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"Educational and Skill Mismatch at work: An Overview"

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SOMMARIO

Lavoratori e aziende sono continuamente impegnati in un complesso processo di ricerca: le aziende cercano sul mercato del lavoro il lavoratore che possa coprire le loro posizioni aperte nel miglior modo possibile; i lavoratori invece, considerate le loro caratteristiche personali, le loro conoscenze e le loro capacità cercano il miglior lavoro possibile, che li faccia lavorare nelle migliori condizioni e che garantisca loro una paga adeguata: entrambi cercano di massimizzare le loro funzioni di utilità cercando tra loro il match perfetto.

Questo processo e in generale il mercato del lavoro tuttavia, sono caratterizzati da grandi livelli di eterogeneità, per via dell'asimmetria informativa, della differenza tra le capacità e le conoscenze richieste dalle aziende e quelle possedute dai lavoratori e la differente collocazione di determinati posti vacanti e lavoratori adeguati a coprirli. Tali eterogeneità rendono la ricerca del match ideale molto complessa, costringendo imprese e lavoratori ad impiegare ingenti risorse, in termini di tempo e denaro, per ottenere tutte le informazioni di cui necessitano per ottenere il match ideale. Tuttavia, non è cosa rara che tali match alle volte siano sub-ottimali. In altre parole, le competenze o conoscenze richieste per svolgere un determinato lavoro possono non essere rintracciate nel lavoratore assunto per svolgere quel determinato lavoro (mismatch educazionali o pratici).

Questo elaborato, mostrando quanto raccolto nella letteratura economica sul tema, ha l'obiettivo di fornire una panoramica sul tema dei mismatch nel mondo del

lavoro. In particolare verranno presentate le varie tipologie di mismatch e alcune loro possibili combinazioni, le loro cause e la loro durata.

Il CAPITOLO 4 invece è particolarmente importante in quanto interamente dedicato alla presentazione dei principali metodi di misurazione del mismatch: una delle principali problematiche del fenomeno. Particolare attenzione sarà data alla sovra (sotto)-educazione e alla sovra (sotto)-capacità pratica, presentando i metodi di misurazione proposti dai principali studi sul mismatch.

In seguito si passerà ad analizzare tutti i problemi causati dai mismatch a lavoratori, imprese e all'economia in generale, con una particolare enfasi per i primi due. Il CAPITOLO 6 si occuperà di tutte le azioni che imprese e lavoratori dovrebbero adottare per ridurre il rischio di mismatch con focus sulle imprese: cosa dovrebbero fare per ridurre il rischio di mismatch al momento dell'assunzione: il processo di reclutamento; e cosa dovrebbero fare in modo tale da evitare che i mismatch si verifichino dopo l'assunzione: i processi di training.

Terminata questa panoramica saranno presentati alcuni fatti. Il CAPITOLO 7 riporterà i risultati ottenuti da Pellizzari e Fichen dall'applicazione del loro modello di misurazione del mismatch ai dati contenuti nel database PIAAC ed infine, il CAPITOLO 8 illustrerà i principali contributi sullo studio del mismatch in Italia.

INTRODUCTION

Workers and firms are continuously involved in a process of searching: firms search for the best available worker in the market to fill their open vacancies in order to increase their efficiency and their productivity, workers search for the best job as possible according to their knowledge, their skills and their personal features in order to work in the best conditions as possible to earn a certain level of wage: both wants to maximize their utilities by finding the perfect match.

The basic Search-Matching model proposed by Pissarides for a steady-state equilibrium in the labour market analyses those processes in which vacant jobs and unemployed workers became matched, passing from trading to production activities. The described equilibrium is a situation in which firms and workers maximize their objective functions and where the flow of workers into unemployment is equal to the flow of workers out of unemployment. Its relevant to highlight that in this steady-state equilibrium unemployment persists because before that all the unmatched job-workers meet, some of the already existing matches break up creating new employment flows. The model shows that exists a unique unemployment rate for which equilibrium in the labour market is granted.

The first equation of the model is the *Matching Function,* which identify the number of matches taking place per unit of time.

Considering:

- **L=** Workers in the labour force (matched workers)

- **u**= Unemployment rate
- **v**= Vacancy rate

The matching function is:

(1)

$$mL = m(uL; vL)$$

It gives the outcome of the investments in resources by firms and workers as a function of its inputs. It's increasing in both arguments, concave and homogeneous of 1°.

Because vacancies and unemployed workers who became matched are randomly selected from $L\ and\ vL$, the process that change the status of vacant jobs and unemployed workers is Poisson where thanks to the homogeneity of 1° of the matching function:

- The rate at which a vacancy is matched to an unemployed worker is:

$$\frac{m(uL; vl)}{vL}$$

- The rate at which an unemployed worker is matched to a vacancy is:

$$\frac{m(uL; vL)}{uL}$$

Those rates are a function of the ratio of unemployment to vacancies: the v/u ratio. The v/u ratio is a good indicator of labor market's tightness and it's useful to identify it with **θ** and thus:

- The rate at which a vacancy is matched to an unemployed worker became: $\boldsymbol{q(\theta)}$;
- The rate at which an unemployed worker is matched to a vacancy became: $\boldsymbol{\theta q(\theta)}$.

From those two rates is possible to identify:

- The probability for firms to fill a vacancy: $\boldsymbol{q(\theta)\delta t}$.
- The mean duration of an open vacancy: $\frac{\mathbf{1}}{\boldsymbol{q(\theta)}}$
- The probability for workers to find a job: $\boldsymbol{\theta q(\theta)\delta t}$
- The mean duration of unemployment: $\frac{\mathbf{1}}{\boldsymbol{\theta q(\theta)}}$

In general, jobseekers find a new job easier if in the market there are more open vacancies than workers and firms find easier to fill an open vacancy when there are more jobseekers than vacancies.

After a job-worker match, the production starts and continues until a negative shock arrives driving down the output value of production at the Poisson rate $\boldsymbol{\lambda}$[1] and Job Destruction takes places causing on one side the movement of workers from employment to unemployment and, on the other side, firms must open a new vacancy.

At this point is possible to identify:

[1] Is the Job Destruction rate. In the model is exogenous.

- The mean number of workers who enter to unemployment in a time δt: $\lambda(1-u)L\delta t$;
- The mean number of workers who leave unemployment in a time δt: $mL\delta t = \theta q(\theta)uL$

The evolution of unemployment in time (ù) is given by the difference between the flows of workers entering and exiting from unemployment:

$$\text{ù} = \lambda(1-u) - \theta q(\theta)u.$$

Because we assumed that in steady-state unemployment remains constant, the two flows must be equal, thus:

$$\lambda(1-u) = \theta q(\theta)u$$

Solving for the unemployment rate we obtain the first fundamental equation of the model, the so-called *Beveridge Curve:*

(2)

$$\boldsymbol{u = \frac{\lambda}{\lambda + \theta q(\theta)}}$$

The Beveridge Curve states that given λ and θ, exists a unique unemployment rate granting the equilibrium in the market[2].

In order to find the second fundamental equation of the model, the process of job creation must be analyzed by using the so-called Bellman's equations.

[2] λ is exogenous; θ must be founded

Job creation takes places when a firm and a worker match, but before this, the firm mut decide if open or not a vacancy following the logic of profit maximization: the profits from one more vacancy must be equals to zero.

Assuming:

- **J:** the present discounted value of expected profit from an occupied job;
- **V:** the present discounted value of expected profits from an open vacancy;
- **pc:** fix costs of the hiring process;
- **q(θ):** the probability to fill the vacancy

V satisfies the Bellman's equation

(3)

$$rV = -pc + q(\theta)(J - V)$$

Where the capital cost of a vacancy (rV) is equal to its rate of return, given by the costs of opening a vacancy (-pc) plus the probability to pass from having an open vacancy to having a filled job (q(θ)(J-V)).

Because in equilibrium all the profit opportunities of opening new vacancies are exploited, the equilibrium condition for the supply of vacant job is **V=0**, which imply that:

(3.1)

$$J = \frac{pc}{q(\theta)}$$

Which states that in equilibrium, market tightness is such that the expected profit from a new job is equal to the expected costs of hiring a new worker, given by the mean duration of a vacancy times the cost of an open vacancy.

The same reasoning could be followed also for the Bellman's equation of occupied jobs but in this case we have:

- **p-w:** the net return of having a matched job;
- $\boldsymbol{\lambda}$**:** the probability of job destruction

(4)

$$rJ = p - w + \lambda(V - J)$$

The capital cost of a filled job (rV) is equal to its net return (p-w) plus the probability of passing from an occupied job to an open vacancy ($\lambda(V - J)$). Considering the equilibrium condition V=0 it becomes:

(4.1)

$$rJ = p - w - \lambda J$$

Putting together (3.1) and (4.1) we obtain the second fundamental equation of the model: *The Job Creation Condition.*

(5)

$$\frac{\boldsymbol{p - w}}{\boldsymbol{r + \lambda}} = \frac{\boldsymbol{pc}}{\boldsymbol{q(\theta)}}$$

Firms create job only if firm's discounted net gains from creating a job cover the expected capitalized value of firm's hiring costs.

To close the model, we must analyze the demand side of the market: worker's behavior.

Assuming:

- **w:** what a worker earns if employed;
- **z:** what a worker earns while searching (unemployment insurance);
- **W:** the present discounted value of expected income stream of an employed worker;
- **U:** the present discounted value of expected income of an unemployed worker.
- **θq(θ):** the probability of finding a job.

U satisfies the Bellman's equation

(6)

$$rU = z + \theta q(\theta)(W - U)$$

The capital cost of being unemployed (rU), which can be considered as the worker's reservation wage[3], is equal to the net return of being unemployed (z) plus the probability to pass from unemployment to employment ($\theta q(\theta)(W - U)$).

The same reasoning can be done for the Bellman's equation for employed workers, but in this case:

- **w:** net return of being employed: the wage earned;

[3] In fact, it represents the minimum wage that an unemployed worker needs in order to give up searching.

- $\boldsymbol{\lambda}$**:** is the probability of job destruction

(7)

$$rW = w + \lambda(U - W)$$

Wages are determined after a Nash bargaining process, and the wage obtained is the one that maximizes the weighted product of worker's and firm's net return from job match: to find the match, workers must give up U for W and firms must give up V for J. This implies that the wage must satisfy

(8)

$$w^* = \arg\max(W - U)^{\beta}(J - V)^{1-\beta}$$

Where $0 \leq \beta \leq 1$ represent the bargaining power of worker's and firm that in this model is a constant parameter that in the simplest symmetric situation is ½.

The F.O.C to solve the maximization problem is given by

(9)

$$W - U = \beta(J + W - V - U)$$

Now substituting in this equation the values of W and J founded with Bellman's equations (7) and (4.1) and imposing the equilibrium condition V=0 we obtain:

(9.1)

$$w^* = rU + \beta(p - rU)$$

Which states that workers wage is equal to their reservation wage (rU) plus a fraction β of the net surplus that they create accepting a job ($p - rU$).

Now, by putting (3.1) and (9) into Bellman's equation (6), we obtain another expression for rU:

(10)

$$rU = z + \frac{\beta}{1-\beta} pc\theta$$

Which if substituted into (9.1) gives the third fundamental equation of the model: The *Aggregate Wage Equation for the Equilibrium*

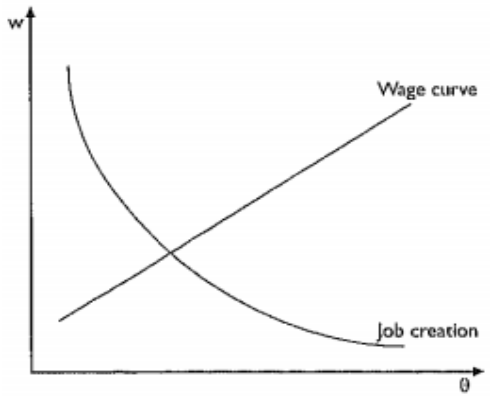
(11)

$$\boldsymbol{w = (1-\beta)z + \beta p(1 + c\theta)}$$

We have now the 3 fundamental equations describing the labor market equilibrium in steady state: The Beveridge Curve, The Job Creation Condition and the Aggregate Wage Equation.

The equilibrium tightness of the market, θ^* and the equilibrium wages, w^*, are given by the intersection of JCC and AWE, graphically:

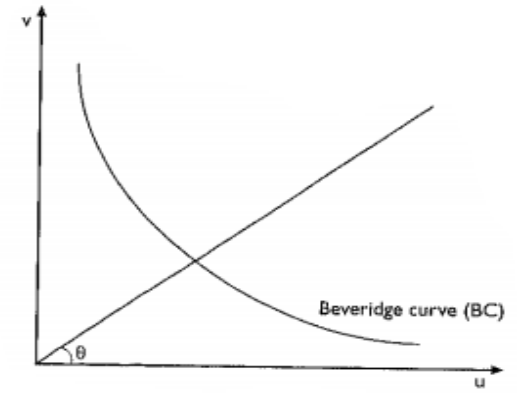
Figure A: Equilibrium tightness of the market, θ^* and wages, w^*



SOURCE: C. Pissarides, "Equilibrium Unemployment Theory", 2nd Edition

Finally, the equilibrium values of unemployment, u^*, and the equilibrium values of vacancies, v^* are founded in the intersection between the Beveridge Curve and the radius leaving the origin with slope θ^*:

Figure B: Equilibrium Unemployment, u^*, and Equilibrium Vacancies, v^*.



SOURCE: C. Pissarides, "Equilibrium Unemployment Theory", 2nd Edition

The model shows how economic cycles determines different equilibrium levels always characterized by a unique unemployment level: in expansion, productivity increase and for firms become profitable to open new vacancies causing an up-ward shift of the JCC in *Figure A*.

This up-ward shift identifies a higher level of θ^*, thus, a higher slope of the radius leaving the origin in *Figure B,* which generate a movement along the Beveridge curve until the new equilibrium is reached characterized by higher vacancy rate and lower unemployment rate.

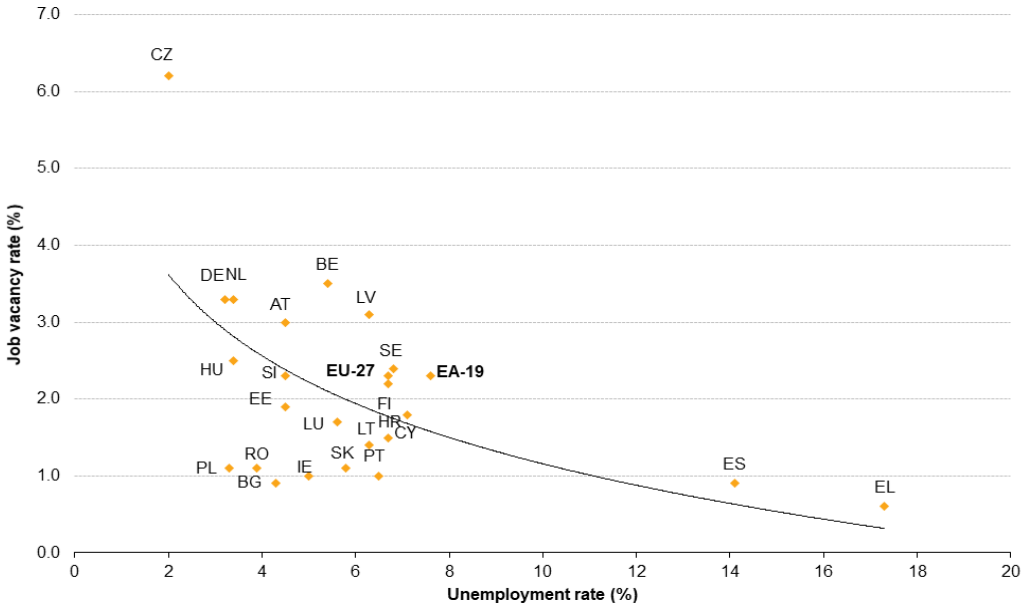
In downturns instead, productivity decreases and for firms become very costly to open new vacancies causing a down-ward shift of the JCC in *Figure A.*

This down-ward shift identifies a lower level of θ^*, thus, a lower slope of the radius leaving the origin in *Figure B,* which generate a movement along the Beveridge curve until the new equilibrium is reached characterized by higher unemployment rate and lower vacancy rate.

The Beveridge Curve can be also utilized to have an indication of the situation of job matching on the national labour markets plotting the vacancy rate and the unemployment rate of a given country in a given time.

The graphic obtained represents the so called "Beveridge Points" for EU-27 and EU-19 in 2019:

FIGURE C: The Beveridge Points



Source: "EUROSTAT".

As can be seen in Figure C, at the upper end of the trend curve are the Czechia (CZ), Germany (DE) and the Netherlands (NL) with rather low unemployment and high

vacancy rates, while at the lower end of the curve are Greece (EL) and Spain (ES) with high unemployment and low vacancy rates. The countries above the curve may have a comparatively poorer matching efficiency than countries situated below.

What is clear is that labour market is characterized by many Heterogeneities: asymmetric information, difference in the skills required by firms and skills possessed by workers and difference in the location of job vacancies and workers. Those heterogeneities make trade in the labour market a very complex activity because they force both: workers and firms to spend money and time searching for all the information they need in order to find the optimal match. Anyway, is not rare that the obtained matches are not the optimal ones: trivially speaking, skills and educational mismatches may occur.

In the first part of this work will be analysed what elaborated in the economic literature about each kind of mismatch, in particular CHAPTER 1 will introduce the many types of mismatches that may occur in the market and some of their possible combinations; in CHAPTER 2 will be highlighted their causes; in CHAPTER 3 their length.

CHAPTER 4 is particularly relevant because it is completely devoted to the presentation of the most used mismatches' measurement methodologies: one of the most debated point in the economic literature. Particular attention at this point will be given to over(under)education and over(under)skilling, presenting the methodology used by some of the most relevant works about mismatches.

All the problems that mismatches cause to workers, firms and the overall economy, with a focus on the first two will be analysed in CHAPTER 5 and CHAPTER 6 will be completely dedicated to what firms and workers should do in order to reduce the risks of mismatches. Particular attention will be reserved to firms, especially analysing what allow them to reduce the risks of mismatches at the hiring moment: a good recruitment process; and what, can help to limit or even solve the problems of mismatches during the work relationship: the training process.

Once terminated the general presentation of mismatches the last two chapters will presents some relevant facts about mismatches. In particular, CHAPTER 7 will shows the results obtained by Pellizzari and Fichen by the application of their measurement model for mismatches to PIAAC database.

Finally, CHAPTER 8 will describes the mismatch situation in Italy, by illustrating some of the most relevant contributes in the economic literature.

CHAPTER 1: SKILLS AND SKILL MISMATCHES

Before going inside a complex and vast argument as skill mismatch is, it would be better to give an accurate definition of what skills are. As clearly emerge from the work of Clarke and Winch, is really hard to provide a clear and shared definition skills, anyway, is possible to identify their main features:

- They are connected to individual attribute;
- They are associated to specific tasks or job;
- They include psychological, physical and manual capabilities;
- They have no particular connection with pre-existing knowledge.

Given those assumptions for this work we can rely on the definition of skills provided by OECD in 2017: "Skills refer to both cognitive and non-cognitive abilities and to abilities that are specific to a particular job, occupation or sector". From this definition, emerge the multidimensionality of skills which can be classified as follow:

- **COGNITIVE SKILLS:** The skills that our brain use to think, learn, remember, reason and pay attention. Thanks to those skills, we are able to understand particular issues, adapt to a new environment and to solve complex problems or situations. In the workplace, cognitive skills help to interpret data, remember team goals, pay attention during an important meeting and similar. These skills help to recall previous information that may relate to organization's goals and help to make important connections

between old and new information improving the effectiveness on a work context.

- **NON-COGNITIVE SKILLS:** Trivially speaking this category is about all the skills that are not included in the "cognitive skills". They belong to multiple fields like social or emotional and they comprehend for example emotional maturity, empathy, interpersonal skills, communication skills, and in practice they influence the overall behavior of a person.
- **TECHNICAL SKILLS:** Are a combination of cognitive and non-cognitive skills used to accomplish specific tasks.

Skill mismatch is a wide concept too. We can refer to skill mismatch at MACRO and MICRO level:

- **SKILL MISMATCH AT MACRO LEVEL:** It is typically referred to a specific geographical area: a city, a region, a country and emerge when there is a GAP between the aggregate demand for skills (of the firms) and the aggregate supply of skills (of applicants). Broadly speaking is when the referment labor market of firms is not appropriate to satisfy firm's needs.
- **SKILL MISMATCH AT MICRO LEVEL:** It describes a situation where there is a GAP between worker's skills (knowledge) and the skills (knowledge) required to carry out his job. "Micro" – skill mismatch can be further classified into:

- **VERTICAL MISMATCH:** Is a situation where the mismatch refers to a GAP between formal education (skills) of the worker and job requirements. It is usually analyzed in terms of over-education[1]; under-education[2]; over-skilling[3] and under-skilling[4]. Broadly speaking vertical mismatches occur when the level of education or skill of the worker is higher (lower) than job requirements.
- **HORIZONTAL MISMATCH:** In this case, the GAP is noticed between the worker's field of study and job requirements: the type of education or skills is not appropriate for the current job.

In order to complete the picture about skill mismatches, other two categories must be introduced: SKILL SHORTAGES and SKILL OBSOLESCENCE.

- **SKILL SHORTAGES:** is the situations in which the mismatch is due to the excess of demand for a particular type of skill with respect to the supply of available people with that skill.
- **SKILL OBSOLESCENCE:** A situation in which skills previously utilized in a job are no longer required or have diminished in importance.

[1] Over-education occurs when the education level of a worker is higher than that required by his or her job.
[2] Under-education occurs when the education level of a worker is lower than that required by his or her job.
[3] Over-skilling occurs when the skill level of a worker is higher than that required by his or her job.
[4] Under-skilling occurs when the skill level of a worker is lower than that required by his or her job.

1.1: MISMATCHES COMBINATIONS

In concrete, combinations of mismatches may occur. A picture of this is given by TAB. 1.1 in which are highlighted all the possible combinations between skill shortages and all the types of vertical mismatches.

TAB. 1.1: Combinations of skill mismatches

	SKILL SHORTAGES
OVER-EDUCATION	Over-education and skill shortages are not likely to occur together for a worker in a given profession, but they can coexist across different professions
OVER-SKILLING	Over-skilling and skill shortages are not likely to occur together for a worker in a given profession, but they can coexist across different professions
UNDER-EDUCATION	Under-education and skill shortages may co-exist in firms if firms react to the problem of skill shortages by up-skilling (training) existing staff
UNDER-SKILLING	Under-skilling and skill shortages may co-exist in firms if after the attempt by the firm of reacting to the problems of skill shortages by up-skilling (training) existing staff some deficits remain.

Source: The skill matching challenge, Analyzing skill mismatch and policy implications. CEDEFOP 2010

Starting from the combination between over-education and skill shortages, the occupations within which the firm employs overeducated workers will not correspond with the occupations where skill shortages are being experienced. However, is possible that the firm may simultaneously experience over-education and skill shortages in different occupations. Nevertheless, there is nothing to suggest a strong correlation at firm level. At macroeconomic level, a high incidence of both over-education and skill shortage would provide a strong indication that the composition of education supply is poorly aligned with labor demand.

Even if is possible to consider over-skilling as a much more direct measure of individual under-utilization than over-education, the relationship between over-skilling and skill shortages is exactly the same pointed out for over-education and skill shortages and again, at economy level, a high incidence of both over-skilling and skill shortages suggests that some rebalancing of post-compulsory education and training supply would benefit both workers and firms.

Is common practice trying to overcome the problem of skill shortages by up-skilling workers to fill vacancies. In some cases, may happen that reallocated workers do not possess the credentials required to fill the post; thus, some correlation between under-education and skill shortages might be expected.

Finally, regarding the combination between under-skilling and skill-shortages, they may occur together if after the attempt by the firm of reacting to the problems of skill shortages by up-skilling (training) existing staff some deficits persist.

CHAPTER 2: CAUSES OF SKILL MISMATCHES

Shifts in demand and supply for skills are driven by many factors and when those shifts are such relevant to misalign demand and supply, mismatches occur. In this chapter, the analysis will be focused on those factors in order to underline why skill mismatches occur.

2.1: CAUSES OF OVER-EDUCATION AND OVER-SKILLING

According to the signaling theory[1], the higher is the education level of an applicant, the higher would be his opportunities to get a good job. Moreover, higher levels of education allow the applicants to have also a better-defined set of jobs obtainable entering the labor market. This fact is particularly notable for people graduated in a narrower field of study like for example medicine than for those people graduated in more broadly defined ones. Thus, is more common for people graduated in less specific areas to be less well informed about labor-market opportunities. This situation can be defined as a case of asymmetric information in the labor market, in particular in the supply side, and can be a cause of over-education. The same

[1] **Signalling Theory**: In contract theory, signalling is the idea that one party (the agent) credibly conveys some information about itself to another party (the principal).
In Michael Spence's job-market signaling model, (potential) employees send a signal about their ability level to the employer by acquiring education credentials. The informational value of the credential comes from the fact that the employer believes that credentials are positively correlated with having greater ability and they're difficult to be obtained by low ability employees. Thus, the credential enables the employer to reliably distinguish low ability workers from high ability workers.

conclusions can be derived also for over-skilling: people with more general skills are less well informed about labor-market opportunities.

Moreover, over-education (over-skilling) may occurs if individual approach to the labor market in periods when there is an excess supply of qualified applicants: In those cases, to find a well-matched job can require a lot of time. Thus, individuals usually are more likely to accept lower quality jobs and, in the meantime, keep on looking for jobs more suited to their knowledge.

Finally, also cyclical effects may generate over-education(skilling): a typical effect of downturns in fact is the so-called SULLYING EFFECT**,** which describes the situation where mismatches increase because the demand for specific skills and knowledge in recession is lower and people accept inferior jobs because of the higher competition in the labor market[2].

Another possible cause could be an insufficient labor-market mobility.

2.2: CAUSES OF UNDER-EDUCATION AND UNDER-SKILLING

The causes of those two kinds of mismatches can be analyzed together. The first possibility is that under-education and under-skilling can be caused by underinvestment in training. From a firm point of view, they are often reluctant to

[2] G. BRUNELLO, P. WRUUCK, Skill Shortages and Skill Mismatch in Europe: A Review of the Literature, "I Z A Institute of Labor Economics", May 2019, pp. 11.

offer a general training to their employees because once been trained, they could ask for higher wages or even spend the skills acquired in the labor market searching for better conditions. Individuals on the other side, may underinvest in training because of the high costs, coupled with uncertain returns. Also in this case, possible causes could be an insufficient labor-market mobility. Moreover, under-education and under-skilling can derive from a poor- and low-quality level of the education system of a country.

Finally, even skill shortages may be the cause of the problem of under-education and under-skilling.

2.3: CAUSES OF SKILL SHORTAGES

Skill shortages are likely to increase in periods of economic growth. In those periods in fact it's common for firms to expand their activities and search for a higher number of new workers with the specific skills and knowledge they need in the external labor market: the demand for specific skills and knowledge arise. The problem is that the supply side is not so fast to immediately respond to this new higher demand because of the distribution of existing skills or the geographical mobility of workers. This "slow" reaction of the supply side with respect to the rapid increase in the demand side unavoidably generate skill shortages.

Moreover, two main factors contribute to the creation of skill shortages: Globalization and Technological Progress.

Globalization is commonly associated with the process of polarization of the labor force and the decline of middle-skilled jobs[3]. If those labors reallocate slowly from declining to growing sectors in which different skillsets may be needed, included middle-level skills, skill shortages occur.

Technological progress cause employment shifts between sectors[4] and changes in the demand for skill. Usually technological changes create the need for new skills that are not immediately available on the labor market, thus, until the education and training systems are able to meet those new requirements, the labor market is characterized by skill shortages. Technological progress also participates to the polarization of the workforce increasing demand for high-skilled workers and decreasing demand for middle-skilled workers, anyway, thanks to the continuous improvements in digital technologies, in the future digital machines will be able to substitute not only routine tasks but also some non-routine tasks typically performed by skilled workers. A study made by Quintini and Nedelkoska shows that the 14% of jobs in OECD Countries in which are employed more or less 66 million workers, have a probability of automation higher than 70% and another 32% of jobs have a probability of automation between 50% and 70%. Jobs requiring professional training or tertiary occupation are less automable.

[3] Economists refer to the **polarization** of the labor force when middle-class jobs seem to disappear relative to those at the bottom, requiring few skills, and those at the top, requiring greater skill levels.
[4] Some sectors gain employment and other lose.

2.4: CAUSES OF SKILL OBSOLESCENCE

First of all, it must be specified that it would be better to refers to skill obsolescence not as state, but as a process in which worker's skills became obsolete. Table 2.1 gives a clear picture of the different types of skills obsolescence associated with their specific causes.

TAB 2.1: Types of skills obsolescence

Type of skill obsolescence	Depreciation of Human Capital by
Technical skills obsolescence	
Wear	Natural agening process, illness or injury
Atrophy	No use or limited usage of skills
Economic skills obsolescence	
Job-specific skill obsolescence	New skills requirements due to developments in society
Skills obsolescence by sectoral shifts	Shrinking employment in occupation or economic sector
Firm-specific skills obsolescence	External mobility

Source: De Grip, A.; Van Loo, J. "The economics of skills obsolescence: a review", 2007.

Two types of skill obsolescence have been identified: Physical (Technical) skill obsolescence which affects negatively the stock of human capital a worker possesses and Economic skills obsolescence which affects the value of the human capital a worker possesses. The former can be caused by:

- the wear of skills which naturally occurs with ageing, illness or any significant injury a worker can suffer during his life;
- by the atrophy of skills caused by a general lack of skills or by a short use of skills.

Economic skills obsolescence occurs in three different cases:

- when technological or organizational development in the production process changes the demand for skills needed for a certain job (job-specific skills obsolescence);
- when shifts in the industry structure of employment occurs. In this case worker's skills are still adequate but demand for those skills in the labor market falls and some workers must to find another job to remain employed;
- when workers after a firm's quit or reorganization lose their job their firm specific skills lose part of their value (Firm-specific obsolescence).

2.5: INDIVIDUAL CHARACTERISTICS

Those analyzed above are all the possible exogenous causes of skill mismatches, anyway workers may have some individual features which expose particular worker's categories to a higher risk of been mismatched. For example, Young workers are likely to be particularly prone to skill mismatch as new entrants into the labor market. This is demonstrated by the fact that overeducation is linked to a lack of work experience.

Older workers are particularly subject to skills obsolescence.

In a dual earner household, there would be greater constraints on married women than married men on account of child-rearing causing intermittent labor-force participation on the part of the wife. Married women would tend to be tied stayers

or tied movers limiting their ability to obtain optimal matches in the labor market. Another reason for gender differences in mismatch can be founded in the presence of fixed costs of employment together with higher quit rates for women than men. This may lead employers to require higher ability from women relative to men when hiring for particular jobs. In general, there is mixed evidence of skill mismatch being a more serious problem for women than for men across countries.

Few studies of skill mismatch across ethnic minorities are available.

CHAPTER 3: LENGTH OF SKILL MISMATCHES

Many different types of mismatches exist and, as already analyzed, different causes can be identified for each of them. The aim of this section is to show that differences in mismatches occur also with respect to their duration, and moreover, the same type of mismatch can have different durations with respect if it is analyzed at firm's level, at individual level or at general economy level. Specific session will be dedicated to each case of mismatch underlining if conclusions are taken from individual, firms or general economy point of view.

3.1: OVER-EDUCATION AND OVER-SKILLING AT WORKER'S LEVEL

Even if there is strong disagreement in literature regarding the persistence of over-education over time, interesting conclusions can be drawn from some studies regarding the graduate labor markets. Dolton and Vignoles found that 38 % of a large sample of UK graduates in 1980 was overeducated in their first job; six years later this proportion still stood at 30 %. Similar results were founded by McGuinness who reported that among a sample of graduates in Northern Ireland, 31 % indicated that a university degree was not a requirement for their first job, and after two to four years this proportion was still at 24 %. According to those results it seems reasonable to think to over-education as a long-standing phenomenon.

Focusing now on over-skilling, unfortunately very little studies exists regarding its persistence, but the results seems to underline that as for over-education also under-skilling is a persistent phenomenon at individual level.

3.2: OVER-EDUCATION AND OVER-SKILLING AT FIRM'S LEVEL

Even if at individual level is possible to assume over-education and over-skilling as a long-standing phenomenon, things change if we consider them at firm's level. Economically speaking in fact, it could seem an advantage for firms to hire over-educated and/or over-skilled workers because it means that they pay those workers less with respect to their "matching salary"[1] and at the same time those workers grant higher level of productivity. Anyway, over-educated and over-skilled workers suffer lower levels of job-satisfaction and the high rates of voluntary and involuntary turnover of those workers suggest that at firm's level over-education and over-skilling are a more transitory phenomenon.

3.3: UNDER-EDUCATION AND UNDER-SKILLING AT WORKER'S AND FIRM'S LEVEL

At individual level is obvious that under-educated and under-skilled workers have no incentives to change their status because they're receiving higher level of wages

[1] Matching salary: the salary a worker receives in a condition of perfect match.

than other matched workers with their same level of education or skill. Thus, at individual level, the more the status of under-educated (under-skilled) persists the better is for workers.

At firm's level things change because those workers represent a cost: the firm pays them a sort of wage premium with respect to other matched workers with their same level of education and skills and at the same time those workers grant low levels of productivity. Thus, at firm's level under-education and under-skill are a problem and it would be better that they would last as less as possible. Their duration depends on the persistence of their already highlighted causes in the referment labor market. For example: if undereducation is due to the presence of skill shortages in the referment labor market, then the duration of undereducation within the firm will be highly correlated with the persistence of the skill shortage.

3.4: SKILL SHORTAGES

The duration of skill shortages varies depending on whether the problem is analyzed at firm's point of view or at general economy's point of view. In the former case shortages persistence depends on the complexity of the vacancies to be filled: broadly speaking, the more complex and skilled the unfilled vacancies are, the longer shortages will persist.

For the economy in general, skill shortages will last much longer, the greater the time that will pass from the moment the demand for certain new skills arises in the

market and the time in which workers will be adequately trained on those specific skills.

3.5: SKILL OBSOLESCENCE

In this case we must refer to the problem in terms of how much time it takes for a worker to become “obsolete” (in terms of skills). The evidences from the literature highlight that the problem is strictly connected to technological progress. In fact, skill obsolescence occurs particularly fast in high-tech sectors, where technological progress ear after ear impose continuous updates for workers in order to remain productive. According to this conclusion, The US National Academy of Sciences concluded in 1985 that engineers could work productively over a longer period if they had access to effective continuing education regardless of the state of the business cycle. This required interdisciplinary approaches and non-technical skills that are not imparted by the formal training of engineers.

CHAPTER 4: MEAURE SKILL MISMATCHES

This chapter will be focused on all the possible methodologies to measure each of the mismatches analyzed till now highlighting their strengths and weaknesses. As it will emerge, the main problem of those measures is their high level of subjectivity in the choice of the questions to be done and in the answers received by workers and employers, which is the most of time cause of overestimated results.

Obviously in order to measure skill mismatches its crucial to have a specific database from which derives all the information needed about skills and their use at work. One of the most complete database in this sense is provided by the Program for the International Assessment of Adult Competencies: PIAAC.

Over and under education measure approach will be analyzed together as Over and under skilling. Specific sessions will be then reserved to skill shortages and skill obsolescence. Before, an accurate description of PIAAC is mandatory.

4.1: THE PROGRAM FOR THE INTERNATIONAL ASSESSMENT OF ADULT COMPETENCIES: PIAAC

It is a cyclical large-scale study developed in 2010 under the auspices of OECD with the main aim of assess and compare the basic skills and the broad range of competencies of adults around the world. The survey is periodically administrated and has already had one cycle, the second is in process. The FIRST CYCLE collects data in three different rounds from 2011 to 2018. The SECOND CYCLE has begun

its first round in 2018 with results to be published in 2024. Scheme 4.1 shows the countries involved in each specific round.

SCHEME 4.1: PIAAC PARTECIPATING COUNTRIES

PIAAC 1st CYCLE	**ROUND 1 (2011-2012)**	AUSTRALIA, AUSTRIA, BELGIUM, CANADA, CZECH REPUBLIC, DENMARK, ESTONIA, FINLAND, FRANCE, GERMANY, IRELAND, ITALY, JAPAN, KOREA,NETHERLANDS, NORWEY, POLAND, RUSSIAN FEDERATION, SLOVAK REPUBLIC, SPAIN, SWEDEN, UNITED KINGDOM, UNITED STATES.
	ROUND 2 (2014-2015)	CHILE, GREECE, INDONESIA, ISRAEL, LITHUANIA, NEW ZELAND, SINGAPORE, SLOVENIA,TURKEY
	ROUND 3 (2017)	ECUADOR, HUNGARY, KAZAKHISTAN, MEXICO, PERU', UNITED STATES
PIAAC 2nd CYCLE	**ROUND 1**	AUSTRALIA, AUSTRIA, BELGIUM, CANADA, CHILE, CROATIA, CZECH REPUBLIC, DENMARK, ESTONIA, FINLAND, FGRANCE, GERMANY, HUNGARY, IRELAND, ISRAEL, ITALY, JAPAN, KOREA, LATVIA, LITHUANIA, NETHERLANDS, NEW ZELAND, NORWAY, POLAND, PORTUGAL, RUSSIAN FEDERATION, SINGAPORE, SLOVAK REPUBLIC, SPAIN, SWEDEN, SWITZERLAND, UNITED KINGDOM, UNITED STATES

SOURCE: OECD, Survey of Adult Skills (PIAAC)

The survey measured key-cognitive and workplace skills of approximately 150.000 working-age individuals (15-65 years old) in 24 countries (5.000 individuals per country). Those skills belong to three main areas:

- Literacy; defined as: “The ability to understand and use information from written texts in a variety of contexts to achieve goals and develop knowledge and potential.” This is a core requirement for developing higher-order skills and for positive economic and social outcomes;
- Numeracy; defined as: “The ability to use, apply, interpret, and communicate mathematical information and ideas”. It is an essential skill in an age when individuals encounter an increasing amount and wide range of quantitative and mathematical information in their daily lives. Numeracy is a skill parallel to reading literacy, and it is important to assess how these

competencies interact, since they are distributed differently across subgroups of the population;

- Problem solving; defined as: "The ability to use technology to solve problems and accomplish complex tasks." It is a measurement of the cognitive skills required in the information age – an age in which the accessibility of boundless information has made it essential for people to be able to decide what information they need, to evaluate it critically, and to use it to solve problems.

  In the more recent 2nd Cycle of PIAAC it has been introduced another area: The Adaptive Problem Solving; defined as: "The ability to use technology to solve problems and accomplish complex tasks. The assessment explicitly considers individuals' ability to solve multiple problems in parallel, which requires individuals to manage the order in which some problems are approached and to monitor opportunities that arise for solving different problem sets.

  Problem-solving can only be taken on computers and those who refuse or cannot use a PC are simply routed out. As a consequence, the number of missing values in problem-solving is relatively high in many countries (on average about 10% across all participating countries but up to over 35% in some). For this reason, the analysis of problem-solving skills is excluded from the majority of papers.

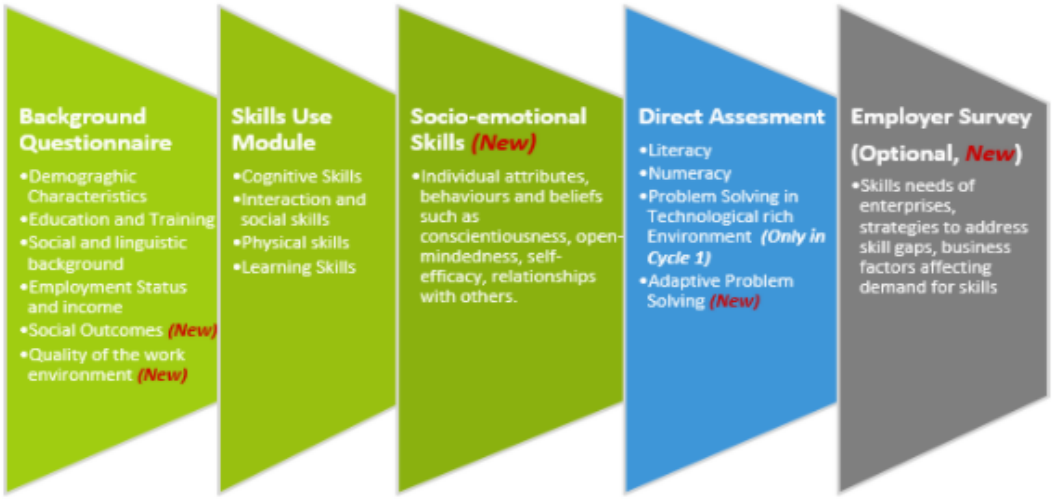
The survey, as showed in Scheme 4.2 is developed in two steps:

1. FIRST STEP; composed by:
   - The Background Questionnaire: It includes a range of information regarding the factors which influence the development and maintenance of skills such as education, social background, engagement with literacy and numeracy and ICTs, languages, as well as information on outcomes which may be related to skills. Information is collected on the current activity of respondents, employment status and income.
   - The Skill Use Module: Individuals are asked about how intensively and how frequently they use cognitive skills, interaction and social skills, physical skills, and learning skills at work
2. SECOND STEP; Direct Assessment: In this step the skills belonging to the three fundamental domains are evaluated with computer-based tests or paper-based tests. Individuals performance is then summarized in proficiency levels measured on a scale from 0 to 500 points, which is then divided into skills levels:
   - from below 1 to 5 for literacy and numeracy;
   - from below 1 to 3 for problem solving.

   Those skills are crucial because they provide a foundation for the development of other, higher-order cognitive skills and are prerequisites for gaining access to and understanding of specific domains of knowledge. In

addition, these skills are necessary in a broad range of contexts, from education through work to everyday life.

SCHEME 4.2: Main Elements of the Survey of Adult Skills (PIAAC)



SOURCE: OECD, Survey of Adult Skills (PIAAC)

Data collected by PIAAC are then used to give different measures skill mismatches.

4.2: MEASURING OVER-EDUCATION AND UNDER-EDUCATION

Three different approaches can be adopted to measure over-education and under-education: the "Subjective method"; the "Empirical method" and the "Job-evaluation method". The biggest problem is that they produce different results, often even conflicting.

The Subjective method is generally based on worker's self-assessment of the qualification level required to get, or to do the job: "**A**", which is then compared to the highest education level acquired by the worker: "**B**". Three possible situations:

- **A=B** → The worker is matched;
- **A>B** → The worker is under-educated;
- **A<B** → The worker is over-educated.

Another way to exploit the subjective method is to ask workers to assess their education as a whole in relation to the qualification needed.

In the Program of the International Assessment of Adult Competencies (PIAAC), individuals were asked, relative to their own education, which level of education do they think would be necessary to perform their job:

- "A lower level" → the worker is over-skilled;
- "A higher level" → the worker is under-skilled;
- "The same level" → the worker is matched.

The advantage of using the subjective method consists in the fact that it is easy to be applied. Its greater weakness lies in the fact that it is too open to potential subjective bias resulting in: a lower response rate (I'm too busy to answer), an under-estimation of the relevance of the question, the willingness of workers to over-estimate both, their education level and their assessment of the qualification level required to get, or to do the job.

The Empirical method, even called "The Realized Matches Method", gives an estimation of the educational requirements of an occupation by assessing the mean of education within a certain job:

- Workers above the mean → over-educated;

- Workers below the mean → under-educated;
- Workers on the mean → matched.

The strength of this method is that thanks to the ease of calculations it can be easily applied to any existing data set. Its drawback consists in the fact that due to sample size constraints the mean educational level is derived for more broad occupational groups (educational professions), and not at individual-job level (primary school teachers).

The job evaluation method is based on the work of professional job analysts who measure the educational requirements of occupations with the purpose of build occupational dictionaries such as for example "SOC" in the United Kingdom. The main advantage of this method is that because it is performed by specialists it should be more accurate. Through its weaknesses can be listed its particularly elevated costs and the fact that classifications are based on the opinions of experts, so it's open to some level of subjectivity.

4.3: MEASURING OVER-SKILLING AND UNDER-SKILLING

Just as for measure over (under)-education, also for over (under)-skilling can be used the Subjective method but, unlike over (under)-education that can be measured with a single question to workers, over (under)-skilling must be measured by comparing the answers of two separate questions. This can be shown analyzing the methodology used in PIAAC.

The question for Over-skilling was: "*Do you feel that you have the skills to cope with more demanding duties than those you are required to perform in your current job?"*

The question for Under-skilling was: *"Do you feel that you need further training in order to cope well with your present duties?"*

Each of the questions had to be answered with "yes" or "no" and the combination of both answers provides the self-reported skill mismatch of the respondent (see Table 4.1).

Table 4.1: Self-Reported Skill-mismatch in the PIAAC Questionnaire

		Do you feel that you have the skills to cope with more demanding duties than those you are required to perform in your current job?	
		Yes	No
Do you feel that you need further training in order to cope well with your present duties?	Yes	Over-skilled as well as under-skilled	Under-skilled
	No	Over-skilled	Well-matched

SOURCE: A.Perry, S. Winderhold, D. Ackerman-Piek,"How Can Skill Mismatch be Measured? New Approaches with PIAAC", 2014

The combination of both questions leads to four categories, where only the three categories: under-skilled, well-matched, and over-skilled are meaningful. It is not entirely clear how the remaining category "over-skilled as well as under-skilled" should be interpreted. A possible interpretation could be that respondents might feel that they are able to generally cope with more demanding work tasks, but at the same time feel the need for continuously maintaining and developing their skills

through training. This is, in particular, the case for highly educated workers who generally have a positive attitude towards education.

Another example could be the "Reflex Project"[1], in which the question for over-skilling was*: "To what extent are your skills utilized in this work?"*, and the question for under-skilling was: *"To what extent does this work require more knowledge and skills than you can actually offer?".* Answers must be given with a score from 1 to 5, where 1= "not at all", and 5= "a very high extent":

- values of 1 or 2 given to the over-skilling question states over-education;
- values of 3 or 4 given to the under-skilling question states under-education.

Another example could be The Cedefop European Skills and Job Surveys where, differently from the other two the question was just one: *"Overall, how would you best describe your skills in relation to what is required to do your job?"* and the possible given answers where two:

- *"my skills are higher than required by my job",* which states over-skilling;
- *"some of my skills are lower than what is required by my job and need to be further developed",* which states under-skilling.

The usage of the Subjective method is prone to subjective bias. Moreover, because there is not a universal question for over(under)-skilling but experts are free to elaborate their own questions on the basis of the datasets they use, is not possible

[1] The Reflex Project Data is a large-scale European survey of education graduates based on data from 15 countries.

to compare results of different research. Anyway, over-skilling measures are considered better accurate measures for mismatches with respect to over-education measures for three main reasons:

- The Over-education approach take for granted that job entry requirements perfectly reflects also job skills contents;
- The Over-education approach take for granted that worker's qualifications adequately reflect their total work-related human capital;
- The Over-education approach ignores the fact that in some cases job-entry requirements are a weak indicator of effective job-contents.

The Over-skilling approach instead, asking workers to compare all their skills and abilities with the actual skill requirements of their current job, grant a more comprehensive measure of mismatches.

Together with the subjective method, other ways can be taken to measure more objectively over(under)-skilling like the one proposed by Pellizzari, M., Fichen, A. in their work "A new measure of skill mismatch: theory and evidence from PIAAC".

4.3.1: Pellizzari and Fichen model for measuring skill-mismatches

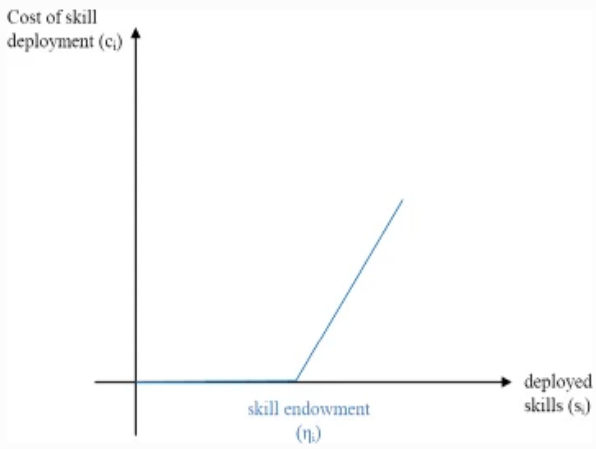
With their model the authors identify skill-mismatches by comparing the level of skills possessed by workers with the level of skills required to carry out their job: a worker whose skills are below job requirements is classified as under-skilled, a worker whose skills are above job requirements is classified as over-skilled.

Data about worker's skills are directly derived by PIAAC background questionnaire.

Job Requirements are instead identified thanks to the following process.

Consider an economy with heterogeneous workers and heterogeneous jobs. Workers, indexed by i, differ in their endowment of skills, labelled η_i and they endogenously decide how much skills to deploy in their jobs (s_i). Because data from PIAAC are about three different skills domains (literacy, numeracy and problem solving), η_i is assumed to be a vector of several skills. Deploying skills is costless within the limit of one's endowment, and it is subject to a constant marginal cost for any skill level beyond one's endowment (Figure 4.3.1.A).

FIGURE 4.3.1.A: Cost of deploying skills



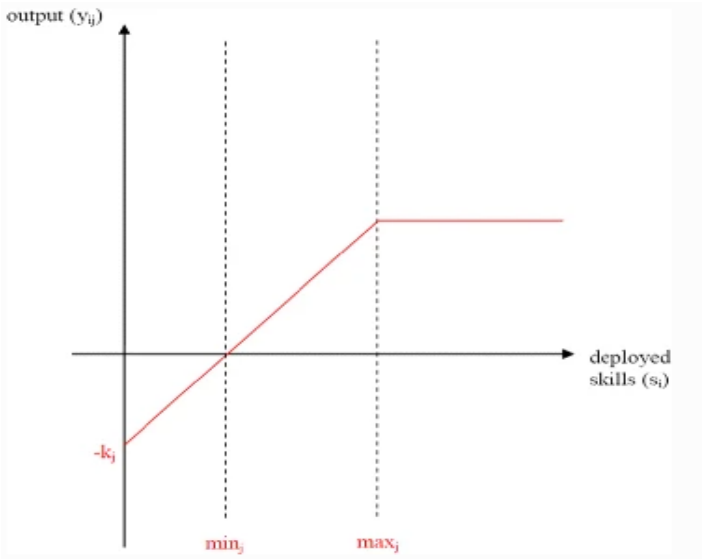
SOURCE: Pellizzari, M., Fichen, A. A new measure of skill mismatch: theory and evidence from PIAAC.

Jobs are defined as production functions, with skills being the only input. Each job employs one worker and is independent of other jobs. Different jobs have different production functions, which are characterized by three key features:

- local linearity,
- fixed operational costs
- discontinuously declining marginal productivity.

More specifically, assume that output y_{ij} of job j filled with worker i is a function of the amount of skills that the worker endogenously chooses to deploy on the job, s_i. Further, assume that there are fixed costs k_j to operate the job and that the marginal product of deployed skills is locally constant and decreases above a certain threshold. For simplicity, the marginal product of skills is assumed to be equal to zero beyond such threshold. Under this set of assumptions, the production function for a generic job looks as in Fig. 4.3.1.B.

FIGURE 4.3.1.B: The production function



SOURCE: Pellizzari, M., Fichen, A. A new measure of skill mismatch: theory and evidence from PIAAC.

The combination of the fixed costs and the discontinuously declining marginal product generates two critical values in the distributions of skills that lead to a definition of skill mismatch:

- Workers with skill endowments below min_j are under-skilled ($\eta_i < min_j$);
- Workers with skill endowments between min_j and max_j are well-matched ($min_j \leq \eta_i \leq max_j$);
- Workers with skill endowments above max_j are over-skilled ($\eta_i > max_j$).

Also job requirements, min_j and max_j will be multidimensional vectors.

Workers are assigned to jobs according to some assignment mechanism and, conditional on the characteristics of their jobs, they choose how much of their skills to deploy in order to maximize the following utility function:

$$U_{ij} = w_{ij} - 1(y_{ij} < 0)F - c_i(s_i)$$

Where:

- w_{ij} is the wage worker i paid in job, proportional to productivity

  $w_{ij} = \gamma_i y_{ij}$;

  and $y_{ij} = \begin{cases} \beta_j s_i - k_j, & x < 0 \\ \beta_j max_j - k_j, & x \geq 0 \end{cases}$ with $\beta_j > 0\ ;\ k_j > 0\ \forall\ j$

- F is a utility cost associated with producing negative output (e.g. the cost of being fired and suffering a spell of unemployment);
- $c_i(s_i)$ is the cost of deploying skills $\longrightarrow\ c_i = \begin{cases} 0, & s \leq \eta_i \\ \delta s_i x, & s > \eta_i \end{cases}$

Given those assumptions is possible to identify the optimal skill deployment s_i^*:

- for under-skilled workers ($\eta_i < min_j$) $\longrightarrow s_i^* = min_j$
- for matches workers ($min_j \leq \eta_i \leq max_j$) $\longrightarrow s_i^* = \eta_{ij}$
- over-skilled workers ($\eta_i > max_j$) are instead indifferent between any level of skill deployment in the interval [max_j ; η_i].

Having access to data that include observable measures of the skills possessed by employed workers in PIAAC, it is possible to identify and estimate the parameters min_j and max_j for each job, defining in this way all Job Requirements. Then, the values obtained must be compared to PIAAC data about worker's skills and obtain precise empirical indicators of mismatches.

4.4: MEASURING SKILL SHORTAGES

Skill shortages can be measured at firm level using also in this case the Subjective method: a series of questions are dispensed to the employer in two steps:

- FIRST STEP: Questions with the aim of establish the presence of unfilled or hard-to-be-filled vacancies;
- SECOND STEP: Questions with the aim of understand the employer's opinion about the reasons behind those difficulties.

The problem of this approach is to understand in which measure the identified difficulties are due to genuine skill shortages or to firm's lacks in the recruitment process, for this motivation generally the obtained results are over-estimated.

4.5: MEASURING SKILL OBSOLESCENCE

Generally, also skill obsolescence is measured using the subjective method. Questions are even in this case dispensed to employees and even in this case there is not a universal question or set of question established a priori, thus, different research, different questions. For example, the Cedefop European Skills and Job Surveys asked: "Compared to when you started your job with your current employer, would you say your skills have now improved, worsened or stayed the same?". In this case skill obsolescence emerges if a certain share of employees, states that a worsening has occurred.

CHAPTER 5: THE COSTS OF MISMATCHES[1]

Skill mismatches represent an inefficiency and generate a number of problems that plague workers, firms and the overall economy. Workers suffers for mismatches especially in terms of job-displacement, wages and low job-satisfaction. This low job satisfaction then is even the cause of most of firm's problems because it is connected to lower level of worker's productivity and higher turnover rate, generating a lot of supplementary costs for new hiring and training. Obviously, all those effects cannot have some negative impacts also on the overall economy: mismatches are inefficiencies and generate costs.

Finally, a section will be dedicated also to the possible positive effects that mismatches may have in terms of short time hiring strategies.

5.1: WORKER'S MISMATCHES' COSTS

Mismatches that represent a problem for workers belong to the family of vertical mismatches: over(under)-education(skilling).

One first result is about the connection between mismatches and the possibility to became job-displaced[2]: skill-mismatched workers are more likely to became displaced, this is particularly valid for under-educated (skilled) workers.

[1] For "costs of mismatches" are intended all the possible problems that mismatches cause in the market.

[2] Job Displacement: involuntary job separations due to economic or technological reasons or as a result of structural change, "Re-employment, Earnings and Skill Use after Job Displacement", OECD, 2013.

Most of literature is concerned on problems connected to wages, job satisfaction and consequently also to worker's productivity.

5.1.1: Effects on Wages

Is possible to identify two different effects on wages depending on which mismatch is analyzed: over-educated (skilled) workers suffers a penalty with respect to matched individuals with their same level of education (skills) but they earn more with respect to their colleagues; under-educated (skilled) workers suffers a penalty with respect to their colleagues but they earn more than if they were properly matched. Anyway, wage benefits of over-education (skilling) tend to decline with additional labor experience. The magnitude of those effects vary with respect to many factors: wage penalties due to over-education appear to be greater than wage penalties caused by over-skilling; they may also vary by level of education: higher level of education lead to higher wage penalties; and for sex: men suffer more with respect to women; obviously differences emerge also from a country to another. Thus, mismatches have a negative impact on worker's wages, in particular for men and for individuals with high levels of education.

This negative relationships between mismatches and wages can be studied thanks to the model proposed by F. Guvenn, B. Kuruscu, S. Tanaka and D. Wiczer in their work "Multidimensional Skill Mismatches": Each worker lives for T periods and supplies one unit of labor inelastically in the labor market. The objective of a worker is to maximize the expected present value of earnings/wages. There is a continuum

of occupations, each using n types of skills, indexed with j ∈ {1, 2, …, n}. Occupations differ in their skill intensity of each skill type, are denoted with the vector $\mathbf{r}_t = (r_1; \ldots\ldots; r_n) \geq 0$, which is fixed over time. Just as skills are multidimensional, so are the abilities to accumulate them, indicated by vector **A** ≡ $(A_1; \ldots\ldots A_n)$.

A worker starts period t with a skill portfolio $\boldsymbol{h_t} = (h_{1,t;\ldots\ldots\ldots} h_{n,t})$, chooses an occupation $\mathbf{r}_t$, accumulates new skills, and then produces output with these upgraded skills.

The technology needed for skill accumulation is given by *Equation 1:*

$$k_{j,t} \equiv h_{j,t} + \left(A_j + \mathcal{E}_{j,t}\right) r_{j,t} - \frac{r_{j,t}^2}{2}$$

where $k_{j,t}$ is the upgraded skill of type j, which is used in production in period t and determines next period's starting human capital level and $\mathcal{E}_{j,t}$ is a random disturbance term. Broadly speaking, this equation says that in a given period, workers first go through training and then produce output with their new/upgraded skills.

The output of a worker in a given occupation is the sum of his end-of-period skills and because in perfect competition worker's output is equal to wages we have:

$$w_t = \sum_j k_{j,t}(h_{j,t,} A_{J,} r_{j,t,} \mathcal{E}_{j,t})$$

Equation 2, is the *General Wage Equation* of the model, and it represents the fact that workers with the same human capital portfolio at the beginning of the period, h_t, who work at different occupations during the period, will end up with different amounts of skills acquired, $k_{j,t}$ and therefore, receive different levels of compensation. Thus, a worker's wage depends on his human capital vector $\boldsymbol{h_t}$, on his learning ability **A**, on his occupation $\boldsymbol{r_t}$, and on the stochastic disturbance, $\boldsymbol{\mathcal{E}_{j,t}}$. Finally, by adjusting $k_{j,t}$ for depreciation, we obtain *equation 3,* which represents the beginning-of-period human capital in period t+1:

$$h_{j,t+1} = (1 - \delta)k_{j,t} = (1 - \delta)\, h_{j,t} + \left(A_j + \mathcal{E}_{j,t}\right) r_{j,t} - \frac{r_{j,t}^2}{2}$$

In order to see how skill mismatches affect wages, we must combine *equations 1 and 2* obtaining *equation 4:*

$$w_t = \sum_{j=1}^{n}\left(h_{j,t} + \frac{A_j^2}{2} - \frac{\left(A_j - r_{j,t}\right)^2}{2}\right) + \sum_{j=1}^{n} r_{j,t}\, \mathcal{E}_{j,t}$$

This equation put into evidence the fact that a worker's wage depends positively on his human capital at the beginning of the period and negatively on $\left(A_j - r_{j,t}\right)^2$, which represents the deviation between his ability level and his job's skill requirement: the skill mismatch.

Going deeper in the analysis, using *equation 3* and substituting for human capital (considering $\delta \equiv 0$ for simplicity) yields

$$h_{j,t} = h_{j,1} + \frac{A_j^2}{2}(t-1) - \sum_{s=1}^{t-1} \frac{(A_j - r_{j,s})^2}{2} + \sum_{s=1}^{t-1} r_{j,s}\, \mathcal{E}_{j,s}$$

Equation 5 shows that human capital grows with experience at a rate that is proportional to ability and it is depressed by the degree of mismatches in all his past occupations.

Substituting this expression in *equation 4*, we obtain the *Key Wage Equation* of the model:

$$w_t = \sum_j h_{j,1} + \frac{1}{2}\sum_{j=1}^{n} A_j^2 \times t - \frac{1}{2}\sum_{j=1}^{n}\sum_{s=1}^{t}(A_j - r_{j,s})^2 + \sum_{j=1}^{n}\sum_{s=1}^{t} r_{j,s}\, \mathcal{E}_{j,s}$$

Where $\frac{1}{2}\sum_{j=1}^{n}\sum_{s=1}^{t}(A_j - r_{j,s})^2$ represents skill mismatches. The equation shows two important facts regarding Human Capital growth:

1. Is proportional to a weighted average of worker's ability;
2. Is depressed by the history of past mismatches.

Finally, introducing another variable, t^c, denoting the period in which the worker switched to his current occupation (i.e., $r_{j,s} = r_{j,t^c}$ for s $\geq t^c$) is possible to identify his current tenure, given by: $(t - t^c + 1)$. Putting it in the *Key Wage Equation* and rearranging the terms we obtain

$$w_t = \sum_j h_{j,1} + \frac{1}{2}\sum_j A_j^2 \times t - \frac{1}{2}\sum_j (A_j - r_{j,t^c})^2 \times (t - t^c + 1) - \frac{1}{2}\sum_{s=1}^{t^c-1}(A_j - r_{j,s})^2 + \sum_{s=1}^{t}\sum_j r_{j,s}\, \mathcal{E}_{j,s}$$

In which is highlighted the negative incidence on wages of both, past skill mismatches $\frac{1}{2}\sum_{s=1}^{t^c-1}\left(A_j - r_{j,s}\right)^2$ and current skill mismatches $\frac{1}{2}\sum_j\left(A_j - r_{j,t^c}\right)^2$.

5.1.2: Effects on Job Satisfaction

As already reported, over-educated (skilled) workers suffers a penalty with respect to matched individuals with their same level of education (skills) and this fact represents an incentive for those workers to search for a more relevant job to their education and skills; under-educated (skilled) workers suffers a penalty with respect to their colleagues but they earn more than if they were properly matched which, opposite to the previous case, is a disincentive for those workers to search for a more matched job. Thus, over-educated (skilled) workers are affected by a lower job-satisfaction with respect to under-educated (skilled) workers. Due to this low job-satisfaction, the level of effort at work of over-educated (skilled) workers tend to decline, absenteeism increases and also their productivity reduces. Another evidence is that unsatisfied workers are characterized by a high level of voluntary turnover: they change job because they want to be matched in order to obtain more satisfaction at work and to earn an adequate wage for their knowledge (skills) level. Finally, over-educated (skilled) workers tend to invest less in training, which implies a decrease of their average productivity and it also exposes them to a higher risk of skill obsolescence.

5.2: FIRM'S MISMATCHES' COSTS

Firms mismatches' costs derives from both: vertical-mismatches and skill shortages.

Starting from vertical mismatches, problems derive from under-educated (skilled) workers, because they grant to the firm lower level of productivity with respect to their matched colleagues just "by definition" because they do not have the level of knowledge/skills (or both) required to well-perform their job; even over-educated (skilled) workers participate to the general loss of firm's productivity because of their low job-satisfaction. Moreover, because over-educated (skilled) workers are associated to higher level of voluntary turnover with respect to their matched colleagues, they generate a lot of other costs for the firm, in terms of new hiring and training costs.

Skill shortages instead, first of all cause to the firm production losses due to the high difficulties that they imply in filling the opened positions and in the subsequent recruitment of under-educated (skilled) workers. Moreover, skill shortages may also limit investments and the adoption of new technologies, with negative impact on productivity and on the improvement possibilities of firms[3].

[3] The EIB Investment Survey (EIBIS), provides information on skills and investment-related aspects, by regularly assessing whether the availability of workers with the needed skills represents an impediment to investments for EU Firms. The results show that since 2016 more or less the 77% of firms report the limited skills availability an impediment to investments.

5.3: MISMATCHES' COSTS FOR THE OVERALL ECONOMY

The negative effects that mismatches have on the overall economy are several and many studies have been conducted about them with important results. First, because mismatches distort the optimal allocation of resources, is evident the negative relationship between skill mismatches and average productivity. In general, higher levels of skill mismatches generate a less accurate allocation of resources across firms and consequently reduce firm's productivity. Secondly, ad aggregate level this fall of average productivity due to mismatches causes also a decrease of a country's GDP[4]. Moreover, mixed evidences emerge with regard to the negative effects that mismatches have on the increase and the persistence of structural unemployment. Finally, mismatches contribute to the increase of wage inequalities among workers.

5.4: POSSIBLE POSITIVE EFFECTS OF SKILL MISMATCHES

Even if vertical mismatches are generally associated with lower level of productivity, for some firms hire over (under)-educated (skilled) workers may represent a strategy in some cases. In fact, over-educated (skilled) workers, at least before that job unsatisfaction occurs, grant higher level of productivity with respect their colleagues and they also "cost less" with respect matched workers with their

[4] Mavromas in a study of 2007 propose a model to estimate the GDP fall due to over-skilling in Australia finding that the over-skilling costs amount to about 2.6% of Australian GDP only in 2005.

same level of knowledge (skills). On the other hand, under-educated (skilled) workers compensate their low productivity level with lower costs with respect their colleagues. But this is just one motivation behind the hiring strategy of firms. Another aspects of the strategy is strictly connected to over-education (skilling): By hiring over-educated (skilled) workers when the supply of highly educated workers exceeds demand for their services, large firms increase their opportunities to substitute high-skill for low-skill workers in times when high-skill workers are in short supply. High elasticity of substitution between high-skill and low-skill workers in large firms explain their higher rates of labor productivity. However, to determine precisely the relative efficiency of using the over-educated instead of matched workers is difficult.

CHAPTER 6: HOW TO COPE WITH MISMATCHES

The responsibility to develop (and to finance the development) knowledge and skills that firms deserve should fall on both: workers and employers. The formers have the responsibility to invest in education in order to increase their knowledge and sending in this way a strong "signal" for employers at the hiring moment. The latter instead must invest first of all in developing an accurate recruitment process in order to be able to select only workers with the adequate level of knowledge (skills) ; and then, in order to avoid the process of skill obsolescence and in order to address any eventual mismatch that can occur, develop accurate training programs including specific training, general training and training on the job.

Nothing can be done neither by workers nor by firm to reduce the presence in the market of skill shortages. In this case is the Government that should intervene with specific policies with the main aim of enhance the responsiveness of the education and training system to emerging labor market needs.

The relationship between education and skill mismatches has been already treated in chapter 2. Education in the labor market (which is strongly influenced by asymmetric information), is the most powerful signal an applicant can send to firms about his talent: higher educational level are connected, under some HPs, to higher level of talent[1]: only more talented individuals will decide to enroll to University

[1] Education can be considered as a good indicator for talent under four HP:

1. Not everyone can reach a certain level of education;

producing the signal "education". This can be analytically demonstrated by considering how individuals take their decisions about to produce or not a given signal. Assuming that:

- θ: the talent of an individual;
- $c(\theta)$: the cost of producing the signal, negatively correlated with θ;
- $p(\theta)$: the probability of producing the signal, positively correlated with θ;
- $w(\theta)$: the wage of an individual with the signal;
- $\hat{w}(\theta) < w(\theta)$: the wage of an individual without the signal is

The Expected Utility of an individual without the signal is:

$$U^N = \frac{\hat{w}(\theta)}{r}$$

The Expected Utility of an individual with the signal is:

$$U^S = \frac{w(\theta)}{r}$$

The Expected Utility of producing a signal (U) is given by the costs of producing the signal plus the discounted values of the expected utilities of obtaining or not the signal weighted by their probabilities:

$$U = -\frac{c(\theta)}{1+r} + \frac{p(\theta)U^S + (1 - p(\theta)U^N)}{1+r}$$

2. Only the most talented individuals find convenient to enroll to higher level of education;
3. Not all the enrolled individuals reach the target;
4. Talent in education is considered a good proxy for work productivity.

Individuals decide to produce a signal only if the Expected Utility of producing the signal is greater than the Expected Utility of not having the signal:

$$U \geq U^N \longrightarrow -\frac{c(\theta)}{1+r} + \frac{p(\theta)U^S + (1-p(\theta)U^N)}{1+r} \geq \frac{\hat{w}(\theta)}{r}$$

After calculations we obtain *equation 6.1:*

$$\boldsymbol{p(\theta)\frac{w(\theta)-\hat{w}(\theta)}{r} \geq c(\theta)+\hat{w}(\theta) \quad \longrightarrow \quad p(\theta) \geq r\frac{c+\hat{w}}{w-\hat{w}}}$$

Is possible to apply *equation 6.1* to the case of a person who must decide if enroll or not to university. Assuming that:

- The enrollment costs are equal for all the individuals so that **c(θ)= c**
- The probability of graduate (which increase with talent: **θ)** is given by:

$$\boldsymbol{p(\theta) = \frac{\theta}{\theta + x}}$$

Where x is a parameter stating the difficulty of graduate,

Equation 6.1 becomes

$$\boldsymbol{p(\theta) = \frac{\theta}{\theta + x} = r\frac{c+\hat{w}}{w-\hat{w}} \quad \rightarrow \quad \bar{\theta} = \frac{x}{\frac{w-\hat{w}}{r(c+\hat{w})} - 1}}$$

If $\boldsymbol{\theta_0 \geq \bar{\theta}}$ (the talent of an individual is greater than the talent for which the gains of been graduated are equals to the costs of graduate), he will decide to enroll to University. Thus, only more talented individuals decide to enroll to University in order to produce a strong signal which should grant them better work opportunities.

Anyway, this could be not sufficient: in practice, individuals graduated in broader fields of studies can be easily mismatched by firms with respect of people graduated in very specific fields of study. This is not to say that the only way to avoid mismatches at work is to graduate in specific disciplines but just to say that also other is required: a good recruitment process by firms able to further reduce the incidence of asymmetric information. Education may also fail as a signal in the case of a weak educational system.

Regarding training, chapter 2 has already treated the relationship between under-investments in training and mismatches, in this chapter will be better highlighted the importance of training for firms regarding mismatches but first a section will be dedicated to firm's recruiting process.

6.1: FIRMS RECRUITING - SCREENING PROCESS

The purpose of the hiring process is to identify the best worker for the open vacancy in the company, which means finding a worker aligned with the culture, the strategy and technology of the firm. Obviously, he must also have the knowledge and skills necessary to perfectly perform his job: he must be totally matched. It's a costly process but is crucial in order to avoid mismatches and all the connected problems. A good recruiting process must work as a filter: step by step it must reduce the pool of applicant of the firm in order to pass from many applicants to the best one of them: the optimal choice for the open vacancy.

The first step is about an important choice: the firm must decide from where to recruit the worker: internal labor market or external. In the first case the problem of asymmetric information is absent, and the "match" is quite granted, but the firm loses the possibility to find a "superstar" from outside and also the possibility to introduce new knowledge and skills in the firm.

If the firm decide to go for the external labor market[2] to cover key-positions, the risks of asymmetric information is high. Thus, the firm must invest in specific recruiting and screening strategies with the aim of reduce this risk.

Once identified the referment market and the kind of workers required, the second step of the recruitment process has the aim of reduce the pool of applicants by pushing them to self-select for the vacancy by asking for specific credentials. The strongest credential to be asked is a particular Master degree: only individuals with that specific credential will apply for the vacancy.

Once defined its pool of applicants, the third step of the recruitment process should consist in the evaluation and further screening of the candidates. In this step the firm proposes a series of interviews and / or tests regarding some specific preparatory topics for the job and/or propose a probationary period.

[2] If a company make a strong use of the internal labor market to cover the most important positions avoiding the risks of mismatches, only the lowest hierarchically positions would remain uncovered and in this case the work of the HRM would be simpler and surely less expensive because for these positions, no particular screening and selection activities are required but it is possible also to proceed with "random" assumptions.

The imposition of a tests is first and foremost a self-selection tool: only those who have the required knowledge or who have the necessary talent to pass the test will present their application. This conclusion can be analytically demonstrated using again the logic behind *equation 1,* the only thing to be adjusted are the costs to be sustained to apply for the test: no more monetary costs **(c),** now costs are given by the time and the effort needed to study in order to pass the test: **e.**

Equation 6.1 becomes:

$$\boldsymbol{p(\theta, e) \geq r \frac{\bar{w} + e}{w - \bar{w}}}$$

Considering that:

- $\boldsymbol{p(\theta, e)}$ increases in talent**;**
- $\boldsymbol{w > \bar{w}}$**.**

Only the more talented candidates will decide to spend time and effort on studying to apply for the test.

In addition, tests and interviews help to further reduce the pool of applicants by giving precise assessments on the various candidates. Thanks to the results obtained the company is aware of the real knowledge, skills and motivations of any candidate and is able to separate the worsts from the bests and obviously choose for those ones. An important thing to add is that during those interviews is not only the "future worker" who gives information about himself: those interviews represent the first opportunity for the company to communicate something about itself. There

is a large number of research supporting the thesis that the better the first impression the worker will have about the company, the better his attitude at work will be: greater satisfaction, better performances, greater commitment, less stress and even a reduction in voluntary turnover. However, it should be noted that relying solely on individual interviews is not the optimal way for the company, as psychological and sociological research has dismantled its effectiveness and reliability in various aspects[3]. The company needs only the best applicant and the one who best passes the interviews is not necessarily the best. To eliminate any doubt, the company could evaluate the worker in the field, proposing a probationary period.

A probationary period consists in hiring applicants with any fixed-term contract to see how skilled they really are in carrying out the job for which they can subsequently be hired. Therefore, a probationary period represents the best tool a company can use in order to fill an open vacancy for two main motivations:

1. It allows the firm to see and concretely evaluate if the applicant is really adequate for the open vacancy;
2. It pushes less talented applicants to not apply for the period, further reducing the pool of applicants.

[3] **The results are too influenced:** the examiners tend to prefer those who socially seem more similar to them or even rely solely on their first impression; **The evaluation of each candidate also depends too strongly on the candidate previously observed.**

In order to elaborate a really effective probationary period 3 conditions must be fulfilled:

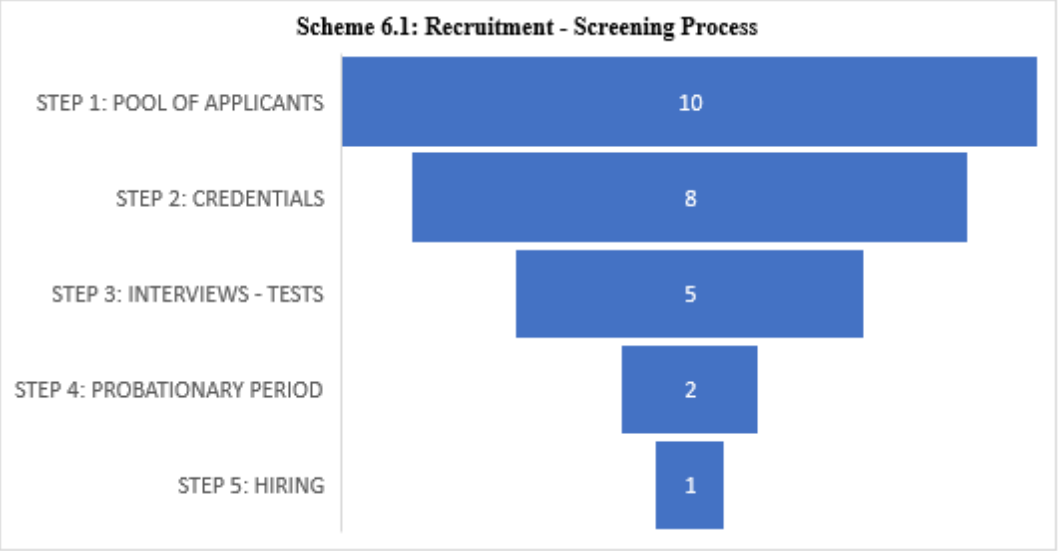
1. The wages offered during the period must be lower than the minimum wage acceptable by the worker (reservation wages): $\boldsymbol{w_1 < \bar{w}}$[4];
2. The wage obtainable once hired must be greater than the employee's reservation wage: $\boldsymbol{w > \bar{w}}$;
3. The probability of getting the job after the period must be strictly dependent on the individual's talent rather than his commitment during the period: $\boldsymbol{p = p(\theta)}$.

A worker who must decide to apply or not to a probationary period must take into account the expected benefits obtainable after probation[5] and the expected costs of applying for the period[6]:

$$\boldsymbol{p(\theta)\left[\frac{w-\bar{w}}{r}\right] \geq \bar{w} - w_1}$$

Considering that the probability to well pass the period increase in talent, and that during the period $w_1 < \bar{w}$ (applicants loose money), only the most talented individuals will decide to apply for the period risking to lose some money because they have more chances to be later permanently hired.

[4] workers must lose money during probation, otherwise all the applicants will participate.
[5] Given by the probability of getting the job multiplied by the discounted sum of the wage premium
[6] Given by the difference between the reservation wage and the wage during probation



SOURCE: Author's elaboration

6.2: TRAINING AND MISMATCHES

Training is about all those activities aimed at increasing the specific or general knowledge and skills of the worker necessary to improve his performance on the job. As emerge from chapter 2, in terms of mismatches the importance of accurate training programs is clear because they reduce the possibility of mismatches, anyway under-investments in training are frequent because they are costly, and because the firm risks to lose its investment: a worker who becomes "better" thanks to training may ask for a wage increase or may even decide to let the firm for a competitor's best offer. The general condition for a company to offer training to its workers is that benefits from training must be higher than its costs. The elements contributing to the choice are 3:

- The cost of training: **C;**
- The benefits that the company obtains if the training actually improves worker knowledge and skills: **B;**
- The increase in wage that probably will follow the training: **S.**

Thus, a firm will offer training to its workers only if: **B – S > C.**[7]

In the general situation in which **B > C**, 3 scenarios are opened:

1. **If S = 0** → Benefits are higher than costs ant the firm will offer training to its workers;
2. **If S < B (but positive)** → After the training the company will have to raise the wages by an amount lower than B and, always taking into account that we are in the general situation in which B > C, the training could be supported by the company and co-financed: the worker will pay a part of the training equal to S, the company instead will finance the remaining part equal to B - S.
3. **If S ≥ B** → In this case the costs are greater than the benefits: offering the training would bring a loss to the company which therefore certainly will not offer training to the workers.

As the model shows, in order to offer the training, is not sufficient that **B > C**, it must also be that **B > S,** and this depends on firm's ability to appropriate most of

[7] For a more accurate analysis of wheater offer or not offer training see S. Staffolani, Dynamic Notes on Personnel Economics, pp. 180-184, Dec. 2019

the benefits of training: firm's bargaining power. The principal factors that affect firm's bargaining power are the specific or general nature of the training and worker's loyalty.

Following the Human Capital Theory is possible to identify two kind of human capital, General human capital and Specific human capital. The former

concerns generic knowledge that can be used fruitfully in several jobs. It can only be increased by generic training and workers will then be able to spend the new knowledge and skills in the external labor market as workers of this kind are particularly required. In this case, the worker's bargaining power is very strong, so much so that the company would certainly lose them if did not increase their salary: is a situation where **S = B** or maybe even **S > B**. In this case the company would suffer a loss due to training, therefore in principle, no company would offer generic training to its employees. Obviously, it is not true that these types of general training do not occur, in fact, if these lead to an increase in profits they can be co-financed by the company and the worker. There are also particular situations in which for reasons related to the condition of the market or the particular conditions of some workers, their mobility is reduced to a minimum, thus, the company aware of this knows that even if they did not raise wages the workers would stay with her and if profits increase thanks to generic training, the company would finance it. The specific Human Capital instead, concerns specific knowledge and skills of a given job and therefore useful only in that job. It can be developed thanks to specific

training. In this case, workers cannot exploit what they learned outside their company, therefore, their demand on the labor market is low and consequently their bargaining power is minimal: **S = 0**. It is the company that holds all the bargaining power and is able to enjoy all the advantages of specific training: As long as the training brings actual earnings to the company, it decides to offer it to its workers.

If the market were truly in a situation of perfect competition, decisions would be driven solely by the maximization of profits and the workers would always move towards better wage conditions. The reality of things is different and human decisions are influenced by many other factors. For example, getting away from family and affections is not so simple. Furthermore, a relationship of mutual loyalty can be established between the company and the worker: A company that has always shown maximum care and interest towards its employees, which has always made them work serenely and possibly in an environment conducive to their duties, over time has gained the esteem and loyalty of its employees, and the more that loyalty is strong, the more the company's bargaining power to retain most of the benefits deriving from a training increases.

To conclude, is undeniable that recruitment and training process are very costly and risky to the firm, anyway if well conducted, the benefits that they can bring to the firm are enormous, because granting higher rate of matched workers in all firm’s positions, they reduce the incidence of all the already cited problems of mismatches

and at the same time they grant higher levels of performance, higher level of productivity and more profits to the firm.

CHAPTER 7: EMPIRICAL EVIDENCIES FROM PIAAC

As it's possible to note from the analysis proposed in this work about mismatches and all their typical features, it is a very broad topic to which a great amount of literature has been dedicated. In order to have complete overview of this particular subject it could be useful to present even some empirical evidences.

In this chapter, the Pellizzari and Fichen model will be put into work in order to show some relevant results deriving from their analysis of PIAAC data about literacy and numeracy skills obtained in the 1st round of the 1st Cycle.

The results obtained are synthetized in Table 7.1 and Table 7.2 respectively for literacy and numeracy.

TABLE 7.1: Skill-mismatches by Countries - LITERACY

Country	Under-skilled	Well-matched	Over-skilled	Country	Under-skilled	Well-matched	Over-skilled
Austria	0.022	0.878	0.100	Korea	0.057	0.758	0.185
	(0.041)	(0.540)	(0.041)		(0.025)	(0.032)	(0.029)
Belgium[a]	0.058	0.855	0.087	The Netherlands	0.040	0.893	0.067
	(0.016)	(0.022)	(0.019)		(0.012)	(0.019)	(0.016)
Canada	0.024	0.880	0.095	Norway	0.058	0.833	0.109
	(0.006)	(0.013)	(0.013)		(0.022)	(0.028)	(0.023)
Czech Republic	0.042	0.818	0.140	Poland	0.103	0.778	0.119
	(0.021)	(0.032)	(0.029)		(0.026)	(0.037)	(0.030)
Denmark	0.047	0.839	0.114	Russia	0.100	0.793	0.107
	(0.011)	(0.018)	(0.014)		(0.042)	(0.047)	(0.036)
Estonia	0.042	0.892	0.066	Slovak Republic	0.102	0.777	0.120
	(0.013)	(0.023)	(0.019)		(0.025)	(0.030)	(0.026)
Finland	0.030	0.900	0.070	Spain	0.171	0.580	0.249
	(0.008)	(0.019)	(0.018)		(0.036)	(0.038)	(0.039)
France	0.044	0.897	0.059	Sweden	0.091	0.810	0.099
	(0.012)	(0.021)	(0.015)		(0.025)	(0.033)	(0.022)
Germany	0.097	0.670	0.233	UK[b]	0.067	0.825	0.108
	(0.036)	(0.045)	(0.041)		(0.017)	(0.024)	(0.020)
Ireland	0.117	0.740	0.142	USA	0.144	0.612	0.244
	(0.032)	(0.042)	(0.033)		(0.039)	(0.037)	(0.042)
Italy	0.102	0.766	0.132	Total	0.093	0.746	0.162
	(0.030)	(0.042)	(0.032)		(0.072)	(0.133)	(0.073)
Japan	0.031	0.876	0.093				
	(0.011)	(0.021)	(0.018)				

SOURCE: OECD Survey of Adult Skills (PIAAC)

TABLE 7.2: Skill-mismatches by Countries – NUMERACY

Country	Under-skilled	Well-matched	Over-skilled	Country	Under-skilled	Well-matched	Over-skilled
Austria	0.018	0.834	0.148	Korea	0.056	0.792	0.152
	(0.043)	(0.060)	(0.041)		(0.024)	(0.035)	(0.031)
Belgium[a]	0.059	0.859	0.082	The Netherlands	0.038	0.904	0.058
	(0.017)	(0.021)	(0.019)		(0.013)	(0.021)	(0.015)
Canada	0.028	0.874	0.098	Norway	0.074	0.848	0.078
	(0.007)	(0.015)	(0.012)		(0.018)	(0.028)	(0.021)
Czech Republic	0.038	0.838	0.124	Poland	0.107	0.739	0.155
	(0.023)	(0.034)	(0.028)		(0.025)	(0.037)	(0.027)
Denmark	0.062	0.842	0.096	Russia	0.065	0.816	0.119
	(0.013)	(0.019)	(0.015)		(0.044)	(0.050)	(0.038)
Estonia	0.031	0.910	0.059	Slovak Republic	0.043	0.782	0.176
	(0.010)	(0.019)	(0.017)		(0.027)	(0.033)	(0.031)
Finland	0.040	0.897	0.063	Spain	0.151	0.599	0.250
	(0.008)	(0.018)	(0.016)		(0.033)	(0.038)	(0.035)
France	0.043	0.892	0.065	Sweden	0.075	0.843	0.081
	(0.010)	(0.019)	(0.016)		(0.025)	(0.031)	(0.022)
Germany	0.105	0.653	0.243	UK[b]	0.069	0.822	0.108
	(0.033)	(0.041)	(0.040)		(0.017)	(0.028)	(0.024)
Ireland	0.121	0.726	0.153	USA	0.139	0.598	0.263
	(0.034)	(0.043)	(0.038)		(0.038)	(0.038)	(0.042)
Italy	0.088	0.771	0.141	Total	0.087	0.746	0.167
	(0.030)	(0.039)	(0.030)		(0.070)	(0.137)	(0.079)
Japan	0.035	0.894	0.071				
	(0.011)	(0.020)	(0.018)				

SOURCE: OECD Survey of Adult Skills (PIAAC)

At literacy proficiency aggregate level, approximately 75% of dependent employees are classified as well-matched across all the countries covered by the survey, about 16% are over-skilled and 9% are under-skilled. Anyway, behind these results exists large heterogeneity across countries. For example, over-skilling can affect as many as 25% of workers in Spain and as few as 5.9% in France. Under-skilling is lowest in Austria (2.2%) and Canada (2.4%) and is highest in Spain (17.1%). The results for numeracy are broadly similar to those for literacy, and the ranking of countries is also similar.

Looking for results about combinations of over and under skilling in literacy and numeracy, Table 7.3 gives three important results.

First, who is mismatched in one field is more likely to present the same kind of mismatch also in the other field. In fact, the 62% of under-skilled workers in literacy is under-skilled even in numeracy; the 67% of over-skilled workers in literacy is over-skilled even in numeracy.

Second, the 30% of workers who is mismatched in literacy is well-matched in numeracy.

Finally, the most important result consists in the fact that more or less the 90% of well-matched workers in literacy is well-matched even in numeracy. The remaining 10% of workers presents in the 3% of cases numeracy under-skilling and in the 7% of cases a numeracy over-skilling.

TABLE 7.3: Overlapping of skill-mismatch in Literacy and Numeracy

		Numeracy		
		Under-skilled	Well-matched	Over-skilled
Literacy	Under-skilled	0.652	0.305	0.043
		(0.017)	(0.016)	(0.008)
	Well-matched	0.033	0.894	0.073
		(0.003)	(0.005)	(0.004)
	Over-skilled	0.016	0.313	0.671
		(0.005)	(0.015)	(0.014)

SOURCE: OECD Survey of Adult Skills (PIAAC)

Finally, is even possible to identify the incidence of over and under-skilling across specific demographic groups.

Men appear to be affected by over-skilling more frequently than women, both with regard to literacy and numeracy, whereas gender differences in under-skilling are minor. This result is not obvious, as one may think that women, who often find

employment more difficultly than men, might be more willing to take jobs that do not necessarily match their skills perfectly. On the other hand, shows that women use their skills less frequently than men, mostly because of the jobs in which they are occupied. Being in jobs where skills are not often used, they might also be less likely to be mismatched.

As one might expect, graduate workers are less likely to be under-skilled than non-graduates. They are also more likely to be over-skilled. Literacy and numeracy follow similar patterns.

Consistent with the higher educational achievement of the younger generations, older workers are more likely to be under-skilled and less likely to be over-skilled, in both literacy and numeracy. This result also conforms with the idea that younger workers need time to experiment and move across jobs in search of what fits their skills well. As for older workers, the presence of a non-negligible share of over-skilled might be interpreted as an encouraging finding, especially for those countries facing rapidly ageing populations, as it suggests that improving the matching of older workers may help mitigate the impact of population ageing on productivity.

Finally, foreign workers are twice more likely than natives to be under-skilled in either literacy or numeracy. The incidence of over-skilling in numeracy (literacy) is 70% (40%) larger for foreigners than natives. This result is easy to rationalize for literacy, given that in most cases, the language of the destination country is different

from migrants' mother tongues. For numeracy, the lower incidence of over-skilling contrasts with the common finding that immigrants often hold formal educational qualifications that are higher than those required by their jobs. The over-qualification of migrants is often attributed to the difficulties in having educational qualifications officially recognized across countries. However, the results in Table 7.4 seem to suggest that some of the over-qualified foreigners simply do not have the necessary skills to carry out their jobs satisfactorily, pointing to a large heterogeneity in the quality of schooling across countries.

TABLE 7.4: Skill-mismatch by socio-demographic groups

	Literacy		Numeracy	
	Under-skilled	Over-skilled	Under-skilled	Over-skilled
Men	0.095	0.184	0.081	0.201
	(0.005)	(0.006)	(0.005)	(0.006)
Women	0.090	0.138	0.094	0.131
	(0.005)	(0.005)	(0.005)	(0.006)
Non-graduates	0.106	0.132	0.102	0.139
	(0.005)	(0.006)	(0.005)	(0.006)
Graduates	0.076	0.202	0.068	0.204
	(0.006)	(0.006)	(0.006)	(0.008)
Age <45	0.083	0.186	0.080	0.185
	(0.005)	(0.005)	(0.005)	(0.006)
Age ≥45	0.108	0.125	0.098	0.139
	(0.005)	(0.004)	(0.005)	(0.005)
Natives	0.082	0.169	0.078	0.172
	(0.004)	(0.005)	(0.005)	(0.005)
Foreigners	0.183	0.100	0.171	0.121
	(0.008)	(0.006)	(0.008)	(0.006)

SOURCE: OECD Survey of Adult Skills (PIAAC).

CHAPTER 8: EVIDENCE FOR ITALY

Most of literature about mismatches in Italy is concerned about educational mismatches, thus, Over(under)-education. In fact, as emerge from the Reflex Project, the educational mismatch in Italy is one of the highest in Europe: With a share of 23 per cent of overeducated workers at the time of their first job and of 13% five years after graduation, Italy is ranks third last, better than only Spain and the UK, which have overeducation rates of 17% and 14%, respectively, five years after graduation. In other EU countries in the sample, overeducation is almost always under the threshold of 10%.

The empirical literature on Italy has focused especially on its low level of both demand and supply of human capital.

From demand point of view, Manacorda e Petrangolo note that the production structure is still based on traditional labour-intensive manufacturing. Therefore, as stated by Cainarca and Sgobbi, the origin of the education mismatch could be found in the weak demand for more educated workers compared with the skills set supplied by the education system.

From the supply side instead, Checchi (2003), Pastore (2009) and Franzini, Raitano (2012), highlighted the low quality of the Italian educational system compared with the average level of the ones of the other European countries. A large literature points to the inefficiency of the education system in providing a sufficient level and composition of skills for the labour market demand. Ordine and Rose (2009), for

example, speculated that inefficient education choices due to the different quality of education supplied by the universities can generate overeducation. This can be reflected by the low level of education attainment, but also by the dramatic social immobility. In addition, Caroleo and Pastore (2012) note a strong correlation between the education level of fathers and that of their children by type of university degree: in particular, most children whose parents both hold a university degree tend to gather in those fields of study that give access to liberal professions, where the intergenerational transfer of human capital is greatest.

Slightly different is the case of over-skilling, for which Italy tends to the country average. This is due to the tendency of over-skilling to be much more common than overeducation. In Italy, over-skilling equals 21% at the first job and 11% five years after graduation. Italy is still under Spain and the UK only, but this time also other countries have similar levels, fluctuating from 8% in Portugal and Norway to 19% in Belgium and 21% in France.

Many studies had been conducted also for what concerns wage penalties due to over-education, for example Cutillo and Di Pietro in their study of 2006 based on ISTAT data about 1998 graduates, individuate a wage penalty of about the 40%.

Ferrante in 2010, uses AlmaLaurea data to assess the impact of a number of individual characteristics on the effectiveness of the university degree in providing a job that is up to the education and skills level of the individual. He reports that the

variables that correlate positively and in a statistically significant way with the effectiveness of the university degree in an ordered probit framework include:

- a high school diploma with a score of 55–60 out of 100;
- a high final grade at university;
- a longer length of job search;
- experience of postgraduate training;
- holding a university degree in engineering, chemistry, pharmacy or law.

The negative and statistically significant determinants include:

- holding a technical high school diploma; belonging to the working class;
- starting their career via starter (so-called atypical) working contracts, such as apprenticeship, stage, or temporary contracts;
- holding an arts degree or a degree in education, psychology or social sciences.

Moreover, the author finds a statistically significant positive effect of the effectiveness of the university degree on job satisfaction.

F. Pastore together with F.E. Caroleo, elaborated in 2017 an important study about the determinant of ever-education in Italy using a logit model based on AlmaLaurea database. Gathering very detailed information on several aspects of university education and the school-to-work transition of graduates, AlmaLaurea is the most important source of information for assessing the quality of tertiary education from a comparative perspective across athenaeums, faculties, provinces, fields of studies

and so on. Moreover, the AlmaLaurea data has a number of advantages as compared to the two main concurrent data sets used in Italy (ISTAT and ISFOL Plus):

- overall, the sample included about 20% of the pre-reform graduates in 2005, the largest possible number for a homogeneous cohort;
- it covers a more recent period, but just before the current economic crisis began;
- it is obtained by merging two extremely comprehensive datasets, of which the first is elicited at the time of graduation and contains all types of information on the study career, both in secondary and tertiary education, and the second contains extensive information on postgraduate training and early labour market experiences;
- it allows the definition not only of overeducation, as in previous studies concerning Italy, but also over-skilling.

The sample identified by the authors was about pre-reform graduates who graduated in 2005 in one of the 36 universities belonging to the consortium at that time. Individuals in the sample are observed at the time of their graduation and thereafter in 2006, 2008 and 2010. The sample consists of 28,976 pre-reform graduates interviewed at the time of graduation, 21,605 of whom answer the questionnaire five years after graduation and 17,387 of whom report being employed.

The employment questionnaire conducted after graduation includes two questions that provide subjective measures of mismatch:

The first question, that identifies the "to-do" definition of mismatch was: *"In your current job, do you use the competences acquired during your university studies?"*

Three answers were possible:

1. The competences acquired are used to a great extent;
2. they are little used;
3. they are not used at all.

The ones who have chosen answer 3 were classified as over-skilled.

The second question, that identifies the "to get" definition of mismatch was: *"Is your university degree necessary to obtain your current job?"*

Four answers were possible:

1. the degree is required by law;
2. it is not required by law, but is in fact needed;
3. it is not required by law, but is in fact useful;
4. it is neither required by law nor useful.

The ones who have chosen answer 4 were classified as over-educated.

Questions about such individual characteristics as civil status are only asked at the time of graduation, not five years later.

Table 8.1 shows that one year after graduation, the over-skilled and the over-educated amounted to about 16.5% and 13.2% respectively, falling to 11.4% and about 8.0% respectively at the end of the period under consideration. It means a reduction down to only about 69% and 61% of the original value, suggesting that

the educational mismatch is not a transitory phenomenon for a large number of individuals, which is in line with the findings of a growing body of literature.

TABLE 8.1: Over-education after 1, 3, 5 years of pre-reform graduates

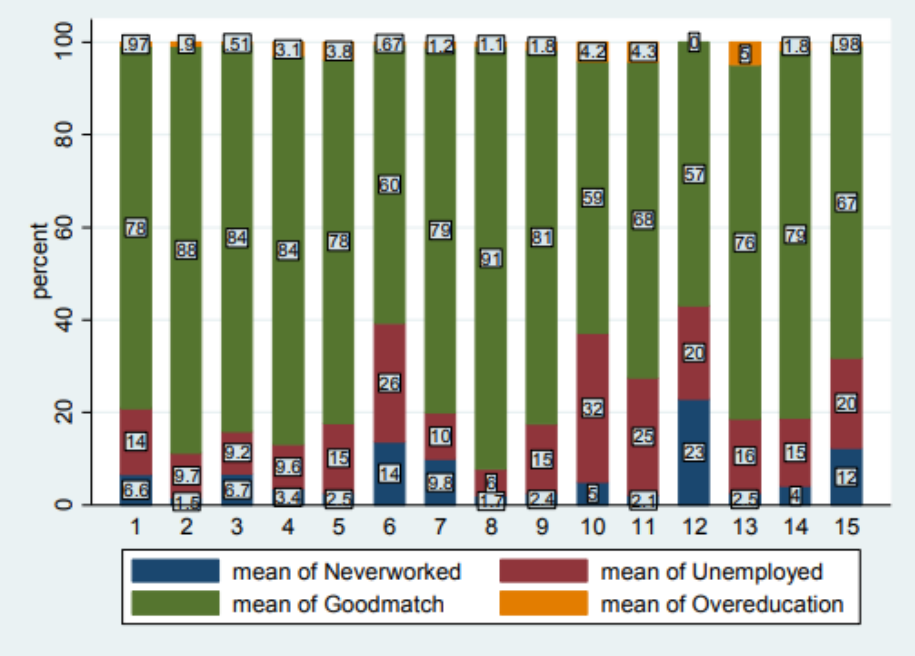
Definition	1 year	3 years	5 years
Overskilled ("to do" definition)	16.47	12.49	11.44
Overeducated ("to get" definition)	13.16	9.37	7.99
Number of wage employees	13,500	17,223	17,387
Number of interviewees	25,196	23,851	21,605

SOURCE: F.E. CAROLEO, F. PASTORE, Overeducation at a glance. Determinants and wage effects of the educational mismatch based on AlmaLaurea data, GLO Discussion Paper, No. 15, Global Labor Organization (GLO), Maastricht, 2017

Figure 8.1, reports the non-employment shares by field of study, the share of overeducation and that of the well-matched graduates five years after obtaining a degree.

The non-employment share, given by the sum of never-worked and unemployed, is quite high for most degrees, with an average of 22.5%. It ranges between a minimum of 7.7% in the case of engineering and a maximum of about 40% in the case of geology and biology. The low employment share of graduates in medicine is due to the fact that most medical doctors are still attending postgraduate schools.

FIGURE 8.1: The disruption of human capital by field of study five years after graduation



Note: The shares are computed based on the total number of graduates.
1=Agriculture; 2=Architecture; 3:Chemistry-Pharmacy; 4=Economics and Statistics; 5=Physical education; 6=Geology and Biology; 7=Law; 8=Engineering; 9=Education; 10=Arts; 11=Languages; 12=Medicine; 13=Political and social sciences; 14=Psycology; 15=Sciences.

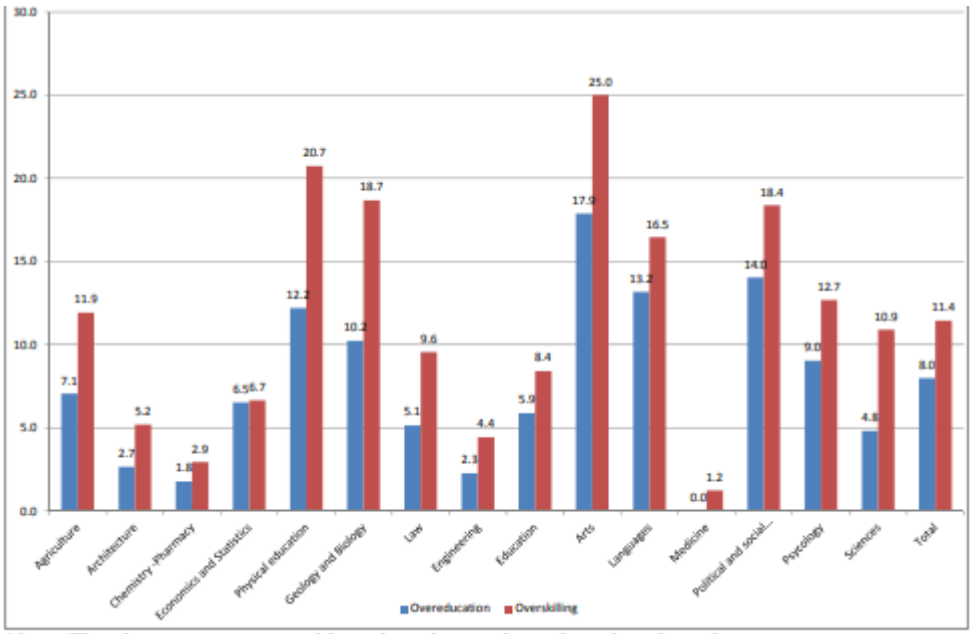
SOURCE: F.E. CAROLEO, F. PASTORE, Overeducation at a glance. Determinants and wage effects of the educational mismatch based on AlmaLaurea data, GLO Discussion Paper, No. 15, Global Labor Organization (GLO), Maastricht, 2017

Figure 8.2 shows the share of employed graduates who are overeducated and over-skilled for each field of study.

Overeducation ranges from zero or almost zero in the case of medicine, architecture, chemistry and pharmacy, engineering and sciences to more than 10% in the case of geology and biology (10.2%), physical education (12.2%), languages (13.2%), political and social sciences (14%) and literature (17.9%). Overskilling follows roughly the same pattern with a share slightly higher for each field of study.

Languages (16.5%), political sciences (18.4%), geology and biology (18.7%), physical education (20.7%) and literature (25%) present the highest percentages.

FIGURE 8.2: Shares of overeducated/overskilled by field of study five years after degree



Note: The shares are computed based on the number of employed graduates.

SOURCE: F.E. CAROLEO, F. PASTORE, Overeducation at a glance. Determinants and wage effects of the educational mismatch based on AlmaLaurea data, GLO Discussion Paper, No. 15, Global Labor Organization (GLO), Maastricht, 2017

Table 8.2 reports odds ratios of the independent variables estimated by logit on the probability of being overeducated (column 1) or overskilled (column 2).

Ceteris paribus, gender is a statistically significant (at a level of 5%) determinant of overskilling, but not of overeducation. Women are about 13 odds points more likely to be overskilled. Other individual characteristics, such as the civil status and having children at the time of graduation, seem to have little impact on the

probability of being overeducated, probably because they might have changed five years from graduation.

Several aspects of an individual's educational quality correlate with the likelihood of experiencing a mismatch: the field of study, the final grade and the time spent obtaining a degree. Fuoricorso graduates with a delay of two or more years have ceteris paribus a 50-odds-point greater chance than the in corso of experiencing educational mismatch. The impact of the field of study is particularly important. All fields of study are associated with a higher chance of mismatch than engineering (the reference group). Particularly strong is the impact of holding a degree in literature, languages, physical education, political and social sciences, psychology and geology and biology. Only architecture and medicine are not statistically different from engineering. Overall, the quality of education, as measured by indicators of university performance, seems to be the most important determinant in the probability of being mismatched.

The well note geographical differences existing in Italy emerge also in the way overeducation manifests itself across regions. As emerge from the study in fact, graduates who seek their job in the north, no matter whether west or east, experience a much lower probability of mismatch than their peers in the centre and even more so in the south. Which is in contrast with the work of Franzini and Raitano who, in 2012, found that in the South overeducation is less frequent and bears a lower wage penalty.

On the other hand, according with the work of Croce and Ghignoni of 2015, it seems that in particular, among the university graduates, movers are less overeducated than stayers and a longer migration distance decreases overeducation risks.

Finally, on-the-job training practices, attending some graduate schools and master degrees of level II reduce the risk of mismatch in a statistically significant manner. Masters of level I reduce the risk of overeducation, but not overskilling, which are positively affected by post-degree scholarships. Other post-degree programmes – such as the doctorate, other types of master degrees, internships, public training programmes and voluntary social work – are not statistically significant.

TABLE 8.2: Determinaits of over-education 5 years after graduation. Log odds ratios from Logit estimates

Dependent variable	Overeducation ("to get")	Overskilling ("to do")
Independent variables	(1)	(2)
Individual Characteristics		
Gender. Default: Men		
Woman	0.9112	1.1277**
Civil Status, Male. Default: Single		
Married	1.3706	1.1783
Partner	1.1641	0.9821
Separated, divorced, widow	0.564	0.9668
Civil Status, Female. Default: Single		
Married	0.9802	0.9523
Partner	1.0728	0.92
Separated, divorced, widow	0.727	0.3719**
Number of children, Men	0.5841*	0.7369
Number of children, Women	0.8543	1.051
Non Italian	1.0766	1.0438
High School		
Type of high school diploma. Default: Science-based grammar school in		
Classical grammar school	0.9079	1.0213
Specialisation in teacher training	0.7900*	1.003
Language high school	1.2582*	1.0705
Art school	1.7490***	1.3975*
Technical school	1.3541***	1.1776**
Professional school	1.5591***	1.6706***
Other high school diploma	1.4884*	1.2664
University performance		
Final grade at university. Default: Magna cum laude		
66-90 out of 110	1.9540***	2.2542***
91-100 out of 110	1.8596***	1.9335***
101-105 out of 110	1.5401***	1.8858***
106-110 out of 110	1.4571***	1.5971***
Time spent obtaining a degree. Default: Curricular years		
1 extra-curricular year late	1.3314*	1.3141*
2 extra-curricular years late	1.5746***	1.3815**
3 extra-curricular years late	1.5557**	1.6536***
4 extra-curricular years late	1.5520**	1.5552***
5 extra-curricular years late	1.9378***	1.8258***
Field of study. Default: Engineering		
Agriculture	4.4684***	3.7624***
Architecture	1.339	1.3471
Economics and statistics	3.4690***	1.6251***
Physical education	9.0089***	7.8656***
Geology and biology	7.0864***	6.2336***
Law	3.6917***	3.2842***
Education	4.3579***	2.4162***
Arts	15.3943***	9.8837***
Languages	9.1920***	5.2738***
Political and social sciences	9.5990***	5.5167***
Psychology	9.8709***	5.9034***
Mathematics and physics	2.5189***	2.8105***

Study abroad. Default: No study experience abroad		
Erasmus experience	0.9245	0.8227*
Other study experiences abroad	1.205	1.0545
Missing observation	0.9828	0.8749*
Post-graduate studies		
Training, apprenticeship aimed at gaining access to a liberal profession	0.5342***	0.5280***
Doctoral studies	0.7701	0.8794
Specialisation school	0.4980***	0.4930***
1st level master degree	0.7819**	0.9925
2nd level master degree	0.6551***	0.7579***
Other type of master degree	0.9797	1.0055
Internship/work grant/on-the-job training	0.8862	1.0935
Public off-the-job training scheme	0.9378	0.9424
Study scholarship	0.8107	0.7053**
Voluntary civil service	1.2048	1.149
Movers and stayers		
Default: S(he) has not moved from the south and islands		
Not moved from the north-western regions	0.7283***	0.7428***
Not moved from the north-eastern regions	0.7059***	0.7436***
Not moved from the central regions	0.9053	1.0346
Moved within the northern regions	0.6776**	0.8608
Moved within the central regions	(omitted)	(omitted)
Moved within the southern and islands regions	1.1731	2.0061***
Moved to the north-west regions	0.6593***	0.9224
Moved to the north-eastern regions	0.7215**	0.9144
Moved to the central regions	0.8151	0.9153
Moved to the southern and islands regions	1.7623	1.1552
Moved abroad	0.6740**	0.7722
Constant	0.0103***	0.0182***
Number of observations	17387	17387
Pseudo R^2	0.1066	0.0989
Correctly classified cases	92.01%	88.57%
Area under the ROC curve	0.7493	0.7315

*Note: Legend: * p<0.05; ** p<0.01; *** p<0.001.*

The figures in the Table represent odds ratios. The odds ratio associated with a characteristic j is the relative risk of being overeducated for individuals with a given characteristics with respect to the reference or default group. E.g., if the estimated odds ratio of, say, being IV years late in obtaining the degree equals 1.5, the corresponding group of graduates have a 50% higher probability of experiencing overeducation than the reference group of graduates who graduated in time. If the odds ratio equals 0.5 the individual with characteristics j have 50% lower probability of experiencing overeducation than the reference group.

SOURCE: F.E. CAROLEO, F. PASTORE, Overeducation at a glance. Determinants and wage effects of the educational mismatch based on AlmaLaurea data, GLO Discussion Paper, No. 15, Global Labor Organization (GLO), Maastricht, 2017

CONCLUSIONS

The economic literature has individuated many different types of mismatches which can be grouped in two main categories: horizontal and vertical mismatches. The focus of this work was about the second ones, thus: over (under)-education and over (under)-skilling but also skill shortages and skill obsolescence. Mismatches at works may be more evident in some countries and less in others, as can be seen from the work of Fichen and Pellizzari because of the different characteristics of the labor market of each country but also of different types of education-system. Many other important authors made studies on this particular subject, because it represents a relevant problem for individuals, for firms and for the whole economy. On average, as emerge for the study analyzed in this work, approximately 75% of dependent employees are well-matched in the literacy domain, about 9% are under-skilled and 16% are over-skilled. The overlap between literacy and numeracy mismatch is substantial: 90% of the workers who are well-matched in literacy are also well-matched in numeracy.

Men are more likely to be over-skilled than women, whereas gender differences in under-skilling are minor. Tertiary graduates are substantially less likely to be under-skilled than less educated workers, but they are more likely to be over-skilled. Foreign workers are substantially more likely to be under-skilled and substantially less likely to be over-skilled. Differences emerge also when looking across age groups. Furthermore, skill mismatch is associated with a substantial degree of skill

over- and under-utilization, with potential sizeable implications in terms of output loss and workers' well-being.

Each of the observed mismatches have their specific features, but also some common points can be founded, especially regarding the causes of mismatches. In fact, educational and skill mismatches may both derive from the particular economic cycle or by the low mobility level of individuals, which varies across different category of people.

Regarding the causes of mismatches in particular, there are in my opinion some points that need further reflection.

First of all, we saw that between the causes of under-education at work can be also listed a low-quality education-system and/or an education system which is not well coordinated with firm's needs especially emerging from new technologies. Without judging how each country organizes the many years of education or the quality of teaching, is in my opinion crucial for any country to develop more accurate and specific "from-school-to-work-systems" which should increase the connection between schools and firms. Firms must be put into condition of clearly express their specific needs in the labor market, thus which kind of knowledge or which kind of practical competencies they need. This should even participate to the reduction of the problem of asymmetric information. Schools on the other side, must be put into condition of capture those needs and organize, together with general-knowledge courses, also more practical courses, in order to teach not only the theory behind a

certain work but also how really that work should be done in practice. In this sense, a good point could be the proposal of more mandatory curricular stages also before university, in order to develop useful skills and also to allow students to have a better idea of what work is, but also a more accurate idea about the skills and knowledge that they should develop in the future in order to be ready for a work instead of another.

One thing that is totally wrong for me, is the fact that some firms choose to generate mismatches in order to obtain an advantage: some firms, despite the problems connected to job-satisfaction at work of over-educated (skilled) workers, decide to hire over-educated (skilled) workers because, even for a short period of time, those workers grant an higher productivity. Other firms instead, decide to hire under-educated (skilled) workers because, even if they're not so productive compared with their matched colleagues, they cost less. Those choices are obviously driven by some economic reasoning and for sure, at least for a certain period of time, they bring some advantages to firms, the problem is that for any mismatched worker there are many other workers that, because their "ideal" job is filled by a mismatched worker, can't find a good place and remains unemployed or, in the most of cases decide to accept a sub-optimal work, becoming in turn mismatched.

Another interesting aspect emerging from the causes of mismatches can be founded through the causes of skill shortages. Technological process is one of the drivers of the polarization of the labor force in favor of high-skilled jobs. Anyway, as we saw

from the work of Quintini and Nedelkoska, the continuous improvements in digital technologies will year after year automate many sectors, reducing in time even the demand for some categories of high-skilled workers. This is in my opinion a big problem for the entire economy that should be maybe better deepen in other specific studies with the main aim of prevent all the negative consequences that automation may bring, especially the increase of the unemployment rate.

One common point in the literature of mismatches are all the difficulties behind their measurement methods. First of all there is not a unique specific database on skills and knowledge of workers but there are many of them and in the most of cases, data are characterized by a high level of subjectivity in both, the choice of the questions to be asked to individuals, and their answers, that are unavoidably overestimated. In my opinion, because of the relevance of the problem that causes damages to workers, firms and the whole economy, it could be useful to identify a standard scheme to measure mismatches, based on an established common general skill database (as can be for example PIAAC) from which take all the key information for the measurement and on a standard model for calculation. This could be a good starting point for countries to understand the efficiency of their labour market in order to be able to realize specific policy with the aim of reducing the frictions of their labour market, helping firms and workers to find their optimal match.

Talking about the Italian case, as it emerges from the text, Italy has one of the greatest educational-mismatch rates in Europe, particularly orientated towards over-education. This can be probably be attributed to the fact that our production system is more oriented towards traditional manufacturing sectors and therefore, the weak demand for more educated workers compared with the skills set supplied by the education system may be the origin of over-education. How highlighted by the work of Caroleo and Pastore, the choice of the field of study, as the final grade and the time needed to graduate, are crucial to reduce the risk of over-education. In particular, the chances of over-education/over-skilling are strongly associated with any other university degree than engineering, medicine and a few others. Particularly strong is the impact of holding a degree in social sciences, but also in some scientific fields, such as geology and biology. Thus, it would be crucial to develop better information systems in order to provide more guidance for families and students when deciding upon their field of study at university.

On the other hand, having completed some post-graduate training or advanced master courses, especially those involving on-the-job training, reduce the risk of becoming mismatched.

The highest problem that emerges from the study analyzed in this work, is, in my opinion, our inefficient school-to-work transition system.

It must be one of our greatest concerns to help our graduates to find their match. More job opportunities in order to stop the so called “brain drain” but also starter

contracts should be offered to fresh graduates, so as to develop sooner their work-related skills. Relative to this point, is useful to highlight that due to the typical informal production structure of the Italian firms, a low propensity to delegate functions and the lack of on-the-job training programs are envisaged, then the Human Resources Management in our firms is not really oriented thorough a dimension of effective development of the work-related skills needed by employees: it would be great to improve our educational system such as to help young graduates to learn as much of the skills that they will use in their future job as possible in order to reduce their risk of be mismatched.

This work is dedicated to my Family and all the People that during my life gave me the strengths to never give up and to always reach my target.

Thanks.

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