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Keynes' Grandchildren: An Analysis of Technological Unemployment Throughout History

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Academic Year 2016/2017

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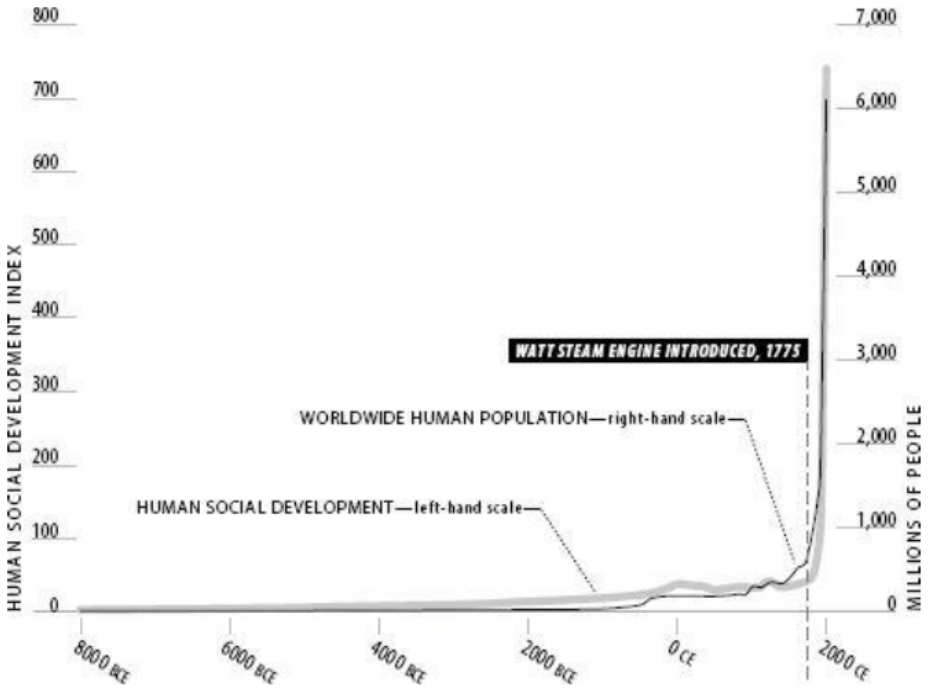
INTRODUCTION

Human history has been characterized by many important developments. From the Homo Sapiens finding himself equipped with language capacities, to the domestication of animals for companionship and labor-saving purposes, to the great Roman, Mongol or Ottoman empires. This list of incredible advancements could go on for longer than this introduction can allow. But how can we quantify the importance of these developments? Anthropologist Ian Morris tried to rank these events in a way that could be evident and significant: through data analysis. He is the first one to admit that *"reducing the ocean of facts to simple numerical scores has drawbacks but it also has the one great merit of forcing everyone to confront the same evidence —with surprising results."*[1] His impressive work on the understanding of what he defines as 'social development', led to a set of results that cannot be considered as nothing less than extraordinary.

Figure 1: The Effect of the Industrial Revolution in Human History



Source: Erik Brynjolfsson and Andrew McAfee, *"The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies",* WW Norton & Co, 2014, p.8

[1] Ian Morris, "*Why the West Rules—For Now: The Patterns of History, and What They Reveal About the Future"*, Profile Books, London, 2010, p. 142.

As the figure above shows, none of the milestones I mentioned above had a significant impact, or at least they did not if compared to something that curved the history of human development like nothing else before. In this graph, the total human population is compared to their social advancement throughout history. The two curves move together in a very slow upward pattern. Until the very end, progress seems slow, almost unperceivable. All the wars, empires and religions did not influence it as much as we would like to think. The sudden change in the curve is caused by an event that took place in the late eighteenth century and would change human lives forever: The Industrial Revolution. The specific machine that caused this jump was the evolution of the steam engine. But this was only the beginning. Many human limitations were overcome, and the era of mass production, factories and mass transportation started. Essentially, this revolution led to what we now consider modern life.
The industrial revolution constituted the first age of machines. The capacity to generate such a massive quantity of mechanical power was so incredible that it *"made mockery of all the drama of the world's earlier history."*[2]

Now we are entering what people are calling the second machine age. The age of information technology, computers and other digital advancements could be a threat to cognitive capabilities in the same way the steam engine was a threat to muscle power. Humans limitations are once again being surpassed, this time by a new type of machines. The Oxford English Dictionary defines "robot" as *"a machine resembling a human being and able to replicate certain human movements and functions automatically."*[3] This term was coined in 1920 by Czech author Karel Čapek, in his theatrical play R.U.R *"Rossum's Universal Robots"*. It comes from the verb "robotovat", which means "to work". It is not surprising to find out that automation and labor have always been connected since their conception.

The aim of this thesis will be to better understand this correlation between technological innovations and labor in the past two centuries. It is sometimes said that the best

[2] Ian Morris, *"Why the West Rules—For Now: The Patterns of History, and What They Reveal About the Future",* Profile Books, London, 2010, p. 497.
[3] Oxford English Dictionary, retrieved from https://en.oxforddictionaries.com/definition/robot

predictor of future behavior is the past. This maxim is very common in forensic science and psychology, in general, to indicate that the expected future actions of an individual can usually be predicted by observing a recurring behavioral pattern from them. I will use a similar research method in this thesis to analyze a problem that has surfaced again in recent times: how do technological advancements affect people's lives in relation to unemployment and standards of living?

The outline of this thesis will be as follows.

In the first chapter I will analyze the controversy in the early 1800', the period of incredible importance for the specific subject of this dissertation, but also for humankind in general. In section **1.1** I will cover the period preceding the Industrial Revolution, to better understand the dynamics that led to it. In section **1.2** I will then reconstruct the theoretical framework in which the debate was born. In section **1.3** I will put the spotlight on David Ricardo, an author whom I think, with his very own conflicts on the subject, embodies this controversy more than anyone else. I will then highlight the instrument that helped him develop a theory on the subject, his famous analytical model. I will then consider how two brilliant economists, John Hicks and Samuel Hollander, reexamined the model and its significance a century after its formulation. In section **1.4** I will then present two views opposing the ones provided thus far, one by Joseph Schumpeter and the other by Knut Wicksell, with the addition of a simple example devised by Paul Samuelson. The **fifth** and final section is focused on the prevailing ideas of the end of the century, the 'victors' of this initial battle in the debate, before moving into the next century.

The second chapter will start right after where the first left off, at the beginning of the twentieth century. Section **2.1** will cover the period of the Great Depression, that saw a surge of technological anxiety and in section **2.2** I will focus on the battles of professor Alvin Harvey Hansen against his contemporaries. In section **2.3** I will concentrate my attention on the most famous economist of this time, John Maynard Keynes. He enters this debate thanks to his famous essay: "*Economic Possibility for our Grandchildren"* which will be at the center of section **2.4**. Here I borrowed the thoughts of great modern

economists like Joseph Stiglitz, Robert Solow, Richard Freeman, Jean-Paul Fitoussi and Benjamin Friedman to cite a few, to understand what Keynes got right in his essay (and what he got wrong), and why. In the **fifth** and last section, much like in the previous chapter, I will conclude the century by analyzing the consensus reached by the end of it, this time with the help of economist Wassily Leontief.

In the third and final chapter, I will then highlight the current situation. Section **3.1** will try to answer, with the help of new studies and recently available data, to the question of why, in the twenty-first century, a debate considered 'dead and buried' by most economists, has come back in fashion. Section **3.2** and **3.3** will be kept in the debate-style that characterized the rest of this thesis. In the first part, I will focus on the modern "pessimists", those who think that machines could replace human beings thanks to what they call the Skill-Biased Technical Change theory. The second side of the debate will have economists arguing that if humanity did not suffer an extinction of labor after the Industrial Revolution, we have no reason to worry about this revolution either. In section **3.4** I will then offer some possible insight into what we might face in this second age of machines in terms of regulations and changes in social structures.

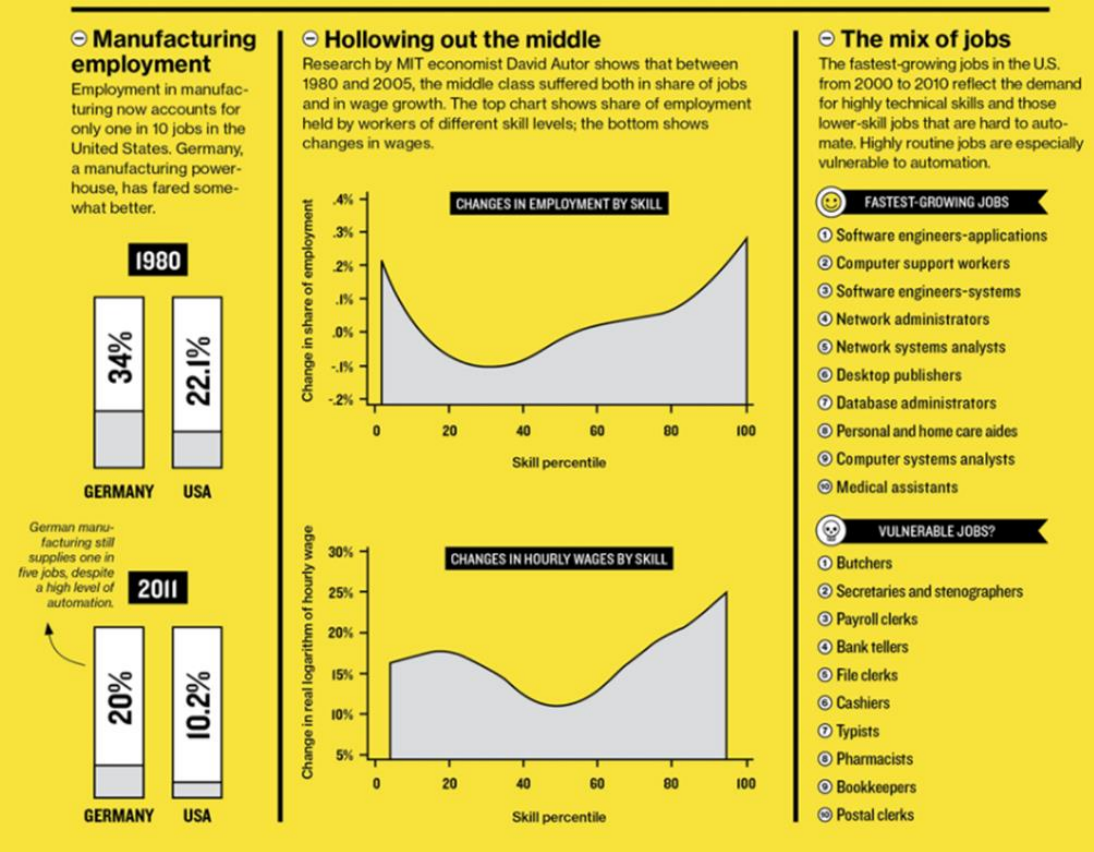
In the last part of this dissertation, I will draw my conclusions on the issue. I will put emphasis on the fact that, while the debate might have not yet come to an end, we are definitely facing another inflection point in Ian Morris' graph and the decisions we will take from this moment forward might shape the world our grandchildren will live in.

CHAPTER 1. The Debate in the Nineteenth Century

1.1 A Historical Debate

At first glance, the effects of a technological revolution might seem easy to understand and very plain to see. The fact that a drastic change in technology might lead to the unemployment of individual workers is an obvious prediction to make. It is also very easy to find examples of jobs and industries that have been affected negatively by changes in technology.

Figure 2: Decoupling Productivity and Employment



Source: David Rotman, "How Technology Is Destroying Jobs" *MIT Technology Review*, June 12, 2013, Retrieved from https://www.technologyreview.com/s/515926/how-technology-is-destroying-jobs/

But can this be really such a clear phenomenon, if it is still a modern object of contention to understand what happens to the workers that became unemployed after

the introduction in the system of these new machines? Can these workers quickly find an equivalent job? Do they need to develop substantial new skills to keep up with the advances in technology? And more importantly, can this temporary unemployment become a more lasting problem, making it something governments should worry about and develop precautionary regulation against?

All these questions are at the front and center of the debate on the technological revolutions that have taken place throughout our history.

In the words of economic historian Gregory R. Woirol, *"as a recognizable phenomenon, technological displacement of labor must date at least to man's first use of the wheel."*[4] It is extremely easy to cite several moments in history where the introduction of new technologies engendered fear of job destruction, a common example being the invention of the press in 1436 which rendered useless the work performed by manuscript copyists. The matter of employment in the economic world has always been examined as a matter of society's ability to adjust to change.

The first time this question emerged as a significant topic of discussion was back in the 16th century. The important realization of that time was that progress could include in its 'equation' both positive and disruptive factors.

This combination of contrasting elements explains the ideas of the early commentators, known as mercantilists, in analyzing the improvements in production in correlation to the effects it had on labor. One fundamental dogma of their movement was the bolstering of production without any sort of limitations as the main determinant of the wealth of the state. In conjunction with this concept, it was important for them to encourage the expansion of a usefully employed population. Finally, they had a tremendous inclination towards innovations. They believed they would help in decreasing the cost of production, while boosting profits which could then be used to

[4] Gregory Ray Woirol, *The Technological Unemployment and Structural Unemployment Debates*, Greenwood Press, Jan 1, 1996, p. 17

enhance production processes and create new forms of enterprises and new mechanical equipment.

One of the main inconsistencies that these theories faced was the fact that economic progress tended towards industrial channels, leaving the sector of agriculture behind. This phenomenon was particularly evident in England, a country that faced an incredible rise in the industrial sector at the expense of farming.

It must be noted, that on the topic of unemployment, mercantilists writers were not particularly concerned with the well-being of the lower class. They were mostly businessmen and statesmen, and thus their main concern was the inactivity of workers that would result from an eventual loss of jobs. They considered low-cost labor to be essential, but they did not aim at having a "reserve army of unemployed". For this reason, they generally encouraged the use of labor-saving devices.

But the public seemed to hold a different opinion on the matter, and judging by the repressive legislation enacted in that period in several countries, even institutions thought that it was a good idea to restrict the use of machinery. This negative sentiment is exemplified very well by Montesquieu's words on the matter: "*The machines designed to abridge art are not always useful. If a piece of workmanship is of a moderate price, such as is equally agreeable to the maker and the buyer, those machines which would render the manufacture more simple, or, in other words, diminish the number of workmen, would be pernicious. And if water-mills were not everywhere established, I should not have believed them so useful as is pretended, because they have deprived an infinite multitude of their employment, a vast number of persons of the use of water, and great part of the land of its fertility."*[5]

The debate continued in the late eighteenth century, with important contributions by the Physiocrats and the writings of Adam Smith, but it is at the beginning of the nineteenth century that it reached its peak.

[5] Charles Baron De Montesquieu, *The Spirit of Laws*. Cosimo Classics, 2011

The return on the spotlight of the issue was caused by the fact that this period started to perceive the effects of the industrial revolution but also those of the amazing advancements made in the discipline of economics.

Machines became the enemy, the object of popular hatred. They were replacing workers and destroying jobs. In this climate, the debate over the influence of machinery on employment intensified considerably.
The most important question at the time was whether the problems generated by technological progress arose because of factors such as wars, political and legislative decisions (like disproportionate taxation, poor laws, corn laws…), or whether they were an unavoidable accessory of industrial development. Whether they were merely a temporary issue, denoting a particular stage of development, or actually long-term and periodic in nature. Whether they could be considered as the reason of temporary displacements subject to reabsorption in time, or as a lasting trend ingrained in the process of technological advancement.

The most interesting point of contest in the controversy still to this day is whether the effect of the displacements caused by technological advancements is to be considered a temporary or a long run issue. This is the very same question that was at the center of the debates argued by the distinguished economists of the Classical School, among which we find great minds like J.B. Say, David Ricardo, Thomas Malthus, Nassau Senior, Karl Marx and John Stuart Mill. Labor displacement and the possible remedies to this problem have been the main topics of discussion of the so-called *compensation controversy*.

In this thesis I will cover only the main points in this controversy, believing them sufficient to represent how these issues appeared to the economists of that period. I will do this by developing the topic in a "debate-style", making a distinction between two main groups representing opposing views. The first side is the one supporting the idea that the effects of technological change on unemployment might be permanent or at least long-term. I will analyze these economists' point of view through the evolution of a famous author's doctrine: David Ricardo's. On the other hand, to represent the ones

who thought that the unemployment issue would only be a temporary problem and that the forces determining the market would be able to compensate for these displacements in the long run, I choose two authors: Joseph Schumpeter and Knut Wicksell.
Before starting this analysis, I will first cover the main theories to introduce the economic framework that accompanied the debate in the nineteenth century.

1.2 Economic Theories Supporting the Debate

The principal belief encouraged by the economic world in the 1800s regarding this debate was the one that stated that the introduction of machines to act as labor-saving devices would result in a displacement of labor.
All the theoretical assumptions that lead towards a faith in the future reabsorption of workers come back to the famous *Law of Markets* of J.B. Say, also called "*Say's Law*".
In his own words this law states that: *"A product is no sooner created, than it, from that instant, affords a market for other products to the full extent of its own value (…) as each of us can only purchase the productions of others with his own productions – as the value we can buy is equal to the value we can produce, the more men can produce, the more they will purchase."*[6]. This statement is most commonly known in Keynes's rewording of the concept: "*supply creates its own demand*"[7].

This means that any cost of production will eventually translate into income that will be used to acquire goods. Because of this principle, an excess of supply over demand (a general glut) can never occur. This argument was applied to the topic of displaced labor being re-absorbed automatically by the economy. This re-employment was supposed to happen naturally because the larger supply generated would be matched by an equal increase in demand, keeping the purchasing power constant. The explanations for this phenomenon were known as the three compensation effects.[8]

[6] Jean-Baptiste Say, *A Treatise on Political Economy: Or, The Production, Distribution, And Consumption of Wealth*, London, Longman, 1821
[7] John Maynard Keynes *The General Theory of Employment, Interest and Money*, Chapter 2, Section VII
[8] John Ramsey McCulloch, *The Opinions of Messrs, Say, Sismondi and Malthus, on the Effects of Machinery and Accumulation, Stated and Examined*, The Edinburgh Review, March 1821

The first one was the increase in demand caused by the reduction in the cost of production. The second one stated that if the elasticity of demand was not enough to let all the displaced workers be absorbed, the decrease in prices, thanks to the lowered production costs, would make it so that consumers would still have money to spend on other goods. The third one, which was argued later on by John Ramsey McCulloch, stated that entrepreneurs would gain extra profits to invest or to use for their own consumption.

To explain it more simply, as the revenue and purchasing power of society remains constant, the decrease in prices translates into an increase in demand and in an expansion in production. This would become a great gain for the working class' consumers.

Say also touches on the topic of the substitution of capital for labor by saying that: *"the introduction of machines, diminishes (sometimes but not always) the income of the classes who derive their subsistence from their corporeal and manual faculties, and augments the revenues of those whose resources consist in their intellectual faculties and their capitals…The person who uses them is, therefore, obliged to purchase more of what we call the productive services of capital, and requires less of what we call the productive services of labourers. At the same time, as they require in their general and particular management perhaps more extensive combinations and more sedulous attention, they require more of that species of service whence the profit of the proprietor is derived."*[9], but doesn't elaborate further on what would become a focal point in later discussions.

The second theory in favor of the technological change was the *wages fund*. According to Say's Law, there is a guaranteed demand for goods after a technological revolution. But this is in contrast with the theory of demand for labor developed by classical economics. The wages and demand for labor were not, in fact, determined by the demands for goods, but by the volume of circulating capital (the wages fund). This

[9] Jean-Baptiste Say, *Letters to Mr. Malthus and the Catechism of Political Economy*, Augustus M. Kelley, Publishers, New York, 1967

meant that, according to this second approach, the effect of a change in technology depended on its effect on wages through its impact on the volume of circulating capital. This line of thought led economists to consider the possibility of net labor displacement, even though they still did not consider it very likely to happen.

David Ricardo argued that an obstacle to employment could arise if the machines were financed out of circulating capital, but since capital investment was considered a slow process, and fixed capital was held to be financed frequently out of profits and rents, the wages fund would be kept constant or would increase thanks to technological change, making it so that the reabsorption of displaced workers would take effect eventually. Ricardo himself ended up agreeing with this conclusion, but his doubts on the matter did not end here, making him the major exponent of his time to go "against the grain" in this controversy.

1.3 David Ricardo

Ricardo initially thought that mechanization was a good thing for any social class, from the workers, to the capitalists and the landlords as well. His ideas were very much in line with the other major economists of the time, since he believed that machines would help improve efficiency, boost output, and decrease costs in productions. This process would then lower prices, increasing the consumers purchasing power, making the laborers class inevitably better off by allowing them access to more goods at a lower price. He was also convinced that this would happen with no effect on jobs and wages: *"I thought that no reduction of wages would take place, because the capitalist would have the power of demanding and employing the same quantity of labour as before, although he might be under the necessity of employing it in the production of a new, or at any rate of a different commodity."*[10]

[10] David Ricardo, *The Works and Correspondence of David Ricardo. Volume 1: On the Principles of Political Economy and Taxation,* Edited by Piero Straffa with M.H. Dobb. Cambridge: Cambridge University Press,1951 p. 387

The exact moment of his historic "volte-face" on the issue can be found in the famous 31st chapter of the third and last edition of his Principles, called "On Machinery". He decided to change his approach on the matter, believing that machinery could decrease the demand for labor, reduce wages and also the national income, (what he called 'gross product' which consisted in Rent plus Profit plus Wages): *"the opinion entertained by the laboring class that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error, but is conformable to the correct principles of political economy."*[11]

His change of mind on the consequences of machinery on employment was the most sensational affair in the debate of the period and blindsided many of his disciples and his opponents both.

"...Although I am not aware that I have ever published anything respecting machinery which it is necessary for me to retract, yet I have in other ways given my support to doctrines which I now think erroneous; . . . I am convinced, that the substitution of machinery for labour, is often very injurious to the interests of the class of labourers. My mistake arose from the supposition that whenever the net income of a society increased, its gross income would also increase; [however] ... if I am right ... the same cause which may increase the net revenue of the country, may at the same time render the population redundant, and deteriorate the condition of the labourer."[12]

One might dismiss the problem by considering this change of mind as being the fruit of the volatile nature of Ricardo, but this assumption could not be further from the truth. This is made particularly evident when examining the attitude of the famous economist in regard to other topics he was interested in.
One example of his stubbornness is provided by his participation in the Bullionist controversy, where, in a similar context, he decided to keep his initial position for fourteen years, even when severely pressured by the economic world. In the history of

[11] Ibid, p. 392
[12] Ibid, p. 357

economic sciences, a reversal of one's opinion is not a very common occurrence. So why did Ricardo change his mind on the topic on technological unemployment?

One answer to this question lies in Ricardo's belief that people act in their self-interest, following in Adam Smith's footsteps. As he witnessed the revolts by the working class against the new machinery, he was compelled to reconsider his position and to start considering the idea that workers' interests might actually be harmed by the introduction of new machinery. He followed a similar line of reasoning in the case of the Bullionist controversy, when he maintained that the Bank of England had been acting in its own interests, maximizing profits from credit creation, which then led the bank notes to be over-issued.

This helps us understand why he could be so persistent in keeping his original position in one situation and so willing to abandon his original beliefs in another. In both cases, he mainly kept to his faith in the idea that economic agents always act in their own interests, a belief on which he based all his theory.

1.3.1 Ricardo's Model

"All I wish to prove, is that the discovery and use of machinery may be attended with a diminution of gross produce: and whenever that is the case, it will be injurious to the labouring class, as some of their number will be thrown out of employment, and population will become redundant, compared with the funds which are to employ it."[13]

The way in which David Ricardo answered questions of political economy, is by analyzing the economic environment of his time with help of deductive theory. It should not come as a surprise then, to see how he used a numerical example to examine the effect of new machines in a system and whether they would generate a loss of jobs and a decrease in gross produce by moving workers from circulating capital (the production

[13] David Ricardo, John Ramsay McCulloch, *"The Works of David Ricardo, Esq., M.P.: With a Notice of the Life and Writings of the Author"*, The Lawbook Exchange, Ltd, Union, New Jersey, 2000, p. 238

of food), into the production of fixed capital. What he used to reverse his original view on the matter is his renowned machinery example.

In his simple analytical case, every year a capitalist, in possession of fixed capital worth 7000£ (a machine) and of circulating capital worth 13000£, obtains a profit of 15000£, with a net product of 2000£. At the end of the year, after spending his profit, he still possesses the rest of his wealth.
But what if, at the start of next year, he decided to fire half of his workers (whose wages were paid from the 13000£ circulating capital), to create an additional machine worth 7500£ and goods worth 7500£?

"The capital of the capitalist would be as great as before; for he would have besides these two values, his fixed capital worth 7000£, making in the whole 20000£ capital and 2000 profit. After deducting this latter sum for his own expenses, he would have a no greater circulating capital than 5500£ with which to carry on his subsequent operations; and, therefore, his means of employing labour, would be reduced in the proportion of 13000£ to 5500£, and, consequently, all the labour which was before employed by 7500£, would become redundant (...). In this case, then, although the net produce will not diminish in value, although its power of purchasing commodities may be greatly increased, the gross produce will have fallen from the value of 15000£ to the a value of 7500£, and as the power of supporting a population, and employing labour, depends always on the gross produce of a nation, and not on its net produce, there will be necessarily a diminution in the demand for labour, population will become redundant, and the situation of the labouring classes will be that of distress and poverty."[14]

Ricardo is thus able to show a situation in which a constant net income is associated with decreasing gross income. This happens because of a change in the capital structure, its total worth remaining constant. What changes is the ratio of fixed capital to

[14] David Ricardo, *"Principles*", Straffa edition, p. 389-390

circulating capital, the first increasing with the introduction of machines, and the second (representing the wages fund) decreasing.

This brings about a reduction in labor demand, at least until the new types of machines provide an increase in productivity that will begin the process of reabsorption of displaced workers. This means that if the introduction of machinery is profitable for capitalists, capitalists will make use of it; if it is damaging to workers, workers will fight it, as in fact they did.

Ricardo believed that the workers replaced by the machines would become superfluous. He will, later on, make some modifications to his results, but he maintained the basic belief that the workers would be worse off.

The machinery case was used by Ricardo to show the possible consequences of technological change on the well-being of laborers. This result is also reachable with the help of neoclassical economics, without the need to resort to the wages-fund theory. I will examine this point further when analyzing Wicksell's rework of Ricardo's system, but for now, it is enough to know that, despite his brilliant analysis, Ricardo was constricted by the limitation of economics theories developed in his time and thus he was not able to find the inspiration to lead him to the formulation of a correct operational theorem on the topic of technological change.

It is important to note that the economic contribution of Ricardo in this debate, with the development of this model on technological unemployment, but also the inclusion of the wages fund model, was not considered on the same groundbreaking level as his theories on diminishing returns and comparative cost models.

1.3.2 John Hicks and Samuel Hollander

Ricardo had the brilliant intuition that the unemployment problem could be the result of a lack of coordination in the introduction of new machinery. Due to the lack of

interest on his findings on the topic of technological unemployment, however, this intuition was relegated to the back rows of economic science for the next 150 years. This was also caused by the fact that he was not able to develop an analytical framework able to explain what happened in-between equilibrium states, a technological reconstruction of production being one of those.

Like it is often the case with experimental new approaches, even with their many faults, they can sometimes help in the development of new conceptual frameworks by other economists. In this case, for example, two authors, John Hicks and Samuel Hollander, ended up focusing a lot of their works on Ricardo's model.

Hicks believed that the introduction of machinery would increase unemployment in the short run and decrease it in the long run. He found Ricardo's formulations on the subject to be solid enough to support his beliefs. He took the Ricardian model as a basis to show how the same result could be derived as a special case from a neo-Austrian growth model.

This 'Austrian model' was developed by Hicks to answer to a problem he encountered with the Walrasian model of growth equilibrium. He states that: *"the Walrasian model had better be left, being useful enough in its own way, whenever our interest is in the horizontal structure of production, structure by industry, the kind of interest for which the facts are provided in a production census. But it should be matched (or buttressed) by an approach from another angle, an Austrian approach, which does not pay attention to structure by industry, but fixes attention on time-sequence."*[15]

The mix of Austrian and classical analytical tools (achieved through the use of the wages-fund concept), provides a different perspective on the concept of short and long run. In the neoclassical analysis, short and long periods are identified only through the constraints under which producers operate. This means that in the long run, we found

[15] John R. Hicks, "*A Neo-Austrian Growth Theory",* The Economic Journal, Vol. 80, No. 318 (Jun., 1970), pp. 257

ourselves in another short run and *"as an element in the determination of the sequence, the Wage Fund comes back into its own."*[16]

He then uses his model to show that the topic of fixed versus circulating capital should not have been the real issue in the debate. He thought the focus should have been on the fact that "*investment at cost is not the same as investment of output capacity"*[17], thus distinguishing the concepts of time inputs from output and proceeds from costs in equilibrium.

This analysis is a fundamental step in dynamic economics since it put production back at the front and center. Adjustments are caused by productive capacity.

At the end of his analysis, he realizes that his results coincide with the same effect described by Ricardo in his chapter On Machinery: *"The increase in net incomes (as we should say, profits) estimated in commodities, which is always the consequence of improved machinery, will lead to new savings and accumulations. These savings . . . are annual, and must soon create a fund much larger than the gross revenue (profits + wages) originally lost by the discovery of the machine, when the demand for labour will be as great as before."* [18]

Hicks criticizes Ricardo's capabilities in presenting an argument of this complexity and attributed to this inability of exposition the fact that this concept failed to become a staple of economic theory.

He finishes by saying that the condition necessary for Ricardo's "machinery effect" to occur, *"is that the new machines should be expensive in labour, relatively to those they displace-and that, in spite of that, they should (of course) be more profitable. This is a condition which is very likely to be satisfied in early stages of industrialisation, so it is likely that in Ricardo's England it was satisfied.*

[16] Ibid, p.62
[17] John R. Hicks, "*Capital and Time: A Neo-Austrian Theory"*, (Oxford: Clarendon Press, 1973), p.97
[18] David Ricardo, *"Principles*", Straffa edition, p.396

The early machines, being largely hand-made, are immensely expensive relatively to their Much is explained when we realise that it is a natural effect of the later stages of industrialisation that this crushing cost, which has such evil consequences, comes down."[19]

Samuel Hollander analysis of Ricardo's work goes even more in-depth than Hicks'. While he worked with the latter on a paper on this subject, this was not his only contribution to the study of the British economist. He published several papers in his analysis and collected them in his book *"The Economics of David Ricardo"* (1979). He commented on every topic of Ricardo's economics, but for the purpose of this dissertation, I will only highlight some of his thoughts on the machinery model.

In the analysis performed with Hicks, the two authors focused their attention on the assumption that Ricardo's model could only be formulated with the wage assumed to be at subsistence level.
Their collaboration started, like it is often the case in the economic world, with a correspondence between the authors. Hollander did not share Hicks' opinion, as developed in a recent book[20], that Ricardo had a fixed wage theory. While he did not argue that Ricardo thought that in the long-run the real wage would be at a fixed level of subsistence, he did not believe that it would persist permanently.

He goes on by saying that Malthus law of population (which Ricardo followed) implies the idea that labor supply will rise when the real wage is above the subsistence level and it will cease to expand when it has reached it.
His conclusion is that: *"Ricardo of course knew that in his day the population of Britain (and of other countries, such as the United States, in which he was interested) was in fact expanding. One should therefore conclude that he needed to believe that wages in those countries were above subsistence."*[21]

[19] J. R. Hicks, *"A Neo-Austrian Growth Theory",* The Economic Journal, Vol. 80, No. 318 (Jun., 1970), pp. 275-276
[20] John Hicks, *"Capital and Time: A Neo-Austrian Theory"*, (Oxford: Clarendon Press, 1973), p. 49
[21] John Hicks and Samuel Hollander, "Mr. Ricardo and the Moderns", The Quarterly Journal of Economics, Vol. 91, No. 3 (Aug., 1977), p. 351-352

Hicks answered that he was more than willing to start a collaboration to better understand how to confront his analysis of Ricardo's model with the British economist statements, and thus their partnership was born.

Their reworked model dealt with an economy based only on circulating capital (and later the introduction of fixed capital). They mainly focused on the role of the wage and labor force as the model approaches the stationary state.

As a result of their investigation, the two authors discovered the reality that wage and labor may not reach stationary state levels smoothly, but might actually oscillate. This would make the wage be at times below and at times above the subsistence level, with the labor force rising and falling accordingly. They concluded that this case might be *"the exception."*[22] That this peculiar approach to stationary state equilibrium would not be the norm. The standard approach would still be a smooth one, with the condition that *"the elasticity of the marginal product curve must be greater than 1"*[23].

In the final part of their work, they concluded that: *"the question which has been so important for later economists-what is the effect on the structure of production (or on the fixed capital-circulating capital ratio) when total capital increases with labor supply constant-was never seriously considered by Ricardo."*[24]

Ricardo examined the issue in his 1821 edition of the Principles, when talking about the substitution of machinery for labor, as the rate of profits decreases and the wage increases: *"The same cause that raises labour, does not raise the value of machines; and therefore, with every augmentation of capital, a greater proportion of it is employed on machinery."*[25]

[22] Ibid. p. 358
[23] Ibid. p. 356
[24] Ibid. p. 368
[25] David Ricardo, *"Principles*", Straffa edition, p. 395

Even though Ricardo was not able to transform his intuition into an indisputable argument, it is almost obvious to say that it is pointless to criticize the failings of the classicists to reach a conclusion discovered only many generations afterward.

It is still interesting to ask ourselves why, an interesting mind like Ricardo's, while able to pioneer ideas that helped develop rent and trade theory, found himself in a difficult spot when considering his machinery case. The answer might be in an intrinsic weakness in classical economics, and particularly, the lack of a clear demand theory.

Ricardo was clearly not hit by the inspiration of using a complement image of his explanation of diminishing returns, to elaborate a demand schedule for labor. This lack of vision was probably caused by the dubious awareness of the "principle of substitution", which is a fundamental element in the theory of demand for goods, services, and liquidity. This lacuna was less relevant in the development of a cost theory, which is mainly focused on the side of production.
A more coherent understanding of the principle of substitution and of the different aspect of a conceptual structure was fundamental in the analysis of the effect of new technologies on unemployment and on wages.

It is not by chance that the next step in the historical journey of this debate, I decided to jump forward in time, to find Ricardo some worthy adversaries and to understand the reason behind the establishment of a common sentiment in the economic world to reach the opposite point of view of the British economist.

1.4 The "Optimists"

1.4.1 Joseph Schumpeter

The view that prevailed in the later stages of the century was the one contesting the conclusions reached by Ricardo. This line of thought was further consolidated in the

early 1900s' by Austrian economist Joseph Schumpeter, which famously stated: *"The cause which leads to practically very striking unemployment is, essentially and in principle, temporary. Therefore, we can only explain transitory unemployment – and mainly as frictional phenomenon – but not other kinds of unemployment. This result is not sufficient, but it is not without value. It doubtlessly explains a good deal of the phenomenon of unemployment, in my opinion its better half."*[26]

The explanation that Schumpeter gives of unemployment is a result of his analysis on the short and long-run consequences of technological innovations, that leads him to view it as a necessarily frictional phenomenon. He started his study by considering the effects of introducing labor-saving machines into a system (the very same machinery problem theorized by Ricardo and revised by Wicksell). This should not come as a surprise, since it is when discussing this topic, that Ricardo develops the Schumpeterian theme of the short-term profit. Which is what can be gained by the first person to introduce the innovation into the economy.
It may seem weird that, while having refused the possibility that machinery might be the cause of long-term labor loss, Schumpeter still decided to focus on technological unemployment to the point of seeing it as the main element of unemployment in a capitalistic system. This paradox can be solved by analyzing the theories developed by Schumpeter in terms of business cycles and the reallocation process associated with them.

The indifference towards Schumpeter's approach on the topic on unemployment by the economists of the 1940s' and 1950s was caused by the fact that unemployment could not be justified by frictions.
An example of this skepticism is provided by Alexander Gourvitch, who, in 1940, criticizes Schumpeter, for defining the concept of technological unemployment as *"ephemeral".* Schumpeter specifically stated that: "*It follows from our model that, basically, cyclical unemployment is technological unemployment ... It further follows that, like profits, technological unemployment is ephemeral. It might, nevertheless, be*

[26] Joseph Schumpeter, *"The Theory of Economic Development"* (1911), Cambridge, MA: Harvard University Press. p. 120

ever present, but, as in the case of profits, every individual source of it in the industrial organism tends to exhaust itself, while new ones emerge periodically. In the same sense as profits, moreover, it may be called frictional, since instantaneous adaptation of the system would kill it at birth."[27]
For Gourvitch, this idea relied too much on Schumpeter's unproven belief that ultimately the system would converge to normal equilibrium unemployment.

These critiques ceased in very recent times, in the early 1990s, when Schumpeter's notion of creative destruction would become the main focus of not only the microeconomic analysis of competition but also to the macroeconomic analysis of the labor market. This was a very important development in the field of growth theory, or as David Warsh said: "as a specimen of the phasemaker's art, 'creative destruction' ranks second only to the 'Invisible Hand'."[28]

1.4.2 Knut Wicksell

While less relevant in recent times compared to Schumpeter, but still one of the most significant challenges to Ricardo's thoughts, will come a hundred years later with Knut Wicksell's contribution to this debate.

Wicksell was heavily influenced by the theories developed by the classical economists, like Malthus and Ricardo. While his interest in the former stemmed mostly from his concern with the population question, his interest in the latter started when he became intellectually involved in the issue of unemployment.
His critique naturally focused on the famous chapter *"On Machinery"*, from the third edition of *Principles*, with the purpose of combining his judgment of Ricardo's work to the ongoing unemployment problem.

[27] Joseph Schumpeter *"Business Cycles"* New York: McGraw-Hill. 1939, pp. 515-16
[28] David Warsh, *Knowledge and the Wealth of Nations*. New York: Norton, 2006, p. 121

He did so by employing the same model used by Ricardo (the same one briefly introduced in section I.III above), but with a different coefficient of elasticity of supply of labor and another theory for the demand of labor. Wicksell's claim was that Ricardo's conclusions were erroneous, and that technological change would not necessarily lead to job or real output loss.

Wicksell reworked the model by using ideas developed in the marginal revolution that took place in the economic world from the 1870s to the 90s. Firstly, he substituted the wage-fund theory of the classical models, with an interpretation provided by neoclassical theory. He then replaced Ricardo's idea of a dated subsistence-wage system, with an approach based on a 'fixed-factor endowment' explanation for the supply of labor.

These changes made the model relevant in terms of marginal analysis, thus developing a structure more in line with modern theories on the subject. They allowed Wicksell to question Ricardo's grim forecasts within this new and improved framework. In this debate, we can simplify the distinction between these two authors on the topic of innovation's effect on jobs and prosperity of labor by saying that Ricardo was a pessimist and Wicksell was an optimist.

Table 1: Ricardo and Wicksell on the Introduction of Machinery

	Before the introduction of machinery (1)	After the introduction: Ricardo's example (2)	Wicksell's example (3)
Circulating capital (wage bill)	£13,000	£5,500	< £13,000
Net produce (profits)	£2,000	£2,000	> £2,000
Gross produce	£15,000	£7,500	> £15,000

Source: Lars Jonung, "*Ricardo on Machinery and the Present Unemployment: An Unpublished Manuscript by Knut Wicksell"*, The Economic Journal, Vol. 91, No. 361 (Mar., 1981), pp. 195-198

As is evident from the table above, Wicksell thought that new machinery would interact with the system by first lowering wages (it will fall below £13,000), so that any excess

labor could be reabsorbed. On the other hand, as the gross product rises, this will make it such that the wages will remain constant or even increase without loss of labor for the employer. This means that wages will probably rise in the future. This table, in general, is useful to explain what are the consequences, according to Wicksell, of short-run effects on wages.

Even though it might look like Wicksell 'won' this contest with Ricardo, his conclusions have been revisited and analyzed by many authors. Paul Samuelson, for example, wrote in his paper titled *'Ricardo Was Right!'* that: *"By thus ruling for Ricardo, the judge is ruling against the plaintiff in the famous suit K. Wicksell vs. D. Ricardo - in which Knut Wicksell denied that a viable invention could reduce aggregate output. My title could therefore have been the less gracious one: Wicksell was wrong!"* [29]

Samuelson also provides several interesting analytical examples to prove his point, one being the one formulated to defend Ricardo's words: *"There is one other case..the possibility of an increase in the net revenue of a country, and even of its gross revenue, with a diminution in the demand for labour, and that is, when the labour of horses is substituted for that of man. ...To substitute the horses for the men… would not be for the interest of the men, and..-it is evident that the population would become redundant and the labourer's condition would sink...."*[30]

He wished to prove that labor demand can be damaged by the introduction of an innovation, together with its hurt to long-run wages, population and the total of Kuznets output. To elaborate on this point, he used a neoclassical Cobb-Douglas case, where land and labor have the same exponents when producing corn. Then he used classical theory to set a subsistence wage of corn per laborer, setting it at one corn per period per man.

[29] Paul A. Samuelson *"Ricardo Was Right*!", Scandinavian Journal of Economics, Wiley Blackwell, vol. 91(1), 1989, pp. 47-8
[30] David Ricardo, *The Principles of Political Economy and Taxation*, Janus Publishing Company Lim, 2002, p. 277

Before the introduction of horses, the equilibrium is given by:

[200 gross corn = 100 rent + 100 wages = 100 Ricardian net product + 100 wage fodder = 200 Ricardian gross Product = Kuznet National Product]
[Population = 100 laborers]

The equilibrium changes when we introduce in the model horses who can each do the work of one man, but only require 5/6 of a man's subsistence, so 5/6 corn per horse per period.
The new equilibrium is such that:

[240 gross corn = 120 rent + 120 corn fodder = 120 Ricardian gross product = Kuznet National Product]
[Horse population = 144, laborer population = 0]

The introduction of the horse has decreased Kuznets' National Product by 40%.
It is clearly a voluntary choice of the author to show a proof of Ricardo's sound reasoning using a neoclassical tool like the Cobb-Douglas to prove that the introduction of machines could be calamitous for human welfare.

What I would like to argue instead, is that both Wicksell and Ricardo are right in their own variants of the machinery model, in the context of the different theoretical settings that they set, but only Wicksell was correct in reality. This is the same conclusion reached by Thomas Humphrey, which states that: *"Realizations match the predictions emerging from his reading of the model, but not from Ricardo's. True, with respect to theory, both economists employed impeccable logic and valid reasoning in constructing and manipulating their versions of the model to grind out the solutions they did. Their versions left nothing to be desired on internal consistency grounds. With respect to practice, however, only Wicksell's optimistic predictions have stood the test of time. He rightly foresaw that output and jobs would expand with labor-saving technological*

progress. He likewise predicted that labor-neutral and labor-using innovations would boost real wages as well. History has confirmed his predictions and falsified Ricardo's. It has revealed his version of the model to be the more realistic of the two."[31]

1.5 Late Century's Conclusions

Although the questions examined so far have been recognized of substantial significance to the analysis of the debate, it is important to remember that the reflections of classical economists were mostly deductive. The only time empirical data was used in the course of this controversy was in relation to the historical wisdom provided by the situation in the cotton textile industry. At the time, there was no statistical documentation to corroborate the thesis developed in answer to empirical questions. This made it so that the controversy was focused mainly on the disagreements over assumptions and the elements of deductive analysis.

After 1870, the nature of the debate changed drastically, since the problem of technological change in relation to employment stopped being a topic of interest for economists. What kept on being studied where the effects of technological change, but as a result of the evidently positive trends in production, employment, investment and living standards supported by undeniable evidence, the repercussions on employment were not considered a relevant issue anymore.

A prevalent theme in the discussions of the late 1800s was the one stating that, even with substantial technological changes, the most recent decades showed trends that were favorable to laborers. To cite a few examples of this optimistic attitude, we can look at several works on the matter produced in the United States. For example, Arthur Hadley wrote that *"machine has not displaced labor. On the contrary, there has been a conspicuous increase of employment in those lines where improvements in machinery*

[31] Thomas M. Humphrey, *"Ricardo versus Wicksell on Job Losses and Technological Change"*, FRB Richmond Economic Quarterly, vol. 90, no. 4, Fall 2004, pp. 5-24

have been greatest"[32]. Another American economist, Arthur Perry, stated that: *"as a matter of fact and experience, it has not been found true that the introduction of improved processes, the substitution of Nature's forces for human muscle, has deteriorated the condition of laborers generally. Exactly the reverse has usually taken place."*[33]

One important development that took place in this moment of stasis of the debate was the progress in the economic sciences. Say's Law and the Wage Fund theories were the main arguments used to explain why technological unemployment was not something to be worried about in the long run, but in the late 1800s another tool was added to the toolbox: the development of marginal analysis. Developed by great economists such as Alfred Marshall, John Bates Clark, the Austrian School, neoclassical theory considered full employment as a part of the equilibrium condition in the economy and technological change was meant to be just another element that could alter that equilibrium. The transformation caused by this change would be the origin of a series of price adjustments that worked on the principle of substitution and research of best processes to increase production, solving most of the problem that had worried Ricardo in his analysis.
The change in prices meant that after a technological shock, unemployment would not exist in the long-run due to an absence of capital or a persistent level of purchasing power.

"The controversy that went on throughout the nineteenth century and beyond, mainly in the form of argument pro and con 'compensation', is dead and buried… It vanished from the scene as a better technique filtered into general use which left nothing to disagree about."[34]

With these words, Joseph Schumpeter summed up the feelings of the economic world on the theory of reabsorption in the new neoclassical context.

[32] Arthur T. Hadley, *"Economics"* (New York: Putnam's Sons, 1896)
[33] Arthur L. Perry, *"Elements of Political Economy"* (New York: Scriber's Sons, 1873)
[34] Joseph A. Schumpeter, *"History of Economic Analysis"* (New York: Oxford University Press, 1954)

These optimistic views, combined with the positive long-term trends in many factors of production, reduced the concerns over the effects of technological changes on employment, but this “intermission” only lasted until the 1920s’.

CHAPTER 2. The Debate in the Twentieth Century

2.1 The Great Depression

At the beginning of the twentieth century the debate on technological unemployment faced a similar problem to the one that afflicted it in the previous century: a lack of substantial empirical evidence to support a prevailing theory. The main problem the economists faced consisted in a conflict between their forecasts and the present reality. The experience of the past century seemed to prove that it was reasonable to have optimistic expectations, yet the evidence did not encourage these conclusions. Still, the prevalent sentiment was that things would improve and that the classical theories of reabsorption of labor would be confirmed. Before this prediction could materialize, however, the Great Depression commenced.

At the start of the depression, the question of technological unemployment remained an interesting topic for economists, even with many other important issues arising during that difficult time. Among some of the most interesting contributions, there is the analysis of Micheal Scheler on employment, productivity and output. He came to the conclusion that: *"these facts prove that the machine, taking all favorable factors into consideration, steadily displaces more men and women than industries old and new, can absorb."*[35]

Another similar study, by William Green in 1930, showed that unemployment had increased by 9% in 1929, leading him to believe that technological unemployment had become a constant in the economy and was a critical factor in the unemployment faced in that time of depression.

[35] Michael Scheler, *"Technological Unemployment"*, The Annals of the American Academy of Political Unemployment and Its Remedies (New York: League of Industrial Democracy, 1931), 17

Thodore Knappen followed up on the topic in 1930, with a research that showed that until 1927 there was a similar rate of jobs created in new industries to jobs destroyed in old industries, but that *"in the recent past, the tide has changed. The machine is now increasingly building up a surplus of labor and a deficit of employment."*[36]

After these initial experimental approaches early in the century, 1930 saw the beginning of the development of a solid theoretical literature. The most significant contribution trace back to a paper written by Paul Douglas, which sparked a series of responses by different economists and a new series of theoretical debates. The question he was asking himself was if there was any truth to *"the common belief (...) that improvements in technology and in administration do throw men permanently out of work."*[37] He admitted that there was a recent surge of data to support these ideas but he was determined to examine the issue on a longer-term point of view. To achieve this, he decided to use an approach closer to the Classical School economics than to the one of Neoclassical theories. He did so by using an improved version of Say's Law theory for the reabsorption of labor.

In his study, his first assumption was that cost savings are conveyed through a decrease in prices. He then analyzed the effect on purchasing power of consumers in scenarios differentiated by levels of elasticity of demand. In the presence of an elastic demand, he noted, the system did not experience unemployment. That is why he decided to focus on the case where the demand was inelastic. He showed that while it was true that the consumers would demand less of the product affected, they would also have extra money to save or spend elsewhere. If they opted for the latter, there would be an increase in other goods; with the former, the banks would invest the money on capital goods. His conclusion was that: *"not only are new opportunities for employment built up (...), but they are built up to an equal degree to that by which the older opportunities decay. For every man laid off a new job has been created somewhere, and the ratio*

[36] Theodore M. Knappen, *"The Machine Turns on Its Master"*, Magazine of Wall Street, May 3, 1930, 68
[37] Paul Douglas, *"Technological Unemployment"*, American Federationist, August 1930

between monetary purchases and employment is still the same as before."[38] This meant that in the long run, he did not see machinery as being a threat to workers or something that could cause a persistent technological unemployment.

Douglas re-interpretation of Say's Law was accepted almost unanimously by the economic world as a way to solve the issue of reabsorption, by using technological change as the cause of the increase in demand.

2.2 Alvin Harvey Hansen

The Say-Douglas theory experienced the first direct attacks one year later, in 1931. The one leading this counter-movement was the so-called "American Keynes": professor Alvin Harvey Hansen.

He believed that Douglas made two crucial mistakes in his analysis. The first one was based on his interpretation of Say's Law. Hansen noticed that in the original Say's formulation, there was no clear explanation for the phenomenon of reabsorption. According to him, the analysis of Say, Mill and Ricardo assumed, without explaining how, that an increase in production already took place, and that *"if idle productive factors are set to work to make goods there will be no want of a market. Goods are exchanged against goods."*[39] Hansen believes this to be true because the case in question assumed a competitive market and a responsive price system. The economists of the Classical School only asked themselves if the new production would find a market, and in Say's Law they found their answer. They did not concern themselves

[38] Ibid, p.930
[39] Alvin H. Hansen, *"Institutional Frictions and Technological Unemployment"*, The Quarterly Journal of Economics, Vol. 45, No. 4 (Aug., 1931), pp. 684-697

with whether the displaced workers would be reabsorbed in the market or not, and yet this is exactly what Douglas was trying to determine.

The second crucial critique Hansen made, was in regard to Douglas identifying the demand for goods with the demand for labor. According to Hansen, any gain in purchasing power obtained by producers, workers and consumers thanks to labor-saving technological improvements, was offset by the loss suffered by the displaced workers. He also dismissed some possible solutions, like supporting the unemployed through ways like charity or relief, since it would only represent a transfer of income and there would be no real increase in purchasing power.

This analysis led Hansen to believe that Douglas was wrong to assume that such an increase in purchasing power would happen and tried to find a solution to the problem himself.

He found the answer to reemployment in wage and credit policies, that he believed to be reliant on institutional factors. In his words: *"Under certain conditions of institutional control of credit and wages, then, we cannot definitely assert that labor displaced by technological improvements will eventually be reabsorbed into industry."*[40]

Hansen's critique was meant to be constructive. However, it showed the limitation of the economic theory on this topic, since it was largely based on Mill's analysis of Say's Law. In the neoclassical economic world, a theory from the nineteenth century was still used to answer questions about technological unemployment.

[40] Ibid, p. 692

But this was about to change, since a series of debates emerged in the following years, that would help develop further economic theory on the issue.

Hansen was at the helm of this revolution and he did so by analyzing the standpoint of the institutional school. He believed that, with flexible wages, prices did not need to be reduced to the same level of the lowered costs, and reabsorption would happen as long as a monopolistic power did not overcome certain areas of investment.

The other point of view that Hansen found lacking, was the one of professor Sumner Slichter. The latter believed that main cause of technological unemployment was the fact that wages had stayed constant, while the prices of capital goods had experienced a substantial decrease. Hansen thought that the analysis of professor Slichter did not focus on the relative productivity of factors, which was just as significant as their price. The closing arguments in his throughout analysis, were based on the idea that reabsorption of displaced workers could only take place in a flexible economic system, *"a flexible system of prices and wage-rates."*[41]

It is therefore necessary, according to Hansen, to have flexible labor and capital markets, to have a complete reallocation of displaced workers.

He concluded this study on the topic with a warning against the optimistic nature that surrounded the debate in those years: *"The conclusion is that we cannot afford to assume a too easy optimism with respect to technological unemployment. The increasing rigidity of modern economic life consequent upon price and wage controls - Die gebundene Wirtschaft, as the Germans so aptly put it - points in the direction of a slackening in the rate at which displaced labor can be reabsorbed into employment. Moreover, should we prove unable to prevent a downward price trend in the next*

[41] Alvin H. Hansen, *"The Theory of Technological Progress and the Dislocation of Employment"* The American Economic Review, Vol. 22, No. 1, Supplement, Papers and Proceedings of the Fortyfourth Annual Meeting of the American Economic Association (Mar., 1932), p. 26

decade or two this growing tendency toward rigidity would become a still more serious matter and the problem of technological unemployment would be intensified."[42]

The debates continued in 1932 when Gottfried Haberler criticized Hansen's theories, believing them to exaggerate the effect of technological advancements. According to him, the problem with Hansen's analysis could become vulnerable when considering a monetary economy instead of a credit one. Under the assumption that the amount of money in circulation and its velocity remain the same, Harberler believed that a study of adjustments over time would show an increase in purchasing power. He claimed that with an increase in demand for other goods, both wages and prices would rise, and the workers could be reabsorbed. He also realized that an initial decline in velocity of circulation could undermine his thesis, together with the possibility of displaced workers saving a part of their money longer than usual. But he disregarded his worries stating that: *"such assumptions are highly precarious."*[43]

Hansen acknowledged that Haberler was right in saying that there was no need to be hostile towards the idea of technological progress. But he still believed that it could be dangerous to think that the unemployment caused by this issue would take care of itself without the necessity of a solid social structure around it. He thought that the rigidity of the economic system could impede the reabsorption process or at least make it more difficult. He then went on to say that his system for the reabsorption of labor was based on a functioning credit system, but that this is not the case in a period of depression.

He argued against Harbeler also on his analysis of a cash economy (since he considered it a not significantly different situation) and on the idea of the velocity of circulation, which he believed may, in fact, slow down.

[42] Ibid, pp. 31
[43] Gottfried Haberler, *"Some Remarks on Professor Hansen's View on Technological Unemployment,"* Quarterly Journal of Economics, May 1932

Finally, he also stated that in the case in which prices would not be lowered and entrepreneurs kept all the revenues from technological change, Harberler's conclusions could not be applied at all.

It is clear at this point, that the economic consensus prevalent in 1928 and 1929, had been substituted with a debate between individual economists. This brought new life to the arguments of the previous century. These advancements in professional considerations were underlined by the fact that after this period of frenetic production of works, the debates on this topic stopped until the end of the depression.

The most important contribution on the issue after this pause, was made at the end of the 1930s' and the 'culprit' was the once again Alvin Hansen, with his stagnation thesis.

This theory was developed by professor Hansen to understand the cause of the ongoing economic troubles. He examined a historical trend in America to evaluate the effects of economic maturity. He believed that they were in the presence of a decrease in opportunities for investments necessary to support full employment and that the solution lied in the key concept of price inflexibility.

Indeed, he considered the maturation of new industries to be a fundamental factor in terms of growth. With this in mind, he viewed several of the institutions of his time, like the rise of monopolistic competition, unions and trade associations as limitations on growth. With these restrictions set in place, his conclusion could only be a negative one: *"it remains still to be seen whether political democracy can in the end survive the disappearance of the automatic price system."*[44]

[44] Alvin H. Hansen, *"Progress and Declining Population Growth"*, The American Economic Review, Vol. 29, No. 1 (Mar., 1939), p. 13

2.3 John Maynard Keynes

To understand how Hansen was able to formulate such interesting conclusions on the topic of secular stagnation, we have to take a step back in time. In fact, in addition to some theories from the classical school of economics, the other great source of influence for him was a contemporary author, whom many consider to be the greatest economist of the twentieth century: John Maynard Keynes.

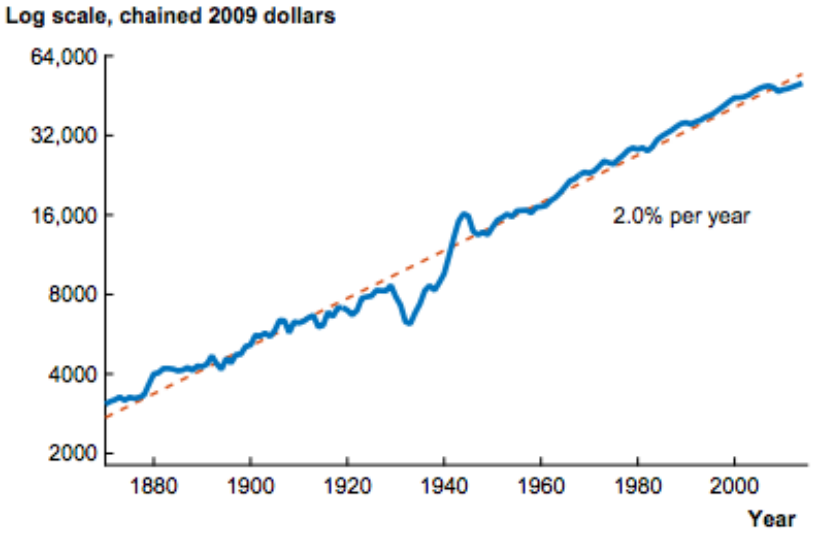
It would be impossible to elaborate the topic of this thesis further without first analyzing the thoughts on the matter of the British economist. In 1931, Keynes published in his collection *"Essays in Persuasion"* a short article titled: *"Economic Possibilities for our Grandchildren"*. In this essay he coined the term "technological unemployment" by stating: *"We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come, namely, technological unemployment. This means unemployment due to our discovery of means of economizing the use of labour outrunning the pace at which we can find new uses of labour."*[45]

In this paper, he tries to imagine what the social and economic life in Great Britain could be in a hundred years' time.

The views he expressed in this work were strangely optimistic, considering the difficult crisis the world was experiencing at the time. It is important to keep in mind the context in which this essay came to life. The 1930s where not an easy time for an economist to predict long run changes with substantial empirical data. During this time, the world was just entering a decade of deep depression and the economic theories developed reflected this challenging period.

[45] John Maynard Keynes, *"Economic Possibilities for our Grandchildren"*, Essays in Persuasion, New York: W. W. Norton & Co., 1963, pp. 358-373

Figure 3: Graph of GDP per person in the United States (1870-2008)



Source: 1929–2014 data are from the U.S. Bureau of Economic Analysis, NIPA table 7.1. Data before 1929 are from statistics on world population, GDP and per capita GDP, 1-2006 AD and Maddison, A. 2008.

Keynes recognized this difficult moment for what it was, as it is clear from the comments he made in different US magazines in an effort to raise awareness on this issue. The most famous example being his declaration in The Nation, May 10, 1930: *"The fact is — a fact not yet recognized by the great public — that we are now in the depth of very severe international slump, a slump which will take its place in history amongst the most acute ever experienced"*[46]

One of Keynes's most renowned statements is the famous: "*in the long run we are all dead*"[47], but this sentiment is clearly not reflected in the optimistic attitude he adopted in writing *Economic Possibilities*. In this text he tended toward the possibility of a solution of the *"economic problem"* as he was used to calling it, in a period of a hundred years' time.

[46] Roy Harrod, "*The Life of John Maynard Keynes"*, London: Macmillan (1972)
[47] John Maynard Keynes, *"A Tract on Monetary Reform"*, London: Macmillan (1923), Ch. 3, p. 80

This positive attitude is evident in most of his predictions in this essay. He believed that by 2030 people would have significantly higher standards of living, with no urgency to consume for the sake of consuming and not really out of necessity, that they would not work more than fifteen hours per week and would substantially increase the time dedicated to leisure and cultural activities.

The most significant reflections Keynes developed in his analysis can be summarized in three interesting points.

In the first one he built a surprisingly modern analysis on the determinants of economic growth. This is one of the most fascinating element of this analysis, since he was able to predict a phenomenon that was not yet studied in detail by the economic world. *"Growth theory – as we know it today – did not exist in the 1930. There was little in the way of theory that would lead an economist of that era to predict confidently a steady state growth path in which output remains close to its long-run trend. The Harrod-Domar model that was developed in the 1930s' predicted that market economies were unstable, with chronically high unemployment and that steady states were knife-edge propositions."*[48]

Keynes was able to identify the most important factors to consider in terms of economic progress: capital accumulation and technological development, proving himself to be an admirable growth theorist. Even though he was a gifted individual, he was still not able to consider all the elements needed in growth theory. He understandably missed some modern issues on the topic, but also disregarded some details, like the idea of distribution across countries, the reversal of political situations and frail government policies. I will go more in detail on some of his failed predictions in section IV of this chapter.

[48] Lee E. Ohanian, *"Back to the Future with Keynes"*, Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 6

The second ‘prophecy’ he elaborated in this essay is strictly connected to the third one. They consisted in a set of forecasts on the living standards and working habits of *‘his grandchildren’* and in speculations about the possible lifestyle changes that would follow. On these issues he was more off the mark compared to the previous one. He thought that, in 2030, people would live in a period of prosperity, a post-scarcity society that would free people from the obligations of activities such as capital accumulation, saving, and work. Without these ‘duties’, people would be free to express themselves in cultural activities, like arts and poetry. He believed that people would be able to improve their lives by changing their views on their principles and philosophies. He saw this social revolution as an inevitable change provoked by the ongoing crisis he was witnessing, combined with his trust in the possibility of recovery of the economic system.

Keynes was not wrong in his assumption that people nowadays would be richer than during his lifetime, but he could not come close to imagining by how much. The misjudgment he made on these points lies mainly in the fact that we still need savings, we practice capital accumulation, and we work long hours, without ever achieving the state of satisfaction that would let us to favor leisure instead of labor. Again, I will cover the reason for these mistakes more thoroughly in the next section.

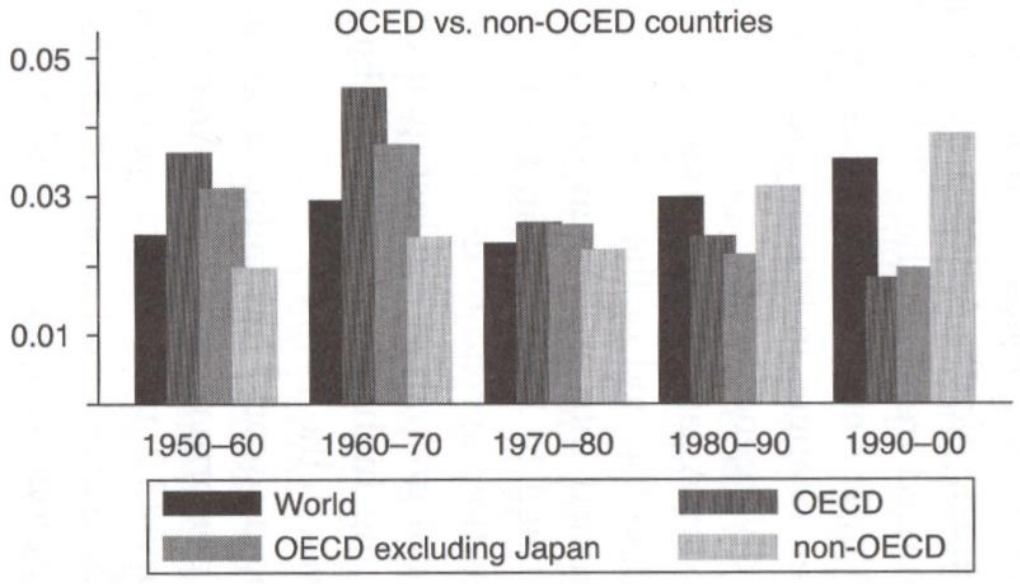
2.4 Keynes’ Grandchildren

Keynes did not actually end up having any grandchildren of his own, but his legacy lived on in his works. This essay is a perfect example of this, since in just a few pages, Keynes was able to develop several stimulating and bold ideas in such an interesting way, that it was impossible for many economists not to feel challenged to put his forecasts to test.

2.4.1 Analyses of Keynes' Forecasts on Growth

As I anticipated in the previous section, his predictions on growth were among the most accurate in his essay, but he still forgot to consider some factors. A noticeable omission is the consideration of distribution in analyzing economic growth. When talking about 'his grandchildren', he was thinking about people living in Europe and North America. Fabrizio Zilibotti focuses on this problem, presenting data from 127 countries that represent up to eighty-five percent of world population. He wants to understand how close to reality Kaynes came with his predictions and to show how growth has differed over time and in several countries. Europe and North America for example, had opposite tendencies in income growth capita, with the former's being very high in the 50s' and 60s and slowing afterwards, and the latter's being moderate in those decades, only to increase substantially in subsequent years. Another opposing trend occurred in the 90s', with the crisis suffered by Eastern Asian countries in a time when countries like China and India showed incredible growth.

Figure 4: Regional Growth Rates from 1950 to 2000



Source: Fabrizio Zilibotti, *"Economic Possibilities 75 Years After: A Global Perspective"*, Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 2, p. 30

Even with these differences, the world economy has managed to achieve a significance advancement in the second part of the twentieth century, confirming Keynes expectations. Still, can we really say that this was a solution to the "economic problem" if by 2000 the average GDP per capita of non-OECD countries was not even equivalent to the GDP per capita in the United States one century prior?

This question is considered by other economists, amongst which Joseph Stiglitz, which states: *"some 50 percent of the world still lives on less than two dollars a day, some one million still live on less than one dollar a day."*[49]

Stigliz continues by saying that the solution to the economic problem is not difficult to imagine. If the $48 trillion dollar global GDP were divided among the totality of earth's population (six and a half billion), each person would receive $7,000. A sum that would be abundantly sufficient to leave nobody in poverty.

This distribution issue was not limited to a difference between countries, inside many advanced countries in fact, we witness an increase in income inequality. Capital owners and skilled workers experience an increase in their living standards at the expense of those of unskilled workers, whose living standards often face stagnation or a very slow growth. This contrasts Keynes prediction that thanks to technological advancements and increasing capital-labor ratios, wages would always rise.

This particular wrong assumption is challenged by an author that is impossible not to acknowledge when talking about economic growth considering his significant contributions on the topic: Robert Solow.

He defines Keynes's essay as a *"jeu d'esprit"* but even so, he still praises the British economist on his modern view on the subject. The mistake he cannot forgive is once again on his lack of consideration for distribution. He says: *"The distribution of income and output between wages and profits depends on the ease with which capital can be substituted for labor (…) If this kind of substitution is relatively easy profits will come*

[49] Joseph Stigliz, *"Toward a General Theory of Consumerism: Reflections on Keynes's Economic Possibilities for our Grandchildren"*, Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 3, p. 42

over time to absorb an ever-increasing share of aggregate income. Wages will also rise, but not enough to keep up with profits."[50]

He continues by saying that the extreme case of this situation, would be a society where robots will take care of all the production. In a world like this, wages would be almost null, and the only workers who could survive would be the capital owners. This scenario encompasses a modern fear that recently emerged in technological unemployment debates. I will cover this problem more in detail in chapter III of this thesis, but I will say here that Solow takes this threat seriously and even suggests the institutions to do so too. For example, by trying to guarantee a fairer share of capital ownership to mitigate the effects of the increasing inequality that many countries are experiencing.

2.4.2 Analyses of Keynes' Forecasts on Standards of Living

Following on the very last point, a society were machines cover most of the jobs, is a society where men will have a lot of free time. Following this line of thought, Keynes believed that people would choose leisure over labor. He believed this would happen because of an income effect provoked by the increase in real wages, that would lead people to choose the superior good: leisure, and consequently to work at most fifteen hours per week.

This assumption he made on future working hours was not that crazy if we consider the trends between 1870 and 1930, when the number of hours worked per person fell by thirty percent. But his forecast did not become a reality, when, after World War II, these decreasing trends slowed down significantly. In 2005, hours per week in the United States were 34.7 on average, while Germany, being one of the countries with the lowest amount of hours worked, averaged 27.6 hours.[51]

[50] Robert Solow, *"Whose Grandchildren?",* Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 4, p. 92
[51] *OECD Employment Outlook 2006*, table F

Richard Freeman commented on this issue by saying: *"The United States is the most striking counterexample to Keynes's prediction that increase wealth would produce greater leisure. The United States has 30 to 40 percent higher GDP per capita than France and Germany, but employed American work 30 percent more hours over the year than employed persons in those countries."*[52]

Why do Keynes' Grandchildren work much more than he expected? Freeman thinks this might be due to a reversal of the relationship between hours worked and pay. Historically speaking, the poorer social classes have usually worked more than the richer ones. They had to work to be able to feed themselves, while the rich were able to live by virtue of their hereditary position in society. In the second half of the twentieth century though, especially in the United States, those earning higher wages were the ones working more.

One answer to what appears to be a contradiction of sorts, could lay in the fact that Keynes did not consider the pleasure that some people derive from working. Freeman argues this point by saying: *"Many people go to work for reasons beyond money, and might prefer to work longer than Keynes's fifteen hours a week under almost any situation. Workplaces are social settings where people meet and interact. On the order of 40 to 60 percent of American workers have dated someone from their office."*[53]

Among other factors that were difficult to predict for Keynes, we can file the rise in participation of women in the workforce which compensated for the decrease in hours worked by men, but also the effects of globalization and inequality. Globalization since it allows people to work from home for example, and inequality because it creates a bigger gap between the higher and lower form of success and gives workers more incentive to work longer to try to succeed.

[52] Richard Freeman, *"Why Do We Work More Hours Than Keynes Expected?"*, Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 9, p. 138
[53] Ibid, p. 140

Keynes based a lot of his assumption on the society he was living in, as argued by Gary Becker and Luis Rayo: *"Keynes was misled in his predictions concerning the effect of higher income on hours worked by the behavior of gentlemen in Britain – who Keynes believed provided a window onto future behavior as everyone's income rose. Their behavior gave a distorted picture of what to expect because these gentlemen had sizeable wealth in the form of physical and financial assets, but not high human capital or earnings. So economic theory would predict that these gentlemen would take more leisure than would equally wealthy persons in the future who in fact would be holding the vast majority of their wealth in human capital, rather than land and other assets. English gentlemen indeed had mainly just an income effect, while those who have to work for their high incomes also have powerful substitution effects."*[54]

2.4.3 Analyses on Keynes' Forecasts on People Future Lifestyles

Before starting this section, I want to specify that Keynes' contribution to the issue was a point of contention in itself, since many people consider his analysis on the topic to be nothing more than a simple divertissement, particularly if compared to his other famous works. In this thesis I focused my attention on his work with the intent to put the emphasis on the answers of important contemporary authors. This way, I developed the discussion utilizing a sort of *"Socratic method",* in which Keynes' paper establishes the questions posed to stimulate critical thinking.

The last issue examined in his short essay is the one Keynes approaches with a more 'philosophical' tone. He thought that people would be able to abandon those vices that identify capitalistic societies, like love for money and avarice. The state of satisfaction

[54] Gary Becker and Luis Rayo, "Why Keynes Underestimated Consumption and Overestimated Leisure for the Long Run", Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 13, p. 180

they would achieve with the elimination of the economic problem, would allow people to focus more on cultural and artistic activities.

His negative opinion of capitalism is criticized by Jean-Paul Fitoussi, who does not understand why a *'carpe diem'* principle should be superior to a capitalistic-based consideration of the future. He believes that *"It may even be that the moral strength of capitalism is its consequentialism as it can lead to intergenerational altruism."*[55]

Keynes' ideal view of society comes from his personal experiences. In fact, he was an active member of the famous literary association, the Bloomsbury Group. This club refused the Victorian limitations on religious, sexual and social issues and advocated for contemporary arts. The utopic society he imagines in *Economic Possibilities* is a direct consequence of that cultural environment he participated in every day.

Nowadays people do not live their lives according to the principles of the Bloomsbury Group, or at least, not everyone does. It is easy to identify in our society, the presence of several different lifestyles at once more so than a prevailing one.

Axel Leijonhufvud drives this point home, by saying: *"People of Keynes's class and generation tended to think that economic progress would have to involve also the acculturation of the lower classes to bourgeois cultural values, and a variety of educational institutions were at one time founded to aid that process. Keynes, of course, was hoping to see bourgeois culture evolve away from what it then was in a Bloomsbury direction. But he would not have envisaged the middle classes emulating ghetto tastes."*[56]

[55] Jean-Paul Fitoussi, *"The End of (Economic) History"*, Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 11 p. 157
[56] Axel Laijonhufvud, *"Spreading the Bread Thin on the Butter",* Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch. 7 p. 121

Keynes believed that the solution to the economic problem would come from the removal of capital accumulation: *"When the accumulation of capital is no longer of high social importance, there will be great changes in the moral code."*[57]

He was both wrong and right in the formulation of this statement. He was wrong because people will always strive to improve themselves, regardless of living standards, and they will want to save, accumulate and work in order to do so. At the same time, he was right in thinking that for an increase in living standards, both a material and a moral advancement were required.

Benjamin Friedman comments on the issue by stating that people today live in *"a more open, tolerant, fair and democratic society"*[58] thanks to the economic advancements achieved by several countries. He also doubts the strength of this connection between living standards and moral beliefs. This uncertainty comes from the mix of economic stagnation and the rising inequality easily recognizable in countries like the United States and the United Kingdom.

Many other authors ended up agreeing with Keynes beliefs that economic growth leads to higher moral standards. That said, the conversion to the good society seems to require a more difficult operation than the one Keynes anticipated.

2.5 End of the Century

Wassily Leontief was a famous economist who devoted a lot of his works to the issue of technological unemployment towards the end of the century. He examined the topic on the same wavelength followed by Keynes, with a significant focus on the adjustment in living habits necessary to embrace progress without suffering from it. He believed

[57] John Maynard Keynes, "*Essays in persuasion",* London: Macmillan, 1972
[58] Benjamin Friedman, *"Economic Well-Being in a Historical Context"*, Revisting Keynes: Economic Possibilities for our Grandchildren, edited by Lorenzo Pecchi and Gustavo Piga, The MIT Press, 2008, Ch 8

that, for technological innovations to have a positive effect in the economy, a change in the social and cultural institutions was necessary to complete the evolution from industrial to modern society. The introduction of new sources of mechanical energy led to a substantial increase in the output of goods and services, with the added benefit of freeing workers from the jobs that required the most physical effort. Labor evolved, as a factor of production, thanks to the added mental skills necessary for each worker to control and manage the new machinery. In a competitive market, this would translate into a rise in labor demand and an increase in real wages. The subsequent increase in purchasing power would then allow families to better allocate a bigger part of their income into leisure activities. He supported this idea, that coincides with Keynes' beliefs, with data stating that: *"One hundred years ago, the number of hours worked in the average week in the United States was over 70; by the beginning of World War II, hours per week sank to 42."*[59]

He anticipated what would be the main issue of the debate in the next century: the concern over computers and robots replacing human beings in more advanced mental and cognitive activities, in the same way they have already substituted men and animals alike in many physical jobs. This will inevitably bring man to lose his role as the most significant factor of production, following a similar situation to the one that befell horses during the industrial revolution.

He also disregarded the popular reabsorption theory by stating that: *"The general theoretical proposition that the worker who loses his job in one industry will necessarily be able to find employment, possibly after appropriate retraining, in some other industry is as invalid as would be the assertion that horses who lost their jobs in*

[59] Wassily Leontief, *"National Perspective: The Defintion of Problems and Opportunities"*, in The Long-Term Impact of Technology on Employment and Unemployment, National Academy Press, (1983), p. 3

transportation and agriculture could necessarily have been put to another economically productive use."[60]

While it is true that the shift in labor from physical to mental contributions brought real wages to increase in many advanced countries, the same rules of competition that made it so that there would be an increase in price of labor and its total share in the national income, are probably going to start working in the opposite trajectory.

He believed that an accurate description of the future might be presented only with the conjunct help between economists, sociologists, engineers, etc., all brought together to design an economic system with enough information on all the different sectors in order to provide a solid empirical basis to study.

His solution to technological unemployment could be found in a combination of factors. The first being labor sharing: instead of having two separate categories of fully employed and unemployed, he considered things like a reduction in working hours, a decrease in the number of workdays in a week, a rise in vacation periods allowed and a reduction of the retirement age.

The problem that could arise from this change in society could be the increase in wages necessary to compensate for the shorter work hours. An increase in the cost of workers would only be counteractive to the mission of limiting the spread of labor-saving machines.

This is why the second factor he considered was the presence of specific income policies. These policies *"would have to consist in supplementing normal wage earnings with income transfers lying outside the operations of the competitive market mechanism. As a matter of fact, we have been practicing such income policies for many*

[60] Ibid, p. 4

years in the form of social security, unemployment insurance, medicare, and many other methods that are used to supplement the income of those who either earn nothing or do not earn enough"[61]

Accomplishing such a task would require a change in the modern social institutions, in addition to the creation of new ones, a complex process to envision. But more importantly, the shorter hours of labor and the consequent increase in leisure time would signify a change in the living habits of society.

These conclusions all led to the same need in a change in cultural and personal values that Keynes predicted in *Economic Possibilities*. This would be particularly challenging in a society like the American one, that lays its foundation on the Puritan work ethic. Leontief believed that people should look back to a time where less working hours were considered benefits befitting the richer social classes and leisure was not seen as a waste of time.

The last point he makes is about *'creative imagination'*, the human quality he considers to be not replaceable by machines. Without it, there would be no advancements to the fields of arts but also science. It is also an essential capability for a leader to possess, especially in the case of entrepreneurs. That said, this faculty is not common among humans and only few individuals possess it and get recognition for it.

Still, he concludes by saying that: *"In private everyday life an individual's own imagination plays a most important role as the source of a great variety of cultural pursuits. While training for the exercise of productive skills will certainly remain one of the principal objectives of formal education even as computers and robots take over, the other, more general objective of education, the development of taste and of*

[61] Ibid, p. 6-7

capabilities for nonremunerative cultural activities, will become more and more important."[62]

After Leontief exhaustive contribution, an important and optimistic statement came from several economists reunited in a panel organized by the National Academy of Science in a report called "*Technology and Unemployment*" in 1987. They had found that the effect of lowering the costs of production and consequently decreasing the price of a good in a competitive environment, would make it so changes in technology would lead to increases in output demand. This in turn would result in a rise in production and a boost in demand for labor, that would cancel out the effects of technological change on labor requirements per unit of output.

The conclusion they reached was that, both from an historical and future point of view, there has been and there will always an offsetting positive effect generated by the increase in total output that usually follow these revolutions. Such that labor requirements born of technological advancements, will always be countered by the beneficial effects on employment.

This idea that automation will ultimately end up creating more jobs than it destroys has become the most widespread theory in the field of modern economics. Those who believe otherwise are usually ridiculed, and said to be falling prey to the "Luddite Fallacy". This is why, in recent times, when the debate resurfaced again, it was mostly thanks to "non-economists" (mostly scientists), that believed technology to be a net job destroyer. But modern economists were quick to rise to the challenge once more.

[62] Ibid, p. 7

CHAPTER 3. The Debate in Modern Times

3.1 Is This Time Different?

Nowadays we seem to find ourselves in a similar position to the dilemma that David Ricardo faced in the early 1800's. But with history on our side, we can deal with the question of technological unemployment with much more knowledge than he did. The past showed us that long-term displacement is not something that should happen, but should this put all our worries aside?

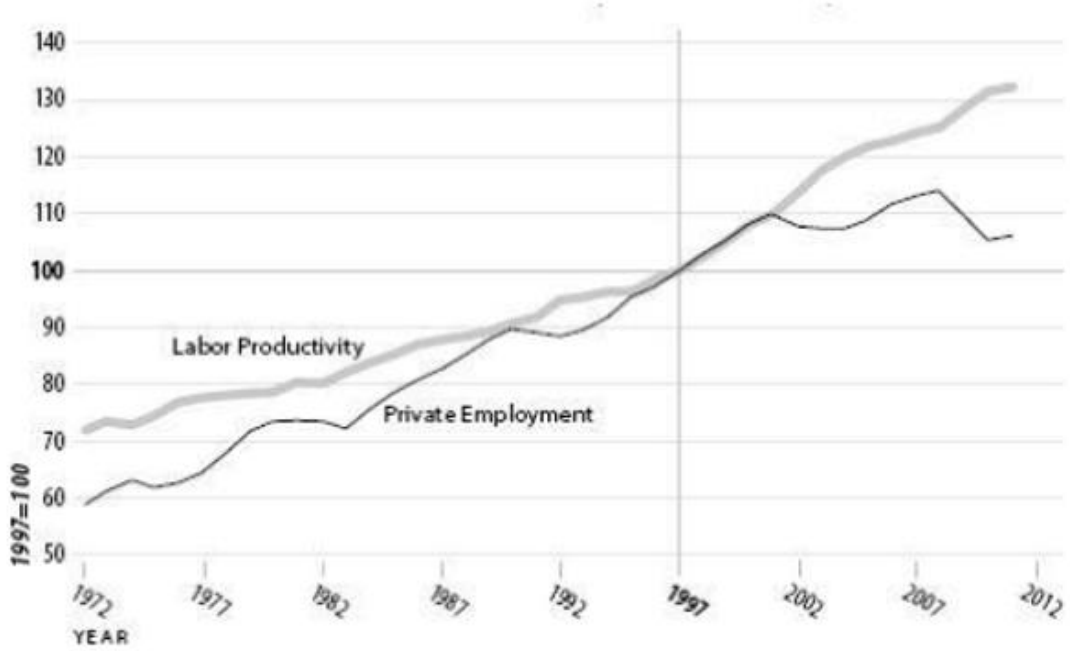
So far, this analysis has been focused on the theoretical frameworks surrounding the debate, but can these ideas find a reflection in modern empirical evidence? In the past two centuries, technological advancements translated in a significant increase in productivity, with statistics showing a parallel rise in employment until the late 1900s'. This is proof of the fact that productivity is not always positively correlated to job destruction. On might even be tempted to suggest that the opposite might be true, finding in productivity a principal cause of job creation. However, recent data shows that in the late 1990s' job growth actually lost its connection with productivity.

This has been a point of contention in the modern debate. The question is, which part of history can we trust to guide us, the one leading up to the late 1990s, or the following years?

The answer comes from the relationship between the factor analyzed. More work does not necessarily imply more productivity. Workers in America worked up to sixty or even seventy hours a week, while the average weekly work week is now around thirty-five hours, but the living standards did not suffer from this, on the other hand, they have increased substantially. Robert Solow himself won the Nobel Prize for explaining that an increase in labor and capital input does not justify the total increase in output in the

economy. It would take a modern worker just eleven hours per week to produce the same amount produced in 1950 in forty hours.

Figure 5: Labor Productivity and Private Employment



Source: Ian Morris, *"Why the West Rules—For Now: The Patterns of History, and What They Reveal About the Future",* Profile Books, London, 2010

The first age of machines, with the introduction of electricity among other inventions, constituted, in the 1940s, 50s and 60s, a spike in productivity in the twentieth century. All the same, 1973 saw a decrease in productivity growth. Robert Solow commented this phenomenon by noticing its correspondence to the start of the computer revolution: *"We see the computer age everywhere, except in the productivity statistics."*[63]

This productivity paradox was resolved by a drastic increase in production twenty years later. A similar situation took place with the introduction of electricity in the 1890s with

[63] Robert Solow, *"We'd Better Watch Out"* New York Times Book Review, July 12, 1987.

labor productivity growth only picking up years later. The dynamics following the introduction of new technologies (even if very different ones) bore similar effects.

These drastic changes, while explainable, have always been a source of worry for workers who discovered themselves with no useful skills to sell to employers. According to people like Harvard economist Lawrence Katz, there is no historical evidence that these trends might become a long-term issue. He examined the problem with an analysis on the effects of technological advancements through the last two centuries on low-skilled workers. He found out that while it might take time for displaced workers to acquire the competencies to find a different kind of employment, this process always takes place. *"We never have run out of jobs. There is no long-term trend of eliminating work for people. Over the long term, employment rates are fairly stable. People have always been able to create new jobs. People come up with new things to do."*[64]

Although these are all very reassuring results, it is still dangerous to dismiss the idea that there might be something different about the new technological revolution taking place right now. The question in the modern debate is whether economic history can be used as an effective guide to understand the future.

Will we see the usual pattern of technology causing job destruction only in the short-term, or will we witness a science-fiction reality in which machines will be able to substitute humans in almost every task?

Even professor Katz consider this to be a legitimate question, and in the next section I will examine this controversy from the point of view of the modern "pessimists".

[64] David Rotman, "*How Technology Is Destroying Jobs*" (June 12, 2013). Retrieved from https://www.technologyreview.com/s/515926/how-technology-is-destroying-jobs/

3.2 Humans Need Not Apply

Our ancestors needed to hunt or gather resources to sustain themselves. But humans, like Adam Smith used to say, have always utilized their worst quality, laziness, to give themselves the incentive to create tools and make their lives easier. We have evolved from hunting our own food to modern agriculture, with almost nobody needing to gather their own food. We did this in every sector, most notably in agriculture, where we introduced machines to help us replace physical labor with indefatigable, artificial muscles. This lets people be free to specialize and allows standards of living to increase and economies to grow. So why are some people scared of what seems to be a clear advancement for society?

The answer about what could make this technological revolution have a different outcome from the rest is embodied in one concept called: Skill-Biased Technical Change.

To explain how technological advancements can influence a system, economists like to use a simple model in which technical progress acts as a multiplier on all other factors, increasing production for everybody. This very simple concept explains the reasoning behind the idea that a technological revolution will inevitably make workers more productive and more valued. Using technology as a multiplier, the output produced should increase every year with the same amount of inputs, labor included.

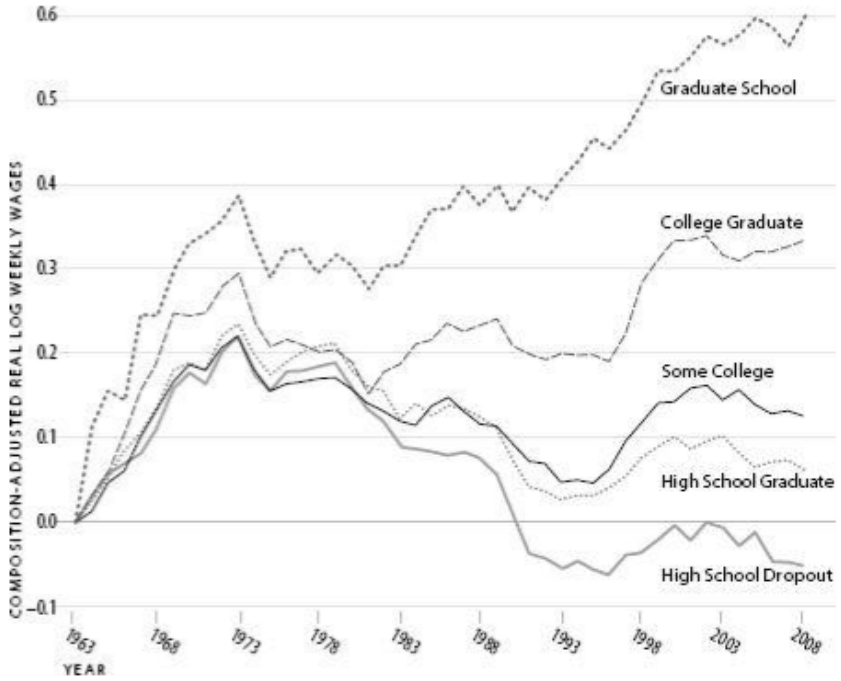
A slightly more sophisticated model will tell us that technology might not, in fact, influence every input in the same way, but it could be 'biased' towards some. Recently, technological improvements have focused on tasks such as automation of factory production, AI machines, word processing, automation of inventory control. This type of labor being replaced is what is generally referred to as "white collar" jobs, and is the easiest prey for modern machines.

The most common example made by the “pessimists” of this second age of machines is the comparison between nowadays workers and the horses at the time of the Industrial Revolution. The protagonists of this story are two horses from the 1900s. They are ‘talking’ to each other about technology. One is worried about the new machines making them obsolete, while the other reminds him of how much labor they have already been spared since their introduction. No more farm work, or riding in battle or delivering mail, only the comfortable and ever-increasing city jobs. But we know now that while there are still ‘jobs’ for horses, they are nowhere near the number the optimist horse hoped for. Not only that, but the population of horses has been decreasing steadily since 1915. There is no universal rule of economics that says that an improvement in technology will generate more or better jobs. The modern lower-skilled workers are the horses of this analogy.

On the other hand, growing technologies like analytics and big data, have strengthened the usefulness of data-driven and more abstract activities, providing a competitive advantage to people with creative, engineering or design capabilities. This caused an increase in the demand for skilled workers to the detriment of less skilled ones. In the same way, mechanical muscles have made physical labor (and horses) less in demand, mechanical minds are making cognitive labor less in demand. This trend has been studied by several economists like David Autor, Daron Acemoglu, Lawrence Katz, Frank Levy and many others. They call this phenomenon skill-biased technological change, which means that, by definition, people with higher human capital with be favored during a technological revolution.

The following graph, based on data collected by economists David Autor and Daron Acemoglu, helps us better understand the effects of skill-biased technological change.

Figure 5: Wages for Full-Time, Full-Year Male U.S. Workers, 1963–2008



Source: Daron Acemoglu and David Autor, *"Skills, Tasks and Technologies: Implications for Employment and Earnings,"* Handbook of Labor Economics 4 (2011): 1043–1171

The different lines represent the patterns of millions of American workers over the last fifty years. It is evident that before 1973, workers of all education levels benefited from the increase in productivity. Then the recession caused by the oil shock decreased all gains for every group. But what is most interesting is what took place afterward. In the early 1980s, we can see a spread forming between incomes. The people without college degrees faced a much more hostile labor market, that left their wages stagnant or even decreased in the case of high school dropouts.

It is not by chance if in 1982 the personal computer was awarded *Time* magazine recognition of "machine of the year". This also came in conjunction with an increase in the number of college graduates, which more than doubled from 1960 to 1980, providing a larger supply of high-skilled labor. What is strange is that this additional flood of graduate workers did not lower their relative wage. Which means that the

demand for this higher skilled labor increased faster than its supply. On the other hand, demand for jobs that could be performed by high school dropouts decreased so drastically, that even though they decreased in number, they still were in surplus. The fact that there was no demand for low-skilled tasks, caused their wages to decrease further. And since most people with a basic form of education were already on minimum wage, this change intensified the already rampant issue in America of income inequality.

Daron Acemoglu recently came back to the subject, this time in partnership with Pascual Restrepo. In their paper, they examine the effect of a rise in the use of machines in US labor markets in the period between 1990 and 2007. They do so using a model in which machine compete against humans in a different task, to show that it is possible for robots to have a positive or negative impact on wages and employment. The positive effect is derived from the productivity effect, while the negative effect comes from the displacement of workers. Their regression is based on the change in employment and wages on the change in exposure to machines in the labor market. With this methodology, they are able to estimate large and robust negative effects of machines on wages and employment.

"We show that commuting zones most affected by robots in the post-1990 era were on similar trends to others before 1990, and that the impact of robots is distinct and only weakly correlated with the prevalence of routine jobs, the impact of imports from China, and overall capital utilization. According to our estimates and assuming that there is no trade between commuting zones, each additional robot reduces employment by about seven workers, and one new robot per thousand workers reduces wages by about 1.6 percent. If we factor in trade between commuting zones, our estimates instead imply somewhat smaller magnitudes: one additional robot reducing employment by 6.5 workers and one robot per thousand workers reducing wages by 1.2 percent. Though sizable, these magnitudes are in the ballpark of the case study evidence on how many workers an industrial robot can directly displace, though only if there are no offsetting

gains in employment in other industries and occupations. Our analysis of the heterogeneous effects of robots is in fact consistent with little or no employment gains in other industries and occupations."[65]

This study is focused on local equilibrium effects, but it is an interesting starting point for any further investigations on the national equilibrium. The results are also somewhat surprising since they only show a small set of increases in employment in different industries and occupations.

Another interesting analytical study on the topic was produced by an author I mentioned in the previous chapter, Joseph Stiglitz. In his paper, he starts his analysis from a model with full employment. He considers different scenarios in which the changing variable is the elasticity of substitution and shows that *"In a model where efficiency wages lead to equilibrium unemployment, … if the elasticity of substitution is less than unity, there will be a bias towards excessive labor augmenting innovation, resulting in too high unemployment, with convergence to the unique steady state being oscillatory, rather than monotonic. Similarly, if the elasticity of substitution between skilled and unskilled labor is less than unity, and there is efficiency wage unemployment for unskilled labor only, there will be excessively skill-biased innovation."*[66]

This result is particularly interesting since the debate has recently focused on skill-biased innovation. The critics of this innovation (which will be the protagonists of the next section of this thesis) claim that one should not obstruct market processes. They believe that in the long run, everyone will be better off. Stiglitz suggests that these ideas might be *'Panglossian'* and that the benefits of technological progress might actually make many people worse off in the long run. This conclusion is consistent with the

[65] Daron Acemoglu and Pascual Restrepo, "Robots and Jobs: Evidence from US Labor Markets", NBER Working Paper No. w23285, 2017, p. 33
[66] Joseph Stiglitz, *"Unemployment and Innovation"*, Working Paper 20670, National Bureau of Economic Research, 2014

stagnation or even decline of wages in the last half-century in the United States, showed in the previous graph.

This study proves that technological advancements might not improve the welfare of every group in society, but also that certain market processes could lead to types of innovation that are not maximizing the output. This implies a lack of Pareto efficiency even with the possibility of a costless redistribution among the different groups.

"Indeed, there is a presumption that unfettered markets will not be efficient in the choice of factor bias, and will lead to excessively high levels of unemployment."[67]

We have been through economic revolutions before, but the robot revolution might be different. Horses are not unemployed because they did not want to work anymore and got lazy, there is no need for them in today's economy. There is not much work a horse can do to cover for its hay and housing.

There are many capable humans who can find themselves to be the new horse, with no employable skills to offer. But not everyone thinks this will be our future. In this next section, I am going to examine the point of view of the experts on the other side of the debate, who developed a more positive outlook on the issue.

3.3 Luddite Fallacy

The term "Luddite Fallacy" comes from an episode that took place in the early 19th century. As we already examined in the first chapter, the dawn of the Industrial Revolution saw in many countries, but especially in Great Britain, an increased concern over the impact of machines on employment. *"The original Luddites were British weavers and textile workers who objected to the increased use of automated looms and knitting frames. Most were trained artisans who had spent years learning their craft,*

[67] Ibid, p. 19

and they feared that unskilled machine operators were robbing them of their livelihood."[68]

History did not confirm these workers worries and the 'optimists' in this debate use the term "Luddite Fallacy" to describe all the people still worried about the recent technological revolution.

These optimists of our time are, for the most part, economists. Their arguments rest on the same conclusions that we have reached thus far in this historical analysis of the subject. They believe that technological revolutions have not and will not cause a reduction of employment in the long run. On the contrary, they believe that automation will serve as a multiplier on productivity, which will generate an increase in the demand for labor.

The Economic literature on the subject does not support the idea that humans could become partially or entirely obsolete in the future leading to a large-scale structural unemployment.

A very simple model to explain this fallacy is provided by Game Theory expert James Miller. He imagines an economy with only two goods: cake and wine. Each person produces one of these goods and trades to obtain the other. If both these goods cost the same, then the real cost of a bottle of wine will be one cake. To shake this simple system, he introduces robots to start manufacturing at a large-scale. This causes an inevitable change in the relative prices of the two goods. The goods produced by machines would reduce in terms of value and make the other goods more profitable to produce for humans. To conclude, he states: *"Just as two people both can't be shorter than each other, two goods can't both cost less than one another. Therefore, regardless of what robots make in our cake/wine world, it will always be profitable for humans to*

[68] Evan Andrews, "Who Were the Luddites?" (August 7, 2015). Retrieved from http://www.history.com/news/ask-history/who-were-the-luddites

make at least one good. Even if robots made huge amounts of both cake and wine, these goods would still have some relative prices in which one of the products was necessarily worth at least one of the other."[69]

He then translates this logic in a world with more than two goods to show its consistency with reality. Very simply, he considers a situation in which machines produce a good X. The latter will become less valuable and at the same time, the value of two other goods Y and Z will increase since they are now worth more in a trade for good X.

This example based on relative prices shows that robots cannot eliminate all jobs. Every time technology eliminates a certain type of job, it will inevitably make other sectors more valuable and profitable.

This line of thought is reasonable only in the long-run since in this system workers could find themselves temporarily without skills to compensate for machines cheaply substituting their work.

In a capitalistic system, job destruction is always paired with long-term job creation.

Another major exponent of this current of thought is professor David H. Autor. He is famous for his contribution to the debate by helping our understanding of the connection between labor and technology in the past two decades.

In his articles, he is willing to admit that there is no universal economic law that guarantees that every person will be granted a job just on the basis of his logical mind and good personality. Yet, he still believes that if automation has not wiped out most jobs over the centuries, there is probably no need to start worrying now.

He believes that the 'Luddites' tend to focus on the idea of automation substituting labor, ignoring the complementarities between these two elements that lead to an

[69] James D. Miller, "Robot Economics", (August 19, 2003). Retrieved from http://www.ideasinactiontv.com/tcs_daily/2003/08/robot-economics.html

increase in productivity, demand for labor and earnings. "*Focusing only on what is lost misses a central economic mechanism by which automation affects the demand for labor: raising the value of the tasks that workers uniquely supply.*"[70]

The question he asks himself is why, if new machines are being invented every day with the purpose of saving labor, have technological change not yet eliminated the majority of jobs in the market? Why is there no automatic reduction in aggregate employment if technological advancements decrease the labor requirements per unit of output produced? All these questions are answered by the economic idea that there are tasks that cannot be substituted by automation, only complemented by it.

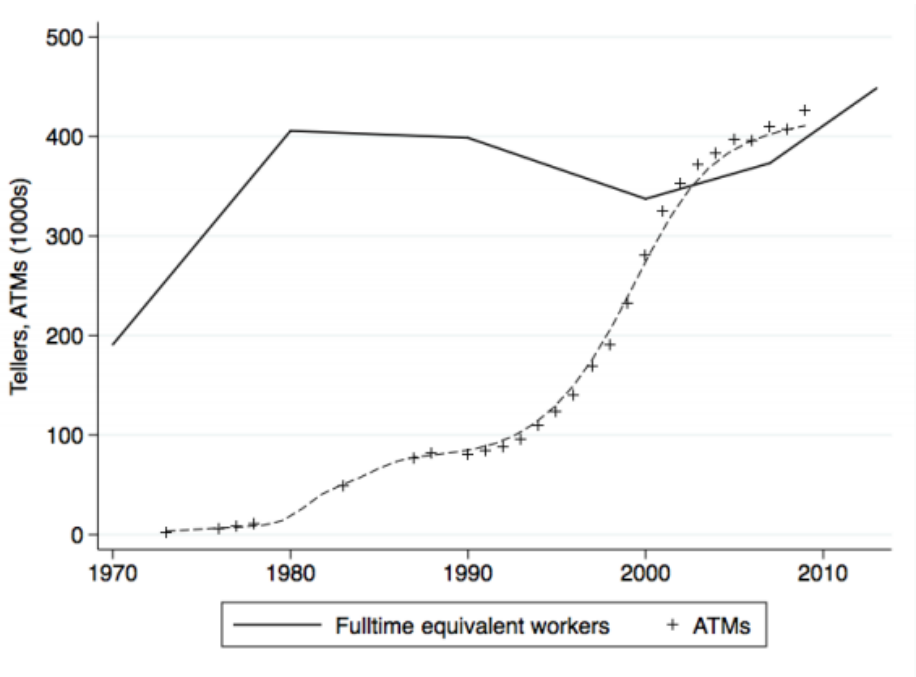
To divide job between low and high skilled ones (like the Skill-Biased Technical Change theory does) would ignore job processes that rely on different sets of inputs. Those combinations could be between creativity and repetition, or labor and capital, or mind and muscles. Usually, these inputs work in conjunction with each other and the substitution of one does not reduce the need for the other. Not only that, but the improvement productivity-wise of one factor will inevitably increase the economic value of the other.

A modern example of this line of reasoning is the complementary nature of technology and employment in the banking sector. This following example is provided by professor Bensen. In this case, he studies the effect of ATMs (automated teller machines) on the routine-intensive job of bank tellers. ATMs first appeared in the Us economy in the 1970s and their numbers quadrupled from 100,000 to 400,000 from 1995 to 2010. It would be an easy assumption to make that bank tellers would have been almost completely substituted in that interval. The data tells us otherwise since, as can be seen

[70] David H. Autor, *"Why Are There Still So Many Jobs? The History and Future of Workplace Automation",* Journal of Economic Perspectives, Volume 29, Number 3, Summer 2015, p. 5

from the table below, employment of bank tellers increased moderately from 500,000 to 550,000 from 1980 to 2010.

Figure 7: Number of Bank Tellers against the number of ATMs installed



Source: Data are from Census and ACS 1% samples. Fulltime equivalent workers are calculated assuming 2080 hours per work year. Data on number of ATMs installed from the Bank for International Settlements

Bessen justifies this result by attributing two main factors working in opposite directions. Firstly, the cost reduction guaranteed by the new technology led to an increase in demand for tellers. *"Indeed, since 2000, the number of fulltime equivalent bank tellers has increased 2.0% per annum, substantially faster than the entire labor force."*[71]

Second, tellers underwent a change in skills. Routine tasks like cash-handling became less relevant, increasing the value of interpersonal skills, marketing and relationship banking in general. Banks started to view bank personnel as something more than

[71] James Bassen, *"How Computer Automation Affects Occupations: Technology, jobs, and skills"*, Boston University School of Law, Law & Economics Working Paper No. 15-49, (November 13, 2015) p. 5

clerks, but as vital elements in creating relationships with customers and presenting them additional bank services. The result was that, although bank tellers ended up managing fewer tasks, their employment rose.

This is just one example that should not be taken as a universal rule. Technological improvements do not necessarily lead to an increase in employment.

The first counter-point to this argument is that while it is true that workers can benefit from automation if they provide tasks that are complementary to automation, they are still at risk of displacement if they primarily supply tasks that are replaced by machines. In our previous example, a bank teller with no interpersonal skills would find himself unable to supply useful labor in a modern bank.

The second concept to keep in mind is how the elasticity of labor can alleviate wage gains. If there is already a developed sector in the complementary task in question (in our example, the relationship banker), then a new wave of workers will mitigate any wage gains that would emerge from the communion of automation and human input.

Third, the combination of output elasticity of demand and income elasticity of demand can act as either as a deterrent or as an amplifier in terms of gains from automation. For example, in the case of agricultural goods, an increase in productivity, in the long run, has come hand in hand with a decrease in income spent on food. On the contrary, in the sector of healthcare, advancements in technology have caused more income to be spent on health. This happens because even if the elasticity of demand of a specific sector is below unity, it does not necessarily imply an increase in aggregate demand when technology improves, the additional income will be spent in other sectors.

3.4 Possible Scenarios and Smart Precautions

The second age of machines is proving to be an era of continuous exponential progress in many areas of computing and exceptionally large quantities of digitalized information. These factors are producing inventions that bring science-fiction scenarios in our daily lives. The advancements in technology we have witnessed in recent years seem to be only the opening act of this play.

The introduction of Artificial Intelligence into this discussion is still a little bit premature. The science behind it is still in the early stages of development and economic theories have yet to take form. But it is interesting to speculate on what could happen in a system where the exponential advancement of automation faces the non-exponential creation of new jobs. Simply put, jobs are being automated quicker than they are being created. AI specifically is replacing many kinds of careers that were believed to be immune to automation. Machines are starting to show incredible abilities in terms of pattern recognition and other areas which used to be exclusive to humans.

A critique that has always been posed to the possibility of machines replacing humans, is their inability to replicate any tasks that might involve cognitive thinking.

On this regard, a test has been used to determine if a machine should be considered capable of thinking. The so-called *"Turing Test"*[72]. Alan Turing was the famous mathematician that, in 1950, in his report *"Intelligent Machinery"*, tried to understand if it was possible for machines to show intelligent behavior. His reasoning was that if a machine can produce an output impossible to distinguish from a human's, then it could reasonably be said to be intelligent.

Recently, and Artificial Intelligence called Deep Blue, defeated Gary Kasparov, the world chess champion, passing the Turing Test while playing the game. But can Deep

[72] Alan Turing, *"Computing Machinery and Intelligence"* Mind 59 (236), 1950, p.460

Blue really be considered intelligent by human standards if it cannot even answer questions about chess, but only play it?

The concept of machine learning could be the solution to this issue since it consists in the ability of a computer to improve its methods and decisions as it gathers more data, or experience.

How do these recent developments work with the theories developed thus far in this chapter? We have seen how many economists, when analyzing this issue, have underlined the importance of humans in the development of machines, mainly to highlight the fact that the latter could not really work without human inputs and thus could not make us obsolete. But what if this symbiosis became more extreme? What I mean is that it is possible that people in the near future (which is not too far in the making) could be part human and part machine. We will see (and in some industries already see) examples of body enhancement, like vision, memory or muscle enhancements. For any science fiction fan, the idea of a world of "cyborgs" might not be a foreign concept, but does it have a place in reality? Science says it does. It is enough to look at Moore's Law, which states that the number of transistors on a chip will double every year (later he will revise this prevision to every two years). This observation is described by Gordon Moore in his famous paper in 1965[73] and so far it has been proven to be correct by the harshest critic in history: time. His statement, to put it in simpler terms, shows that in a hundred years, a machine could be smarter than any human being.

There is a lot of talk throughout history about what kind of economic system would fit best to adapt to automation and machine labor. These most recent contributions vary from the most interesting in vision such as the Natural Law, Resource Based Economy as proposed by The Venus Project and The Zeitgeist Movement to things like the Steady

[73] Gordon E. Moore, *"Cramming more components onto integrated circuits",* Electronics, April 19, 1965, pp. 114–117

State economy, Ending Infinite Growth and involved in all of the ideas like Universal Basic Income, crypto-currencies, simple living.

In the past, the idea of a post-scarcity society has been developed by many authors, most famously by Karl Marx, which examined this issue in his Grundrisse, in the section defined as the *"Fragment on Machines"*[74]. In this part of his work, he imagined a society after the fall of capitalism, where the role of technological advances would be to reduce the amount of labor required to produce basic necessary goods, and allowing people to be free to allocate more of their time in leisure activities.

The utopian reality envisioned by Marx is quite similar in some aspect to the future Keynes imagined for his grandchildren. But a major point, not often taken into consideration in future predictions, is that if labor was made useless by automation, the economic issue that would surface is one of distribution, not of scarcity. People will have values in the form of human capital, that will produce a flow of income over the course of their career. If labor became redundant, we would end up having a large aggregate of wealth, but the question would consist in the determination of its owners.

One might believe distribution to be an easy problem to solve, with such an abundance of wealth to share, but history tells us otherwise. There is always a struggle over distribution and an idea of perceived scarcity is ever present. There is no reason to believe that automation will make this problem go away.

The idea of developing policies and regulations in advance is the right track. But we must be careful not to adopt the wrong rules. The authors of the article *"Robots Are Us"* warn us about this possibility: *"Other policies for managing the rise of smart machines may backfire. For example, restricting labor supply may reduce total labor income. While this may temporarily raise wages, it will also reduce investment and the long-term capital formation on which long-term wages strongly depend. Another*

[74] Charles Barbour, *"The Marx Machine: Politics, Polemics, Ideology"*, Lexington Books, 2012

example is mandating that all code be open source. This policy removes one mechanism by which capital is crowded out, but it leads firms to free ride on public code rather than hire new coders. This reduces wages, saving, and, in time, the capital stock."[75]

Since this problem seems to have come out of a science-fiction novel, maybe our solution could come from one too. The solution provided by the most famous author is to regulate robots' behavior towards humans with three main rules, the famous laws of robotics:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm;

2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law;

3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.[76]

While it might be a little too much to start styling rules and dictating policies on a threat that is not here yet, it may still be wise to start developing some regulation in advance to control the future application of AI.

For example, in 2016, the European Parliament Legal Affairs Committee presented a report on civil law regulations on robotics. Among the different recommendations in the report, it is evident the need to fill some gaps in the law regarding the topic of robotics. For instance, a point states: *"whereas, ultimately, robots' autonomy raises the*

[75] Seth G. Benzell Laurence J. Kotlikoff Guillermo LaGarda Jeffrey D. Sachs, *"Robots Are Us: Some Economics of Human Replacement"*, Working Paper 20941, February 2015
[76] Isaac Asimov, *"Runaround"*, Astounding Science Fiction (March 1942)

question of their nature in the light of the existing legal categories – of whether they should be regarded as natural persons, legal persons, animals or objects – or whether a new category should be created, with its own specific features and implications as regards the attribution of rights and duties, including liability for damage;"[77]

This preemptive piece of legislation shows us that the worry about a robot conscience is real. The issues to evaluate when developing a machine's brain will be moral and ethical in nature, adding a layer of social responsibility to the engineering process.

A philosophical issue that has surfaced on this same topic is the famous Trolley Problem[78] applied to machines. In the original example, a trolley is going towards five people, but you can switch its course by pulling a lever. By doing so, you are sending the trolley against just one person. The question is, should you intervene and kill one instead of five? This moral problem has recently been translated into a moral issue for drive-less cars. Should software designer teach the cars to save five instead of one? Would the solution change if the car's passengers consist of children instead of adults? The possible scenarios are countless, and many people would react differently when put in this type of ethical decision, so how can we teach a machine something that is not universally true for every human?

[77] Committee on Legal Affairs, *"Draft Report with recommendations to the Commission on Civil Law Rules on Robotics"* (31.5.2016) p. 5

[78] Philippa Foot, *"The Problem of Abortion and the Doctrine of the Double Effect",* Oxford Review, No. 5. (1967)

CONCLUSIONS

We don't have a crystal ball to predict the future, in this thesis I showed that while it's true that history gives us reason to put most of our worries at rest, preparing for the possibility of a different outcome might not be so unreasonable.

It would be a dream come true for humanity if we were able to achieve that utopian reality where all our material wishes will be answered without struggles, leaving us free to follow our passions, our interests. The kind of reality Keynes envisioned for his grandchildren, with the additional science-fiction element of robots providing aid in all the troublesome tasks related to clothing, food, shelter. Throughout history, man has invented legends to support this fantasy, from the Norse legend depicting clay giants built to fight gods, to the gold servants engineered by Hephaestus. The materials differ, but the idea stays the same.

Now, these legends are becoming a part of our reality if we can imagine a task being replaced by a machine, but automation is not there yet, it is safe to believe that someone is already dabbling at home on an alpha version of a solution.

This period we are living in is an inflection point, the beginning of a shift similar to the one caused by the Industrial Revolution. New technologies are moving at an exponential level, with most of the gains still very far ahead on the horizon. In the following couple of years, the world will develop more computational power than in all previous history. Scientists, innovators, and entrepreneurs will use this wealth of progress to build machines that will bring on many benefits and improvements in our lives.

With technological advancements, new challenges will arise. The integration with machines in our daily lives is already inevitable, but how far will it go? There are two

main currents of thought on what could happen when machines develop real minds. A dystopian vision (along the lines of Terminator movies) where machines acquire such an advanced level of self, that they decide to work together against us. The second (and more plausible) one, is a utopian version of digital awareness. In this future, humans work together with machines, uploading our minds to the cloud and becoming a, as author Vernon Vinge defined it, *"technological singularity."*[79]

The prediction toward this type of future is derived from Moore's Law. Its magnifying action tells us that a computer with better processing and storing capabilities that a human brain.

While it is true that scientists are often inspired by biology in the development of these innovations, this is not always the case. AI advancements do not always come from imitating the human brain. Like journalist Stephen Baker found out: *"The IBM team paid little attention to the human brain while programming Watson. Any parallels to the brain are superficial, and only the result of chance."*[80]

What this means is that modern AI appears to be intelligent, but it is just an artificial likeness. This might change when we will build machines to resemble more closely our minds.

Even among these economic, biological, societal and existential challenges, my belief is that humanity should keep its optimistic view of the future. In the last part of this thesis, I amplified the focus on data, to show the availability of a reasonable amount of evidence to support this.

Erik Brynjolfsson and Andrew McAfee explain the uncertainty of the ending of the present debate in their book by stating: *"In Charles Dickens's A Christmas Carol, when*

[79] Vernor Vinge, "*First Word"*, Omni Publications International Ltd., January 1983, 10

[80] Gareth Cook, *"Watson, the Computer Jeopardy! Champion, and the Future of Artificial Intelligence,"* Scientific American, March 1, 2011

the Ghost of Christmas Future pointed at Scrooge's tombstone Scrooge asked, "Is this what must be, or what might be?" For questions of technology and the future state of the world, it's the latter. Technology creates possibilities and potential, but ultimately, the future we get will depend on the choices we make. We can reap unprecedented bounty and freedom, or greater disaster than humanity has ever seen before."[81]

I started this historical journey with a spotlight on economic theories responsible for framing and shaping this debate, but in the long run, the answers might come from something other than economic growth. A society where machines do more and more work-related activities is a society where people can spend more time in leisure activities, but also in inventions, creativity, friendship. It is difficult to put a specific quantitative measure to these values, but it is inevitable to imagine their growth in importance in a life where the economic necessities are met.

Technological revolutions have helped us transform the world around us, while the current machine age might lead us to the discovery of human ingenuity. This revolution will have to make us humans think about what it is that we really value, and what we want as individuals and as a society. We, Keynes grandchildren, have inherited the capability to change the world more than any generation before us. This has to be a source of optimism, but only if we are careful with our choices.

[81] Erik Brynjolfsson, Andrew McAfee, *"The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies",* WW Norton & Co, 2014

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