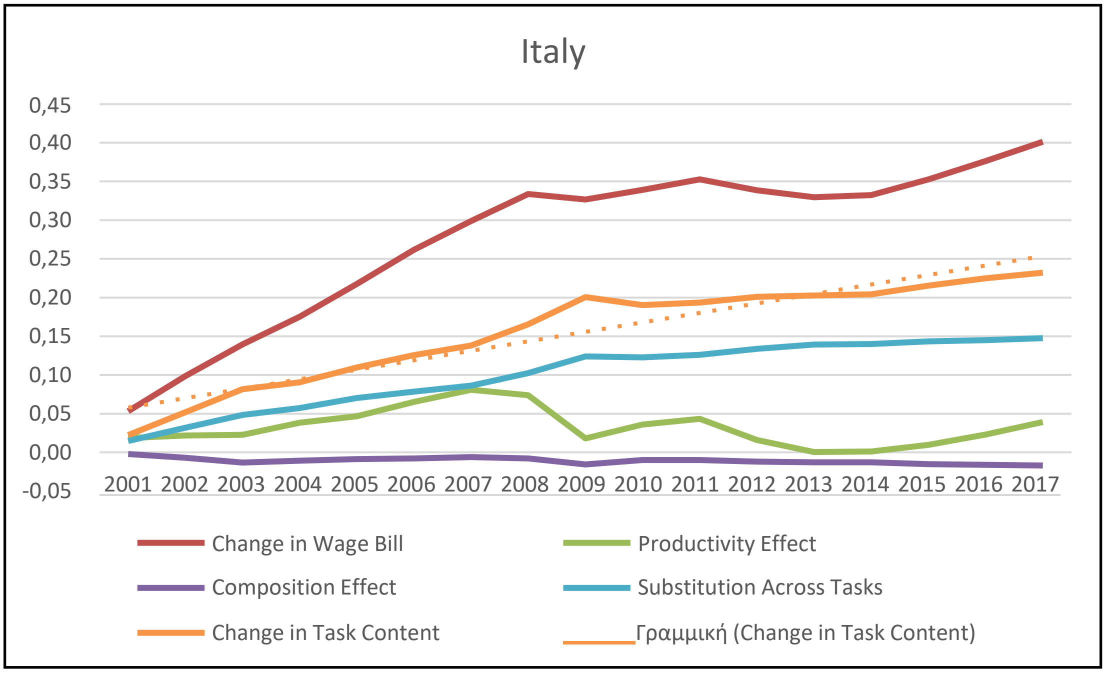

Diagram 4.5. Decomposition of Labor Demand in Italy, 2000-2017

In diagram 4.6, in further analysis we can find that the Italian “Composition Effect” component displays the same slightly negative trend as found in previous European economies. On the other hand, the “Productivity Effect” component seems to different from the countries that we analyzed previously. This component, as it is referred in theory, comes from the possibility that industries are able to select the cheapest production factor between capital and labor once tasks can be produced by both factors. In Italian data this downwards behavior during period 2008-2013 affects the “Wage Bill”. This could be an indication that maybe Italian industries are using so-so technologies as it is referred in (Acemoglu & Restrepo, 2019). This means that industries are not using technology in a way that does not help labor augmentation and in parallel these technologies are not so effective to replace labor efficiently. Furthermore the “Substitution Across Tasks” component and the “Change in Task Content” component are in an almost increasing pattern. Similar patterns of these components were also found during the analysis of the previous European countries.

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0,953911531					
R Square	0,909947209					
Adjusted R Square	0,903943689					
Standard Error	0,020098286					
Observations	17					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	0,061224935	0,061225	151,5689624	3,04359E-09	
Residual	15	0,006059117	0,000404			
Total	16	0,067284051				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Higher 95%*
Intercept	0,045474934	0,010195854	4,46014	0,000458333	0,023742986	0,067206882
year	0,012249943	0,000995013	12,31133	3,04359E-09	0,010129123	0,014370764

Table 4.6. Regression of “Change in Task Content” component trend line in Italian Data

Extracting once more (Table 4.6) the estimate of coefficients in trend line of “Change in Task Contend” in Italian data we found a positive relation between years in the time series and the component. The slope of this trend line was found strictly increasing as the significance of the “Year” variable level is again less than 0.001. We found that the value of this coefficient is approximately 0.012 which means that we observe approximately a 1.2% increase of the “Change in Task Content” component each year and this is also the approximate reflection of this component of the “Wage Bill”.

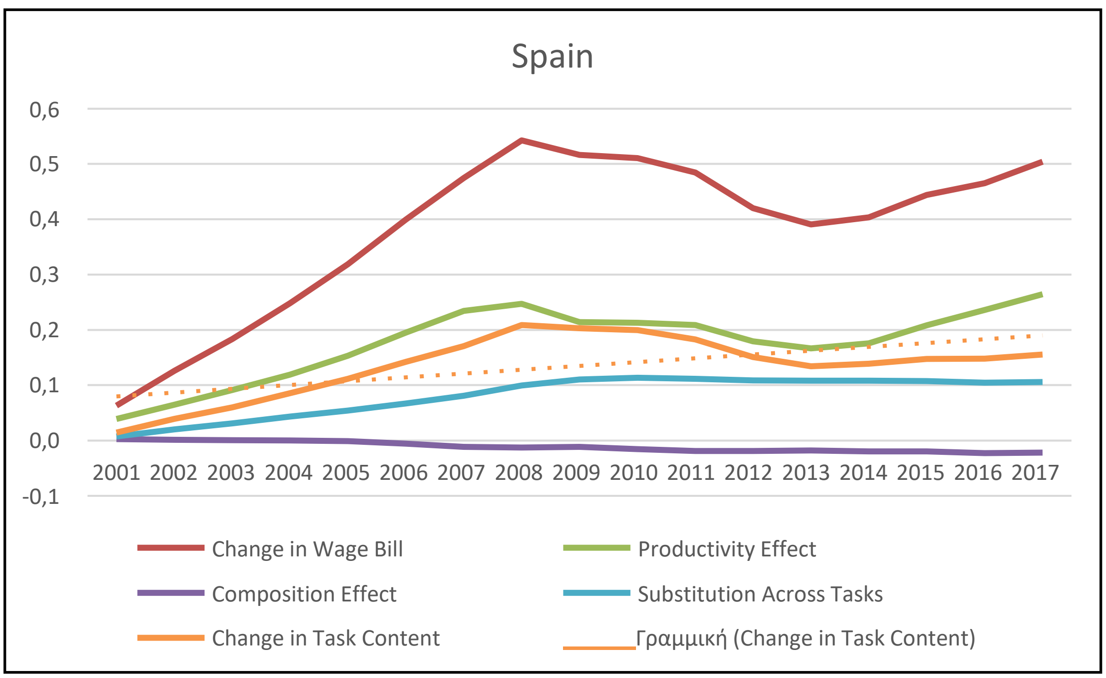

Diagram 4.6. Decomposition of Labor Demand in Spain, 2000-2017

The last country left to be analyzed for the group with higher usage of robot shares is Spain. In Diagram 4.6, during period 2000-2008 is observed a steady increase is observed in “Wage Bill” at a rate of 0.7% per year. This increase is followed by a crisis period (2008-2013) in Spain (ESM, 2013). This crisis forced Spain to borrow from the ESM in 2012 and in this way to overcome the economic problems. As we can see in the diagram, after borrowing the “Wage Bill” starts to be increasing again. The same pattern was observed in Greek data too. In Greek data after each borrowing episode, we were observing a slowdown in decreasing rate of “Wage Bill”, and after the last time “Wage Bill” started to be increasing again. Finally during period 2013-2017 it is observed that “Wage Bill” started rising again at a steady rate of 0.3% per year. This increasing rate is similar to the other countries after the Worldwide Recession period. Finally, Spain is an old member in European Union as it is enlisted from 1986.

In component analysis we can find the following findings. The “Productivity Effect” component follows the shape of “Wage Bill”, a behavior found in most countries in our analysis and in US data. Furthermore, the “Composition Effect” component was found slightly negative and decreasing, a feature that occurs in all European countries. The “Substitution Across Tasks” component was found positive and increasing during period 2000-2008 and during the next period 2008-2017 seems to have stabilized. Finally the most important component in our analysis is “Change in Task Content” component,0 found increasing during the period before Recession 2000-2008. The next period 2008-2013 of Spanish economic crisis seems to be a decreasing period for this component. And after the borrowing year in 2012 it seems to start a slight increase.

Table 4.7 presents the results of the estimated trend line fitted to Spanish “Change in Task Content” component. In these results we can observe that the coefficient of the regression line is not just positive but is also significant (<0.01) More accurately Spanish data show an approximate rate of 0.7% increase in “Change in Task Content” per year and a positive relationship of new technology and higher wages, because of higher demand. This 0.7% increase is lower than the corresponding 1.6% and 1.2% found in Finnish and Italian data respectively and this possibly could be explained because these two countries did not experience an economic crisis as was experienced by the Spanish economy during 2008-2013.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,61486759
R Square	0,378062154
Adjusted R Square	0,336599631
Standard Error	0,046083844
Observations	17

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0,019364437	0,019364	9,118165648	0,008621042
Residual	15	0,031855811	0,002124		
Total	16	0,051220248			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Higher 95%
Intercept	0,072926889	0,023378318	3,119424	0,007032518	0,023097183	0,122756595
year	0,006889257	0,00228149	3,01963	0,008621042	0,002026375	0,011752138

Table 4.7. Regression of “Change in Task Content” component trend line in Spanish Data

4.5. Further Discussion of Result

To sum up all the above findings, we found that “Wage Bill” presents the same pattern in countries that did not experience any economic crisis after the Great Recession. All countries found expansion in “Wage Bill” in period 2000-2008. During this period was found greater increase in “Wage Bill” in countries that were new European Union members. Another similarity found in the data, was that countries that were using low share of robots, experienced larger expansion in “Wage Bill”. This statement is confirmed by the “Change in Task Content” component that we will analyze later. During the period of Worldwide Economic Recession all the countries experienced a reduction in “Wage Bill” with a quick recovery. For Greece, Finland and Spain we found a further reduction in “Wage Bill” found in literature review, that after country’s access to loan procedures, the very next year found that the “Wage Bill” started rising again. Only Greece found that the first loan reduced the downslope in “Wage Bill”, followed by the second time that we saw a second arrest in this downwards attitude and finally the third time in 2015 start increasing again. In comparison to US data, in Europe overall we can see that there is an increase in the “Wage Bill” in European countries while there is a stability during this period.

In component analysis we start analyzing "Productivity Effect" component shows in most European countries, except for Italy and Finland, that follow the shape of "Wage Bill" and this behavior is similar to that found in US data. "Productivity Effect" comes from the ability of companies to choose the most efficient factor between labor and capital in order to accomplish a task. When firms choose capital to perform these tasks instead of labor when capital is cheaper but not more efficient this is an example of so-so technologies (Acemoglu & Restrepo, 2019). These technologies give tasks to capital by reducing the labor demand and reducing "Wage Bill" without increasing the efficiency in this task. As a result, there is an indication that Finland and Italy used so-so technologies during the period 2012-2015.

The second component is the "Composition Effect" that is slightly below zero and almost stable. This behavior is similar to all European countries that we analyzed and the US data follow the same pattern. The third component is the "Substitution Across Tasks". In European data we found this component to be positive and most of the time increasing while in US data it is around zero. "Substitution Across Tasks" is the ability of employees to move across the different industry sectors and finding jobs that best suits them and being more effective, and in this case achieve higher wage. Furthermore, we analyzed in a previous chapter that technology replaces old tasks and creates new ones. In this case personnel should be flexible and during periods of rapid technological changes should be alert and change profession in case of decrease of labor demand in a specific task. In this way the difference between the European data and US data is that there are European polices that offer tuition fees in universities without tuition fees or in some cases much more cheaper than US. This policy may give the potential to personnel to move across tasks and industry sectors that give positive value in "Substitution Across Tasks" component.

The final and most important component in our analysis is "Change in Task Content". European countries have a positive rate in this component while the US was found to be negative. This finding means that increasing technology helps employees achieve higher salaries and this coming from increase in labor demand. Furthermore, another factor that maybe explains this phenomenon is not only the improvement of technology but also the technology share in each country. In our analysis we found that countries with lower share of robot usage have higher coefficients in this component's trend than countries with higher rate. Estonia, Lithuania and Greece had rates of 2.9%, 2.5% and 1.7% respectively, while for countries of the second group, Finland, Italy and Spain, we found 1.6%, 1.2% and 0.7% respectively. Also, in this component we found that countries that experienced a longer crisis period (Greece and Spain) in each group experienced a worse performance in this component and this is why they have the smallest increasing rate in each group.

In (Qian, Huang, Zhang, & Zhu, 2023), a paper that applies the (Acemoglu & Restrepo, 2019) model to Chinese data, it was found that technological augmentation led to an increase of the "Wage Bill". As in all countries that we have tested, the "Productivity Effect" component was also increasing across the years of technological improvement. And of highest importance to us, "Change in Task Content" was found to be negative.

All the above findings bring us to the conclusion that the strength of each economy affects the technology that firms can use in production. In the Worldometer database (wordometer, 2023) ranking all countries according to their nominal 2017 GDP (which is the year reached our survey), the US are in first place, China in second, Italy in ninth, Spain in fourteenth, Finland in forty second, Greece in fifty first, Lithuania in eighty fifth and Estonia in hundredth. Except for Spain, this ranking is in the same order between GDP and "Change in Task Content" component. The large economies were found to have negative Change in Task Content (with US data indicating more negative "Change in Task Content" component compared to China) and in European data, we found less positive trend slope in Spain, then in Italy, followed by Finland, then Greece, Lithuania and more positive in Estonia. Consequently, this finding suggests future research into the possibility that the reinstatement effect tends to be relatively larger than the displacement effect in economies with smaller GDP, whereas the displacement effect being larger than the reinstatement effect indicates an economy with a high GDP.

Chapter 5. Conclusions

In this chapter reference will be made to the trends prevailing in society in relation to the effect that technological progress has on work matters. Then the conclusions obtained both by analyzing the data and in terms of impressions given by the books which express people's perspective intuitively will be presented. This helps us to take a social approach as the average person does not have sufficient knowledge of the socioeconomics to form an opinion. This dimension is very interesting, and must be considered, as states operate with the aim of improving the standard of living of society on the one hand and protecting it on the other, and human behavior and psychology significantly affects the economy.

5.1. Social Trends

All social phenomena tend to divide the opinion of society. We often notice that something that for one person's data is correct, finds others in the opposite position. Even the same person can change his opinion on a subject. The diversity of opinion of individuals is a common feature which we also find in ourcase. There are many trends that appear in society. Trying to approach them, we will refer to the most basic ones towards which the rest also tend.

On one side we meet the followers of the optimistic scenario. This perspective includes those who perceive the benefits offered by technological development. The specific social group realizes that the environment which is exposed to technology is experiencing rapid developments. Such an environment creates new opportunities and advantages for anyone who follows these changes. In this sense, new technologies upgrade living standards and comforts. Thus, the real salary increases as with the same hours sacrificed for work the person can use services and products of higher quality. An example is the price of portable computers that tend to maintain the same price range over time with their features being constantly upgraded. In addition, technological development is a pattern of economic cycles. Old professions tend to disappear giving way to new professions. In addition, society produces more efficiently as a whole and a proportionately greater amount of goods per person.

On the opposite side we find the followers of the pessimistic scenario. This social group considers that technological progress simply improves the quality of products. Also, that it helps businesses to reduce their costs, but businesses do not reduce the price of their products. Therefore, they consider that the benefits of technology are not fully enjoyed by all of society, but only by part of it. In addition, they believe that technology is one of the factors that cause unemployment in society. In this view there is an argument which states that the level of unemployment in 2021 may be at the same level as that of 1970, with the difference that several parameters have changed. As an example, it is mentioned that nowadays there is the category of part-time employment. An employee who works in part-time conditions is paid half the salary but is not counted as unemployed. In addition, the percentage of people who choose to continue their studies in higher education after completing secondary education has increased, but people in this situation, although they do not receive an income, are not counted among the unemployed. Therefore, a similar percentage of workers today has lower levels of employment than the same percentage that existed fifty years ago. A further problem is found in diagram 2.4. during which a higher absorption is observed in professions with lower education requirements. If this continues to exist, it may eliminate the need for further education as the complacency to easily find a job with the educational resources possessed, is not a motivation for improving the educational level, which also affects the level of the society of which the individual is a member. Thus, a reasonable question is what happens if individuals' choice to obtain higher education is decoupled from the motivation to find a job.

In addition, extreme trends continue to exist. Thus, there is the view which supports the eclipse of any kind of Job Replacement Technology. In such an environment there will be more employment. Something that finds application in a society that follows as a model the general theory described by John Maynard Keynes. At the opposite extreme is the view of the complete replacement of work by technology. In this environment man will not work and the state will provide everyone with an equal income. This accordingly finds application in a society which follows as a model the theory of Karl Marx. However, there is also the moderate attitude in which its supporters are more indifferent and the percentage that supports it is variable depending on the stimuli it receives and the prevailing social, political and economic conditions.

5.2. Final Comments

"In one area there were workers engaged in digging. One of these bought an excavator with which he performed the same work, of all workers, in much less time. The rest of the workers revolted by demanding to stop using the excavator, as it was causing them unemployment. In response he said that he would stop using the excavator if everyone starts using spoons for digging and then, even more jobs would be created."

This example is obviously not a real event, but it illustrates the different tendencies and opinions that a society can have. The state is called upon to balance these by taking the appropriate political decisions with which it will satisfy as many of its members as possible, setting the necessary frameworks within which the economy will move to make it sustainable. So, businesses tend to replace human resources with production machines and artificial intelligence systems. The policies of businesses allows them to have mass production capabilities, reduce theircosts and upgrade their product by incorporating new technologies into it. It is therefore observed that a business policy (microeconomic environment) can cause instability in the labor market which the state is asked to deal with (macroeconomic environment). State intervention must contribute to the improvement of the product market with as little negative impact on the labor market as possible. It is worth noting that technology is constantly evolving and states do not have time to take adequate measures.

Another important aspect worth noting is that a person, considering the current needs of the market, starts his specialization from the last two years of high school and then follows four years of studies to obtain a degree. To these years we can add two more years of specialization with postgraduate studies. Therefore, we see eight years of preparation for a person's professional orientation and forty years of employment, i.e., forty-eight total years in which he walks in a certain way even when he is forced to undergo training and retraining to adapt to the ever-changing market data work. However, in diagram 2.4 we notice that within a period much shorter than the above time, in the thirty years examined in this diagram, he may experience extremely unexpected changes in his workplace, which may cause instability in his personal life, in its consumer habits as well as in the society in which it interacts.

We therefore observe that technology has the potential to change work. The change in work issues can have many dimensions as it is not only described by the unemployment index but is a key part of people's everyday life. Thus, any change both in the level of employment and in wages and in its environment may also take on social dimensions. Therefore, the state must be particularly careful in the implementation of policies, both in labor matters, and in trying to dampen the shocks caused to society by the effect of technological changes.

Epilogue

A good practice in any new data is to distinguish the benefits offered by the new dimension and to try to integrate them into society by adapting them to the new emerging conditions for the benefit of society. Thus, from the above study of the subject, it the necessity emerges of investigating the appropriate economic model that can be applied, with variations and adaptations to the evolving needs. It is also possible to examine any possible flexibility that will simulate various related economic theories such as the theory of John Maynard Keynes that states that man will work less while enjoying the same or even more, as for example to examine whether there is the possibility of applying a legal framework that will allow working hours to be reduced, without a corresponding change in monetary benefits as the costs will be covered or even exceeded by the use of new technologies. It should also be considered whether technologies to replace low-wage groups should be encouraged, as from Diagram 2.4. it follows that this group has a higher absorption, to the benefit of the lower absorption groups. Finally, perhaps it would be beneficial for society to study a process for detecting the rate of use of Work Assisting Technologies and Work Replacement Technologies and especially when the latter have the character of increasing productivity and when reducing jobs, to the unfair advantage of businesses, so that the state can intervene effectively in order to control the impending negative effects on society.

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Appendix

In order to reach to reach to "$\Gamma(N,I)_{i,j} = \frac{s^L_{i,j} \left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma}}{\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma} + s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - s^L_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}}$" solution of equation (5) is required.

In this way we have:

$$\overset{(5)}{\Rightarrow} s^L_{i,j} = \frac{\Gamma(N,I)_{i,j} \left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}}{[1-\Gamma(N,I)_{i,j}]\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} + \Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}}$$

$$- s^L_{i,j} = \frac{\Gamma(N,I)_{i,j} \left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}}{\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - \Gamma(N,I)_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} + \Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}}$$

$$- s^L_{i,j}\left[\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - \Gamma(N,I)_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} + \Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}\right] = \Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}$$

$$- s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - s^L_{i,j}\Gamma(N,I)_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} + s^L_{i,j}\Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma} = \Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}$$

$$- s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} = \Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma} + s^L_{i,j}\Gamma(N,I)_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - s^L_{i,j}\Gamma(N,I)_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}$$

$$- \Gamma(N,I)_{i,j}\left[\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma} + s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - s^L_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}\right] = s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma}$$

$$- \Gamma(N,I)_{i,j} = \frac{s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma}}{\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma} + s^L_{i,j}\left(\frac{R_{i,j}}{A^K_{i,j}}\right)^{1-\sigma} - s^L_{i,j}\left(\frac{W_{i,j}}{A^L_{i,j}}\right)^{1-\sigma}}$$