Industrial Robot and Manufacturing Employment

—Opportunity or Displacement

Student Name: Zhihan Cai

Student #: 52204310

University of British Columbia

Abstract

The development of the technology creates a structural change in job market. Although there might be a general trend that machinery substitutes for middle-skilled manufacturing jobs, leading to the shift from manufacturing industry to services, there are still some specific middle-skill occupations emerges as a result of robotics, especially the robot-producing and installation in manufacturing industry. This paper use cost-benefit analysis to analyse current situation of job polarization and the reason behind it, involving some economic knowledge like cost graphs and cost-minimizing formula. The further data is about the displacement of production workers and employment of robot technicians with the calculation of the job displacement and creation ratio. Using quantitative methods above, this paper aims to investigate the present situation of job displacement and creation and make the ideas of job polarization and structural change more thoroughly. The result shows the current job displacement largely overtake the effect of job creation, with the most extreme case presents a job displacement in ratio of 17.12 times to creation. Finally, this paper discusses the factors that pose challenges for robots to completely substitute middle-skilled manufacturing occupations and the feasibility of the existing technology. Therefore, although the current job displacement transcends the job creation, challenges faced by industrial robot create new occupations continuously, there are still many unknown factors may affect the job market in the future.

Introduction

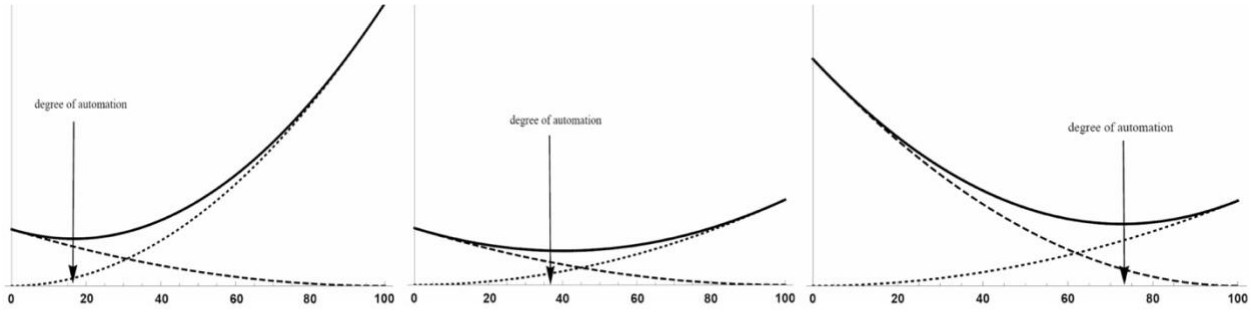
Utilizing information and computer technologies (ICT), industrial robot plays an important role in conducting works that require moderate precision and technics in manufacturing industry, data shows these works tend to be in the middle of the wage distribution. Barany, Zsofia and Siegel (2018) suggest that the development of ICT has led to the higher productivity growth in manufacturing than in low- and high-skilled services, and therefore increases employment and wages in both the low-skilled and the high-skilled service sector—job polarization in the last 50 years (p. 88). Many scholars and researchers believe there is a structural change from manufacturing to services, some thinkers even come up with a view that "robots and other automated systems would conduct the entire assembly operation and humans could be totally eliminated" (Bogue, 2014, p. 305). Nevertheless, they neglect a crucial factor, which is, the emergence of industrial robot also creates new jobs, in particular, robot-producing and installation in manufacturing industries. Therefore, during the time industrial robot substitute for manufacturing occupations, new manufacturing work born. Obviously, this is a knowledge gap. In order to fill this gap, I construct a research question: does job creation overtake the job displacement?

This research question is narrowly-defined enough that can be answered by comparing the data of how much work are displaced by robot and how many new jobs are generated by robot-manufacturing industry or other derived occupations.

After solving this question, I can get a general idea about the effect of derived job of robot on job polarization, to see whether this polarization is possible to be relieved by it. Then I can get a conclusion either deny the idea of structural change or make this idea more comprehensive and considerate using the research results.

Background

"Today, the robot is increasingly able to perform not only manual and routine cognitive tasks but also non-routine manual and cognitive tasks" (Decker, Fischer & Ott, 2017), it largely improves the productivity and efficiency. At the same time, the cost of robot plays an important role within the allocation between labor and machine.



(a) Baseline scenario.

(b) Impact of reduced automation costs (dotted line shifts downwards).

(c) Impact of increasing labor costs (dashed line shifts upwards).

Dashed line – manual production; dotted line – machine production; solid line – semi-automated production;
Source: own presentation based on stylized cost curves.

Figure 1: comparison of the impact of increasing cost in automation and labor on production. Adopted from "Input costs and optimal degree of automation," by Decker, M., Fischer, M., & Ott, I., 2017, *Robotics and Autonomous Systems,87,* 348-354.

The semi-automated production is the combination of labor and machine, the horizontal axis shows the degree of automation from 0% (complete human production) to 100% (complete automation), and the vertical axis means the cost.

The figure uses the cost-benefit analysis to address the optimal point for the allocation of resource. In long run, it can be expressed by the formula: $MP_L / P_L = MP_K / P_K$ (L=labor, K=capital (machine), MP=marginal production (the change in quantity of output when additional unit of production factor is used) and P=price of per labor or machine). The increasing cost means the declining production per dollar, as see in the figure, as the cost of labor factor increase, the marginal production per dollar on labor decrease, so the left hand side of the formula decrease. In order to balance the formula, we should reduce the right hand side, we assume the price of per unit machine (P_K) in the short run will not change, so we should reduce MP_K, according to law of diminishing marginal production (the MP_K will decrease as more machine are used, the same for MP_L), we should use more machine and less labour, vice versa. Therefore, the figure shows an increasing usage of machine when the cost of labor increase and the cost of machine decrease.

In fact, it is the reason why more and more robots are used in production. As the robot has higher efficiency, it has higher MP than labor, as several low-cost robots invented, the price go down. It causes $MP_L / P_L < MP_K / P_K$, in order to minimize the cost, we should balance the equation, which means we should increase MP_L and lower MP_K, so there is a shift from usage of labor to machine.

According to the knowledge above, the high efficiency and low cost of the robot are main reasons for the displacement of labor by industrial robot.

Although industrial robot can do almost all jobs human do, how does a robot being produced? The answer is obvious, there is a demand of human workers who can proceed the manufacturing of industrial robot, maybe we can use robot to produce robot, but it also requires a premise that large amount of robot has been produced, and as more and more industrial robot substitute for labor, the demand for robot-manufacturing increase, the increase in demand will cause the increase

in employment and wage, and the job polarization would be relieved. Does this phenomenon possible to happen?

Here comes to the analysis part about the rate of substitution and job creation.

Analysis

Although the rapid introduction of programmable machinery led to large scale displacement of workers, some economists come up with an idea about “direct job creation”, which is the job generated by robot manufacturing, direct suppliers to robot manufacturers, robot systems engineering, and robot users (maintenance) (Howell, 1985, p. 297-298).

Does the job creation overweight the job displacement? The following table gives us some research information.

Aggregate Results

Source of employment effects	Scenario A: 1. low use		Scenario B: 2. intermediate use		Scenario C: 3. high use	
	A1: no imports	A2: imports 40% of mkt.	B1: no imports	B2: imports 40% of mkt.	C1: no imports	C2: imports 40% of mkt.
Use						
1. Displacement of production workers	−215,605	−215,605	−389,093	−389,093	−855,436	−855,436
2. Employment of robot technicians	23,956	23,956	43,210	43,210	95,083	95,083
Production						
3. Net direct employment creation	7,375	4,424	17,110	10,270	20,060	12,030
4. Net indirect employment creation	16,674	10,152	39,573	24,199	48,693	29,933
5. Net impact	−167,600	−177,073	−289,200	−311,414	−691,600	−718,390

Figure 2: Table of job creation and job displacement. Adapted from "Aggregate Results," by Howell, D. R., 1985, *Technological Forecasting and Social Change,28*(4), 297-310.

No signs indicates a gain in employment and a "-" sign means the displacement of workers. According to the table, we see that the job creation indeed offset some displacement, but whenever which scenario is used (low use, intermediate use or high use of robot), as rows 1 and 2 shows, the employment workers is not large enough compare with the job displacememt, industrial robot lead to the unemployment to many workers. And the data in rows 3 and 4 indicates the net direct and indirect job creation. First, we look at the first situation, which is the first column, in which there is a low diffusion of robot and no purchases of robot from foreign countries. In this case, robots are utilized in the lowest rate, which means the human workers should take an advantage. However, it still reach a net loss of 167,600 jobs, which is much more than the sum of direct and in dtrect job creation (7,375+16,674=24,049). The ratio of job displacement to job creation is 167,600 / 24,049 = 6.97. Therefore the job displacement in this case overtake the job creation. In the cases where foreign robots are imported but still low use of robot (column 2), it can be deduced that net

employment creation will decrease because with import, the domestic robot-manufacturing industry will shrink and the ratio will become larger, with 177,073 / (4,424+10,152)=12.1 for column 2. For rest of the columns, the ratio of displacement to creation is 5.10, 9.03,10.06 and 17.12.

Therefore, the result shows that the job displacement largely exceeds the job creation, therefore, the effect of derived job of robot just relieve the job polarization to some extent, but it cannot be totally offset.

Method

A quantitative method is used here to show the ratio of job displacement and creation. Firstly, I use the cost curve and the cost minimazing formula: $MP_L / P_L = MP_K / P_K$ to illustrate the reason and current situation of job polarization. Then I reference the data concerning net job gain and loss and caculate the ratio of job displacement to job creation. These data shows that the job creation does not overtake the job displacement. Therefore, the job polarization does exist and just be relieved a little by job creation.

Conclusion

The rapid development in robotics lead to both job displacement and job creation, with job displacement largely transcend the effect of job creation. It is true that there is a job polarization and the structural change in modern society in developed country.

However, there are also some challenges face by industrial robot in different fields. For example, because of the high level of hygiene and safety required in food industry, with the direct contact with food, robots represent a real disadvantage due to the material properties of robot and the changing environmental conditions during manufacturing process. (Khan, Khalid & Iqbal, 2018, p. 17-18) For instance, some industrial robots are made by material containing plastics and composites, plastic can improve speed and efficiency during production, but it will cause problem for food safety. (Moreno Masey, Gray, Dodd & Caldwell, 2010, p. 513), this is common sense that plastic is toxic under high temperature, while the manufacturing process is quite complex with a big change of temperature. To solve this problem, a new job of safety supervise is needed. Specifically, 'wash-down robots' are equipped with IP65 compliant hygiene cover which can be washed and changed easily (Khan *et al,*. 2018, p. 17-18).

Consequently, with the further development of robotics, more and more challenges will be met. Although job displacement largely transcends the job creation currently, to enter into a robot era, lots of works still need to do, new middle-skilled jobs will derive continuously, it cannot be ensured that structural change will be further proceed. In addition, with an international perspective, many countries still have manufacturing industry as their main industry, such as China, even some countries' main industry is still agriculture.

In conclusion, it is still difficult to realize the structural change in a world perspective. Although the job polarization and structural change does exist and the job displacement does transcend the job creation, it is still challenging to predict the variable factors and tendency in the future.

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