Artificial intelligence, digital transformation and on-the-job training: Measuring the macroeconomic impacts

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Long Summary

Vocational training is a key issue for our economies: an aging population leads to the opportunity of working longer, and creative-destruction due to innovation generates a polarization of the labor force with the disappearance of middle-class jobs compared to those at the bottom, requiring few skills, and those at the top, requiring greater skill levels. Considering individuals, unemployment deteriorates living conditions if they cannot improve their skills. It is thus crucial to reform vocational education across the working life, particularly in France where vocational training is not very efficient. Only 36% of adults are involved into vocational training each year compared to 53% in Germany and 56% in the UK (OECD). Moreover, the unskilled and the elderly working population do not benefit from vocational training whereas they both face the highest probability to be unemployed (Domingues Dos Santos et Pelletan, 2015). This paper proposes a vocational training programme to offset the skills obsolescence due to the spread of Artificial Intelligence (AI) and digital transformation.

How artificial intelligence and digital transformation may impact employment? It is not easy to evaluate the number of jobs potentially impacted. A first approach consists in evaluating automation perspectives by profession (Frey and Osborne, 2017). Using French data and the method proposed by these researchers, consulting firm Roland Berger (2014) estimates that 42% of jobs would be highly automated, and therefore threatened in industry and the tertiary sector in France. However, two limitations can be seen in this approach: (i) jobs identified as threatened by automation often have many tasks that are difficult to automate (Arntz, Gregory
and Zierahn, 2016); (ii) not all persons in the same profession perform exactly the same duties. Therefore, we can seek to assess the risk of automation at a more detailed level, the task. As part of this approach, Arntz et al. (2016) estimate that "only" 9% of jobs in France have a high probability (greater than 70%) to be automated. If historically the tasks most affected by the rise of the digital transformation have been manual tasks, today it is the repetitive or non-repetitive characteristic that distinguishes the tasks threatened or preserved, whatever their skill level.

Some tasks and individual profiles will be complementary to new forms of production, others substitutable, which may make it difficult to conclude on the impact of automation - especially Artificial Intelligence - upon employment (Rodrik, 2016). These tasks correspond to two forms of human capital that can be distinguished and that one can think of complementarity or substitutability with the machine (DeCanio, 2016).

The aim of this article is to propose a lifelong learning system allowing to convert a “substitutable” human capital into a human capital “complementary” to technological innovation. The overhaul of our lifelong learning system can thus lead to improved productivity and retention. Indeed, productivity - individual and collective - comes from both forms of human capital and the transfer from one to the other makes it possible to maintain a satisfactory level of productivity in a context of digital transition. It is also a question of assessing the macroeconomic impact of such a continuous training system on productivity and growth.

A first study by (Chusseau et Pelletan, 2018) was based on a model allowing to measure the impact for an individual and the society of a free-access to a full-time retraining programme (6 months or a year) during her working life for the population knowing a skill obsolescence due to technological change. Whatever the type of funding and under conservative assumptions, a full-time six-month full-time training for 10% of the population would bring long-term gains in production of 2.48%, or about $ 62 billion. Euros.

This paper proposes to evaluate the impact for an individual and the economy of an access to a retraining programme in the context of digital transformation. We compare this situation to a standard schooling situation without vocational training and technological innovation.

We build an overlapping generation model in which individuals face a per unit of time probability of dying which is constant throughout life. The dynamic accumulation of human capital is made through standard education (no vocational training). We consider two different
population endowed with two types of human capital: a human capital corresponding to routine tasks which are substitutable for innovation, and a human capital which is complementary. Individuals are endowed with one unit of time and receive utility only from consumption. They invest in education at the beginning of their lives, then work. Their wages depend on their human capital, which is given by a standard function of schooling. There is no education cost except the foregone earnings. Each individual maximizes her intertemporal consumption which is financed by her intertemporal income (income due to the amount of assets possessed and to the level of human capital). The individual chooses the optimal schooling time during which she will accumulate human capital before entering the labour market (no vocational education), by maximizing the initial level of consumption. We assume the appearance of a technological shock, and both populations undergo digital transformation. The one whose human capital is substitutable will know a skill obsolescence, whereas the other population will see an increase in its productivity. Individuals can decide to retrain or not. The retraining programme consists in converting “substitutable” human capital for new forms of automation into human capital “complementary” to these evolutions. By solving the model, we are able to calculate the aggregate human capital, the aggregate capital stock and the aggregate consumption. We can thus calculate the aggregate production from a Cobb-Douglas production function.

We simulate two scenarii which will be compared in the long-run and correspond to stationary equilibria:
- individuals have no access to vocational education and their human capital is fully determined by the length of standard schooling even after the technological shock;
- individuals endowed with substitutable human capital are able to pursue vocational training to offset the depreciation of their human capital due to the spread of AI and digital transformation. They optimally choose the length of this programme. The human capital function for vocational training is assumed to have the same properties as the function for standard education.

The first results of our simulations show a positive impact upon production. We need to run a parameter sensitivity analysis of the model by simulating different scenarii using different shares of the population that can be retrained, and different returns to schooling.

**Keywords.** Education, Vocational training, OLG model, Calibration
JEL Classification. I21 / I26 / O11/O40

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