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Disappearing middle class

Job polarization and policy approaches

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Contents

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Nir Jaimovich works on macroeconomics questions with special emphasis on business cycles, labor markets, and the macroeconomic implications of micro product level data. Within these research areas, he combines new data and quantitative theories to tackle long-standing macroeconomic questions. His work in the area of labor/macro shows how demographic composition and occupation structure of the economy shape the dynamics of the business cycle. In addition, it examines the empirical and theoretical plausibility of signals and uncertainty about future economic fundamentals functioning as important drivers of business cycles. Finally, his micro-pricing product-level data shows how actual firms' pricing strategies shape the insights regarding the extent that monetary policy has an impact on the economy. His work has found large resonance inside and outside academia and was featured within policy circles (such as White House official publications) and media outlets such as *The New York Times, The Washington Post, The Economist, the Financial Times, The Wall Street Journal, The Guardian, Forbes,* Swiss and German media. Before joining the University of Zurich, Professor Jaimovich was on the faculty at the Marshall Business School at USC, Duke University, Stanford University, and University of California, San Diego.

Abstract

The creeping hollowing out of the middle class and the simultaneous rise of automation have become hotly debated topics in the popular media and among policymakers, and there is certainly no shortage of dire predictions about the ascent of robots and subsequent obsolescence of workers. But – doomsday prophecies aside – what are the facts? What is happening to workers, specifically middle-class ones? And, from a policy perspective, what can (or should) be done to address this fundamental shift in who – or what – does which jobs?

This Public Paper tackles these questions head-on. We first identify the types of individuals who are likely to work in middle-class occupations and track how they act on the labor market outcomes. Then we evaluate policies proposed in recent years that have been aimed at combating the labor market malaise middle-class workers have experienced.

Introduction

Over the past four decades, technological advances such as computing, robotics, and artificial intelligence have substantially changed labor markets. These advances, while making us more productive, have also modified and altered the types of jobs we do.

In this same time period, the US economy and other industrialized economies have seen a sharp drop in the share of the population employed in middle-skilled occupations. A growing literature shows that this employment loss is linked to the disappearance of routine jobs, that is, those jobs for which tasks are repetitive and follow a set of clear instructions.[1] These types of activities are, by their nature, highly vulnerable to takeover by new automation technologies.[i]

Indeed, until the mid-1980s, about half of employment in the US was concentrated in routine occupations, while that fraction has fallen to one-third today. The collapse of employment in routine occupations, which tend to be middle-class jobs, is known as "job polarization." Job polarization is defined by observed growth in either the high-skilled, high-paid and the low-skilled, low-paid categories, and a shrinking of the middle-skilled, middle-wage jobs category. These dynamics have led the middle class to experience a hollowing out in terms of wages and employment opportunities.

As an example, consider the birthplace of modern American automobile manufacturing. At the beginning of the 20th century, Henry Ford revolutionized the factory floor and helped create an industry that would support generations of middle-class workers. Several decades later in 1969, General Motors installed its first spot-welding robot, automating almost all welding operations. Thus, the industrial genesis of the middle-class also became ground zero for replacing workers with automation technologies.

This Public Paper's goal is to enrich our understanding of the adjustment to this new economy by studying two integrated topics. First, the paper seeks to document in the empirical section how workers with "routine characteristics" have adjusted to these changes. For example, are these individuals now employed in other jobs? Do they tend to be more frequently unemployed? Or are they more likely to drop out of the labor force completely?

Second, the paper evaluates the most prominent policy proposals that have been recently proposed as part of the plan to address the demise of the middle class: a universal basic income, the reform of the unemployment insurance system, changes in the tax code, and the retraining of workers. We introduce a conceptual framework to evaluate the outcome of these proposals and to identify the potential winners and losers of each of these policy reforms.

What is “job polarization”?

In a seminal work, Autor, Katz, and Kearney documented that the job market has become increasingly polarized since the 1980s.[1] That is, the share of employment in the upper and lower parts of the wage and occupation distribution has increased, while the share of employment in the middle-paying occupations has decreased, as have the relative wages in these same middle-paying occupations. In other words, the pay difference between top-paying and middle jobs has increased, while the difference between middle- and lower-income (and lower-skills) ones has been shrinking.[2]

What could explain these changes in the labor market? The modern approach is to relate these findings to the task content of a given occupation. That is, researchers noted that (i) occupations at different parts of the wage distribution differ in the type of tasks they consist of, and (ii) those middle-paying occupations were specialized in tasks with a fall in demand.[1, 3]

But what specific tasks characterize middle-paying occupations? Following the work of the economists Daron Acemoglu and David Autor, it is useful to categorize every occupation along two dimensions as presented in Figure 1 A: “cognitive” versus “manual,” and “routine” versus “non-routine.”[4] The distinction between cognitive and manual jobs refers to the extent of mental versus physical activity required in a given occupation. The distinction between routine and non-routine jobs refers to whether the job-specific tasks can be performed by following well-defined instructions and procedures.[5] If an occupation follows a clear, linear set of instructions, it is considered routine. In contrast, if a job involves tasks that require flexibility and “non-linearity,” then it is considered non-routine.

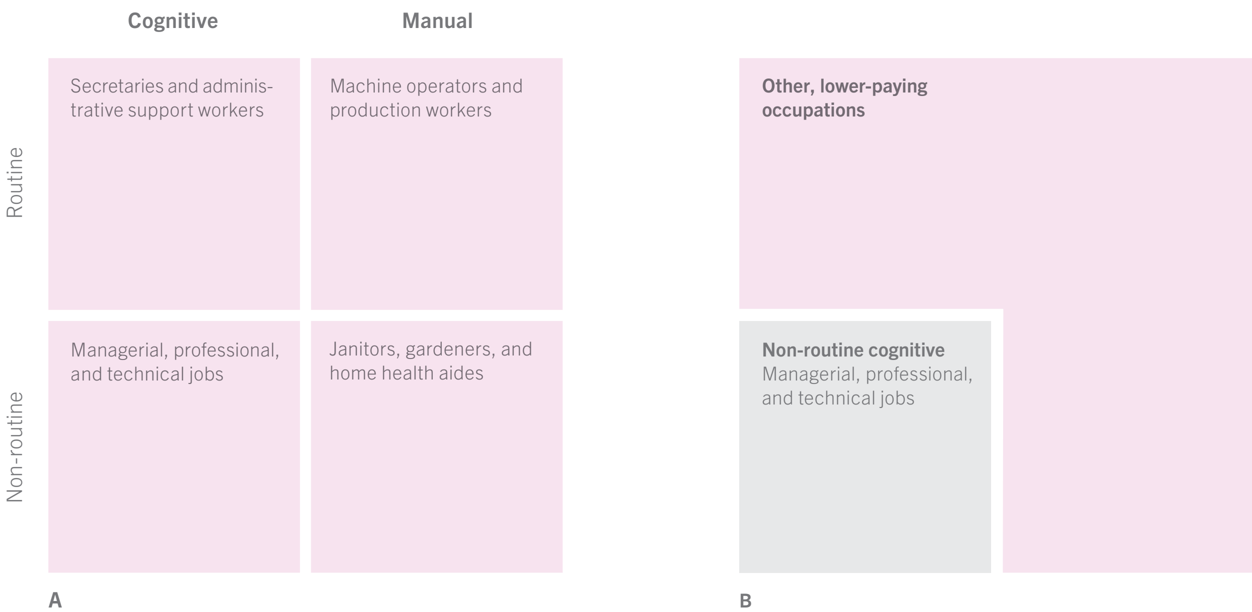
Equipped with this definition, researchers have emphasized that occupations specializing in routine tasks occupy the middle of the wage distribution, and are thus “middle-class jobs.”[3] For example, as indicated in Figure 1 A, routine manual occupations include machine operators and production workers, while examples of routine cognitive occupations include secretaries and administrative support workers. Thus, the polarization of the labor market amounts to a falling share of these routine, middle-skill occupations, while growth is observed in the high-paying, non-routine cognitive occupations (such as managerial, professional, and technical jobs), and in the low-wage, non-routine manual occupations (such as janitors, gardeners, and home health aides).

A natural question then arises:

What is causing the fall in both employment and wages for these middle-class routine occupations?

The key insight from the existing literature is that the tasks typically required for these middle-class routine jobs are the very same tasks that are easy to automate or to substitute with automation technologies. In contrast, given their very nature, non-routine tasks – be they cognitive or manual – are neither easily automated nor substituted by automation technologies.

Fig. 1 **Classification of occupations**



Note: The distinction between cognitive and manual jobs refers to the extent of mental versus physical activity required in a given occupation. The distinction between routine and non-routine jobs refers to whether the job-specific tasks can be performed by following well-defined instructions and procedures. Figure 1 A depicts the classification by Acemoglu and Autor (2011), distinguishing four different occupation groups. For our study, we combined all the lower-paying occupations to compare them with non-routine cognitive occupations as shown in Figure 1 B.

Source: Acemoglu and Autor (2011)

This observation has led researchers to suggest that technological change in the form of automation technology, which is best at substituting routine occupations, is the primary driver of job polarization. A further, somewhat less conclusive hypothesis is that the increase in globalization is a possible cause of job polarization.[6] Indeed, subsequent work has shown how changes in the incentives to adopt automation technologies leads to the substitution of routine workers and mainly benefits non-routine cognitive workers.[2]

Routinization and the way we work

Overall, the share of employment that was concentrated in routine occupations has fallen sharply during the last four decades. Interestingly, job polarization did not happen gradually, but rather was clustered in specific periods. In a study together with Henry Siu, we find that of all the employment losses in routine occupations experienced in the US, almost 90% occurred during recessions.[12] Before the job polarization era, recessionary job losses in routine occupations would quickly rebound after the end of the economic downturn. However, once we entered the job polarization era, these same recessionary losses in routine occupations became permanent, and the routine occupations did not bounce back even once the economy had recovered.

The permanent nature of these routine-employment losses raises the following question: What happens to people who were previously employed in these middle-class jobs? Where do they go?

Consider, for example, a 30-year-old man with a high school diploma back in 1980. Data suggests that such an individual most likely worked in a routine manual occupation and earned a middle-class salary. Fast forward to 2019: What would such an individual's employment prospects be? How likely is it that he would still work in the same type of routine manual occupation? Would he be more likely to work in a lower-paying job? Or would he be more likely to not be working at all?

Finding the answers to these kinds of questions is crucial for understanding the welfare implications of automation, as well as for evaluating policies that are meant to support workers affected by automation. For example, if these types of workers could upgrade their skills and move into better-paying, higher-skilled occupations, addressing the disappearance of routine occupations is probably less urgent, if even necessary. In contrast, if these types of workers drop out of the labor force entirely, the policies governments should consider are different.

Back to our questions – to answer these in a methodical way, we need to first identify what these "routine" characteristics are. Are they related to education attainment? Or perhaps to an individual's age or gender? To formalize the notion of routine characteristics in an agnostic way, one option is to pursue machine-learning techniques. In my research project with Saporta, Siu, and Yedid-Levi, we use computer algorithms to predict how workers would be working in different occupations.[7] As we take data from the past, we can both predict what they could have been doing in the past, and compare this with what they actually did.

Male employment evolution

We use the approach discussed in Figure 1 B and end up having one group consisting of the non-routine cognitive skill set and the other made up of all other occupations (i.e., routine manual, routine cognitive, and non-routine manual).[7] We will refer to the latter as "lower-paying occupations," since they tend to pay wages below those paid to workers in the non-routine cognitive group.

What were the employment outcomes of workers in the 1980s who had charac-

Using machine-learning techniques to identify job market decisions

In our research project on the macroeconomics of automation, my co-authors and I use data from the late 1980s, that is, prior to increasing automation and job polarization, to simulate the individuals' employment and occupational choices over time. We use computer algorithms to search for the best mapping of various combinations of individuals' observed attributes to the observed probability of working in different occupations. With this mapping at hand, **we use algorithms to predict what individuals would have been doing, and then compare this with what they actually did.** We can thus answer what happens to workers with "routine characteristics" during periods characterized by a rise in automation.

It is perhaps useful to clarify this machine-learning, technical approach with the following example. Consider our fictitious 30-year-old man. Assume that back in the 1980s, the only thing that determined this man's occupation was his age. Hence, the algorithm would stipulate that in the 1980s all 30-year-old men worked in routine occupations. The algorithm would then look at 30-year-old men in 2019 and calculate where they currently work. For example, assume that half of the men in that age group still work in routine occupations, but half are doing something else (i.e., not working at all). Then the algorithm would conclude that (a) the probability that 30-year-old men now work in routine occupations has fallen to 50% (while before it was 100%), and that (b) the decisive change is the probability that this type of individual is not working at all.

teristics that made them likely to work in lower-paying occupations? First, consider the employment evolution of men with these routine characteristics. In the eighties, about two-thirds of them were working in routine occupations, 10% were in non-routine manual occupations, and the remaining quarter were either looking for a job (i.e. unemployed) or were simply not participating in the labor force (i.e. neither working nor looking for a job). In other words, for every 100 male workers with these characteristics, around 66 worked in middle-skilled jobs paying middle-class incomes, 11 worked in lower-paying jobs, 17 were outside of the labor force, and the remaining six were looking for a job (see Figure 2).

Fast forward to 2018. What has changed? The first thing to note is that there are simply fewer of these types of individuals in the economy. For example, the algorithm classified almost two-thirds of the male population in 1989 as having the characteristics that mapped them to work in lower-paying occupations. Today, the share of men with these characteristics has fallen to slightly more than half.[ii]

What has happened in the meantime to the half of the workers with characteristics that map them to lower-paying occupations? Consider again 100 workers. Now only 55 would be working in the middle-skilled routine occupations paying middle-class incomes.

Hence, the difference between today and the 1980s is that now there are 11 fewer middle-class workers for every 100 male workers with the relevant characteristics.

So, what happened to those 11 workers? They must be somewhere! Our analysis finds that seven of these 11 workers, on average, have simply dropped out of the labor force – they're neither working nor looking for a job.[7] The remaining four workers are working, albeit in lower-skilled roles; that is, they have moved from routine occupations to non-routine manual occupations. This means the fraction of these types of workers who are either (i) working in high-paying non-routine cognitive occupations (essentially zero) or (ii) unemployed (remained constant) has not changed.

Employment evolution of women

Next, we turn to examine the employment evolution of women. Over the last five decades women's labor force participation rate has increased, which makes the analysis of their occupation dynamics somewhat complicated. As such, it is more informative to analyze the last two decades, when the labor force participation of women stabilized. Indeed, during the last two decades, the same evolution observed within the corresponding group of males was also observed within the group of relevant females. This group of women with characteristics linked to lower-paying occupations is less likely to still be employed in routine occupations; yet, there is no obvious increase in their likelihood of being unemployed or of working in non-routine cognitive occupations. Hence, as with their male counterparts, this group of women was more likely to drop out of the labor force or work in non-routine manual occupations, with a similar split to that observed with the men's group.[iii]

While the machine-learning approach is useful as an agnostic detection device, where the computer alone identifies the relevant routine characteristics, studying how specific demographic groups adjust has also proven fruitful. For example, in my work with Cortes and Siu, we show that the fall in routine manual jobs was primarily observed in young (20–29 years) and prime-aged (30–49 years) men

Fig. 2 **Men in lower-paying occupations**

Note: The figure compares the employment outcomes in 1980 and in 2018 for workers who had characteristics that made them likely to work in lower-paying occupations.

Source: Jaimovich et al. (2019)

The end of men

The current changes in the labor market have negative impacts on many people. However, there are also groups of people who benefit from job polarization. While many middle-income jobs are being cut, there are significantly more well-paying jobs and increased demand for highly skilled workers today. In one of my studies with Cortes and Siu, we analyze the demand for highly skilled workers who perform cognitive tasks in the United States. The demand has increased dramatically over the past four decades, with the biggest change between 1980 and 2000. Our research shows that the two genders did not experience the increase in demand equally: despite rapid growth in employment in high-paying occupations, the probability that a college-educated man was employed in such a job fell, while the prospects for college-educated women improved.

What explains these divergent trends? Research in psychology and neuroscience suggests that women hold a comparative advantage in social skills relative to men. As a result, it is important to understand the relationship between changes in female employment shares within occupations and changes in occupational skill requirements.

We find that a significant fraction of the increase in the share of women in "good jobs" over the last 40 years can be explained by the rising importance of social skills in these jobs as shown in Figure 3 and 4. Evidence based on wage data also indicates a clear increase in the returns to social skills over time and across all jobs. This further supports our hypothesis that the US economy has experienced an overall increase in the demand for these skills during this period.

Further reading: The end of men, UBS Center Policy Briefs series, 2018

with high school diplomas (or below).[8] For routine cognitive jobs, most of the decline was concentrated in young and prime-aged women with intermediate levels of education.

Loss of routine occupations

In summary, the likelihood that workers with "routine" characteristics will work in routine occupations has fallen by about 20% over the last decades. Two changes can explain this drop: first, an increase in the probability of working in non-routine manual occupations, and second, an increase in the probability of not participating in the labor force at all. About one-third of the fall in the probability of working in routine occupations relates to a shift towards more non-routine manual occupations, and two-thirds can be explained with dropping out of the labor force.

Fig. 3 **Social skills and female bias**

Cognitive vs other occupations

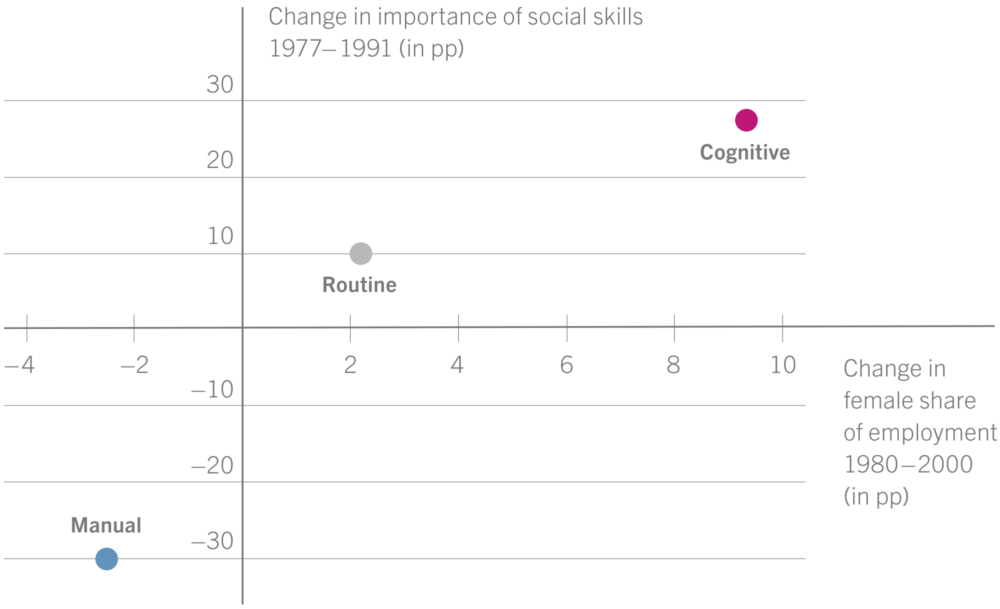
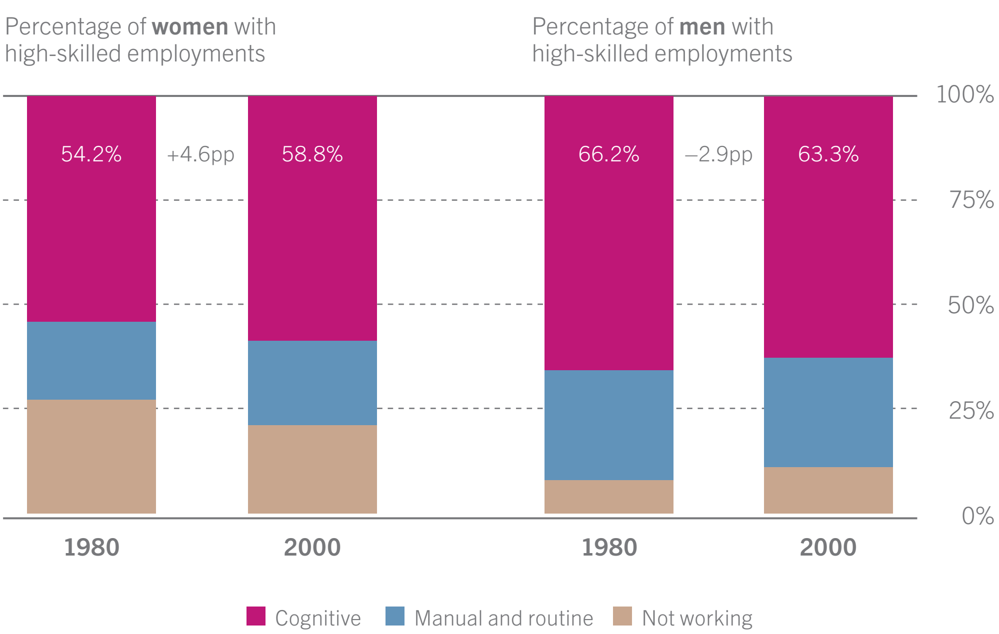


Fig. 4 **Development in relative terms**



Source: Jaimovich (2018), The end of men, UBS Center Policy Briefs series

The price of automation

From a worker's perspective, our research on automation implies that he or she is:
- less likely to work in a routine, middle-skilled job;
- more likely to be out of the labor force;
- or more likely to be working in a less-skilled job.

Or, in other words, the worker is likely to be worse off than before, at least in terms of employment and income.

What can policymakers learn from these empirical findings? Which policies can be effective in combating the decline in routine occupations? What are the implications of implementing these policies? And, finally:

Who will be the "winners" and "losers" if these policies are adopted?

The findings discussed above are informative about detecting empirical patterns. But they do not tell us about the adjustments the economy will potentially undergo if we introduce big policy changes. To answer such questions, we must use a more complex approach and turn to economic and quantitative modeling.

We develop a framework that makes it possible for us to evaluate the outcomes of various policy proposals. The seminal work of Autor, Katz, and Kearney, while not meant to be quantitative, lays the conceptual building blocks of modern theory and enables us to tackle these critical questions.[1]

The basics: labor demand and supply

First, to state perhaps an obvious point, there are different types of workers. Some workers, usually because of lower educational attainment, are only qualified to work in routine or non-routine manual occupations. Others, typically those with higher educational attainment, are qualified to work in non-routine cognitive occupations.

Second, firms' demand for routine workers depends on the wages these workers command and the relative cost of alternative means of production that can substitute these workers (such as automation technology). In this framework, when automation technologies become cheaper, they will be used more. At the same time, demand for routine workers shrinks, and wages will fall.

Figure 5 depicts the logic of this framework in a traditional labor market diagram. Specifically, we depict the amount of routine labor on the x-axis, and the wage of routine workers on the y-axis. The upward blue curve is commonly referred to as "labor supply;" it captures the notion that the higher the wage, the higher the supply that workers are willing to provide. The downward red curve is commonly referred to as "labor demand," as it captures the notion that the higher the wage, the lower firms' demand for workers. The intersection of the two graphs in point A is the equilibrium in the labor market.

At that point, labor supply and labor demand are equal since workers are supplying exactly the amount of labor that firms want to hire.

Fig. 5 **Traditional labor market diagram**

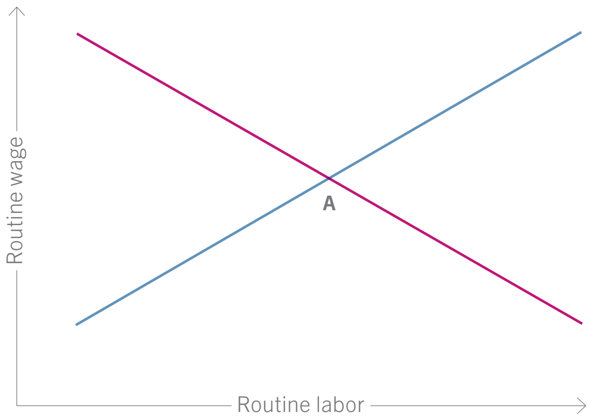
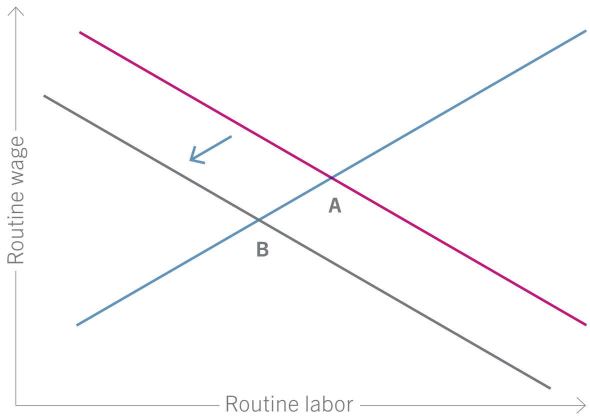


Fig. 6 **The effects of automation on the labor market**



Labor supply — Labor demand

Note: Figure 5 depicts the amount of routine labor on the x-axis and the wage of routine workers on the y-axis. The "labor supply" curve captures the notion that the higher the wage, the higher the supply that workers are willing to provide. The downward "labor demand" curve captures the notion that the higher the wage, the lower firms' demand for workers. The intersection of the two graphs in point A is the equilibrium in the labor market.

Figure 6 depicts the reduction in the demand as a downward parallel shift of the original labor demand (the red curve) to the new black one. The resulting equilibrium is in the new intersection point B, which reflects a fall in routine employment and routine wages relative to the previous equilibrium in point A.

Source: Jaimovich et al. (2019)

The effects of automation on labor demand

Now, consider a firm that has the ability to substitute a worker for some type of automation technology. What effect would it have on the demand for routine workers? Perhaps when the price of installing this automation technology is too high, or its productivity is not high enough given its price, it will have no effect.[v] However, as automation technology's price starts to drop, it becomes more profitable to introduce it. Once installed, this technology completes some of the work that routine workers previously did. The fact that the automation technology can now substitute routine workers reduces the demand for these workers. This reduction is depicted in Figure 6 as a downward parallel shift of the original labor demand (the red curve) to the new black one.

The resulting equilibrium is now in the new intersection point B, which reflects a fall in routine employment and routine wages relative to the previous equilibrium in point A.

This graphical discussion highlights a key question: Has the price of automation technology fallen? In other words, is automation technology, indeed, becoming cheaper? Let us take a step back: to address this question, we must first be able to define what automation technology is, and then make sure "automation technology" is a measurable object.

In line with research by Eden and Gaggl, we focus on automation related to information and communication technologies (ICT).[9] The information and communication technologies are in economic terms "capital," that is, a factor of production that can help produce other goods in the future; we refer to this as ICT capital. Eden and Gaggl show that the price per unit of productivity (for example the dollar amount for a specific computing calculation) of ICT capital has fallen by about 66% during the last 30 years, while its share in the economy has risen immensely. Interestingly, non-ICT types of capital have not experienced such a price reduction, nor have they increased their share in the economy.

Quantitative effects of automation on employment, wages, and welfare

Having laid the conceptual foundation of labor economics and automation in the previous section, we will now analyze how enhanced automation affects employment, wages, and welfare. The quantitative framework discussed below is based on my recent work with Saporta, Siu, and Yedid-Levi; this framework serves as one of the few comprehensive analyses to date.[7]

Occupational choices

To begin with, it is useful to discuss how an individual decides which occupation to pursue. Consider an individual who can work in either a routine or a non-routine manual occupation. The routine occupation could be a secretarial job that involves typewriting, and the non-routine manual occupation could be a janitorial job that requires cleaning rooms. This specific individual is endowed with the ability to work in either occupation. For the secretarial work, the individual can type 1,000 words per hour, while for the janitorial work, the individual can sweep five rooms per hour.

How do these abilities translate into the individual's potential wage for each of the two occupations? In economics, it is common to think about the salary a worker earns as the product of his ability and the price (wage) per one unit of ability. Hence, in the example above, assume there is a wage per one typed word, which we denote W_{word}, and a wage per one swept room, which we denote W_{room}. Then, the worker in our example would earn $1{,}000^*W_{word}$ as a secretary and 5^*W_{room} as a janitor and will naturally choose whichever occupation offers a higher wage.

Note that two factors determine the individual's decision. These are: (i) the worker's endowed ability (i.e., skills) in each occupation, and (ii) the current market wages per one unit of ability. Hence, the higher the wage per one typed word (W_{word}), the more likely the individual is to choose the secretarial job, if abilities and W_{room} do not change.

Figure 7 A depicts this scenario. An individual's ability as a secretary is depicted on the x-axis, while the janitorial skill set is depicted on the y-axis. The diagonal thus represents the ratio of W_{word} to W_{room} (i.e., the wage per one ability unit as a secretary divided by the wage per one ability unit as a janitor). In this figure, all individuals who miraculously have the ratio of abilities that equals W_{room}/W_{word} are indifferent between the two occupations, as they would earn the same salary in both occupations.

However, given the current relative wages per secretarial and janitorial ability unit, all individuals below the diagonal prefer to work as secretaries, while those above the diagonal prefer to work as janitors.

Now, consider Figure 7 B where we add to the mix a third group of people: those who are not in the labor force, but instead receive a fixed income from the government that is independent of their abilities. As is evident in the figure,

Fig. 7 **Quantitative effects of automation on employment and wages**

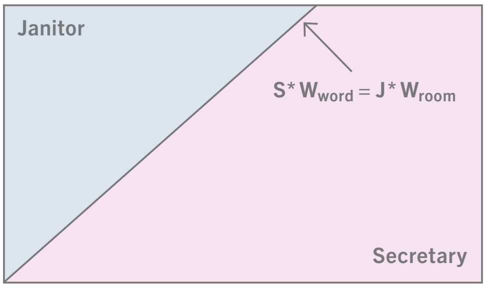


Fig. 7 A

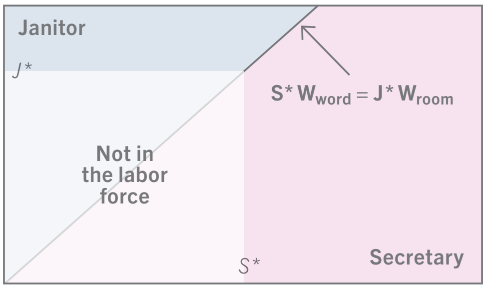


Fig. 7 B

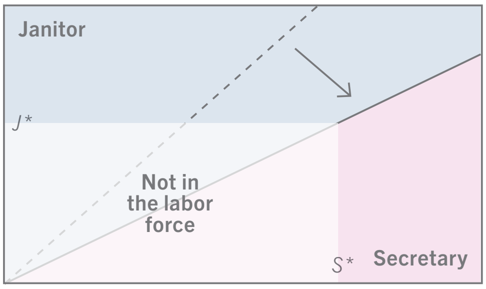


Fig. 7 C

Note: An individual's ability as a secretary is depicted on the x-axis, while janitorial skill set is depicted on the y-axis. The diagonal thus represents the ratio of W_{word} to W_{room}.

Source: Jaimovich et al. (2019)

this group includes individuals whose secretarial and janitorial abilities are below two cutoffs: S* and J*. These are the ability cutoffs below which individuals find themselves better off not working at all, since they would receive a higher transfer from the government than what they could earn in the labor market given their abilities and existing wages per ability.

To summarize, three elements in our scenario determine an individual's occupation and whether he or she participates in the labor market at all: (i) skill set in each of the two occupations, (ii) the wage per ability unit in each occupation, and (iii) the magnitude of the benefits when not participating in the labor force.

Armed with this framework, we can now consider the qualitative effects of automation. As previously discussed, a fall in the price of ICT will result in an increase in the adoption of this form of capital, which substitutes routine workers. This substitution leads to a fall in the demand for routine workers, which manifests itself in Figure 7 C as a fall in the slope (i), since an individual will now be earning a lower salary for the same secretarial ability unit. This would also imply that the vertical line that determined the cutoff for S* will move to the right (ii), meaning that the individuals who previously were indifferent between working as secretaries and remaining outside the labor force will now face a decline in the value of being a secretary. This decline suggests that they will move out of secretarial jobs; yet, whether these individuals move out of the labor force or into a janitorial occupation will depend on whether janitorial occupations benefit from the increase in the adoption of ICT capital.

Moreover, how far the new cutoff is to the right will depend on the degree of substitution between ICT capital and secretaries.

A new quantitative framework

My co-authors Saporta, Siu, Yedid-Levi and I use the logic described above to develop a macroeconomic model that accounts for various empirical observations in the US economy. With this model, we can evaluate the impact of the fall in the price of ICT on the following unknowns:
- the likelihood of working in routine occupations,
- the income distribution in the economy, and
- the welfare impact.[7]

First, we find that our model predicts a fall in the probability of working in routine jobs, which is about half of the observed probability fall in the data. This is in line with the microeconomic empirical results discussed previously regarding the substitution of routine workers by automation technology.

Second, the model predicts that the income shares in the model economy will adjust in a similar way as observed in the data: the share of national income of routine workers falls, while the share of non-routine cognitive workers' income increases, overall leading to a fall in the share of national income that goes to labor. Quantitatively, the model accounts for about half of the income share movements observed in the data.

Finally, regarding welfare, the model economy predicts that the fall in ICT prices increases output by about 10%, but that not all individuals will enjoy this rise in output.

- Those high-skilled individuals working in non-routine cognitive occupations will enjoy the increase in ICT capital because it increases their productivity, resulting in a higher salary. Moreover, these workers tend to hold firm equity whose value increases following the increase in automation.

- Similarly, those workers who used to work in non-routine manual occupations will also enjoy the increase in ICT since it leads to a rise in their salaries.

- However, routine workers will experience a significant drop in their welfare since their salaries will fall given the increased adoption of ICT capital. Some routine workers will now find themselves outside of the labor force, some will move to lower-paying occupations, and some will remain working in routine occupations. All will be worse off than what they were before the ICT capital price fell.

The model therefore suggests overall that a fall in the price of information and communication technologies is one of the main reasons for changes in routine workers' labor force participation, income, and welfare. Moreover, the model's results indicate that the distributional welfare implications are significant. Or, in simple terms:

Our model indicates that if ICT becomes cheaper, fewer people will be in routine jobs, and they will earn less from these jobs.

However, non-routine workers, both in cognitive and manual jobs, will benefit from higher salaries.

Policy evaluation

The model developed with Saporta, Siu, and Yedid-Levi allows us to evaluate the impact of different measures to address this increasing job polarization. We analyze the impact of each measure – or policy – on labor market, output, and income distribution.

The most prominent policies, which we discuss below, include:

i **retraining program:** improve the non-routine manual abilities of those who are outside the labor workforce, and

ii **transfers and redistribution programs:**
  a. increase the unemployment insurance,
  b. introduce a universal basic income program, or
  c. reduce the income taxes levied on those working in lower-paying occupations.

Importantly, as in the real world, new policies and changes to existing policies need to be financed via taxation.

In what follows we discuss each of these programs in detail, including the taxation effects.

Retraining program

In this first analysis, we consider a retraining program: all individuals who are outside of the labor force go through a retraining program that increases their non-routine manual abilities.

The logic behind such a program is as follows: advances in automation technology will further limit the options for routine employment, but also increase the demand for non-routine manual services. As such, it makes more sense to retrain workers to improve their abilities in this latter category, which is complementary to automation technology.

To understand the impact of retraining within the context of the model, consider Figure 7. For simplicity, assume that the prices per secretarial and janitorial task are fixed and do not change following the retraining program. Then, consider an individual who was outside the labor force and will be retrained. If a retraining program enhances that worker's non-routine manual abilities, the value of joining the labor market (i.e., non-routine manual abilities times the price per janitorial task) increases, resulting in an increase in the labor force participation.

We attempt to pinpoint by how much the abilities need to be improved for the labor force participation rate to increase back to its pre-polarization period levels. Once we find the required magnitude, we conclude that such a program would influence the economy in several ways.

First, in our model, the program would raise aggregate output by slightly more than 1%. It would also result in an increase in welfare for many segments of the population, including those who were outside the labor force and received the training benefit from the increased labor opportunities.

Moreover, individuals who previously worked in routine and non-routine cognitive occupations would benefit from this increase in employing non-routine manual workers because the jump in numbers of the latter directly enhances the productivity of the former. Non-routine cognitive workers would also see a reduction in the taxes levied on them since the increase in the number of workers participating in the labor force reduces the magnitude of required government transfers.

At the same time, perhaps surprisingly, some people in the economy would see a reduction in their welfare following the retraining program. Who might these people be? They are the workers who were already working as non-routine manual workers before the initiation of the retraining program.

Following that program, these workers would now face stiffer competition for their services, which would result in falling wages.

Finally, a retraining program like this incurs various costs. That said, as long as these costs amount to less than 30% of GDP per capita, the program – from an aggregate perspective – is welfare-enhancing.

Unemployment insurance benefits

The second program we consider is one where unemployed individuals receive increased transfers. What would the effects of such a policy be?

To better understand the potential impacts of such policies, it might be useful to digress for a moment and dive into the modern theory of unemployment, which we use and build upon in our policy analysis. This theory is based on the Nobel Prize-winning work of Dale Mortensen and Christopher Pissarides, and it departs from the common assumption of competitive labor markets.

In this theory's framework, firms seek to hire workers who produce an output which the firm can sell. If firms are unable to hire an individual, they do not produce and they continue to look for workers. Workers benefit from being matched with a firm because when they work they enjoy a wage that is higher than the income they receive while unemployed. When a firm and a worker meet, they negotiate and bargain over the wage. Naturally, firms prefer to pay workers the lowest possible salary, while workers prefer to earn the highest possible salary. Changes in the economic environment that affect the value of a match between a firm and a worker would, among other things, change wages and the likelihood that an unemployed worker would find a job.

Within this framework, now consider what a change in unemployment benefits does to the bargaining problem between an unemployed individual and the firm. The higher the unemployment benefits, the less worried is an unemployed person about finding a job. In essence, this individual's bargaining position is now stronger since the value of working vis-à-vis remaining unemployed became lower. As a result, if the firm wants to hire the worker it now must pay a higher wage.

What are the implications of such a wage increase from the firm's perspective? The firm now needs to pay higher wages, but the value of output that the worker produces has not changed! This implies that the firm will now face a reduction in the value of having the worker, i.e., lower profits. Such a fall in the profits generated by workers prompts the firm to recruit fewer workers than it did before the change in the unemployment benefits. And recruiting fewer workers naturally increases the unemployment rate. Hence, the increase in the unemployment insurance results in both (i) an increase in the wage workers receive, and (ii) an increase in the unemployment rate.

Yet, such a change to the unemployment insurance system improves the workers' situation in general, and the overall effect of the increased wage more than makes up for the increased unemployment rate. Thus, all workers who were already in the labor force benefit from this policy change.

However, the change in the unemployment insurance has an important additional effect. Since the value of working has increased, some of the workers who were outside the labor force now prefer entering the labor force. The bigger the rise in unemployment insurance, the bigger the fraction of those outside the labor force who now find it optimal to enter the labor force, whether they are immediately matched with new jobs or simply enter the ranks of the unemployed who are actively searching for a job.

Hence, the analysis suggests there is a trade-off for increasing the unemployment insurance policy. The bigger the increase, the higher the number of people entering the labor force. However, that also means that the bigger the increase, the higher the unemployment rate.

From an output perspective, we show that the increase in unemployment cancels almost one-to-one with the increased labor force participation: while overall a larger fraction of the population is either working or looking for a job (i.e., participating in the labor force), fewer people are actually working. Overall, these two effects cancel each other almost fully.

What is the welfare impact of such a policy change? All workers who were not working in non-routine cognitive occupations would be supportive, since, essentially, the change would improve their bargaining position and boost the wages they would receive, making them better off (even at the cost of higher unemployment rates). However, non-routine cognitive workers would perceive their welfare as essentially unchanged. This point might not seem obvious given that more workers participating in the labor force reduces the required taxation levied on non-routine cognitive workers, that is required to fund the transfers. Yet, the fall in the employment of routine and non-routine manual workers leads to a drop in the productivity of non-routine cognitive workers. Overall, welfare-wise, these two effects essentially cancel out.

In short, an increase in unemployment transfers increases both labor force participation and wages for routine and non-routine manual workers, along with an increased unemployment rate for these same workers. Overall, output remains essentially unchanged, and routine and non-routine manual workers see their welfare increasing while non-routine cognitive workers experience no change in their welfare.

Switzerland’s voters were first to reject basic income plan

In 2016, Switzerland was the first country to hold a vote on a proposal to introduce a guaranteed basic income for all. The initiative aimed at introducing a new system by means of a constitutional amendment that would require the Swiss Confederation to provide an unconditional basic income. In this scenario, the federal government would pay a certain amount of money to every person living in Switzerland, regardless of their income and assets. The supporters had suggested a monthly income of 2,500 Swiss francs for adults and 625 Swiss francs for each child. The amounts reflected the high cost of living in Switzerland. The supporters had also argued that since work was increasingly automated, fewer jobs were available for workers.

Although the proposal gathered more than 100,000 signatures and was put to the vote under the Swiss plebiscite system, there was little support among Swiss politicians for the idea and not a single parliamentary party came out in favor. In the end, Swiss voters overwhelmingly rejected the proposal. Results showed that nearly 77% opposed the plan, with only 23% backing it. The obvious reasons were that the initiative did not include any conditions for receiving a basic income and it specified neither the size of the unconditional basic income nor the means of financing it.

Source: The Federal Council. The portal of the Swiss government. (2016)

Universal basic income

The next policy we assess introduces a universal basic income to the economy. This policy mandates that all individuals receive a transfer from the government irrespective of their employment situation.

What are the potential impacts of such a policy? To analyze possible effects, let us first go back to the discussion of what an increase in unemployment insurance does to the bargaining problem of the worker and the firm. When individuals collect a universal basic income, they receive the transfer whether they are employed, unemployed, or even completely outside the labor force. Thus, the worker's bargaining situation will not change as much as it did when the worker was receiving the transfer only when unemployed. Since the bargaining situation will change less, the resulting bargained wage will not change either. And, as a result, the firm will not experience an equally large change in its need to reduce hiring, resulting in almost no change in unemployment.

Overall, we show that the main effect of introducing a universal basic income program is that it significantly reduces labor force participation and leads to a massive fall in output. This happens due to the very large increase in taxation that is levied on non-routine cognitive workers, which is required in order to fund the program. Such an increase in taxation leads to an increase in the distortion in the economy and to a fall in employment of the non-routine cognitive workers. The fall in the labor supply of these workers leads to a dramatic fall in output of almost 10%.

Thus, the universal basic income mainly acts as a redistribution program whereby non-routine cognitive workers endure a massive fall in their welfare, while manual workers – including those who are outside the labor force – enjoy a very big increase in theirs.

Reduction in payroll taxes

The final policy we consider is a change in the tax code involving a reduction in the labor tax rate for routine and non-routine manual workers. Such a reduction increases labor force participation since workers enjoy a higher value in participating and working. This increase in labor force participation increases output in the economy.

Welfare-wise, a reduction in labor taxes leaves the routine and non-routine manual workers better off, as they receive a higher after-tax wage. But what about the non-routine cognitive workers? They sustain a reduction in their income due to the increase in the payroll taxes they pay. This increase is required to make up for the reduction in the taxes collected from the manual workers.

Overview of the effectiveness of different policies

	Retraining	Increase unemployment insurance	Universal basic income	Reduce labor taxes for routine and non-routine manual workers
Aggregate output	Increases a bit +	Unchanged	Falls a lot – –	Increases a bit +
Unemployment	Unchanged	Increases a bit +	Increases a bit +	Unchanged
Labor force participation	Increases ++	Increases ++	Falls a lot – –	Increases ++
Routine workers	Benefit a bit: higher productivity +	Benefit a bit: increase in wages +	Benefit a lot: increase in wages and transfers ++	Benefit a lot: lower taxes ++
Non-routine cognitive workers	Benefit a bit: higher productivity and lower taxes +	Unchanged	Lose a lot: lower productivity and higher taxes – –	Lose a bit: lower productivity and higher taxes –
Non-routine manual workers	Lose: stiffer competition –	Benefit a bit: increase in wages +	Benefit a lot: increase in wages and transfers ++	Benefit a lot: lower taxes ++

Conclusions on how effective the proposed policies are

We have discussed four different government interventions. The three transfer programs (i.e., the increase in unemployment insurance, the universal basic income, and the reduction in labor taxes) increase the welfare of routine and non-routine manual workers and reduce the welfare of non-routine cognitive workers. Reduced labor taxation increases output and labor force participation.

Unemployment insurance, on the other hand, sparks increased labor force participation that is accompanied by a fall in the employment rate and a fall in output. And, finally, a universal basic income results in a fall in both labor force participation and output.

In contrast to the transfer programs, the retraining program is the one that seems to benefit most of the individuals in the economy, increasing both output and labor force participation. However, even an economy that includes workers with enhanced skills is not one that necessarily improves the welfare of all.

Summary

The changes in the labor market that have occurred over the last few decades are most likely here to stay, if not to accelerate. Indeed, the discussion today has turned to how occupations that were previously thought to be immune from automation and digitalization are more likely to experience the same kind of cannibalization by automation technology that has already affected other routine occupations. Perhaps the impact of automation on labor opportunities depends on which of the following two possibilities will prevail. Will job opportunities simply vanish as automation takes over completely, or will automation enable us to specialize in tasks for which we have a comparative advantage, leaving the mundane, routine work to our robot replacements?

In the meantime, this Public Paper has attempted to explore and account for some of the key adjustments that workers with "routine characteristics" have made in response to increased automation in the labor market. In analyzing the potential economic effects of different policies currently under discussion, it becomes clear that – perhaps not surprisingly – there is no single "magic bullet" policy that will make everyone better off. Each policy we evaluated results in winners and losers and implies different consequences for the economy at large.

Further work is required regarding the evaluation of labor market retraining programs and the development of empirically relevant macroeconomic models that can be used for policy analysis.

These efforts are crucial both for helping policymakers evaluate the possible strategies for meeting the challenges which the rise of automation poses, and for safeguarding the ever-shifting future of middle-class labor market opportunities.

Notes

i The discussion in this Public Paper is focused almost solely on the US economy. However (and importantly), job polarization and its effect on routine occupations have been documented in many industrialized economies. See, for example, the work in Goos, Manning, and Salomons (2009) for Europe.[10]

ii This fall is driven mainly by the increased educational attainment observed in US education serving as a strong predictor of which occupation group an individual belongs to (more highly educated individuals are more likely to belong to the non-routine cognitive occupation group).

iii Has this fall in employment in routine occupations occurred because there is a higher probability of routine workers leaving routine occupations (perhaps for other occupations), or because there is a lower probability of these types of workers entering into routine occupations? Cortes, Jaimovich, Nekarda, and Siu (2016) find that most of the reduction in routine employment has come from changes in the entry into routine employment by the unemployed, or by those previously not participating in the labor force.[11]

iv Interestingly, the fall in the labor force participation in these demographic groups accounts for all of the fall in the aggregate labor force participation rate observed in the US over the last three decades.

v Technically, what matters is the price of a unit of automation technology per its productivity. For simplicity, we refer to the price of the automation technology as already encompassing this ratio in this Public Paper.

References

1 Autor, David H., Lawrence F. Katz, and Melissa S. Kearney. 2006. "The Polarization of the U.S. Labor Market." *American Economic Review: Papers & Proceedings 96 (2):189–194.*

2 See for example: Autor, David H. and David Dorn. 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market." *American Economic Review 103 (5):1553–1597.*

3 Goos, Maarten and Alan Manning. 2007. "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain." *Review of Economics and Statistics 89 (1):118–133.*

4 Acemoglu, Daron and David Autor (2011): "Skills, Tasks and Technologies: Implications for Employment and Earnings." *Handbook of Labor Economics, edition 1, vol. 4: 1043–1171.*

5 As established by Autor, David H., Frank Levy, and Richard J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics 118 (4):1279–1333.*

6 Autor, David H., David Dorn, and Gordon H. Hanson. 2015. "Untangling Trade and Technology: Evidence from Local Labour Markets." *Economic Journal 125 (584):621–646.*

7 Jaimovich, Nir, Itay Saporta-Eksten, Henry E. Siu, and Yaniv Yedid-Levi. 2019. "A Tale of Two Workers: The Macroeconomics of Automation." *University of Zurich working paper.*

8 Cortes, Guido Matias, Nir Jaimovich, and Henry E. Siu. 2017. "Disappearing routine jobs: Who, how, and why?" *Journal of Monetary Economics 91:69–87.*

9 Eden, Maya and Paul Gaggl. 2018. "On the welfare implications of automation." *Review of Economic Dynamics 29:15–43.*

10 Goos, Maarten, Alan Manning, and Anna Salomons. 2009. "Job Polarization in Europe." *American Economic Review: Papers & Proceedings 99 (2):58–63.*

11 Cortes, Guido Matias, Nir Jaimovich, Christopher J. Nekarda, and Henry E. Siu. 2016. "The Micro and Macro of Disappearing Routine Jobs: A Flows Approach." *University of British Columbia, working paper.*

12 Jaimovich, Nir, Henry E. Siu. 2020. "Job Polarization and Jobless Recoveries." *Review of Economics and Statistics 102(1): 1–19, forthcoming.*

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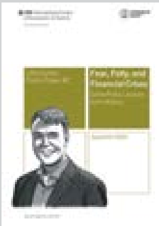

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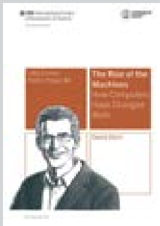

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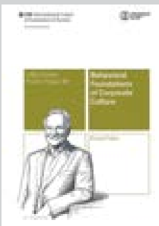

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