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Computer technology and probable job destructions in Japan: An evaluation☆

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ABSTRACT

Computer technology is currently experiencing important developments by generating new tools and methods with increasing capacities. This suggests that a growing share of economic tasks could be performed by this new capital at the expense of labor. This paper evaluates the risk of job destructions induced by computer technology in Japan. We aim at assessing the vulnerability of employment from a technical point of view by considering jobs' differential dotation in non-programmable skills. Relying on machine learning technique, we find evidence that approximatively 55% of jobs are susceptible to be carried by computer capital in the next years. We also show that there is no significant difference on the basis of gender. On the contrary, non-regular jobs (those that concern temporary and part-time workers) are more vulnerable to computer technology diffusion than the others. These findings, based on technical background, shed light on the scale of the potential capital/labor substitution but this dynamics will also depends on economic and social factors.

1. Introduction

In recent years, an important dissemination of computer and communication technologies has been observed in Japan and in other industrialized countries. This diffusion in economic activities is a broad and international movement with country specific timeline. According to Murata (2010), this process begins in Japan in the 1950s via the acquisition of a US computer (Bendix G-15) by the *Railway Technical Research Institute* (1957) and continued through the 1960s by the introduction of second and third generation of computers.[1] These machines which were both imported and produced locally, were progressively dedicated to special purpose terminals in manufacturing, distributions and financial industries in the 1970s. During the 1980s, Japan undergone a massive development of office automation benefiting from the invention of Personal Computer (PC) and other specific programs such spreadsheets or word processors.[2] The spread of computers has continued until now and they are used every day in a large range of economic activities. In parallel, technical advance and deregulation policies have caused the emergence of networks supported by computer infrastructure. This concerns the use of the fax machine in the 1980s and above all the development of the Internet and mobile phone in the 1990s and 2000s. Networks have hugely modified the modalities of communication and reduced their costs. The actual situation is characterized by a massive access to these networks: 90% of Japanese people have an access to Internet and the ownership rate of mobile phone is equal to 120% (International Telecommunication Union, 2015).

Another aspect of the actual technological diffusion is the massive development of robotics that can be viewed as a component of the computer revolution (Spong et al., 2012).[3] In this field, Japan is a key country both in terms of production and use to the point that it was labelled as "robot kingdom" (Schodt, 1988). Indeed, Japan has a long and fruitful history in this matter which began in the 1960s by the introduction of industrial robots dedicated to welding, assembling or painting, followed by the first mobile robots used in inspection, transport or spatial tasks in the 1980s (Kumaresan and Miyazaki, 1999). Production and use of robots continue at a large scale and were extended through the development of micro-robots and services robots. Illustrations of this trend

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[1] The second generation of computers is characterized by the introduction of transistors and the third by the use of integrated circuits.

[2] The first PC produced in Japan was the NEC PC 8001 (1979).

[3] They argue that "The key element in the above definition is the reprogrammability of robots. It is the computer brain that gives the robot its utility and adaptability. The so-called robotics revolution is, in fact, part of the larger computer revolution".

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are the actual efforts in the humanoid robotic field initiated by researchers of Waseda University who created *Wabot 1* (1973) as well as other famous examples as *ASIMO* (Honda), *Wakamaru* (Mitsubishi), or *Pepper* (Aldebaran Robotics and Softbank). Data also show the importance of robotics diffusion in Japan. In 2013, this country has the second highest robot density in the world (323 units per 10,000 workers) behind the Republic of Korea and has the most important robot density in the automotive industry with 1520 industrial robots per 10,000 employees (International Federation of Robotics, 2014).[4]

All these digital devices share a common theoretical and technical background based on binary logic and basic electronic components such as transistor or microprocessor.[5] Many scholars suggest that this set is not a simple group of incremental innovations but constitute a "Technological Revolution" or a "technological-discontinuity" (Brynjolfsson and McAfee, 2011) able to "transform profoundly the rest of the economy" and produce a "new economic paradigm" (Perez, 2009).

Indeed, efforts of characterization of technologies in the literature suggest that innovations or interrelated cluster of innovations are not comparable in their scale and their degree. In this perspective, ICT can be viewed as a major technological set susceptible to produce large-scale impacts. In support of this vision, the literature on "General Purpose Technology" (GPT) (Bresnahan and Trajtenberg, 1995; Rosenberg and Trajtenberg, 2004) supposes that the most important technologies share the feature of generality. This crucial point was anticipated by Simon (1987) which stress that the higher is the level of generality of a technology, the higher is its potential because there is a very important number of possible applications. In the case of computer technology, the degree of generality is very high because all economic activities include information processing tasks.

This view is reinforced by the actual process of digitization of human activities which makes the amount of information available more and more important ("Big Data"). Furthermore, digitization is coupled with an impressive improvement of ICT capacities in information processing as well as in terms of transmission, storage and transformation of information (Nordhaus, 2007; Nagy et al., 2011; Koomey et al., 2010). Thus, it supposes that the field of application of computer technology is growing, a characteristic that could have notable effects on many economic matters. Among the possible consequences of ICT adoption, an important aspect is its potential destabilizing impact on employment. Indeed, labor activities do not escape this trend of digitization: in production activities, there are many tasks consisting of manipulation of information but also that some other tasks can be modeled as information flows. For example, accounting calculations is a task which consists of transferring, stocking and transforming information. On the other hand, some physical activities such as assembly, construction, transport can also be represented as information. Material elements, the space in which they are situated, and movements can be defined as mathematical objects. From this perspective, these tasks are susceptible of being carried out by robots within computer programs representing physical objects, environment and motions in information way.

Indeed, in addition to digitization and growing computing capacity processes, significant efforts have been made in computer science as in machine learning to improve data processing. We could point the example of "deep learning" which made possible breakthroughs in many fields such as image and speech recognition or natural language understanding (LeCun et al., 2015). A spectacular example of this improvement is the victory of AlphaGo program designed by Google-Deepmind over the Go master Lee Sedol in March 2016. These news techniques constitute a major qualitative leap opening new economics applications.

At the same time, there are important developments in robotics that benefit from the machine learning advances. We refer, for instance, to mobile robots in use or at an advanced stage of development. The best known example is the autonomous car currently developed by many firms such as Toyota or Mercedes-Benz. Several firms also work on autonomous trucks (see European Truck Platooning Challenge[6]) while many drones are designed for observation, security, delivery (Rakuten, Amazon, DHL...) or military applications. We also note the apparition of industrial and service machines such as warehouse robots, cleaning robots, gardening robots...This new generation of information technologies strongly proposes capacities and application fields very extended with large number of economic applications. This is the scale of the potential of this new wave which makes the issue of automation particularly important.

With this in mind, it could be expected that a large number of tasks in a wide variety of fields could be given over to computers now and in the near future. This perspective constitutes a biggest challenge for modern economies. Acknowledging the importance of this topic, our aim in this paper is to investigate the risk of job destructions in Japan due to computer technology.

The perspective from which a growing share of tasks will be performed by computer capital has strong implications for several Japanese specific economic questions especially those pertaining to the labor market. Among these issues, we can mention the ageing process sustained by gains in longevity, while life expectancy is already one the highest in the world, and low immigration flows. Even if this process concerns several countries in Europe (Germany, France) or in Asia (Korea, China), it is important to stress that "Japan has the most rapidly aging population in the world" (IMF, 2013). On the supply side of the labor market, significant consequences of this evolution are the massive reduction of the overall labor-force, or a dependency ratio reduction in the coming years and decades. A possible response face to this scenario is to call to the technological solution. Growth of ICT capital stock could contribute to maintain the level of production and to help in the care of elderly people. On the demand side, we note that the Japanese labor market has experienced the introduction of more flexibility from the 1980s. This situation originates in the labor law reform in a context of asset-inflated bubble economy collapse (Asao, 2011). The system characterized by job rigidity and wage flexibility (shūshinkoyō) has progressively left space for a growing number of non regular jobs which represent roughly twenty millions people (Statistics Bureau, 2015). It is important to underline that if computer technology will replace workforce, it could do it differently according to the type of employment. Indeed, it is possible that computer technology destroys more easily non-regular employment either because dismissals are facilitated by legal disposition or because computer technology realizes rather tasks typically carried by non-regular workers. Inversely, if computer and communication tools threaten regular jobs, we can expect that the share of non-regular workers in overall active population increases significantly, thus profoundly affecting the structure of Japanese workforce. We also note that the computer revolution could have notable effects on other questions such as the participation of women in the workplace or could significantly modify the "return to education".

[4] Moreover, Japan not only employs robots but is a major producer with 127,491 robots produced in 2014 of which 98,882 were exported (Japan Robotics Association, 2015).

[5] For this reason, we consider the following expressions as synonym: "computer technology", "computer and communication technologies", "Information Technology (IT)", "Information and Communication Technologies" (ICT).

[6] https://www.eutruckplatooning.com/default.aspx