Educational Mismatch and Productivity
A Review

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RÉSUMÉ
Dans cet article, nous expliquons comment comprendre le développement du mismatch éducatif, sous l'angle de la sur-éducation, et réalisons une synthèse de la littérature existante au sujet de la relation entre le niveau d'éducation du travailleur et la productivité de la firme. Nous mettons notamment en évidence en quoi les recherches existantes à ce sujet apportent des éclairages contrastés, aux plans théorique et empirique. Nous relevons qu'à notre connaissance, une seule approche a estimé l'impact du niveau d'éducation sur la productivité de manière directe. Celle-ci montre non seulement que le niveau d'éducation requis a un impact positif sur la productivité de la firme, mais que la sur-éducation lui est aussi bénéfique, au contraire de la sous-éducation qui lui est préjudiciable.

ABSTRACT
In this paper, we explain how to understand the developing educational mismatch phenomenon, in terms of over-education. We then summarize the existing literature on the relationship between worker's level of education and firm productivity. We highlight the fact that existing researches present contrasted theoretical and empirical conclusions. We notice that, to our knowledge, only one research has estimated the impact of education on direct measure of productivity. It not only shows that the required level of education exerts a positive influence on the firm productivity, but also that over-education is beneficial for firm productivity, while under-education is detrimental.

Keywords: Educational mismatch; Productivity; Literature review.

INTRODUCTION
Human capital improvement is a main target of the central policies of our advanced economies. According to the European Commission (2012), the tertiary attainment level in the EU27 countries for the age group 30 to 34 years old increased from 22.4% to 34.6% over the decade 2001-2011. Moreover, one of the objectives of the European Union (2009) is to reach a proportion of 40% of tertiary educated workers aged between 30 and 34 by 2020. Concerning Belgium, policy makers took commitments for 2020 and have to reach a proportion of 47% tertiary educated workers aged between 30 and 34 by 2020, which is higher than the target of the European Union (Belgian Federal Government, 2013). In 2012, the proportion of Belgian tertiary educated workers for the same age group was evaluated at 43.9% and Statistics Belgium (2013) shows some disparities among Belgian regions since they were 40.0% in Wallonia and 45.3% in Flanders. In order to reach this target, the Belgian regions have to implement several policies. In that way and concerning Wallonia, the Walloon Government (2013) has set up the so-called "Plan Marshall 2022", which gathers the main political lines to be followed by Wallonia in order to set up a new strategy for a regional development by 2022. Compared to the previous "Horizon 2022" and "Plan Marshall 2.vert" that already act in favour of the human capital for the period 2009-2014, this new plan particularly focuses on two main taskforces: the economy and the education. Concerning educational policies, the Chapter 3 of this plan aims to improve the quality of higher education in order to make of the Walloon higher education system an education system of excellence.

Given its importance, the consequences of an increasing level of education have been extensively studied by researchers. A particular attention has been devoted to investigate situations in which job requirements in terms of formal education and worker's level of education don't necessarily match, leading to what Freeman (1976) was among the first to describe as the

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educational mismatch phenomenon. Educational mismatch thus represents the inadequacy between the workers' attained level of education and the level of education required for their jobs. Workers are then considered as either over-educated if their level of attained education is higher than the level of education required for their jobs, or under-educated in the opposite case. This phenomenon is found to be important since the European Union (2012) shows that it has concerned 36% of workers aged between 25 and 64 years old in the EU27 countries over the decade 2001-2011, with massive variations from one European country to the other[31], and that roughly 30% of tertiary educated workers were over-educated in 2009. Over-education may also represent a cost for three economic actors involved (McGuiness, 2006): for individuals themselves, when over-educated workers earn less than their peers in jobs that match their level of education; for firms, when over-educated are less productive than adequately educated workers; and for the entire economy, when financing excessive levels of education causes inefficiency.

Considering this increasing and important phenomenon, the objective of this paper is threefold. First, section 2 documents on how to understand mismatch, more specifically over- and under-education. Section 3 then presents a brief conceptual review of the different measures of required education and educational mismatch. Third, the main section 4 proposes a review of the impact of educational mismatch on productivity. Section 5 then concludes and presents forthcoming developments.

1. WHY TO BE OVER-EDUCATED?

There is no real consensus concerning theory of over-education. A wide range of theoretical models have been developed to explain the over-education phenomenon (McGuinness, 2006; Leuven and Oosterbeek, 2011). These models are based on Duncan and Hoffman (1981) developments on the educational mismatch phenomenon and its impact on wages. We consider four of these models in this paper. They use individual data in order to be able to compare, on the basis of the following Mincer wage equation, the returns to required, over- and under-education:

$$ln\, w_i = \delta^r S_i^r + \delta^o S_i^o + \delta^u S_i^u + X_i + e_i$$

where:

- w_i represents the hourly wage of worker *i*;
- δ^r, δ^o and δ^u are the returns to required, over- and under-education, respectively;
- S_i^r, S_i^o and S_i^u are the number of years of required, over- and under-education of worker *i*, respectively;
- X_i represents a vector of other worker's *i* characteristics;
- e_i is the error term.

[31] For example, 17% of workers are concerned by educational mismatch in Slovakia but 51% in Ireland (European Union, 2012)

1.1. Human capital and higher wages

This model that has been developed by Becker (1964), states that workers are paid at their marginal product, which depends on their level of human capital. Then, differences in levels of wages would be due to differences in worker's characteristics, and more precisely differences in years of schooling, whatever the job requirements. So, job requirements do not matter in the relation, and the returns to (years of) required education are then equal to both the returns to (years of) over- and under-education. So:

$$\delta^r = \delta^o = -\delta^u$$

This model also supposes perfect competition in the labour market, so that potential disequilibria are automatically corrected, leading over-education just being a temporary phenomenon. Blundell *et al.* (1999) include other elements than formal education in the level of human capital of a worker, such as ability, experience or skills acquired during on-the-job training. Workers can thus possess the same level of human capital even if their level of formal education differ, and over-education can then be seen as a substitute for a lack in other human capital variables (Sloane, 2003). Other researchers rely on an adaptation of the human capital theory and develop the career mobility theory according to which workers invest in education for the long run. Over-education is then a temporary state at the early stage of a career only, and a wage penalty for being over-educated can appear in the short run, which is further compensated by higher wages thanks for example to promotions (Sichermann and Galor, 1990; Sicherman, 1991).

1.2. Job competition and better chances to be recruited

Developed by Thurow (1975), this model suggests that marginal product depends on the job rather on the worker's characteristics. Wages are then fully determined by the level of required education for the job. So:

$$\delta^o = \delta^u = 0$$

He argues that skills that are useful to perform a job are mainly acquired through on-the-job training and learning-by-doing, rather than through formal education. While wages are tied to the characteristics of the jobs rather than those of the workers, variables such as education are used by employers in order to take their hiring decisions in order to minimise training costs. According to these cost minimising considerations, the worker's position in the queue is then determined by his expected cost in terms of training, which is negatively related to education: the more educated the employee, the less he has to be trained. So workers have then incentives to invest in education and to be over-educated, in order to be placed upper in the queue and to get better chances to be recruited, even though over-education does not lead as such to higher wages.

1.3. Frictions and higher probability to fill vacancies

In frictions models, over-education appears because workers try to find vacant jobs even if it requires a different level of education than theirs. Supposing that on-the-job search is impossible, Albrecht and Vroman (2002) define two types of jobs and two types of workers. Jobs requiring high skills can be done by high skilled workers, while job requiring low skills can be done by either low skilled workers or high skilled workers. At the equilibrium, it is possible that high skilled workers accept low skills jobs. Dolado et al. (2009) go a step further and allow on-the-job search, leading the over-education phenomenon then to be a temporary concept.

1.4. Higher preferences for education

In preferences models (Battu *et al.*, 1999; Chevalier, 2003; Verhaest and Omey, 2006; Korpi and Tahlin, 2009; Leuven and Oosterbeek, 2011), individuals do not share the same propensity to go to school since some enjoy attending classes and some do not. The former may thus overinvest in schooling while the latter may dislike going to school and thus underinvest in schooling. Combining leisure and job can also be a requirement for some workers, so that they could find happiness in jobs that require less education than they have because these jobs allow them to enjoy more leisure[32]. Preferences models also suggest a gender differential, with women being more likely to accept jobs for which they are over-educated because of family constraints (*e.g.*, children) or spouse success in job (*i.e.*, which lowers their financial responsibility).

2. MEASURING REQUIRED EDUCATION AND EDUCATIONAL MISMATCH

As defined in the introduction, educational mismatch is measured as the difference between the worker's attained level of education and the level of education which is required to perform his job. Empirical literature defines three ways to measure the level of required education and thus over- and under-education, each of these methods possessing advantages and weaknesses:

- First, external methods (generally job analysis data) can be used to evaluate the required level of education for a given job. For example the U.S. Dictionary of Occupational Titles (DOT) provides the level of required education by occupation. This objective evaluation method, known as the "job analysis" method, is used for example by Rumberger (1987) or Kiker and Santos (1991). This method seems very attractive in the way that it relies on explicit and objective definitions and measures. However, it requires careful and time expensive work to carry out on a large scale (Hartog, 2000). This method is also criticized by Verdugo and Verdugo (1992) who state that the DOT is sometimes based on a single job analyst discussing requirements with the employer, leading to some doubts over the reliability and the validity of this measure.

- Secondly, the "Realized Matches" method is based on the educational attainment of workers in each range of occupation. Two alternative measures can be used. First, the mean level of education across a range of occupations is calculated and workers whose educational attainment is greater (lower) than one standard deviation above the mean value for their occupation are considered to be over-(under-)educated (Verdugo and Verdugo, 1989). Secondly, the modal year of education in the worker's occupation can be calculated and workers whose educational attainment is greater (lower) than the mode are considered to be over-(under-)educated (Cohn and Khan, 1995; Kiker *et al.*, 1997). However, the main shortcoming of this method is that it does not measure real requirements for a job as such, but rather the actual assignment practice as determined by hiring standards and labour market conditions (Hartog, 2000).

- Finally, questioning techniques can be used according to which survey respondents are asked directly the minimum level of education which is needed to perform their job, in other words where workers specify the level of education which is required for their own job. This so called "self-assessment" method is used for example by Duncan and Hoffman (1981) or Sicherman (1991). It interestingly gathers up-to-date information, and the level of required education corresponds precisely to the respondent's job, and not with any aggregate measure. However, it does not rely on rigorous measurement as respondents can overstate the requirements of their own job. They can also reproduce hiring standards through years, leading to major issues in case of constant increase in the effective workers level of education over-time (Hartog, 2000).

In a nutshell, Job Analysis method seems to be more appropriate. But its proper measurement can be highly costly to implement and to keep up to date. Finally, choosing a method rather than another especially depends on the available data.

3. PRODUCTIVITY EFFECTS OF EDUCATIONAL MISMATCH

Concerning the effect of educational mismatch on firm productivity and from a microeconomic point of view, two different approaches can be considered in the literature. These two approaches, namely the human capital theory and the job satisfaction theory, lead to different conclusions and to some limitations.

3.1. The human capital theory

As developed above, the human capital theory states that education allows developing capabilities that makes workers more productive. And the gap in earnings could reflect these different levels of productivity. We could thus deduce the effect of educational mismatch on productivity by estimating its impact on wages.

[32] However, empirical evidence mainly suggests a negative impact of over-education on job satisfaction (see "The job satisfaction theory" in section 4)

Empirically, Duncan and Hoffman (1981) analyse returns to over-education in U.S. labour force, by using a dataset (the Panel Study of Income Dynamics, PSID) that provides information on a representative national U.S. sample of over 5 000 households over the year 1976. They find that nearly 40% of the U.S. workforce was over-educated, and also that this surplus education is rewarded by higher wages (from 2.9% more for white men to 5.2% more for white women). Concerning under-education, each additional year of under-education reduces wages from 4.2% for white men to 4.8% for black men.

Rumberger (1987) also estimates, on the basis of U.S. cross-sectional data for the late 1960's and 1970's, that the impact of a year of over-education on wages is positive (a return of 3.1% for male over-educated in 1973) but lower than the impact for a year of required education (a return of 5.2%).

Sicherman (1991) also uses the PSID, and more specifically a sample of male heads of households aged between 18 and 60, covering the years 1976-1979. He finds that about 40% of the workers were over-educated, while 16% were under-educated, but also that over-educated workers have fewer market experience, while it is the reverse for under-educated ones. His main finding concerning the impact of education on wages is twofold. Over-educated workers get higher wages (3.9% higher) than their adequately educated colleagues, and under-educated get lower wages (1.7% lower) than their adequately educated colleagues in similar jobs.

Battu *et al.* (1999) investigate why British individuals have the tendency to invest in increasing their education. They estimate earning returns by using a British dataset composed of 3 678 salary workers and they find positive returns to required education. They also find that increasing the level of required education leads to greater returns. Finally, they find positive returns for over-education, with a return assessed at 2.8% for the whole sample, 3.3% for males and 2.5% for females and negative returns for under-education, with a penalty reaching -3.4% for the whole sample, -4.8% for males and -0.5% for females.

Groot and Maassen van den Brink (2000) conduct a meta-analysis of 25 studies on the impact of education on wages. They find that the high range of ways to estimate the relationship leads to large differences in the incidence of over-education. They also show, by controlling for study-specific variations in the meta-analysis, that the 'true' return to a year of required education is 7.9% for the 1970s and 1980s studies and reaches 12% in the 1990s. Concerning over- and under-education, the 'true' returns are 2.6% and -4.9%, respectively.

Bauer (2002) uses a German panel dataset covering the period 1984-1998 and shows that the return to a year of over-education is positive (+9%) while the return to a year of under-education is negative (-10%).

Galasi (2008) estimates the impact of educational mismatch on wages for 25 European countries by using the European Social Survey data (about 13 500 observations) collected during the period 2004-2006 by common questionnaires, in order to check whether the other authors' findings could be confirmed or not. He concludes that most of the empirical findings are holding for his sample. In that way, he finds that the return to over-education is positive but smaller than the return to required education for each of the 25 countries. Moreover, for 23 countries, the return to under-education is negative. This suggests, according to the human capital theory, that over-education increases productivity whereas under-education decreases it[33].

3.2. The job satisfaction theory

A second tide of studies relies on the job satisfaction of workers. According to this theory, educational mismatch has an impact on job satisfaction and on some other variables that influence the workers' productivity such as absenteeism or shirking. Over-educated workers, due to their frustration of using fewer skills than they have, would be less satisfied, more absent, sicker, than their adequately educated peers. The consequence would be that firms are reluctant to hire over-educated workers because of their negative impact on firm productivity (Büchel, 2002).

Empirical studies are however not unanimous. On the one hand, Hersch (1991) uses original data collected in the Eurogen, Oregon area in 1986 over 414 male and 213 female employees, and shows that over-educated workers are less satisfied than the others. The conclusion is quite similar for female under-educated workers. Then, male over-educated workers are more ready to quit their job.

Tsang, Rumberger and Levin (1991) use data from the Survey of Working Conditions in 1969 and the Quality of Employment Surveys of 1973 and 1977, representing about 1,500 working Americans. They confirm the results of Hersch (1991), except for the relationship for female over-educated workers. On the other hand, according to the results of Büchel (2002) based on German data covering the period 1984-1995, there is no significant relation between over-education and job satisfaction. Moreover, he finds that over-educated workers are healthier, more work- and career-minded and stay more years in the same firm.

Verhaest and Omey (2006), using Belgian data on Flanders covering the period 1999-2002, find that over-educated workers have a higher turnover but they don't find any significant relationship between over-education and job satisfaction. However, using an extended data set on Flanders, Verhaest and Omey (2009) find a significant negative impact of over-education on job satisfaction. They also find that the negative

[33] It is however important to note that Verdugo and Verdugo (1989) use a different approach also based on the human capital theory. They compare over-(under-) educated workers with their peers having the same level of education but in jobs that match this level of education. Their results show that over-educated workers earn less and under-educated workers earn more than their similarly educated peers in jobs that match their level of education. This may suggest that the fact of being over-educated, maybe due to the characteristics of the worker's occupation, does not necessarily increase worker's productivity. This specification is also followed by other researchers (Groot, 1996; Battu et al., 1999; Hartog, 2000; Dolton and Vignoles, 2000; Chevalier, 2003; Frenette, 2004; McGuinness, 2006; Dolton and Silles, 2008).

consequence of over-education on job satisfaction decreases according to the number of years of experience.

Tsang (1987) uses a firm-level job-satisfaction index in his study and estimates the impact of job satisfaction on firm productivity. His results show that over-education impacts job satisfaction negatively, and that job satisfaction is positively and significantly correlated to productivity. He concludes that over-education impacts the worker's productivity negatively.

So, these two main strands of theories lead to different conclusions. Moreover, they suffer from some methodological limitations. The human capital theory supposes that both the level of education and wages are directly proportional to individual's productivity. But the relationship could be more complex than that. For example, Spence (1973) exposes the signalling theory (screening model) in which the productivity is related to some qualities such as the family background, the worker's history or even talent. According to this signalling theory, which leaded Thurow (1975) to develop his job competition model, education is just a way for an applicant to prove his capabilities to the employer, serving as a screening signal to be distinguished from other job applicants.

Concerning the job satisfaction theory, many studies seem to forget that job satisfaction is not the only factor influencing productivity through education. In that way, even if over-educated workers are less satisfied with their jobs, if someone unsatisfied is less productive as such, the educational mismatch may affect productivity through other factors than job satisfaction. For example, someone over-educated (who is less satisfied with his job) might have additional skills and capabilities acquired during schooling in a way that compensate the effect of job satisfaction on productivity.

To sum up, the evidence regarding the impact of over-(under-) education on productivity is mixed and the source of many shortcomings. But above all, all these approaches study the effect of educational mismatch on productivity in an indirect way. Hartog (2000) highlights this issue and states it would be interesting to know the *direct* effect of over-(under-)education on productivity instead of its *indirect* effect through wages, job satisfaction or other related characteristics of the workers.

3.3. Investigating the direct impact

Kampelmann and Rycx (2012) are to our knowledge the only ones to investigate the direct impact of educational mismatch variables on firm productivity, measured as the value added per worker. Considering their available linked employer-employee panel data for Belgium covering the years 1999-2006, they rely on the realized matches' measure of required education, and define the required level of education for a job by the mode of the workers' years of education within each occupation. Then, a worker is over-educated if his level of attained education is higher than the level of education which is required in his occupation, and under-educated in the reverse case. Finally they quantify the intensity of over- and under-education by measuring the number of years of over- and under-education for a given worker.

In order to explore the impact of educational mismatch on firm productivity, they rely on an ORU (Over-, Required and Under-education) specification, aggregated at the firm level, that describes the relationship between the workers' level of required, over- and under-education within firms and their productivity, by controlling for mean workers and firms characteristics and year dummies.

Concerning the data, they use panel data for Belgian firms covering the period 1999-2006 coming from a combination of two large data sets. The first is the 'Structure of Earnings Survey" (thereafter, SES), carried out by Statistics Belgium[34] and which provides information on workers' (*e.g.*, age, education, tenure) and firms' (*e.g.,* sector, number of workers) characteristics. However, there is no financial information in the SES. It has thus been merged (on the basis of the firms' social security numbers) with the 'Structure of Business Survey' (thereafter, SBS), also carried out by Statistics Belgium and which provides financial information such as the firm-level value added, or the gross operating surplus per worker. Due to the fact that information in the SES refers to the month of October for each year and that these of the SBS are given for each month for each year, there is a risk that information on the dependent variable precedes the date to which the explanatory variables have been recorded. To avoid this issue, all explanatory variables have been lagged by one year, leading the dependent variable to be explained by its lagged value and by the lagged values of educational mismatch variables. In that way, the information on educational mismatch relative to October in year t is used to explain the productivity of the firm in year *t+1*.

Their final sample consists of an unbalanced panel of 8 954 observations from 3 062 firms representative of all medium-sized and large firms in the Belgian private sector (except a large part of the financial sector and the electricity, gas and water supply industry, respectively NACE J and NACE E).

Concerning the results of their empirical analysis, table 1 assesses the impact of educational mismatch on firm productivity, according to three different methods: the pooled Ordinary Least Squares, thereafter *OLS*, the Fixed Effects estimator, thereafter *FE* and the Generalized Method of Moments, thereafter *GMM* (see Box 1 for technical aspects). The second column of this table concerns results for the *OLS* specification and shows that current productivity depends positively and significantly on its previous value. Then, additional year of required education leads to positive impact on firm productivity. More specifically, firm productivity increases by 1.7% when the mean number of years of required education increases by one year. Focussing on the educational mismatch variables, they show that the firm productivity increases (decreases) by 1.6% (0.9%), following one year increase in the mean years of over-(under-)education. Due to the firm-level time-invariant heterogeneity issue, they re-estimate the model with a *FE* estimator.

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Box 1: Technical aspects over the estimation techniques

$$lnVA\ CAPITA_{j,t} = \beta_0 + \beta_1(lnVA\ CAPITA_{j,t-1})$$
$$+\beta_2\left(\frac{1}{m_{j,t}}\sum_{i=1}^{m_{j,t}} REQ_{i,j,t}\right) + \beta_3\left(\frac{1}{m_{j,t}}\sum_{i=1}^{m_{j,t}} OVER_{i,j,t}\right) + \beta_4\left(\frac{1}{m_{j,t}}\sum_{i=1}^{m_{j,t}} UNDER_{i,j,t}\right) \quad (1)$$
$$+\beta_5(X_{j,t}) + \beta_6(Z_{j,t}) + \gamma_t + \vartheta_{j,t}$$

where:

(a) $VA\ CAPITA_{j,t}$ is the productivity of firm j at year t, measured by the average value added per worker.

(b) $m_{j,t}$ is the number of workers employed in firm j at year t.

(c) $REQ_{i,j,t}$ is the required years of education for the worker's job i in firm j at year t, measured by the mode of years of education in worker's i occupation at ISCO 3-digit level at year t.

(d) $OVER_{i,j,t}$ = (Attained $education_{i,j,t}$ – $REQ_{i,j,t}$) if > 0, 0 otherwise.

(e) $UNDER_{i,j,t}$ = (Attained $education_{i,j,t}$ – $REQ_{i,j,t}$) if < 0, 0 otherwise.

(f) Attained $education_{i,j,t}$ is the number of years of schooling attained by worker i in firm j at year t.

(g) $X_{j,t}$ is a vector representing aggregated characteristics of workers: the share of the workforce that has at least 10 years of tenure, the fractions of workers respectively younger than 25 and older than 49, and the shares of women, blue-collar and part-time workers.

(h) $Z_{j,t}$ is a vector containing firm characteristics: the sectorial affiliation (8 dummies), the age and size (number of workers) of the firm, the conditional dispersion in hourly wages, and the level of wage bargaining (1 dummy).

(i) γ_t is a set of 7 year dummies.

(j) $\vartheta_{j,t}$ is the error term

This equation describes the relationship between the workers' level of required, over- and under-education within firms and their productivity, by controlling for mean worker and firm characteristics and year dummies. Kampelmann and Rycx (2012) estimate this equation with three different methods. The first is pooled Ordinary Least Squares (thereafter *OLS*) estimator with standard errors robust to heteroscedasticity and serial correlation. However, in order to consider for unobserved time-invariant heterogeneity of firms (e.g., a better geographical position), they re-estimate the model with a Fixed Effects estimator (thereafter *FE*), which estimates the change in productivity (where time-invariant heterogeneity vanishes) rather than the level of productivity. Finally, in order to tackle potential simultaneity between firm productivity and educational mismatch (i.e., to take into account a potential reverse relationship, where the mean years of over-education within firms could increase as a result of a lower labour productivity), they estimate the model with a dynamic system Generalized Method of Moments (thereafter *GMM*) proposed by Arellano and Bover (1995) and Blundell and Bond (1998). The use of a dynamic model allows to obtain consistent results when estimating a production function with serially correlated productivity shocks and explanatory variables that are correlated to these shocks (Bond, 2002). The *GMM* basically estimates a system of two equations, one in level and one in differences, simultaneously, and it relies on internal instruments to control for endogeneity (due to simultaneity). In order to examine the validity of their instruments, they apply two reliability tests. The first is the Hansen's (1982) test of over-identifying restrictions, with the null hypothesis (not to be rejected) of valid instruments. The second is the Arellano-Bond's (1991) test for second-order autocorrelation in the first differenced errors, with the null hypothesis (not to be rejected) of no second order autocorrelation.

The third column of Table 1 shows that productivity is still significantly and positively related to its lagged value. However, results concerning educational mismatch variables all turn out to be statistically non-significant. Moreover, these results are still inconsistent because of the endogeneity of variables. This issue suggests that, besides the fact that productivity may be affected by over-education, mean years of over-education within firms may also increase as a result of a lower labour productivity. This appends for example when highly educated workers, during recession, take jobs for which they are over-educated. Kampelmann and Rycx (2012) thus finally re-estimate the model with a *GMM* estimator. When testing

the reliability of these results, Hansen's (1982) and Arellano-Bond's (1991) tests both show that the estimates are reliable. The results from the fourth column of Table 1 show that current productivity is related to its past value but also that other coefficients (except the under-education one) are now significant. They mean that, when the mean number of years of required education increases by one year, the firm productivity increases by 2.4% the year after. Turning to over-education, increasing the mean number of years of over-education by one year is estimated to increase firm productivity by 3.5% (the year after).

Table 1: Educational mismatch and firm productivity (OLS, FE and GMM estimates, 1999-2006)

Dependent variable	Value-added per worker (ln)		
	OLS	FE	GMM-SYS[e]
Value-added per worker (one year lagged, in ln)	0.819*** (0.017)	0.152*** (0.030)	0.553*** (0.049)
Required education (one year lagged, in years)	0.017*** (0.003)	0.008 (0.005)	0.024*** (0.008)
Over-education (one year lagged, in years)	0.016*** (0.005)	0.003 (0.006)	0.035*** (0.010)
Under-education[a] (one year lagged, in years)	0.009** (0.006)	-0.001 (0.005)	0.012 (0.008)
Worker characteristics[b]	YES	YES	YES
Firm characteristics[c]	YES	YES	YES
Year dummies (7)	YES	YES	YES
Sig. model (p-value)	0.000	0.000	0.000
Adjusted R-squared	0.774		
Within R-squared		0.043	
Hansen statistic p-value			346.1 0.21
Arellano-Bond statistic (AR2)[d] p-value			1.36 0.18
Number of observations	8954	8954	8954
Number of firms	3062	3062	3062

*Note: Robust standard errors are reported between brackets. (***, **, *): Significant at respectively 1%, 5% and 10% levels.*

[a] By definition, mean years of under-education take negative values in the dataset. Therefore, a positive regression coefficient should be interpreted as follows: when mean years of under-education increase (decrease), i.e., become less (more) negative, productivity rises (decreases).

[b] Shares of the workforce that: (i) has at least 10 years of tenure, and (ii) is younger than 30 and older than 49 years, respectively. The shares of women, blue-collar and part-time workers as well as the conditional dispersion in hourly wages are also included.

[c] Sectorial affiliation (8 dummies), number of workers, age of the firm, and level of wage bargaining (1 dummy).

[d] AR2 displays the test for second-order autocorrelation in the first-differenced errors.

[e] First and second lags of explanatory variables are used as instruments in the GMM specification, excluding time dummies.

Finally, the relationship between education and productivity could be stronger when the workers are younger. In that way, older workers could compensate their lack of schooling by their experience and on-the-job training, leading to higher levels of productivity, even if they are under-educated. Kampelmann and Rycx (2012) thus test whether the impact of educational mismatch on firm productivity differs when the age of the workers is taken into account. They then find that mean years of over-education, for both young and older workers, affects positively firm productivity. They also show that under-education exerts a significant and negative impact on firm productivity, but only among young workers.

CONCLUSION AND FORTHCOMING DEVELOPMENTS

Educational mismatch, defined as the inadequacy between the worker's level of education and the level of education which is required for his job, is an increasing phenomenon. One of its two forms, over-education, can be explained from different points of views. Over-education could first be considered as a temporary phenomenon, and over-educated workers could accept a wage penalty for being over-educated in the short run if they can obtain higher wages in the longer run (through promotion for example). Workers can also decide to over-invest in education in order to get better chances to be recruited, education being seen as a signal of fewer training costs for the employer. Third, over-education can be seen as a way to fill vacancies on the labour market as soon as possible. The more you are educated, the higher your chance to find a job. Finally, a worker can decide to take a job for which he is over-educated, simply because this job offers other advantages, such as more leisure.

Different measures can be next considered in order to apprehend this phenomenon and its consequences. External methods, based on professionals' analyses, settle the level of required education by occupation. Secondly, realized matches methods calculate the mean level of education across a range of occupations. Finally, questioning methods ask directly each worker the level of education, which is needed to perform his job.

Coming next to the existing literature that analyses the impact of educational mismatch on firm productivity, we remark that it goes in different directions. Some researchers such as Duncan and Hoffman (1981) or Rumberger (1987) rely on the human capital theory. They study the impact of over- and under-education on firm productivity by estimating its effect on wages and find that over-educated workers earn more than workers having the required level of education, suggesting that over-education increases productivity while under-education decreases it. Others, such as Büchel (2002) or Hersch (1991), rely on the job satisfaction theory. They study the impact of education on job satisfaction and on some other variables correlated with productivity, such as absenteeism or shirking, and state that over-educated would be less satisfied with their job, and thus less productive.

The main shortcoming concerning these studies is that no one investigates the *direct* impact of educational mismatch variables on productivity as such, until the research made by Kampelmann and Rycx (2012). By relying on representative linked employer-employee panel data for Belgium covering the period 1999-2006 and using advanced estimation techniques,

they find that increasing the level of required education has a significant and positive impact on firm productivity, but also that increasing the level of over-education is beneficial for firm productivity and that increasing the level of under-education is detrimental for firm productivity.

Their last study lets the door open to further developments. It thus would be interesting to investigate whether this relationship between educational mismatch and firm productivity depends on the working environment of the firm, such as for example the skills that are required by the job, the degree of technology used in the firm's processes or the economic uncertainty. These working environments suggest that other characteristics could interfere with education while determining productivity. For instance, some characteristics, such as ability, innovation capacity or creativity that belong to some extent to over-educated workers, could be useful in these changing and challenging environments. So we could expect to find different (stronger) relationships between over-education and productivity when these working environments dominate.

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