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Technological Unemployment and Policy

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Abstract

This paper investigates the history and future of technological unemployment, with presentation of economic theory, empirical evidence, and policy suggestions. It is found that historically the concern has always been revived when the speed of progress increased, placing human labor under threat of being left behind. However, unemployment always proved to be transitory and concerns subsided sooner or later. Still, the economic debate has never been conclusively resolved. The fundamental model "compensation theory" is disputed and modern forecasts and empirics are heavily mixed. For this reason, a shift in focus from forecasting employment towards uncertainty-incorporating policies is advocated. Innovation is unknown by nature and therefore current employer-employee relations cannot be overly relied upon to provide basic livelihood. A policy measure is suggested which attempts to embrace the uncertainty along with maintaining essential competitive forces via a more widespread ownership of capital.

Technological Unemployment and Policy

Introduction

The advent of industrial robots, artificial intelligence, big data, 3D printing, self-driving cars and the like have spurred an anxiety over persistent technological unemployment and a proliferation of theoretical and empirical studies particularly in the past five years. Unfortunately, the results and projections of these studies are heavily mixed as to the connection between innovation and employment.

In fact, technological unemployment has been debated for thousands of years but has always proven to be a passing concern (Woirol,1996). The philosophical and later scientific debate has not been resolved, and the relatively modern discipline of economics also does not have a conclusive answer to the effects of innovation on employment, especially of *process* innovation.

Two important terms in the economic debate are *process* and *product* innovation. Process innovation is labor-replacing technology. This is what has been theoretically and empirically both rigorously defended and denied. In contrast, *product* innovation – the introduction of new products – is generally regarded as employment-adding even by technology pessimists. (Vivarelli, 2014)

To facilitate meaningful discussion, *technological unemployment* in this paper is defined as a persistent long-term structurally lower level of employment due to labor-replacing process innovations. Because short-term displacement due to innovation is not disputed by even ardent technology optimists, it is more efficient to restrict the term to this socially relevant domain, which explores the relationship between desirable technological progress and undesirable structural unemployment. The debate on technological unemployment is essentially a debate as to the existence of a causal mechanism between technological progress and problematic levels of unemployment (Campa, 2017).

Furthermore, and necessary for subsequent practical deliberations, it will be argued that even this definition of the term is inhibitory as it frames the problem as the level of employment, whereas the underlying desired societal statistic is income. This is an especially important note for policy considerations.

The prevailing economic theory for the matter is called *compensation* theory (developed by classical-era economists in the 19^{th} century), which maintains the existence of balancing effects that restore employment after an initial technological shock. While the tenets of compensation theory have been intellectually criticized, its descriptive adequacy for the 19^{th} and 20^{th} centuries is accepted (Woirol, 1996). Hence, economic debate is often oriented towards trusting market clearing mechanisms of making sure a return to full employment happens. Can experience from the past be relied on to ensure that compensation effects will eventually bring desirable outcome after technology shocks, even when these mechanisms have sometimes taken over a lifetime to adjust.

An “agnostic” view is advocated for technological progress, as it seems the objective premise for meaningful investigation. This means that all analysis takes the future to be unknown, not presuming that certain technologies improve, others do not, that any particular task can be automated, etc. This type of thinking is suggested due to the very conflicting academic and empirical work, as an approach to avoid possible biases in the prevailing discussions that arise from initial positive or negative “gut-feeling” premises on the future short or long-term progression of technology.

Taking this agnostic view, which internalizes that the future and technological advances are unknown, leads to a clear precept for the requirements of the institutional framework and policy reforms. It highlights that policy should incorporate uncertainty into its directive framework on a fundamental level. This means that policy makers should not rely on current status quo to exist, but rather strive to formulate policies in a way that the existing state of the world works, *and* regardless which path technological progress takes from this state, that the outcomes in society are desirable. In essence, policies must try to incorporate *technological uncertainty*. A novel policy measure fulfilling these requirements is proposed.

The paper is structured as follows

I. History of the Debate

Concern of technological unemployment is likely to date thousands of years, ever since the invention of the wheel and Ancient Egypt and China (Woirol, 1996). Ancient Greeks and Romans supported unemployed workers through charity and government spending to create work, and

Aristotle speculated that human labor might not be needed if machines improved enough (Vivarelli, 2014).

Some Roman emperors forbid labor-saving inventions due to signs of increasing numbers of displaced workers, but by the second century AD the problem had dissolved and there was instead a shortage of workers. The concern did not return until the Middle Ages and Renaissance, when again rapid advances were made (and rediscovered) (Schumpeter, 2006). However, artisan and merchant guilds saw new technologies as threatening their crafts. They had significant political power and managed to cause the banning and slowing down of many of these new technologies in continental Europe. (Campa, 2017)

A major historical turn happened in Britain, along with the "Glorious Revolution" (1688), which ended the absolute power of the monarch. The supremacy of Parliament made property-owning classes politically dominant, and mercantilist ideology reinforced acceptance of innovation, seen to strengthen the competitive position of British firms in the international market. These developments eventually led to the Industrial Revolution, the deskilling of tasks via mechanization powered by steam and water. (Frey & Osborne, 2017)

Along the way, numerous riots by displaced skilled artisans occurred where they took to destroying machines. One of the most famous riots were the "Luddite" riots, led by fictional leader Ned Ludd. The movement became organized in a very systematic manner and attacked weaving machines nationwide in Britain, eventually requiring a 12,000-strong British military force to suppress them. Normatively, the Luddites did not oppose technology per se, but rather its impact on their livelihood. Nevertheless, due to the severity of the events the term "luddite" came to mean anybody who opposes new technologies. (Jones, 2013).

The Industrial Revolution favored unskilled labor because it was cheap and complementary with machines that simplified tasks (Frey & Osborne, 2017). There is debate as to how long it took for the welfare of workers to increase in accordance with the productivity advances, but it is clear that there was a notable delay. (Mokyr et al., 2015)

A shift from unskilled back to a demand for skilled labor started at the turn of the 20th century, when industry made a shift to electric power. The machines did not need as much hands-on work anymore, but rather more skilled blue-collar workers to operate them. In addition, a revolution in transport increased competitive forces, dissolving local monopolies and incentivizing efforts to further enhance productivity. This caused a demand for managers and white-collar office workers, along with better education. The story ever since has been the competition between technology and education, as rapid advances in technology extend to even these high-skill cognitive tasks. (Frey & Osborne, 2017)

The Great Depression arrived, and some blamed sticky prices while others claimed that the underlying reason was the massive flow of rural people to cities because of the tractor displacing their agricultural jobs (Mokyr et al., 2015). The mechanization of the routine manufacturing jobs continued, and in the 1980s the machine workers started to heavily migrate to low-skill service tasks. These developments are taken to explain the “hollowing out” of the middle class, where automation has affected routine tasks the most, leaving a demand for high-skill cognitive tasks and low-skill service operations. Still, these occupations have been able to accommodate the changes, and widespread unemployment has not been an issue. (Frey & Osborne, 2017)

This debate in the 1930s, and another in the 1960s were the major times technological unemployment was discussed in the 20th century. Neither debate was intellectually resolved, but subsided due to the outbreak of a war (Woirol,1996). After the 1970s unemployment started to rise once more, and stayed high for the rest of the century. Again, some economists (e.g. Paul Samuelson) argued that the cause was technological progress, and the view gained slight momentum until the end of the century, mostly in Europe (Samuelson, 1989). Still, the majority opinion was that technological progress did not cause unemployment in the long run.

The concern and subsequent debate over possible technological unemployment has experienced a major revival in the second decade of the 21st century, with observations of computer technologies advancing into cognitive domains. The advancement and decline in price of computational power and software developments facilitating machine learning, the use of big data, artificial intelligence, improved sensors, 3D printing and the like have led many to doubt a sustaining competitive advantage of labor is possible. (Frey & Osborne, 2017)

Wassily Leontief explains that the reason workers eventually gained from inventions in the past is that the machines needed human work or oversight to function. Labour was necessary for the operation of the machines and thus demand for it rose, lifting employment and wages. He argues that the current progress is fundamentally different because of computer technologies performing mental functions, not mechanical. While mechanical technology replaced physical labour (but still needed human cognitive efforts to operate), current advances make human labour obsolete as a factor of production. He says that this time the technological unemployment will not be a short-term phenomenon and the growing service sector is just a result of increased service demand due to higher incomes, and that automation of also these jobs will eventually exceed the capacity of service jobs to absorb workers. (Leontief, 1983)

Let us examine what economic theory has to say about the matter.

II. Economic Thought

The historical debate was first formalized during the Age of Enlightenment when use of the scientific method throughout previously philosophical endeavors gained emphasis (Campa, 2017). In *The Wealth of Nations* (1776) as he denounces mercantilism, Adam Smith sets the general optimistic premise that is thereafter to persist in the field. He states that annual produce can only be increased with more labor, a more efficient allocation of existing labor, or innovation. Importantly, his normative viewpoint is that of the capitalist employer:

"… a much smaller quantity of labour becomes requisite for executing any particular piece of work, and though, in consequence of the flourishing circumstances of the society, the real price of labour should rise very considerably, yet the great diminution of the quantity will generally much more than compensate the greatest rise which can happen in the price." (Smith, 1812 (reprint), p. 208)

Hence, there is explicit reasoning that the amount of labor employed will experience a "great diminution", but this is taken to be a positive thing as for employers it makes up for the negative effect of a supposed increase in wages.

II.1 Compensation Theory

The optimism persisted, and classical economists, most notably John Stuart Mill, Nassau Senior, and David Ricardo created a rigorous theory directly addressing the fate of the working class, called *compensation theory*. It is still the fundamental economic model used for debating the effect of process innovation on technological unemployment (Campa, 2017):

Compensation theory initially had four parts, and a fifth effect was added in the early 20th century:

1) *new machines* if process innovation replaces labor with machines, a greater demand for machines should then create jobs in the industries which create these machines, e.g. as industrial robots develop, employment in the sector producing these robots should grow to fulfil the demand.

2) *decrease in prices*: as production becomes more efficient, competitive markets should lead to a decrease in prices of final consumption goods/services. The lower prices in turn increase demand, which leads to more production and hence employment.

This effect became the most important part of compensation theory after John-Baptiste Say argued that any supply of goods was an indication of an equivalent demand. It meant that persistent general gluts, or surpluses of supply over demand should not exist, which bolstered the connection between lower prices, increased demand, and hence increased supply. Say's Law was developed by other economist into what is now called the *law of markets*, adding that if money was also regarded as a good then gluts of other goods might occur if the desire to hoard money was high. Nevertheless, compensation via a decrease in prices became the most widely evoked component of compensation theory.

3) *new investments*: if markets are not perfectly competitive, innovative entrepreneurs may gain extra-normal profits, which can be invested in new projects that then create jobs. This effect also relies on Say's Law, which signifies that increased profits translate into increased investment.

4) *decrease in wages*: as jobs are destroyed, wages decrease which creates a shift back to more labor-intensive production methods. Proponents of this effect blame wage-setting institutions and unions for causing downward rigidity of wages, preventing them from adjusting to enable continuing employment.

5) *increase in incomes*: in the presence of negotiating power by workers' unions (in contrast to the previous effect), workers may be able to benefit directly from the productivity by attaining higher wages. Then, their increased consumption due to higher wages leads to more production and higher employment. This effect was noted during Fordist practices in production, when workers received a part of the productivity gains associated with mass production.

(Piva & Vivarelli, 2017)

II.2 Critique of Compensation Theory

One of the initial fathers of the theory, David Ricardo was the first to argue against its efficiency. Ricardo saw the unemployment and poverty in the wake of the Industrial Revolution and concluded that technological progress can be devastating for the working class, as English workers were wrecking machines due to job insecurity and low wages. By raising these insights, he brought the general concept of technological unemployment into economic literature, as concerns had not been academically addressed before. Still, Ricardo accepted compensation mechanisms overall and agreed with Adam Smith in that innovation was good for capital owners. (Campa, 2017)

Economists had to accept Ricardo's observations and they started recommending aid by the government to help workers suffering from technological unemployment due to transitory frictions in the labour market (Crespi, 2012).

The consensus is that compensation effects worked for the 19th and 20th century, as mass unemployment did not persist. Nevertheless, the theory has been intellectually debated, so we review some critique against each of the different effects.

John Maynard Keynes famously attacked Say's Law in the 1930s during the protracted unemployment of the Great Depression. He pointed towards pessimistic expectations as emotions or "animal spirits" causing a lack of demand in meeting supply, making surpluses possible (Piva & Vivarelli, 2017). In doing so, he reinforced the concept of technological unemployment, as a critique of Say's Law heavily contrasts compensation effects 1, 2, and 3.

Keynes voiced a concern that very well fits the current 21st century discussion brought on by computerization of cognitive tasks, when he predicted the spread of technological unemployment "due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour" (Keynes, 1933, p. 3).

Compensation via new investment could be significantly delayed if profits due to labor-replacing technology are not reinvested due to pessimistic expectations (Vivarelli, 2014). The nature of the supposed new capital investment also plays a role - Leontief (1983) argues that increased investment would increase the amount of labor-replacing technology and thus lower employment instead of alleviating the problem.

Malthus and Mill (Vivarelli, 2014) showed that the first event after labor being displaced by technology is a decrease in aggregate demand (due to lost wage income). This means that for compensation via prices to occur, the lower prices must increase demand over and above this initial negative effect. The existence of demand constraints, as opposed to Say's Law, would further hinder the power of compensation effects. Another objection to the mechanism via lower prices is that if competition is imperfect, not all cost savings may be transferred to lower prices in the first place, as extranormal profits are enjoyed instead. (Piva & Vivarelli, 2017)

Compensation via new machines can occur either from additional new investment or by disposing of existing machines. The first method faces the critique of compensation via new investment, and the second does not logically lead to a compensation effect, as old machines may be scrapped and forfeit their employment. (Vivarelli, 2014)

If employers fear a decrease in aggregate demand due to process innovation, they may not hire additional workers even with lower wages. A moral objection to the effect is that it does not consider a generally regarded level of subsistence wage. The objection states that even in the case that firms employed the whole supply of labor at a low wage, the outcome could be very undesirable if these wages indeed are very low or steadily decrease. (Vivarelli, 2014)

This concern is voiced by Wassily Leontief, as he says that the decrease in demand for human labour also brings an unequal distribution of income as owners of productive capital gain from the increased productivity while the displaced labour does not. (Leontief, 1983)

So, the negative effects of process innovation are potentially dampened by compensation effects. Their efficacy depends on the institutional and societal environment, and whether the type of innovation influences the effects in an unforeseeable way. Hence, the overall effect can be substantially different in different periods and contexts.

In essence, the economic thought is summarized well by the following piece from Piva & Vivarelli (2017):

"… the relationship between innovation and employment can be represented by a very complex picture where the direct labour-saving impact of process innovation, the compensation mechanisms, the drawbacks and hindrances which can severely weaken the effectiveness of such mechanisms, and the labour friendly nature of product innovation can combine in very diverse outcomes."

II.3 Modern Theory

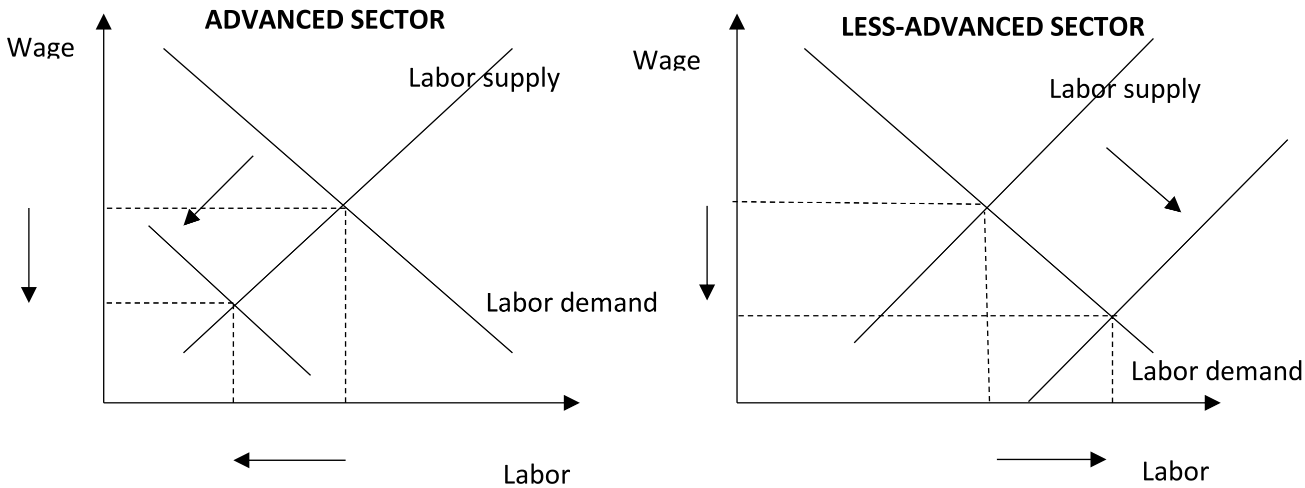
Marginalist and neoclassical economics brought the concept of marginal productivity to the analysis and concluded that if wages adjusted there could be no long-term unemployment. Swedish economist Knut Wicksell hypothesized that as labor demand in advanced sectors decreases, wages also should. As seen in Figure 1, less advanced sectors can hire more workers with these lower wages and employment returns to normal levels. (Campa, 2017)

Critics of neoclassical economists' take on technological unemployment argue that it places the blame of any unemployment of workers and unions who are not willing to work for low-enough wages (Campa, 2017). In addition, its results are very similar to compensation theory and hence face the same critique that employers may not hire additional labor if they take the lower wages to signal lower business expectations (Vivarelli, 2014).

The modern theory is indeed essentially still compensation theory, with an additional separation of qualitative and quantitative effect of innovation. Quantitative effects are the short-term displacement of labor, while qualitative effects concern a possible skill bias. This skill bias is addressed among others by Author (2015).

Autor (2015) makes a separation between tasks and jobs, arguing that even though many middle-skill tasks may be automated, workers would still have a comparative advantage in supplying the non-routine tasks so these jobs would not be lost entirely.

Figure 1: Neoclassical Labor Adjustment Model, with Advanced Sector and Less-Advanced Sector



Bessen (2018) brings an opposing view, by invoking Engel's Law which states that after consumer prices fall enough there is a point of satiation after which any further decreases in demand do not increase quantities. They observe a U-curve where employment initially rises in innovative sectors but later falls as demand is satiated and the market size does not expand enough anymore to absorb the displaced workers.

Hence, demand plays a major role in understanding an observed initial employment growth and subsequent decline in innovative sectors, as elasticity of demand may initially be high for many goods but declines as prices fall.

Despite these developments and sophistication of economic theory via the onset of e.g. marginalist analysis initiated by Wicksell, the fundamental arguments remain the same and hence the debate remains a contest of the efficiency of compensation mechanisms.

Nevertheless, the majority's benign stance of technology on employment persisted for first decade of the 21st century, but has been changing after 2013 due to studies predicting labor-displacing technological advances and empirical evidence displaying falling employment in manufacturing sectors despite increases in productivity (Vivarelli, 2014). We will look at these studies next.

III. Empirics

Motivated by Keynes's predictions of technological unemployment, Frey & Osborne (2013) develop a method of assessing the probability of automation in different jobs. Their study has become somewhat of a seminal paper in the literature, is widely cited and its methodology is used by others to perform similar studies.

They assume a Cobb-Douglas production function with two labor inputs, one classified as susceptible to automation (L_S) and one non-susceptible (L_{NS}), of the following form:

$$Q = (L_S + C)^{1-\beta} L_{NS}^{\beta}, \quad \beta \in [0, 1]$$

They then use US labor market data to estimate how many jobs are at risk by using a Gaussian process classifier and classify 47% of US jobs at high risk: manufacturing occupations, office workers, transportation/logistics jobs, but more surprisingly also a large share of service and cognitive task occupations. They find support for the finding in the recent progress and growing demand of service robots. The main conclusion is that automation affects low-skill and low-wage occupations the most, leading to polarization in the labor market.

Numerous other studies have since forecast similar-sized effects, and even substantially larger shares of jobs at risk in developing countries. European think tank Bruegel released a study

(Bowles, 2014) estimating that technological progress such as the advancement of artificial intelligence would replace 54% of jobs in the EU and predicts that the issue will take center stage in the near future. Chang & Huynh (2016) put the number at 56% for the average of the ASEAN-5 countries (Cambodia, Indonesia, the Philippines, Thailand and Vietnam), the highest being 70% in Vietnam and lowest 44% in Thailand.

The validity of the Frey & Osborne and similar studies to it have been criticized by others for not considering new jobs that are created due to automation (compensation effects), for neglecting the presence of multiple tasks within the same occupation, and the variance of tasks along different positions with the same occupational title. For instance, a study by the OECD (2016) copies the methodology but takes a task-based approach and finds that a substantially lower number of occupations are under threat. The number for the US drops to 9%, and similar levels are found for other countries. This is echoed by Arntz et al. (2017) who also find 9% of US jobs at risk when task diversity within occupations is accounted for.

An interesting finding by Feldmann (2013) is that technological change is likely to increase unemployment for 3 years, after which the adverse effect disappears. They use data from 21 countries and the period 1985-2009. This seems to be in direct contrast to the U-curve that Bessen (2018) found where employment initially rises and later falls. However, no distinction is made between process and product innovation, and Feldmann (2013) do not investigate possible divergent effects between workers of different skill levels.

Bessen (2016) finds that computers are not causing notable amounts of lost jobs, but that automation does shift employment to the industries with higher productivity due to it. Overall, they find a small increase in employment rather than a decrease. Similar to what Frey & Osborne forecast, Bessen finds that automation leads to lost jobs for low-wage jobs. The small number of job gains are found for high-skill employment. They speculate that if the labor market is not flexible, then the transition to higher-skilled jobs may cause unemployment.

Acemoglu & Restrepo (2017) investigate the effect of industrial robots on employment in the period 1990-2007 and find a significant and large effect of robots on both wages and employment by regressing employment and wages against the exposure to robots in a commuting zone. They control for the possible conflating factors such as the general decrease in routine jobs, offshoring, and other types of non-automation capital increases, and include the labor-creating effect in other industries. They find that every new robot/1000 workers decreased employment/population by 0.18-0.34 % and wages by 0.25-0.5%. With these bounds, they estimate that so far 360,000 – 670,000 jobs have been lost due to robots.

Matuzeviciute et al. (2017) use longitudinal data from 25 countries in Europe and the years 2000-2012, and do not find any significant positive or negative relationship between unemployment and innovations in technology even when using various measures for innovation (number of patents and R&D-to-GDP ratios).

Having looked at the theoretical and empirical literature, the debate is still open as to the long-run effects of automation. There seems to be a consensus that technology is driving *task loss*, but no answer as to whether this means long-term *job loss.*

Innovation is an endeavor at the limit of what was previously thought possible, which makes it fundamentally unpredictable and unquantifiable. All progress in technology is by definition an extension of human knowledge, and the impact of knowledge on variables such as employment cannot be precisely determined or forecasted; Innovation has no exact unit of measure which to use in statistical modelling. Hence, the perennial debate on the matter is no wonder, along with conflicting forecasts and empirical research as to the effect.

IV. Policy Measures

"Sooner or later-and better sooner than later-it will have to be admitted that the demand for "employment" is in the first instance a demand for "livelihood," meaning income." (Leontief, 1983)

There appears to be a status-quo bias in the discussions of implications of new technologies, with undue emphasis on employment effects. A shift of focus is needed from the elusive question of whether the relationship between technology and employment is positive, negative, or neutral - to policy measures. However, the prior debate has been instructive in discovering a criterion for these policy measures: they must incorporate the uncertain effects of new technology. If the wrong options are chosen, it could lead to millions of people without work and livelihood, causing social instability and upheaval. If instead the *possibility* of the current employer-employee institution breaking down is acknowledged and addressed in time, the transition can be smooth and leave everyone better off, as progress should.

In this light, we examine some of the policy proposals.

For one, innovation can be banned. This is not a viable solution, as it would lead to stagnation and likely catastrophe especially with the current population size and a limited amount of natural resources. To interdict the use of new technology would also mean to sacrifice the economic and welfare benefits, and would drastically weaken a country's competitiveness in the global world. In addition, such a policy runs in strict contrast to human nature. (Marchant et al., 2014)

Government work programs have been used for thousands of years, and they also helped during the Great Depression (Marchant et al., 2014). Another proposal is to mandate firms to hire labor, which is argued to bring a more efficient market outcome compared to government programs. This policy is difficult to implement as it lowers the competitiveness of firms and is merely an indirect way of prohibiting the use of technology as employment of human labor may be required even if a piece of automating equipment could do the job faster, more safely, and cheaper (Marchant et al., 2014).

An increase of investment in education is very commonly proposed. For instance, a Bruegel study in 2014 prescribes education as the solution to provide workers with skills that are complementary to the new technologies. Autor (2015) prescribes the same solution to alleviate the loss of middle-skill jobs. Developing education is certainly essential, and lifetime learning as an enriching activity should be promoted regardless of what the future of employment is. It has wide personal benefits and externalities that society can gain from, one of them an increasing degree of innovation itself. However, for the current issue even it does not fulfil our criteria of accommodating technological uncertainty.

Increasing skills with education assumes that technology will continue to complement human labor if labor is retrained. An opposing viewpoint is that of Keynes and his followers, that if labor-replacing technology advances rapidly, the speed that humans would need to retrain themselves to adjust would be too high. Bessen (2016) also concedes that the need to develop new skills may be a major hurdle for the labor force. In addition, Beaudry et al. (2015) argue that in the US, the demand for cognitive work already peaked around the year 2000.

Redistributive indirect welfare benefits of various kinds exist, and they are more durable than work programs. However, welfare payments carry the risk of dependency on them and moral hazards that prolong adjustment (Marchant et al., 2014). In addition, they also do not fit the criteria of technological uncertainty, as they depend on the ability of a tax-collecting government, which in turn depends on the status-quo of employment to exist. If employment disappears, the circular flow of income is broken, and companies have no more customers to sell to, and thus a major depression could occur. This in turn would naturally harm and eventually stop the ability to collect taxes for redistribution if there is no entity to collect them from.

The same argument ultimately contests the frequently proposed “universal basic income” (UBI), an unconditional lump-sum payment to everyone. The policy would guarantee a basic income to all, but it is already acknowledged that one of the major problems with universal basic income is the financing of such a program (Tondani, 2009). Even now it is politically difficult to increase taxes on capital income, so what would happen if the circular flow of income breaks in the case that the current main form of delivery of disposable income to consumers, their wages, is gone? Hence UBI does not escape the same problems as the above other welfare programs and mandatory working schemes. Also, the more we tax capital income the less investment and innovation will be made, which we have determined to be undesirable (Worstall, 2017).

The goals of innovation and income are equally important, and one should not be traded off for the other. If returns to capital and labour diverge too much, an undesirable amount of inequality may occur, causing social distress and potential upheaval (Peters, 2017). At the same time, it is essential to maintain competitive forces which drive innovation and growth (Freeman, 2015). To get to the root of the problem, it seems a more widespread ownership of capital is needed.

An encouraging event occurred in 1862 when Lincoln's Homestead act gave a piece of land to propertyless Americans. It was the greatest economic policy incentive in the history of the US, fundamental in providing a foundation for the ascension of US in becoming the world's largest industrial economy. Of course, land eventually ran out, yet no similar act has been made to facilitate benefits from technology. (CESJ, 1998)

Freeman (2015) asserts that the best solution to the problem now is to give workers some capital stake in the business with employee stock ownership programs (ESOPs). This may be a good transitionary policy to implement, but still does not completely solve the issue of uncertainty related to work.

IV.1 Suggestion

So, the earlier mentioned policy measures do not fully address the root problem in case the pace of innovation exceeds the pace at which workers can adjust – the inherent uncertainty of innovation. In addition, the burden of adjustment is fully on the workers through constant training and accepting lower wages for the employer-employee institution to survive.

Intrinsic in corporate law is a special fiduciary relationship between the executives of the corporation and stockholders. Corporations have come under critique for considering the rest of society's interests (stakeholders) only instrumentally and to the extent that they drive stockholders' interests. However, the other extreme is at least as problematic from an ethical standpoint: if managers consider all stakeholders' interests equally, the fiduciary relationship and profit motive of companies is sacrificed. This dilemma is called the "stakeholder paradox" by Goodpaster (1991).

In the current system, the extra-fiduciary relationship between companies and society is managed through a regulatory framework that guides management but takes other stakeholders into consideration only instrumentally through the need to follow laws and regulations.

He calls for policies that facilitate the honoring of the special fiduciary relationship between stockholders and management, but also promote the extra-fiduciary civil relationship between managers and society at large.

To solve the paradox and address the criterium we have outlined for an adequate policy measure, I propose a demand-driven stakeholder stock-ownership plan (SSOP). Each citizen is assigned a portfolio, mostly highly diversified but a part of which is constantly adjusting weighted by where the individual visits as a customer.

Figure 2 shows how the economy would function in such a system. When stakeholders become stockholders, the regulations are internalized and taken fundamentally into account by management in decision-making. The system is not vulnerable to displacement of work as workers gain dividends and may continue consuming products and services, preserving aggregate demand.

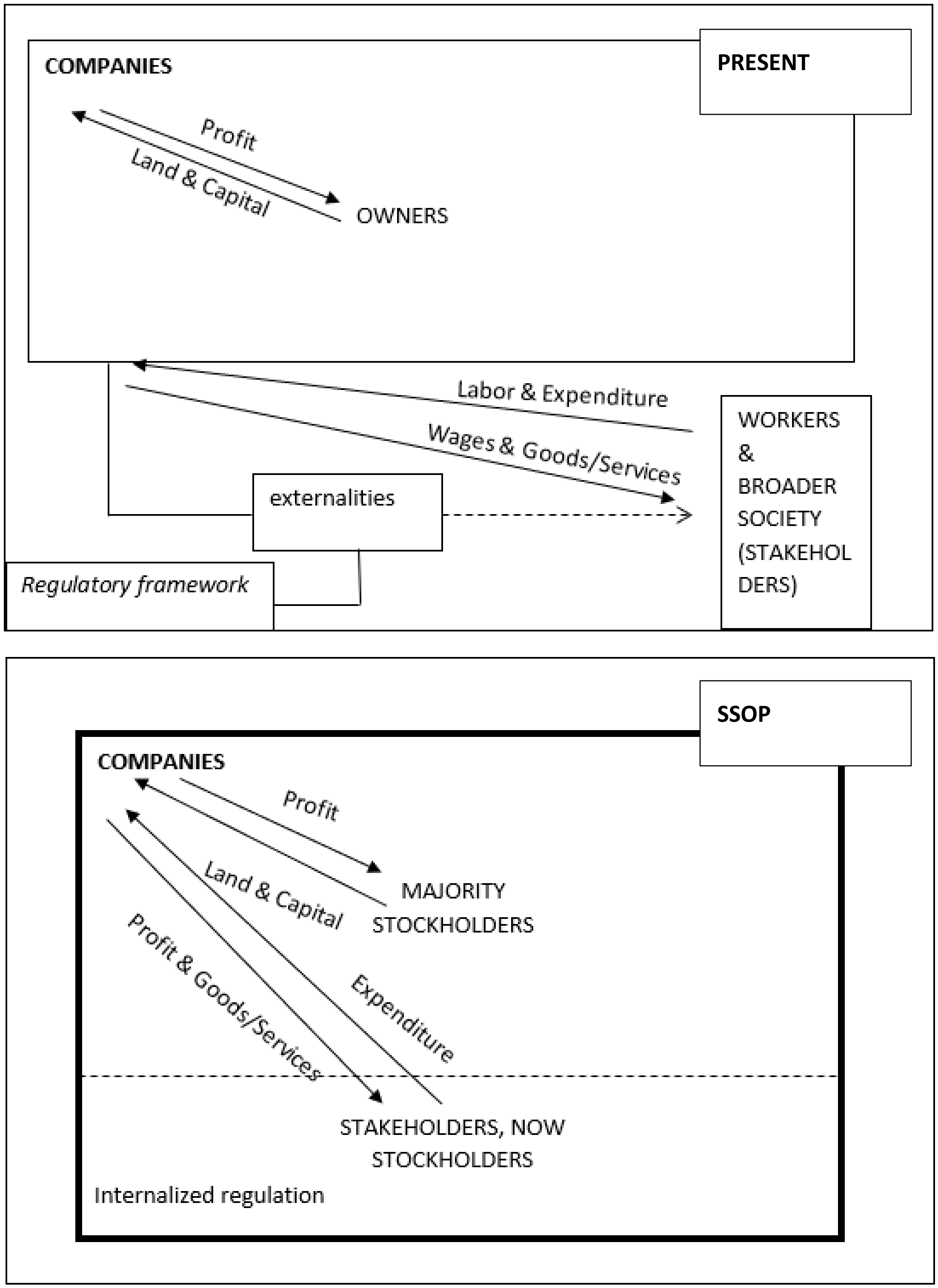
This system would maintain competitive elements while allowing a widespread direct gain of capital productivity. Also, it would facilitate long-term responsible consumption behavior as individuals would consider the fact that a sizable portion of their ownership and hence welfare is determined by the future success of the companies that they are customers in, because they then have an ownership stake in those companies. Only companies of a determined size or amount of impact on society would be required to take part in the SSOP.

Competitive elements through an incentive for entrepreneurial effort remain, and non-entrepreneurs compete by optimizing their ownership stakes via thoughtful consumption in order to gain higher dividends.

The suggestion may also allow better anticipation and direction of education for the transitory adjustment period towards skills in which humans can provide value, activities where we wish a human contact such as volunteering, culture, and possibly healthcare. When people are not as reliant on wage income, a more long-term approach of lifetime learning can robustly be implemented.

To approve of this plan, first corporate taxes would have to be lowered, and then a stock split would be made. The newly created stock would end up in a public ledger instead of among the existing owners. The size of the stock split would be such that in principle, together with lower corporate taxes, the stock price would remain the same. This would relieve opposition to the policy, as stockholders should not experience loss aversion. After the stock split, the new stocks would be constructed into highly diversified citizen portfolios which would then be allocated to everyone. The lost government income from corporate tax would be offset by savings in welfare benefits, which is a significant outlay.

Figure 2: Stakeholder Stock-Ownership Plan (SSOP)



V. Conclusion

This paper has first examined the literature of economic theory on the matter of technological unemployment, forecasts made for the threat, and empirical research on how much it has materialized in the past. The outcome of this exploration is that the debate is unsettled in that there is no clear, reliable model of innovation on employment. Compensation mechanisms have the potential to alleviate the impact of process innovations, but these mechanisms work under a restricted set of assumptions.

The world can be regarded as constantly being in a state of transition towards an unknown state, which poses a challenge for policy making. Recent debate rests on the concern of the fate of labor, which reflects a status-quo bias. This paper presents a stakeholder stock-ownership proposal where the question of wage income is sidestepped, perhaps creating a more solid basis for facing future labor uncertainties. It is argued that more widespread capital ownership, along with maintaining the essential component of competition is needed.

The focus should be on policy measures which incorporate the inherent uncertainty of innovation, ones which provide a framework for desirable outcomes regardless of the speculative progress of automation or of the efficiencies of compensation mechanisms. To this regard, the only plausible solution appears a more widespread ownership of productive factors.

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