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University of Campania Luigi Vanvitelli and IZA

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

New Education Models for the Workforce of the Future*

This paper addresses the directions to follow when designing new educational systems and school-to-work transition regimes to adhere to the needs of Industry 4.0. Although a high level of general education will be important for its training content to develop adaptability, it is not the only component to develop. What will be more and more important are work related skills, both the general ones and the ones which are job-specific and need, therefore, on-the-job training to develop. This will require important educational reforms to favour an ever-better integration between educational institution and the world of work. Young people and their families alone will not be able to adapt on their own to the new human capital requirements of Industry 4.0 production. A new framework for an integrated action by governments, firms, educational institutions and families is needed to smooth the school-to-work transition in the future. The duality principle is the basis for a strong diversification of the supply of education.

JEL Classification: J24, L16, O15, O33, Q2, Q55

Keywords: Industry 4.0, robotics, sequential versus dual education systems, human resources management and policy

Corresponding author:
Francesco Pastore
Department of Economics
University of Campania Luigi Vanvitelli
Corso Gran Priorato di Malta
I-81043, Capua (Caserta)
Italy
E-mail: francesco.pastore@unicampania.it

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Introduction

The 4° industrial revolution, which is still ongoing, is a multifaceted process involving a number of concurring processes of innovation in the fields of robotics, artificial intelligence, renewable energy sources, digitalization of production and consumption patterns and so on. These changes are and will continue to be pervasive in every field of production and consumption.

The consequences on labor markets are already important, but are going to be even more important than they are now. A large number of existing jobs will be destroyed, Robots are substituting labor in an increasing number of jobs, not only the most repetitive ones, but also the creative ones. Just to give an example: drivers of cars, trucks and planes are going to disappear to a large extent. Other examples include: telemarketers, tax preparers, sports referees, fast-food cooks, including pizza chefs, long term care givers, jobs as tutors of kids, even surgical doctors. The main novelty of recent robotics and artificial intelligence is that some robots are learning skills from humans. One example is RoDyMan who has learned activities considered to be the result of human creativity and destress, such as making pizza: it is the robot who has become a pizza chef.

At the same time new products, new consumption patterns and therefore new jobs are going to appear. At the moment it is impossible to say the number of new jobs that will be created and the field in which they will be created. We can try to guess from the skills that are more under challenges also those which will be still on demand, whatever the job that will be created.

Our educated guess is that the jobs which will survive and even develop will be those applying creativity to production and consumption. It means that they are job that will need to embody a higher and higher level of human capital. Human capital is not only general education, but also work-related skills, including the general ones and the job specific ones.

The overall number of jobs which will be destroyed and that of the jobs which will be created should equalize in the long run, although we don't know when the long run will come. Much will depend on the ability of educational systems to develop the right skills in the shortest possible time. Education policy is therefore at the heart of the ongoing process of structural change.

In order to ease the process of human capital formation and in particular of the formation of work related skills educational systems should implement on a scale which was never attempted before the dual education principle, in substitution of the sequential principle. The dual education principle involves that work-related skills should be developed together with general education, rather than after completing education. It requires that the mission of education systems should be the generation of human capital, rather than education only.

The focus of this policy paper is on education policy, but the government must play a role also in other forms, such as the provision of public infrastructure which might solve some market failures and at the same time favor the implementation of investment and innovation in the economy. Incentive for firms in specific sectors might also favor the acceleration of structural change and therefore the creation of new jobs which should reduce the unemployment rate. The state should also provide a completely new labor regulation to define under the new context the new forms of organization of labor and the new rights of laborers.

This paper is structured as follows. Section one summarizes the main features of the industrial revolution. Section two will underline the main directions of labor market change

trying to work out the main skills in need. Section three studies the role of firms, by distinguishing what firms will likely do and what they will likely have to do. Section four summarizes the main types of governmental intervention which are needed. Section five will focus on the industrial policy direction, the guideline for the new legislation and the new education policy. Some summary remarks follow.

1. The 4th industrial revolution

The economy has gone through a number of dramatic processes of structural change in the organization of production. The main steps are as follows:

- Merchant capitalism
- 1st industrial revolution (1784-1870)
- 2nd industrial revolution (1870-1969)
- 3rd industrial revolution (1870-1969)
- 4th industrial revolution (2000)

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Merchant capitalism. A merchant paid very skilled self-employed artisans piecewise. The more they worked and produced with their own production means the more they were able to sell and earn. These artisans were the owner of the product of their work to use the words of Karl Marx.

1st industrial revolution: Industrial capitalism. Mechanical productions were able to substitute the traditional one-man textile machines. Production was organized around complex machines, often in the textile sector, which represented the most important manufacturing sector. Many less skilled manual workers were involved in the production. A process of deskilling of the labor force from artisans to laborers took place. Alienation was the name used by Marx to descrive the loss of control overt the product of their labor of these workers who ware paid a fixed wage rate based on a given number of hours worked within the factory.

2nd industrial revolution: Mass production and automation of production. Mass production was possible thanks to a dramatic automation of the production process. The production chain was such to use less and less skilled manual workers who were paid much less than earlier. However, this allowed for a dramatic increase in productivity and reduction in the costs of production, which favored the reduction of prices on the market and easier access to a large pattern of consumption goods also to the so-called middle class of blue and white collar workers, employed in the development of executive tasks in the large firms.

3rd industrial revolution: Almost full automation of manual work, ICTs and increased demand for skilled labor, fossils fuel energy. This industrial revolution implied a deepening of the previous processes of automation and, at the same time, the diffusion of new technologies in the field of Information and telecommunication. The overall process has neem sometimes named skill-biased technical change. It favored the polarization of workers between a lsmall number of very skilled intellectual workers and an ever-increasing number of unskilled manual and executive white-collar workers. This led to increasing wage inequality by skill.

4th industrial revolution. It implies: clean and renewable energy, completion of digitalization in consumption and production, extreme diversification of productions with possible extreme customization of consumption, robotization of many jobs especially within firms, but also in outside economic activities, some also requiring creativity and job specific competences for the first time. 3-D printers are likely to further develop the process of innovation.

Artificial intelligence is expected to be pervasive not only within manufacturing, but also in the service industry. Examples of famous robots include the following. Sophia is a robot designed to serve in healthcare, education, customer services. Designed to look very human-like. Sophia is capable of natural-face expression, understands speech, understand expression…. In the future, she hopes to go to school, study, make art, start a business…but she is not considered a legal person and cannot do that…YET. She is already famous, having been featured on the first page of the popular magazine *Cosmopolitan*.

RoDyMan is the robot who has become a pizza chef… robot start doing jobs which were supposed to be creative and therefore not reproducible by robots. In fact, RoDyMan can learn from observation of real workers. It memorizes the movements of pizza chefs by making the latter dress a special apron from which it is able to learn the movements to do to make pizza. It can reduce the cost of pizza and free money for other consumption goods

Da Vinci is a robot who has become a surgeon and can make operations that no human can make with the same level of precision. Ipal is a robot specialized in playing with children and helping them make exercises and homework from the university, Other robots take care of the elderly. Self-driving cars already go without a driver, although experimentation is still on-going. Similar robots will drive trucks, aircrafts and other transportation means.

Like any other very important persons, all these robots have dozens of pages on the YouTube and other online repositories which are easy to find.

Globalization is an important part of industry 4.0. Economies are ever more integrated and will continue to be such. Globalization is per se an important engine of change: first of all, it drives the diffusion of skill biased technical change, meaning a technical change which is using an ever more increasing share of skilled labor as a way to face international competition. Moreover, it contributes to make very unstable any economic activity.

2. Diffusion of the new technologies

Information on the diffusion of new technologies is still partial and incomplete. New statistical sources will need to be defined and data collected more systematically, but we already have a vivid picture of the main features of the phenomenon. For space constraints we will only mention a few indicators.

Let look first at robots. There is a wide cross-country variation in the use of robots. The average number of robots per 10,000 employees in manufacturing was 137 worldwide in 2016. There is a large variation, though, with South Korea driving the race at 631 (a factor of 4.6). Singapore follows at 488; Germany and Japan at about 300.

In 2016, a total of over 294,000 new robots were installed: + 16% with respect to the previous year and more than 250% with respect to 2007, only 10 years ago. With this growth rate in mind, the number of robots will increase dramatically in the coming years.

If we look at the stock of robots by continent, South East Asia is leading the game. The EU is following at a distance. North-America is lagging behind. Astralia and Asia are still close to zero.

However, these numbers refer essentially to the use of artificial intelligence within manufacturing where it is already widespread. More dramatic changes will happen in services and consumption in the coming years.

Moreover, the biggest changes are already taking place in consumption patterns and style, with online shopping becoming more and more widespread at the cost of traditional retail trade, which is disappearing, and, more recently, also of shopping within malls.

3. Effects on employment and skills

The new technologies will dramatically diminish the labor requirement of the production of the old goods and commodities which will survive to the evolution of consumption patterns. This would in principle cause unemployment, but fortunately the reduction of production costs and the availability of new technologies and needs will allow the production of new consumption goods and new businesses which will generate new jobs.

Among the jobs more at risk of disappearance or just of dramatic changes are: telemarketers, tax preparers, sports referees, fast-food cooks, including pizza chefs, drivers of cars, pilots of aircrafts, long term care givers, tutor kids jobs, surgical doctors and so on. As it is apparent, not only executive jobs implying repetitive tasks are challenged, but also jobs requiring some creativity or dexterity.

The more at-risk jobs include the following. Jobs that are on some level routine, repetitive and predictable, but also some creative jobs. Only jobs that require a great deal of creativity and also job-specific competences will not be reproducible. Genuine creativity, such as being an artist, being a scientist, developing a new business strategy. Occupations that involve building complex relationships with people: nurses, for example, or a business role that requires you to build close relationships with clients. Jobs that are highly unpredictable – for example, if you're a plumber who is called out to emergencies in different locations.

To sum up, the likely consequences will be: a) the reduction of the labor requirements of all productions; b) an increasing instability of labor to face the ever increasing volatility of any economic activity; c) Changing the nature itself of work, with a reduction of the share of life-time jobs; an increasing share of self-employment and liberal professions; and an increasing share of entrepreneurs. Self-employment and entrepreneurship jobs will become more and more common with a revival of old forecasts of neoclassical economists who were thinking about the evolution of perfect competition.

The social structure will also dramatically change. Let us take the digitalization of consumption as an example. It involves, reduced size of blue and white collar jobs because of the automation of production and digitalization of consumption and distribution of goods; the re-emergence of low skill precarious jobs, including jobs which involve piecewise payment methods which had disappeared after the end of merchant capitalism; the emergence of dramatic unprecedented income inequality between billionaires and low wage, low skill workers; emergence of a small middle class of innovators, technicians and of entrepreneurs.

Will there be enough aggregate demand or unemployment will grow indefinitely? A very interesting paper by Vivarelli (2018) provides an answer to this question by surveying the theoretical literature. The classical view of economists on this matter is based on what is

sometimes called Nickell (1997) principle of the irrelevance of technical change for labor markets in the long run, which is based on the observation of the unemployment rate over a sufficiently long-time span. Technological unemployment is increasing in some periods of exceptional diffusion of new technologies, especially those more frequently labor saving. Several previous technologies were also labor saving, but although millions jobs went lost, even more jobs have been created. The overall impact will depends on an algebraic sum of opposite effects. If the reduction in wage employment and the labor share of GDP will be lower, higher or equal to the increase in professional jobs and incomes. Much will depend on whether the reduction in labor cost and ensuing increase in productivity will make enough new products and businesses possible. If we look at the unemployment rate over the last 150 years, we can see that it has increased at the beginning of the industrial revolution to reduce again later. The prediction of an ever increasing unemployment rate has always proven to be wrong.

4. The role of firms

Firms are expected to behave in the traditional way, because their aim will remain that of profit maximizing. They will have to implement a (labor) cost reducing strategy to face ever increasing competition from global markets and volatility of any business activity due to globalization. They will also continue to substitute labor with machines wherever possible to become as flexible as possible to face the necessary changes and the increasing globalization. As a consequence, firms will continue to reduce the share of permanent employment in favor of temporary employment for more standard tasks and external labor resources of professional workers operating in liberal professions.

In order to favor the creation of new jobs which is necessary to reduce the labor market effect of technical change, firms will have to develop new entrepreneurial activities to exploit the opportunities offered by the new technologies. Firms are important knowledge centers. They should be the drivers of the change and produce an ever-increasing share of new businesses. Paradoxically, it will depend on this strategy whether there will be enough increase in the demand for labor to absorb unemployment and absorb the emerging youth unemployment rate

Firms and especially their human resources management centers will understand that in order to get the manpower they need, namely manpower well-endowed with creativity and very high level of job-specific competences, they will have to: a) Partly change their mission, to become a training ground for workers; b) Collaborate closely with educational and training systems; c) Become part of an education and training system based on the dual principle. The new model of firm will resemble the Gilds model of merchant capitalism: in fact, it will involve production, labor and training in one place; and, at the same time, school-/university rooms will not be anymore the only place where to build knowledge.

Moreover, in order to exploit better the advantages of the new technologies, firms will have to introduce: Smart working environments and teleworking. There is need for new labor regulations. A critical issue of the new regulation will be the right to disconnect. Teleworkers have no more fixed hours of work and are involved into work all day long, which will reduce the space they can dedicate to their family and other businesses. That is why the right to disconnect at least some part of the day should be guaranteed to smart workers.

5. A new labor regulation

As noted in the previous sections, industry 4.0 implies the risks of increasing inequality, disappearance of the middle class and re-organization of work within firms; and precariousness of labor market experiences. These changes will need to be accommodated also by a new labor legislation.

Three main broad directions should be followed. First is the reduction of the cost of permanent work to make it less costly than temporary work. Second is the introduction of new rights and forms of guarantees for the low skill workers. Third is the need of regulating new types of work relationship, such as smart working, which has already been addressed in the previous section.

Also due to globalization, labor relations become ever more unstable. The horizon of entrepreneurs becomes shorter and shorter pushing them not to hire on a permanent, but on a temporary basis. It is important to guarantee stable economic growth to favor permanent work. It is also important to reduce the relative cost of permanent versus temporary work.

Unskilled workers need to receive better guarantees: piecewise payments should be substituted by wage employment, considering the dependent nature of the working relationship

Smart working becomes more and more common changing the structure and organization of firms. Labor rights need to be reformulated. E.g. the rigt to disconnect is an important novelty.

The gig-economy implies the diffusion of new types of low skill jobs, such as bellboys or delivery workers. In Italy they are also known as «bike riders» or simply «riders». They have become about 50,000 in few months. Often the only job opportunity offered to many young people. Some of the companies are: Foodora, Glovo, Deliveroo o Just Eat. It's a worldwide phenomenon.

Italian delivery workers have defined a new chart of the rights for them. They ask first of all to be treated from a legal point of view as wage employees rather than self-employed if the work is «related to some online platform and algorithm decided by the firm», independent of whether they use or not their means of production (the bike). They should have an acceptable minimum wage (higher than €2-4 per hour) to define within collective agreements like any other worker in the traditional sectors. They ask to be guaranteed a right to disconnect (at least 11 hours out of 24). They also claim the right to paid holidays, insurance for illnesses, and maternity rights, like any other worker. They ask to be provided with proper bikes by firms (as wage employees rather than independent workers), paid insurance against work accidents, paid third party insurance.

These rights will likely increase the cost of online products and a possible risk is that firms will be out of market, unless people accept to pay an overprice for the requested service.

6. Government intervention

Three approaches to government policy have been defined:

a) The liberalist approach (Anglo-Saxon and EU countries);
b) Dirigiste approach (China, India and South Korea);
c) Balanced approach (still to come).

According to the liberalist approach, institutions (educational institutions, businesses and governments) will find the right way on their own. Moreover, private firms will do all the R&D which will be necessary based on market conveniences. The government has just to create the

better conditions for them to operate in the best possible way. The main shortcoming of this approach is that markets are often short sighted.

In the dirigiste approach, instead, to overcome the shortcomings of market mechanisms, the government should provide massive investment in a number of fields, such as infrastructures, education and R&D to develop innovation within production. The main shortcoming of this approach is that predictions may be wrong and sometimes huge investment are made which are could be not profitable in the long run.

Finally, a more balanced approach requires that the government should suggest guidelines to firms which should do an important part of the innovation themselves. The state should solve the market failures which do exist, such as investing in infrastructures and in research of common interest, including above all base R&D and also other fields with economies to scale.

The main fields of intervention for the state include at least the following four. First is the provision of public material and immaterial infrastructure. Second is to provide financial incentives to: a) the training of staff in the field of the production and transfer of new technologies; b) production of new technologies through applied research; c) transfer of new technologies; d) new labor regulation. More importantly, the state should introduce in-depth reform of every aspect of the education system.

An increasing number of scholars is going back to the old dirigiste approach to state intervention in the field of industry 4.0. For instance, Mazzuccato (2017) supports the idea of «an entrepreneurial state» which invests directly into innovation and the production of new goods and commodities. The state should provide the main public infrastructures that private companies will never produce alone. Examples include: Wired networks; Continuous information and debate about the importance of new technologies; Progress advertising.

Additionally, the state should provide incentives in favor of firms investing in innovation and new technologies and generate different institutions which involve collaboration among the three helices: universities, firms and the government (Reischauer, 2018). Examples of programs involving such a type of collaboration are Digital Innovation Hubs (DIH), Competence Centers (CC) and creating an environment which favors innovation.

Examples of financial and fiscal incentives to investment in innovation are: Super-amortization; Iper-amortization; Tax credit. The advantages of these system are: Favoring the most innovative firms; Accelerating planned investments; Needs based (bottom-up) rather than planned from above; Automatic incentives with co-financing should prevent gaming. The risks involved include: creating dependence from public spending; favoring investment which were already planned; affecting only a limited share of firms.

Institutions called CCs are advocated in many countries, often with different names (Japan, Singapore, South Korea etc). In Denmark, they are called RoboClusters. They are generally set up by the Government and involve selected universities, polytechnic schools and firms operating in a given sector or in more sectors. CCs provide competences to firms in terms of: training of workers to employ in DIHs; Business incubators; Labs of digital innovations.

DIHs are different. They are spontaneously organized by firms unions together with the government. They are intended to provide training on new technologies, specific solutions to firms operating in given sectors, development of structures for the diffusion and transfer of technical change and innovation among firms.

7. Educational reforms

Last but not least, the government should provide an in-depth reform of the educational system and the entire school-to-work transition. As noted above, the skills less at risk as a consequence of the diffusion of new technologies are the skills that involve high general and technical knowledge, applied to the world of work, namely production and consumption. Such skills, unlike general education, cannot be produced in school or university rooms, but on-the-job. They are called work related competences or skills and are of two types, general and job-specific. General work-related competences may be learned in any kind of job and transferred to any kind of job. According to the Nobel prize winner, Gary Becker (1962), there is market failure in the production of these skills, because firms are not interested to generate such skills which eventually can be used in any kind of job. Workers generally pay for these competences in terms of lower than market clearing wages. Job-specific training is possible to generate only for during a prolonged employment in a given type of job. They require time and can only be used in that kind of jobs. According to Becker, job-specific skills or competences require an investment which firms tend to transfer or not to workers and consumers according to the degree of competition of labor and product markets (Acemoglu and Pishcke, 1998; and Lazear, 2009).

A solution to market failure could be the implementation at all levels of the educational system of the dual principle as opposed to the sequential principle. A sequential school-to-work transition system is one where work related competences are generated after completing general education, whereas in a dual education system, both general education and work-related competences are generated during the school and university period (Pastore, 2015; 2018a). The mission of the education system should be not only to generate general education, but also (general and job-specific) work related competences and that's why the Ministry of Education should be called instead Ministry of human capital.

The main directions of a systematic reform of educational systems should be based on the following directions:

a) Increasing spending in education and training systems;
b) Moving from a sequential to a dual educational system;
c) Diversifying the supply of skills;
d) Favouring an increasing degree of integration between educational institutions and the world of work
e) Developing well-functioning and comprehensive systems of lifelong learning

The dual principle is key to the development of the work-related skills which will be more and more on demand with the 4th industrial revolution. Implementing the dual principle at all levels of the educational track it is possible to strongly diversify the education system. The following reforms should be implemented, one for each level of education:

a) At high school:
    a. Work related learning (WRL);
    b. Vocational Education and Training (VET);
    c. Apprenticeship, the most developed type of VET;
b) At the university
    a. Professional or vocational universities;
    b. High level apprenticeship for university students;
c) After the university:
    a. MBAs and other well-designed master programs;
    b. Business incubators and training for entrepreneurship and self-employment

c. Industrial Ph.D. programs
d. Life-long learning.

WRL is the blandest form of VET. It aims to develop work related competences sooner than earlier, already at high school. It is a tradition typical of Scandinavian countries in Europe. It is becoming common also to Germany and to an increasing number of EU countries, also Italy from 2015 (Pastore, 2018b).

It is part of high secondary school and involves short periods (from 200 to 400 hours) of on-the-job training for high school students. It is compulsory for all students: Also students who graduate from gymnasium may dropout without a university degree.

It should not be mixed up with apprenticeship, due to the lower skill content of WRT. The latter aims only to generate the general component of work related competences.

A good practice was made in Italy by Ducati the bike making industry, which now belongs to the Audi-Volkswagen group. The implemented project was called DESI (Dual Education System in Italy). The company has invested half a million euros to build within the factory a laboratory for teaching mechanical concepts. Then the concept learned in the training area are implemented directly in the production of bikes, just outside the training area. What are the determinants of this project? Is it a cultural one, considering that now Ducati has a German general management? In Germany they consider the production of skills through apprenticeship one of the missions of private companies, a form of social responsibility of firms. Or is it more a consequence of economic convenience for given types of firms? Bikes are still a handicraft production, rather than an automated one. The work is done manually by a large number of mechanic workers. Throughout the DESI project, Ducati is insuring itself a continuous production of the skills which are needed for their production.

VET (Vocational Education and Training) systems develop manual and practical skills and, as such, require, at the same time, teaching in school rooms and on-the-job training. Unfortunately, it is not much developed outside of few Central and North European countries.

One should consider that VET education is not inferior to gymnasium; it is just different. It is especially designed for young people with manual skills, which does not mean with no skills. It covers a part of the demand for labor services which is otherwise unsatisfied.

Technical and professional knowledge are very important and will be even more so in the future. It works if it involves also work-related learning. VET systems allow young people to defend themselves from precariousness, poverty, informality and unemployment in the short run.

The main disadvantage of VET is that it is very specific and in case the skill learned are not used anymore, then students with VET are less able to adapt because of the lack of general skills. There is hence a trade-off between the outcomes in the short and in the long-run. This is why VET students should acquire some general education before entering VET. The German case is problematic exactly because the choice between gymnasium and apprenticeship is done already at the age of 10. It would be better to start apprenticeship after having acquired more general education, although some young people who choose apprenticeship are not interested in general education.

Apprenticeship is the extreme form of VET as it involves a high share of on-the-job training. It is more widespread in Germany. In other EU countries and also in non-EU countries, where apprenticeship is not school-based necessarily it reaches a share of only about 5% of any cohort of students. In Germany, where apprenticeship is made at school, it covers 60% of every cohort of students. Probably this share is quite high and there is an increasing request for more general education also because it is hard to find good training places for all those students who

should do apprenticeship. Maximum development of job-specific skills, but poor development of general skills (Eichhorst et al., 2015).

Again, like VET education, also apprenticeship is associated to a higher employment probability, but higher risk of being trapped into their skills. Workers holding a professional qualification acquired at school through apprenticeship are hard to retrain if unemployed especially if middle-aged.

In the German dual system, a way to provide university education to the people with an apprenticeship diploma who cannot access academic university is by professional, rather than academic universities. A large share of German people has attended very high technical and specific education. Professional universities are on specific fields. Examples include universities for public servants of public employment services; public servant in general and so on.

Coming to graduate programs, one should mention Master programs which could be very important for university graduates to complete their education, by covering fields of study which were not covered during university studies. The former CEO of the Fiat and Chrysler Automobiles group, Sergio Marchionne, who recently passed away, graduated in Philosophy and therefore had not the skills to become a top manager. Once he understood that that was his interest he attended 2 Master programs in Business Administration (MBAs) and has become a top manager at a world level. Master programs should be open to provide work related knowledge and skills to well educated people. This requires that academic education at the university level should be neither too slow nor too specific. Flexibility should be allowed (moving from one type of education to another).

Competence centers should be created already at the university, with teaching to students willing to become self-employed and entrepreneurs. This education should be made by universities and firms managers together. Entrepreneurs can be created, are not coming out of a black box or a hat like a rabbit. Business incubators should be available in any province and in any university with state funds to support young people willing to start new businesses. Young people should be helped to develop their business ideas in detail and from a financial and technical point of view.

Last but not least are the so-called industrial Ph.D. Firms need applied research to support the innovation of their activities. Most Ph.D. holders tend not to work in the academia, but in the world of business or in the public sector. In Italy only 2000 out of 14000 Ph.D. holders remain in the academia. Many of them experience overeducation and also receive a wage penalty because of the mismatch between their academic knowledge and the knowledge required on-the-job (Gaeta et al., 2017). What if we help them to do research applied to the world of work? Industrial Ph.D. are used to train students to implement innovation within the firms/PA.

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