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Matching frictions and the divide of schooling investment between general and specific skills*

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Abstract: This paper examines the impact of labor market frictions and institutions on the divide of schooling investment between general and specific skills. We offer a simple matching model of unemployment in which individuals determine the scope and intensity of their skills. In partial equilibrium, we show that the severity of market frictions distorts the schooling allocation towards more general skills. Then, we endogenize job creation and argue that changes in labor market institutions may well originate a non-monotonous relationship between unemployment and the divide of skills between specific and general human capital. We also investigate more carefully the impacts of unemployment compensation, minimum wage and firing costs. We suggest that unemployment compensation has an ambiguous impact on the skill divide, while minimum wage and firing costs are detrimental to general skill acquisition.

Keywords: Matching frictions; education; general and specific skills; labour market institutions

J.E.L. classification: I21, J24

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1 Introduction

This paper examines the impact of labor market institutions (LMI) on the divide of schooling investment between general and specific skills. We offer a simple matching model of unemployment that highlights the trade-off between general and specific skills at the time of educational investment. Individuals have to allocate a fixed amount of educational investment between general and vocational education. General education increases the scope of skills, while vocational education raises the intensity of these skills. In partial equilibrium, we show that the severity of market frictions distorts the schooling allocation towards general skills. Then, we endogenize job creation and argue that changes in LMI may well originate a non-monotonous relationship between unemployment and the divide of skills between specific and general human capital. We also investigate more carefully the impacts of unemployment compensation, minimum wage and firing costs. We suggest that unemployment compensation has an ambiguous impact on the skill divide, while minimum wage and firing costs are detrimental to general skill acquisition.

Our paper has two main motivations.

First, there is a substantial theoretical literature on the relationships between matching frictions and the magnitude of educational investment (see among others Acemoglu, 1996, Moen, 1999, Burdett and Smith, 2002, Charlot and Decreuse, 2005). By contrast, the literature on unemployment and the sharing of educational investment between different types of skills is very scarce. This discrepancy between the two literatures is not necessarily fair in light of the aggregate evidence. The OECD provides with aggregate data that sort individuals by educational level (from pre-primary schooling to research program) and type of education (from general to vocational). These data feature substantial heterogeneity in both components of education. In the Appendix, we argue that the magnitude of between-country heterogeneity in type of education persists over time, while heterogeneity in level tends to decline over time. Put otherwise, the way individuals allocate their schooling investment between general and specific skills is probably as economically meaningful as the amount of investment itself.

Second, LMI and the divide of schooling investment have been put forward recently to explain the relatively low performance of a number of European labor markets since the end of the 1970s. On the one hand, the minimum wage, the generosity of unemployment insurance and the strictness of employment protection legislation would favor the persistence of high unemployment rates while significantly slowing down the job reallocation process necessary to sustain high productivity growth (see Ljungqvist and Sargent, 1998, Mortensen and Pissarides, 1999, Nickell et al, 2005). On the other hand, vocationnally-oriented European schooling systems would alter workers' between-sector mobility (see Krueger and Kumar, 2004). What about their interactions? Do stricter LMI distort educational investment towards specific skills? From an empirical point of view, we show in the Appendix that aggregate data do not allow to identify a clear Anglo-Saxon and a clear continental European model. Of course, the proportion of graduates with a vocationnaly-oriented secondary education is very high in Germany, while it very low in the US. But these statements do not generalize to other countries. In addition, what is true at the secondary level of education is not necessarily true at the tertiary level. Hence, there are no simple relationships between LMI and the allocation of educational investment between general and specific skills. Our paper offers a rationale for such ambiguous outcome that is based on the interaction between partial and general equilibrium effects.

From a theoretical point of view, in a contribution devoted to on-the-job training, Wasmer (2006) argues that matching frictions should favour the acquisition of specific skills rather than general skills. Wasmer uses an elegant metaphor to explain his result: "in an economy made up of far-spread islands, it is better to learn the technology of the island on which one lives." Our paper questions the generality of Wasmer's result when one considers human capital investments before the labor market entry, rather than once in the job. Our main conclusion is that the severity of frictions directs investments towards general rather than specific skills. Compared to Wasmer's, our framework can be interpreted as follows: students are sailing the ocean, waiting for an island to inhabit. As the density of islands goes down, the knowledge of one peculiar technology becomes less and less useful. This messages is closer to Rosen (1983), who studies the allocation of skill investment in a framework where individuals also allocate their time endowment between the different skills. Rosen argues that the incentives to specialization are very related to skill use: "the return to investment in a particular skill is increasing in its subsequent rate of utilisation". Following this argument, LMI should bias educational investment towards general schooling: LMI increase market frictions, which in turn lowers the rate of utilisation of any particular skill. Actually, this intuition governs the general equilibrium effects in our model.

Importantly, the abrupt distinction between general and specific human capital cannot be directly used in the study of general versus vocational education. At the time of educational choices, workers are not informed of the identity of the firms they will meet. Hence, human capital accumulated through vocational schooling cannot be purely specific in the traditional sense: workers would have no chance to use such a kind of human capital, and, consequently, the whole investment would be spent in general human capital. Our paper proposes a theoretical framework allowing to capture these two dimensions of education. We build on Charlot et al (2005), who consider a matching model with multi-dimensional skills and ex-post wage bargaining. The idea is that general education provides basic cognitive skills in different fields of knowledge and vocational education transforms such abilities into productive skills. General education determines the scope of one's skills, that is the fraction of jobs on which the worker can operate. Vocational education determines the intensity of one's skills, that is worker's productivity on these jobs. This view of human capital is not only useful to understand schooling investments, but it is also in line with Becker who himself noted that human capital is neither purely general nor specific.

In Charlot et al, the divide of investment between vocational and general education is fixed. We complete that paper by endogenizing the mix of general and specific skills. We thus assume that the total investment in education is given. Students have to allocate this investment between vocational and general education. As in Wasmer, therefore, the scope of one's skills and the intensity of these skills evolve in opposite directions: an individual devoting a larger part of her resources to vocational education will be more productive once in the job, but her skills will be worthwhile in fewer jobs. In the competitive environment – the limit case where frictions disappear –, general education is useless because it is very easy to contact any type of job. Therefore, individuals devote the main part of their investment to vocational schooling. Conversely, very specific skills become much less attractive when contacting a proper job takes a lot of time/resources. Thus, matching frictions originate incentives to acquire general skills[1].

We proceed in three steps.

First, we build a simple model of educational choice in which individuals have to set the mix of general and specific skills. Skills are acquired before the labor market entry. Then, workers receive job offers at a constant and exogenous rate. The job offer rate characterizes the intensity of matching frictions. We show that the proportion of educational investment that is directed towards general skills is decreasing in the job offer rate. Indeed, the purpose of general skills is to increase the share of match surplus accruing to the worker. However, match surplus goes down when the contact rate goes up. The result follows.

To further explain our result, we consider Wasmer's case of on-the-job investment. To simplify, we consider a once-in-life human capital investment achieved while occupying a job. We show that such worker chooses a basket of skills that contains fewer general skills and more specific skills than students do. We also show that the job offer rate has two effects on the composition of skills. The first effect is common to educational and on-the-job investments. Match surplus goes down, which is detrimental to the acquisition of general skills. The second effect is specific to employed workers. The share of outside opportunities in overall utility goes up with the job offer rate. This implies that employed workers pay more attention to their outside opportunities, which requires to invest more in general skills. The interplay between these two effects leads to a $\cap$-shaped relationship between the job offer rate and the proportion of investment in general skills.

Second, we turn to macroeconomic implications of our model. The partial equilibrium relationship highlighted below suggests that unemployment and the proportion of educational investment spent in general skills should be positively correlated. It is not what the data seem to say. Hence, we turn to general equilibrium considerations. Unemployment and the divide of skills are two equilibrium outcomes. Their movements reflect changes in a third variable. From that perspective, Europe and the US mainly differ with respect to their labor market institutions (LMI). Which type of relationship between unemployment and the divide of skills should we expect given that changes are actually driven by alterations in LMI? We enrich our model to answer such a question: there is a matching

[1]In a different setting, Gould, Moav and Weinberg (2001) argue that unemployment creates educational incentives, because it originates a demand for precautionary education from risk averse individuals. Unlike Gould et al, individuals are risk neutral in our paper, and education can offer both general and specific skills.

technology on the labor market, and the number of vacancies responds to a zero-profit condition. In that environment, the size of LMI is broadly captured by workers' bargaining power. The equilibrium ratio of vacancy to unemployed strictly decreases with workers' bargaining power. The amount of general skills is first decreasing, then increasing in such bargaining power, reaching a minimum when the Hosios condition is met. It follows that changes in workers' bargaining power induce a non-monotonous relationship between unemployment rate and the amount of general skills.

Third, we revisit the partial and general equilibrium effects of several labor market institutions. In this purpose, we consider three extensions of our model. Each extension is devoted to a particular institution: (i) unemployment compensation, (ii) minimum wage, and (iii) firing costs.

(i) In line with our general discussion below, we argue that unemployment compensation has a non-monotonous impact on the proportion of educational investment spent in general skills. We particularly discuss the fact that young entrants are generally excluded from unemployment insurance eligibility. This generates an entitlement effect very close to Mortensen (1977) according to which the generosity of unemployment insurance motivates general skill acquisition.

(ii) The case of the minimum wage is more intriguing as the minimum wage distorts investments towards specific skills. It has already been shown that the minimum wage provides with incentives to skill acquisition, as potential employees must increase their skills to meet employers' standards (see Agell and Lommerud, 1997, and Acemoglu and Pischke, 2005). We complete that view by suggesting that this effect may lower the efficiency of the matching process by reducing the general skills of the workforce. From that perspective the minimum wage belongs to the factors that may explain moves in the Beveridge curve.

(iii) We argue that firing costs tend to distort educational investments towards specific skills. The key mechanism relies on the fact that administrative costs lower the matching surplus that the firm-worker pair has to share at the time of match formation. The marginal returns to general skill acquisition falls as a result. This prediction strengthens Wasmer's point, who claims that the strictness of employment protection distorts on-the-job investments towards specific skills. It is also interesting because it shows that the key relationship of our model between matching frictions and the direction of the bias in skill acquisition is compatible with the fact institutions that are usually associated with labor market sclerosis are detrimental to general skill acquisition.

This paper is related to different strands of literature. The paper which seems apparently the closest is Mukoyama and Sahin (2006). They are interested in the impact of unemployment compensation on the incentives to specialization. As Rosen (1983), they assume there are two tasks and each workers has the choice of investing in both corresponding skills or just one of them. A worker needs to form a match with another worker to produce and the payoff is maximized if at least one worker can perform on each task. Therefore, search frictions create uncertainty and investment in general skills helps one to cope with such uncertainty. There are three key differences with our paper. First, there is no trade-off between general and specific skills. A worker who invests more can perform more tasks with unchanged productivity. From that perspective Mukoyama and Sahin (2006) are more interested in the level of educational investment than in the composition of such investment. Second, there are no general equilibrium effects: contact rates are exogenously given in their analysis. Finally, they highlight another decision margin, namely the fact that a worker may refuse a match in order to find a better match in the future.

This paper is also related to the literature that emphasizes the role of industry-specific skills in labor markets where workers are imperfectly mobile between sectors. Stevens (1994) introduces the notion of transferable skills. These skills are neither specific nor general. They can only be used in a proportion of the different available jobs. Stevens argues that there is an underprovision of transferable skills by employers. Smits (2007) goes a step further and distinguishes industry-specific skills from generic skills (that have a higher value elsewhere in the economy). He examine the following conflict of interest at the time of training investment: workers want more generic skills than is socially optimal, while firms do not want that the worker learns generic skills at all. Our paper complements this literature in two ways. First, it focuses on educational investments rather than on-the-job training. Second, it examines the role played by job availability, and shows that job availability tends to distort the trade-off between general and specific skills towards more specific skills.

There is a growing literature that analyses the role of LMI on the incentives for firms to fund general training investment. Unions may encourage training because they reduce labor turnover (Booth and Chatterji, 1998). Wage compression induced by a minimum wage increase may have a positive effect on the incentives to train the less skilled workers to improve their productivity (Acemoglu and Pischke, 1999, 2003). Finally, Fella (2004) predicts a positive correlation between investment in general training and the strictness of employment protection rules. The present paper complements this literature mainly by analyzing the role of labor market institutions on the schooling allocation between general and specific skills.

The trade-off we analyse between vocational and general education borrows from the notions of marketability and specialization highlighted in the literature on money and search (see e.g. Kiyotaki and Wright, 1993, and Shi, 1997). The main idea in these papers is that each producer faces a trade-off between specialization and marketability. Specializing in the production of a given commodity allows better productivity (or, equivalently, saves on production costs), but at the expense of reducing the proportion of consumers interested in purchasing the good, *i.e.* marketability is smaller. Typically, money plays a crucial role in this approach as it enlarges the size of the market and therefore allows producers to specialize. From that perspective, the reader should not be very surprised by our results. We simply argue that market size increases the probability of trade, which in turn allows the workers to get more specialized where they have comparative advantages at the time of educational investment.

The rest of the paper is organized as follows. Section 2 introduces our framework, and discusses the divide of skills in partial equilibrium, that is at given rate of contacting a job offer. Section 3 considers job creation decisions, and analyzes movements in unemployment rate and general education induced by changes in workers' bargaining power. Section 4 concludes.

2 The divide of skills in partial equilibrium

In this section, we propose a model of educational investment that features (i) a trade-off between general and specific skills and (ii) matching frictions on the labor market. We first show that matching frictions distort the trade-off towards general skills. We then argue that this phenomenon is very related to education: Using the same model of multi-dimensional skills, we show that market frictions are likely to distort on-the-job investments towards specific skills rather than general skills.

2.1 Educational investments

We are interested in the schooling investment of an infinite lifetime individual living in a stationary environment. She is risk neutral, and discounts time at rate r. Her total human capital investment I is given. It can be viewed either as the exogenous schooling duration, or total spending in education. The individual must divide this investment between specific and general skills, i.e. vocational and general education. Let g denote the amount of general skills, while $s = I - g$ denote the amount of specific skills.

The notions of specific and general skills rely to the technological side of the economy. There are a continuum of sectors, each producing a final good entering preferences symmetrically. Sectors are of mass one. Each sector is associated to a particular technology. While dividing human capital, the worker chooses the scope and the intensity of her skills. General skills thus increase the share of technologies the worker can operate, while specific skills raise the productivity in each known technology. Formally, the proportion of technologies the worker knows is $H(g)$, with $H(0) = 0$, $H(I) \leq 1$, $H'(g) > 0$, $H''(g) < 0$. The intensity of her skills is $f(s)$, with $f(0) = 0$, $f'(s) > 0$, $f''(s) < 0$.

The labor market is frictional. Matching frictions have two important consequences. First, there is only a probability of contacting a job per period. Let μ denote the flow probability that a worker receives a job offer from a particular sector. Thus μ^{-1} measures the severity of frictions. Given that $H(g)$ is the proportion of jobs the worker can occupy, $\mu H(g)$ is the rate of acceptable job offer. It is increasing in g, and decreasing in the severity of frictions. Second, each match is associated to a match surplus that the employer and the worker must share. We follow the literature and assume that there is wage bargaining over the match surplus.

Let $U = U(s, g)$ denote the utility of an unemployed, and $W = W(s, g)$ the utility of an employed worker. We have:

$$rU = \mu H(g)[W - U] \quad (1)$$

$$rW = w + q[U - W] \quad (2)$$

where q is the (exogenous) rate of job destruction and w is the wage. Symmetrically, $J = J(s, g)$ is the value of a filled job. We have:

$$rJ = f(I - g) - w + q[V - J] \tag{3}$$

where V the value of a vacancy is given. The wage splits the match surplus $S = W - U + J - V$ according to

$$W - U = \beta S = \frac{\beta}{1 - \beta}(J - V) \tag{4}$$

It follows that the match surplus is:

$$S(s, g) = \frac{f(s) - rV}{r + q + \beta\mu H(g)} \tag{5}$$

At the time of investment, the individual does not know which firm will hire her. As a consequence, she maximizes the value of her future search. From the different equations, we have

$$rU(s, g) = \beta\mu H(g) S(s, g) \tag{6}$$

The optimal allocation of educational investment between general and specific skills must maximize the contact surplus $H(g) S(s, g)$. The divide of skills results from

$$\frac{H'(g)}{H(g)} + \frac{\partial S(I - g, g) / \partial g}{S(I - g, g)} = \frac{\partial S(I - g, g) / \partial s}{S(I - g, g)} \tag{7}$$

where

$$\frac{\partial S(s, g) / \partial g}{S(s, g)} = -\frac{H'(g)}{H(g)} \frac{\beta\mu H(g)}{r + q + \beta\mu H(g)} \tag{8}$$

$$\frac{\partial S(s, g) / \partial s}{S(s, g)} = \frac{f'(s)}{f(s) - rV} \tag{9}$$

The optimal divide of schooling investment balances the marginal returns to general and specific skills. General skills increase the contact surplus by raising the probability that such contact gives birth to an employment relationship. However, general skills reduce the match surplus because they improve the chance of contacting an adequate employer, thereby making the economic position of the unemployed closer to that of an employed worker. The size of the latter effect increases with the product $\beta\mu$, that is with the chance of contacting a vacancy times the share of contact surplus obtained in such an event. Specific skills do not alter the probability to match, yet they raise match output, thereby increasing match surplus.

It follows that:

$$\frac{H'(g)}{H(g)} \frac{f(I - g) - rV}{r + q + \beta\mu H(g)} = \frac{f'(I - g)}{r + q} \tag{10}$$

The divide between general and specific skills responds to alterations in their respective marginal returns. Our main result follows: the severity of frictions μ^{-1} originates incentives to acquire general skills rather than specific skills. Intuitively, the purpose of general skills is to improve the ability to receive job offers, thereby raising the share of the match surplus accruing to the worker. The share of investment accruing to such skills thus goes up with the match surplus. Hence, the severity of frictions motivates the acquisition of general skills because frictions increase the size of the match surplus. For instance, general skills are useless when it is very easy to get matched with a proper vacancy. Consider the walrasian environment. There, μ tends to infinity, which implies that unemployment spells are arbitrarily short, and contacting any type of alternative employer is immediate. The match surplus is nil, and there is no need to speed up the job search. The whole investment is then devoted to the acquisition of specific skills, i.e. $g = 0$. Conversely, market frictions reduce the interest of very specific skills, which become much more difficult to trade.

One may be interested in the impact of bargaining power on the divide of skills. General skills decrease with bargaining power β. Indeed, worker's bargaining power reduces current match surplus as it allows the job-seeker to capture a larger part of alternative match surpluses. Together with the negative impact of μ on general skills, this negative impact of β suggests that the divide of skills may respond non-monotonously to changes in β once the negative impact of β on job creation has been accounted for. This is the subject of the next section.

2.2 On-the-job investments

Our main result differs from Wasmer (2006), who argues that matching frictions deteriorate the incentives to acquire general skills. There are two important differences with his paper.

First, there are two different views of human capital involved. Wasmer considers Becker's case of specific human capital where specific skills can only be used in one firm[2]. The severity of frictions, therefore, does not alter the incentives to invest in specific skills as there is no market for such skills regardless alternative employers are easy to contact or not. Conversely, specific skills are not limited to a single firm in our view. For instance, they can be used at the sector level, or at the industry level. In such a case, the return to specific skills increases with worker's ability to contact an alternative employer.

The second difference with Wasmer originates from the timing of investment: Wasmer analyses on-the-job investments, while we are interested in educational investments. To discuss the role played by this second difference, we assume in the remaining of this section that individuals choose the divide of skills once in the job rather than before the labour market entry. For simplicity, we assume that this is a one-shot investment, that will not be done again in the future.

Assume that the individual chooses the divide of skills once in the job rather than

[2]This assumption is the only assumption allowing to reach a non-walrasian result (i.e. a positive match surplus) in the walrasian model. If specific human capital could be used in at least two firms, they could enter Bertrand competition to attach worker's services, and the worker would be paid her marginal product.

before the labor market entry. The value of a job is

$$rW(s,g) = \beta[r + \mu H(g)] S(s,g) = \beta r S(s,g) + rU(s,g) \tag{11}$$

The combination of matching frictions $\mu < \infty$ and positive discount rates $r > 0$ originates rents associated to the fact of having a job. That is why $W > U$. Importantly, the size of rents increases with workers' bargaining power β and discount rate r. General skills result from:

$$\frac{H'(g)}{H(g)} \frac{\mu H(g)}{r + \mu H(g)} + \frac{\partial S(I-g,g)/\partial g}{S(I-g,g)} = \frac{\partial S(I-g,g)/\partial s}{S(I-g,g)} \tag{12}$$

The marginal return to general skills is typically lower than before: employees have small incentives to capture the match surplus derived from another employment relationship. Thus, employed workers invest more in specific skills than the students at given magnitude of investment[3]. The divide of skills results from:

$$\frac{H'(g)}{H(g)} \frac{\mu H(g)}{r + \mu H(g)} S(s,g) = \frac{f'(I-g)}{(1-\beta) r + q} \tag{13}$$

The term $\mu H(g) / (r + \mu H(g)) = U/W$ is the ratio of unemployed utility to employed utility. It measures the size of rents extracted by the workers, as well as the size of outside opportunities in workers' wealth. The purpose of general skills is to increase such outside opportunities. They are all the more useful than outside opportunities matter for the employed workers. Now, changes in the contact rate μ have two effects. The first effect is common to employed and unemployed workers. An increase in μ reduces match surplus, which lowers the incentives to acquire general skills. The second effect is specific to the employed workers. An increase in μ raises the ratio of outside opportunities to workers' utility. Employed workers, therefore, pay more attention to their outside opportunities, which requires to invest more in general skills. Formally,

$$\frac{dg}{d\mu} \overset{sign}{=} r(r+q) - \beta [\mu H(g)]^2 \tag{14}$$

The relative size of the two effects depends on the discount rate, which governs the size of rents obtained by employed workers. Thus, investment in general skills increases with the contact rate (like Wasmer) when the discount rate is large, while it decreases with the contact rate when the discount rate is small (unlike Wasmer). Note, however, that the negative effect dominates the positive effect for realistic values of the parameters. This means that the severity of market frictions directs on-the-job investments towards specific rather general skills.

[3]This provides a rationale to papers assuming that educational investments are purely general. Actually, they are more general than on-the-job investments.

3 Equilibrium unemployment and the composition of human capital

In this section, we suggest that there are no reasons to expect a monotonous relationship between the divide of skills and the extent of unemployment. Both are equilibrium outcomes which are influenced by structural parameters like labor market institutions (LMI). In our model, the size of LMI is measured by workers' bargaining power β. We incorporate the framework of the previous section into an equilibrium matching model of the labor market, and show that changes in β drive a non-monotonous relationship between the unemployment rate and the share of schooling investment spent in general skills.

To close the model, we need an explicit matching market with a matching technology for heterogenous jobs and heterogenous skills. We assume that there is a unique search market for all workers and vacant jobs, i.e. search is undirected[4]. Let θ be the labor market tightness, that is the ratio of vacancies to unemployed. The rate of contacting a vacancy is thus $\mu = \mu(\theta)$, while the rate of contacting a worker is $\mu(\theta)/\theta$. The function μ is such that $\mu'(\theta) > 0$, $\mu''(\theta) < 0$, and $\mu(0) = \mu(\infty)^{-1} = 0$.

We also need agents who must take schooling decisions at each instant. We thus assume that new cohorts enter the economy at rate $n > 0$.

Equilibrium tightness is derived from a zero-profit condition. Assume that workers have all the same amount of general and specific skills. Let V denote the value of a vacancy, and c be the flow cost of posting a vacancy. One has

$$rV = -c + \frac{\mu(\theta)}{\theta} H(g) \left[J(s,g) - V \right] \tag{15}$$

In equilibrium, $V = 0$ and

$$c \frac{\theta}{\mu(\theta)} = (1-\beta) H(g) S(\theta, s, g, \beta) \tag{16}$$

This equation defines tightness as an increasing function of contact surplus $H(g) S(\theta, s, g, \beta)$, where the dependence of match surplus vis-à-vis θ and β has been highlighted. As discussed in the previous section, general skills improve the probability to match with an adequate worker, but deteriorate match surplus. Specific skills raise output, thereby increasing match surplus. It follows that tightness is increasing in s. Finally, tightness is decreasing in workers' bargaining power β, which lowers firms' profitability.

Equilibrium tightness θ^* and general skill investment g^* jointly solve

$$\frac{H'(g)}{H(g)} S(\theta, I-g, g, \beta) = \frac{f'(I-g)}{r+q} \tag{SD}$$

$$(1-\beta) H(g) S(\theta, I-g, g, \beta) = c \frac{\theta}{\mu(\theta)} \tag{MT}$$

[4] Alternatively, the search market could be segmented by technology, and workers would participate to all the submarkets they know the underlying technology. The results would be the same.

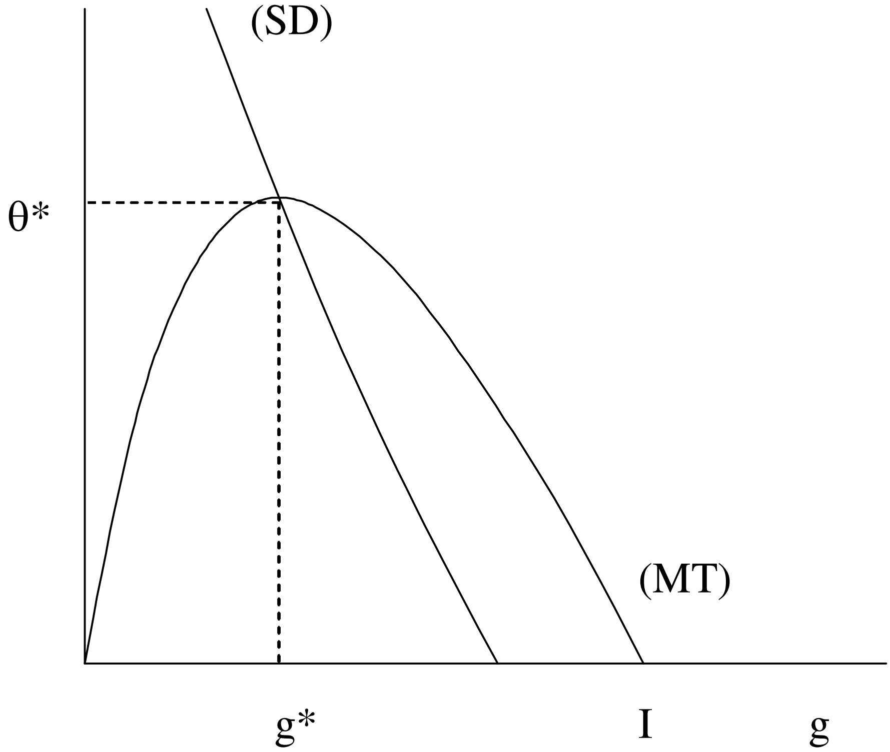

Figure 1: Existence and uniqueness of equilibrium

The skill-divide equation (SD) defines the investment in general skills as an increasing function of match surplus, while the labor market tightness equation (MT) defines tightness as an increasing function of contact surplus. Equation (SD) thus defines an implicit function $\mathbf{g}(\theta, \beta)$ which is strictly decreasing in both arguments. Equation (MT) defines an implicit function $\boldsymbol{\theta}(g, \beta)$. It is strictly decreasing in β, while it is non-monotonous in g, increasing at first, reaching a maximum and then decreasing.

Figure 1 depicts the two curves. The curve (SD) is strictly decreasing, while (MT) describes a bell-shaped curve. The two curves intersect once at the maximum of (MT). Indeed, investment in general skills maximizes match surplus for every tightness, while tightness is increasing in the latter surplus. It follows that there is a unique equilibrium.

We now turn to the impact of the bargaining power β. We have[5]

$$\frac{d\theta^*}{d\beta} = \frac{\partial \boldsymbol{\theta}(g^*, \beta)}{\partial \beta} < 0 \tag{17}$$

$$\frac{dg^*}{d\beta} = \frac{\partial \mathbf{g}(\theta^*, \beta)}{\partial \beta} + \frac{\partial \mathbf{g}(\theta^*, \beta)}{\partial \theta} \frac{d\theta^*}{d\beta} \tag{18}$$

Thus,

$$\frac{dg^*}{d\beta} \overset{sign}{=} \frac{\partial S(\theta^*, I - g^*, g^*, \beta)}{\partial \beta} + \frac{\partial S(\theta^*, I - g^*, g^*, \beta)}{\partial \theta} \frac{d\theta^*}{d\beta}$$

[5] Note that $\partial \boldsymbol{\theta}(g^*, \beta) / \partial g = 0$ - see Figure 1.

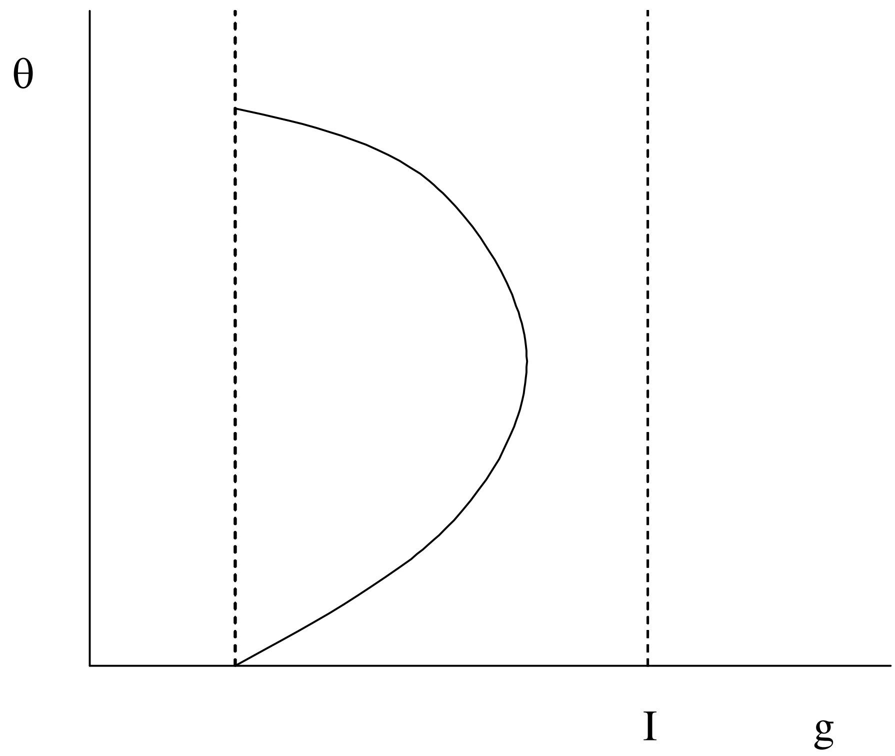

Figure 2: Non-monotonicity of the relationship between equilibrium tightness and equilibrium investment in general skills

The bargaining power affects the skill divide through changes in match surplus. The bargaining power has two opposite effects. On the one hand, it directly decreases match surplus, which reduces the return to general skills. On the other hand, it reduces tightness, thereby increasing match surplus and thus raising the return to general skills. Finally,

$$\frac{dg^*}{d\beta} \overset{sign}{=} \beta - (1 - \alpha(\theta^*)) \quad (19)$$

where $\alpha(\theta) \equiv \theta\mu'(\theta)/\mu(\theta)$ is the elasticity of the contact rate with respect to tightness. The proportion of investment spent in general skills follows a ∪-shaped curve as β goes from 0 to 1. It reaches a minimum when the Hosios condition is met (Hosios, 1990), that is when $\beta = 1 - \alpha$. This property follows from the fact that the amount of general skills is increasing in match surplus, and such match surplus is minimized at the Hosios condition.

Thus, tightness is strictly decreasing in bargaining power, while general skills non-monotonously respond to changes in β. If a statistician were to observe changes in tightness and general skills, while such changes are driven by modifications in parameter β, she would find a non-monotonous relationship between tightness and general skills. Such a relationship is depicted by Figure 2.

Figure 2 has a major implication. Consider two economies with different β and otherwise seemingly identical. The economy with the largest β may well spend fewer resources in general skills despite unemployment is higher. Put otherwise, the model can predict that (i) matching frictions creates incentives to acquire general rather than specific skills and (ii) that the Germans invest less in general skills than the Americans even though the contact rate is higher in the US than in Germany.

4 Labor market institutions and the composition of educational investment

In this section, we examine more carefully the role played by different labor market institutions on the divide of educational investment between general and specific skills. We begin with unemployment compensation, which is a clear substitute to bargaining power in matching models. Then, we turn to the minimum wage. Finally, we focus on firing costs.

4.1 Unemployment compensation

It has been argued that unemployment insurance allows the workers to invest in specific skills (see e.g. Grossman and Shapiro, 1982, Estevez et al, 2001). In this sub-section, we revisit this prediction in two steps. First, we show that unemployment benefits should have a non-monotonous impact on the proportion of investment spent in general skills. At the micro level, unemployment benefits favor the acquisition of specific skills. However, there is a negative effect at the macro level due to the negative impact of unemployment benefits on job creation. Second, we account for the fact that most of the youth are non eligible to unemployment insurance because they have never been employed. There we show that unemployment compensation has an entitlement effect that tends to favour general skills.

We modify our model as follows. Let b_0 denote unemployment income of a young worker who never contributed to unemployment insurance. In our view, it mainly corresponds to the family contribution to the unfortunate child. Let also b denote formal unemployment benefits. For simplicity, there are no time limit to unemployment benefits, we do not account for taxes, and we assume that eligibility for unemployment insurance is obtained with the first job. We must distinguish U_0 the intertemporal utility of a newcomer on the labor market from U the intertemporal utility of an unemployed who is eligible to unemployment insurance. We have:

$$rU_0 = b_0 + \mu H(g)[W - U_0] \quad (20)$$

$$rU = b + \mu H(g)[W - U] \quad (21)$$

The rest of the model is unchanged. Wages are perpetually bargained, so that match surplus is worth:

$$S(s,g) = \frac{f(s,g) - rV - b}{r + q + \beta\mu H(g)} \quad (22)$$

As it is well known in matching models, unemployment benefits mimic the impacts of bargaining power. As a result, they deteriorate match surplus as they reduce the utility differential between having a job and being unemployed.

Students aim at maximizing

$$rU_0\left(s,g\right)=b_0+\beta\mu H\left(g\right)S\left(s,g\right)+\mu H\left(g\right)\left(U-U_0\right) \tag{23}$$

which can also be written

$$rU_0\left(s,g\right)=b_0+\beta\mu\left(\theta\right)H\left(g\right)S\left(s,g\right)+\frac{\mu H\left(g\right)}{r+\mu H\left(g\right)}\left(b-b_0\right) \tag{24}$$

The return to search is worth instantaneous income b_0, plus contact rate times the proportion β of contact surplus HS, plus a term that corresponds to the permanent gain achieved once the first job is obtained. This gain increases with general skills, which strengthens the incentives to invest in general skills.

Formally, the optimal trade-off between general and specific skills results from:

$$\frac{H'\left(g\right)}{H\left(g\right)}S\left(I-g,g\right)+\frac{H'\left(g\right)}{H\left(g\right)}\frac{b-b_0}{r+q}\frac{r\left[r+q+\beta\mu H\left(g\right)\right]}{\left[r+\mu H\left(g\right)\right]^2}=\frac{f'\left(I-g\right)}{r+q} \tag{25}$$

The marginal return to general skills must account for the marginal increase in probability to benefit from a permanent increase in unemployment income.

What are the effects of parameters b and b_0? We begin with b_0. This parameter reduces the marginal return to general skills, without affecting the marginal return to specific skills. Hence, b_0 raises the incentives to invest in specific skills.

Now, consider b. The marginal impact on the investment in general skills results from two effects:

$$\underbrace{\frac{-1}{r+q+\beta\mu H}}_{\text{diminishing surplus effect (-)}}+\underbrace{\frac{1}{r+q}\frac{r\left(r+q+\beta\mu H\right)}{\left(r+\mu H\right)^2}}_{\text{entitlement effect (+)}} \tag{26}$$

On the one hand, unemployment benefits deteriorate match surplus, which raises the incentives to invest in specific skills as the general intuition suggests. On the other hand, unemployment insurance generates an entitlement effect that raises the incentives to invest in general skills. Indeed, just like unemployment benefits tend to increase search effort/decrease search choosiness among non-entitled workers, unemployment benefits also tend to favour general skills that speed-up job-finding.

Quantitatively, the latter expression has the sign of

$$-\left(1-\beta\right)r\mu H\left[2\left(r+q\right)+\left(1+\beta\right)\mu H\right]+q\left[\left(r+q\right)r-\mu^2H^2\right] \tag{27}$$

The two effects discussed below combine so that general skills may either increase or decrease with unemployment benefits. More particularly, the effect is negative when μ is sufficiently low. However, realistic values of the parameters and endogenous variables suggest that the overall impact of unemployment benefits on general skills is negative. The entitlement effect is not sufficiently strong to dominate the diminishing surplus effect.

From a more general perspective, this suggests that the entitlement effect is maximized in labor markets characterized by heavy frictions. Low unemployment benefits in such a context strengthens the incentives to acquire specific skills, which further raises the unemployment problem.

4.2 Minimum wage

Changes in the minimum wage may seem very close to changes in bargaining power. Indeed, they are model-substitute *at given educational investment*. However, they are deeply different once the endogeneity of educational investments is taken into account. This sub-section makes two contributions. First, it suggests that heterogenous workers respond very differently to changes in the minimum wage. Constrained workers direct their investment towards more specific skills, while more able workers spend a higher proportion of their educational investment in general skills. Second, it argues that changes in the minimum wage may explain moves in the Beveridge curve.

Hereafter, we focus on the low-skilled segment of the labor market. Hence, the level of educational attainment I that we discuss is the secondary level following the ISCED classification. Assume that there are two types of workers index by $i = 1, 2$. Type-i workers lie in proportion $\pi_i \in (0, 1)$, $\pi_1 = 1 - \pi_2$. The productivity of each type of workers is worth $y_i(s) = A_i f(s)$, with $A_1 > A_2$, i.e. type-1 workers are more productive than type-2 workers for every possible level of specific skills.

We now investigate how these two individuals share their investment between general and specific skills. For this purpose, let $w_{\beta,i}(s, g)$ denote the bargained wage of a type-i worker whose basket of skills is (s, g). Let also $\widehat{g}_i$ denote the optimal investment of such worker in the absence of the minimum wage. This investment solves:

$$\frac{H'(g)}{H(g)} \frac{A_i f(I-g)}{r+q+\beta\mu H(g)} = \frac{A_i f'(I-g)}{r+q} \tag{28}$$

This implies that $\widehat{g}_1 = \widehat{g}_2$. Now suppose that $w_{\beta,1}(\widehat{s}_1) > w_{\min} > w_{\beta,2}(\widehat{s}_2)$. Put otherwise, the skill divide achieved by lower able workers does not provide them with sufficient specific skills to get employable. Such workers will be compelled to invest more than they would like in specific skills. Consequently, $A_2 f(s_2^*) = w_{\min}$. This has a number of implications. First, $s_2^* > s_1^*$, reflecting the fact that skill allocation is distorted towards specific skills for the lower able. Second, higher able are more productive than lower able workers: $y_1 > y_2$ (if not, higher able would also be compelled to invest more in specific skills). Third, higher able benefit from a larger exit rate from unemployment: $\mu H(g_1^*) > \mu H(g_2^*)$.

Following a minimum wage increase, lower able workers increase the share of their investment devoted to specific skills. This idea according to which the minimum wage may create incentives to skill acquisition has already been put forward by different studies (Cahuc and Michel, 1996, Agell and Lommerud, 1997, Acemoglu and Pischke, 2005). The key prediction of our paper relies on the opportunity cost of the increase in specific skills:

workers have to reduce their investment in general skills, which lowers their employment prospects[6].

To derive general equilibrium implications, note that the free entry condition must be modified as follows:

$$c\frac{\theta}{\mu(\theta)} = \widetilde{\pi}_1 (1-\beta) H(g_1) S_1 (I - g_1, g_1) \quad (29)$$

where $\widetilde{\pi}_1$ is the proportion of lower able workers among the unemployed. As g_1 maximizes the contact surplus $H(g_1) S_1 (I - g_1, g_1)$, the only effects of the minimum wage translates through changes in $\widetilde{\pi}_1$. But,

$$\begin{aligned} \widetilde{\pi}_1 &= \frac{\pi_1 \frac{q}{q+\mu(\theta)H(g_1)}}{\pi_1 \frac{q}{q+\mu(\theta)H(g_1)} + (1-\pi_1) \frac{q}{q+\mu(\theta)H(g_2)}} \\ &= \frac{\pi_1}{\pi_1 + (1-\pi_1) \frac{q+\mu(\theta)H(g_1)}{q+\mu(\theta)H(g_2)}} \end{aligned}$$

which decreases when g_2 goes down. Tightness decreases with the minimum wage as it raises the proportion of lower able workers. In turn, the fall in tightness incites higher able workers to change the skill allocation. However, unlike the lower able workers, higher able increase the proportion of investment spent in general skills rather than in specific skills.

We conclude this section by examining the effects of the minimum wage on the Beveridge curve:

$$u = \pi_1 \frac{q}{q+\mu(\theta)H(g_1)} + (1-\pi_1) \frac{q}{q+\mu(\theta)H(g_2)} \quad (30)$$

The increase in the minimum wage alters the shape of the curve as it reduces g_2. The curve moves rightward in the (u, v) plane. A high minimum wage is somehow paid by deterioration in the matching process due to falling investments in general skills.

To summarize, an increase in the minimum wage should decrease (within-group) wage inequality, increase unemployment inequality, deteriorate the Beveridge curve.

4.3 Employment protection

Wasmer argues that employment protection distorts on-the-job skill investments towards specific rather than general skills. In his model, this result arises because firing costs increase search frictions, which are detrimental to general skill acquisition once in the job. In this sub-section, we show that Wasmer's main message also holds at the time of education: firing costs incite individuals to allocate a larger proportion of their educational investment in specific skill acquisition. However, the mechanisms involved are deeply different: specific skills become more attractive because matching surplus goes down with employment protection, and this is so *despite* falling tightness.

[6]Becker (1964) also argues that the minimum wage tends to reduce skill acquisition. His argument relies on the fact that the minimum wage prevents from wage cuts used by firms to finance on-the-job training.

The modelling aspects of employment protection and job destruction closely follows Mortensen and Pissarides (1994) and Wasmer (2006). The productivity of a job depends on specific skills $f(s)$ and on a firm-specific component ε as follows: $y = f(s) + \varepsilon$. The firm component is random. It evolves according to a Poisson process with intensity λ and is drawn from a density function $g(\varepsilon)$ with c.d.f. $G(\varepsilon)$. The density has support $[\varepsilon^-, \varepsilon_0]$ and ε_0 is also the initial value of ε at the time of match formation. Before a new shock arrives, separation takes place at no cost. After the shock, the firm must pay the administrative firing cost T in case of separation. We assume that $\varepsilon_0 > \lambda T$.

In the remaining, we distinguish match surplus according to whether the job never experimented any productivity shock – $S^0(s,g)$ – or a productivity shock already occurred – $S(s,g,\varepsilon)$. We define value functions accordingly, i.e. worker's and firm's value functions are denoted by $W^0(s,g)$, $W(s,g,\varepsilon)$, $J^0(s,g)$ and $J(s,g,\varepsilon)$. Match surpluses are defined as follows:

$$S^0(s,g) = W^0(s,g) - U(s,g) + J^0(s,g) - V \tag{31}$$
$$S(s,g,\varepsilon) = W(s,g,\varepsilon) - U(s,g) + J(s,g,\varepsilon) - V + T \tag{32}$$

Match surplus is still split between the firm and the worker so that $W^0(s,g) = \beta S^0(s,g)$ and $W(s,g,\varepsilon) = \beta S(s,g,\varepsilon)$. This simple rule has two well-known implications. First, it leads to efficient job separation: job destruction occurs whenever match surplus becomes negative. Let $\varepsilon^d \equiv \varepsilon^d(s,g)$ denote the reservation productivity such that match surplus is equal to zero, i.e. $S\left(s,g,\varepsilon^d\right) = 0$. Second, $S^0(s,g) = S(s,g,\varepsilon_0) - T$.

After simple and usual computations, and setting V to zero, we get

$$S^0(s,g) = \frac{\varepsilon_0 - \varepsilon^d(s,g) - (r+\lambda)T}{r+\lambda} \tag{33}$$
$$\varepsilon^d(s,g) = \beta\mu H(g) S^0(s,g) - f(s) - rT - \frac{\lambda}{r+\lambda}\int_{\varepsilon^d(s,g)}^{\varepsilon_0} [1 - G(\widetilde{\varepsilon})]\, d\widetilde{\varepsilon} \tag{34}$$

This way of writing initial match surplus is particularly comfortable, because changes in educational mix (s,g), tightness θ or bargaining power β only transit through changes in ε^d. Importantly, initial match surplus decreases with firing costs T.

The optimal divide of schooling investment between general and specific skills results from

$$\max_g \left\{ rU(I-g,g) = \beta\mu H(g) S^0(I-g,g) \right\} \tag{35}$$

The f.o.c. writes

$$\frac{H'(g)}{H(g)} S^0(I-g,g) = \frac{f'(I-g)}{r + \lambda G\left(\varepsilon^d(I-g,g)\right)} \tag{36}$$

The left-hand side is still the marginal return to general skills, while the right-hand side is the marginal return to specific skills. An increase in firing costs distorts investments towards specific skills. On the one hand, initial match surplus S^0 goes down, which deteriorates the returns to general skills. On the other hand, ε^d decreases and jobs last longer, which raises the returns to specific skills.

To close the model, consider tightness determination

$$c\frac{\theta}{\mu(\theta)} = (1-\beta) H(g) S^0(\theta, I-g, g) \tag{37}$$

where the dependence vis-à-vis θ has been highlighted. An increase in firing costs lowers tightness as it depreciates initial match surplus S^0. This alters the way students allocate their investment between general and specific skills in the following way. First, it moderates the direct negative impact of firing costs on initial match surplus. However, this is only a second-order effect and the marginal return to general skills decreases. Second, it further raises the marginal returns to specific skills by increasing expected job duration. To conclude, accounting for endogenous tightness does not alter our general result: firing costs lowers the returns to general skills and raise the returns to specific skills at the time of educational investment. This conclusion strengthens Wasmer's point who examines on-the-job investments, despite the fact that falling tightness further increases the returns to specific skills in his framework, while it increases the returns to general skills in our analysis. Put otherwise, general equilibrium effects are not sufficiently strong to offset the partial equilibrium impacts of firing costs.

5 Conclusion

This paper examines the impact of labor market frictions and institutions on the divide of schooling investment between general and specific skills. We offer a simple matching model of unemployment in which individuals determine the scope and intensity of their skills. In partial equilibrium, we show that the severity of market frictions distorts the schooling allocation towards more general skills. Then, we endogenize job creation and argue that changes in labor market institutions may well originate a non-monotonous relationship between unemployment and the divide of skills between specific and general human capital. Finally, we consider more carefully the impacts of three labor market institutions which role on skill acquisition has been particularly emphasized by the previous literature: unemployment compensation, minimum wage and firing costs. We mainly argue that unemployment compensation has an ambiguous impact on the skill divide, while minimum wage and firing costs are detrimental to general skill acquisition.

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APPENDIX: The measure of the skill divide in schooling achievement with aggregate data

In this Appendix, we discuss the aggregate evidence on the skill divide of educational attainment in OECD countries. We show two results. First, there is substantial heterogeneity between countries in the skill divide which seems to persist over time. Second, it is difficult to argue that there is a clear Anglo-Saxon model and a clear (continental) European model.

The discussion makes use of ISCED data, which organize an horizontal differentiation of educational attainments. These data rank educational attainments into six levels (1 to 6), that go from pre-primary schooling to research. Within upper-secondary and tertiary schooling, there are three different types of education: from A (general) to C (vocational). We aim at thinking about type B and type C as vocational schooling, while A is general education. We compute the proportion of workers who choose a vocational education rather than a general education at each level. Such computation involves some methodological choice. Namely, we must think about two issues. First, some of the cells do not contain any numbers, because the relevant authorities did not provide with any number. This means that corresponding individuals have been assigned to other cells, either explicitly (authorities told in which cells they have been put) or implicitly (authorities did not tell anything about it). We have chosen to assign the value zero to such cells. Second, there is a particular column that deserves some attention: post-secondary non-tertiary schooling. These people have more than a secondary education, but this education has not been given by a tertiary establishment (e.g. university, college, and so on). This mostly corresponds to specific training for professional workers like nurses, teachers, and so on. We have grouped these people with people with a tertiary education of type B.

It is important to recognize that these data have shortcomings, especially in light of our debate. Our paper focuses on the individual trade-off between general and specific skills at the time of educational investment. Namely, we want to understand how matching frictions and labor market institutions alter the skill divide *at the margin*. However, the aggregate data we use concern people who either completed a vocational education, or a general education. We believe that these data allow us to proxy the phenomenon we want to capture, but one must keep in mind that changes in the proportion of people who choose a vocational education are not necessarily correlated with changes in the individual proportion of educational investment that is invested in specific skill acquisition.

1. There is substantial cross-country heterogeneity in the skill divide which persists over time

We only focus on graduates who have completed a tertiary education – we lack the corresponding data for the upper-secondary educated. Table 1 gives the proportion of tertiary educated by age group. Table 2 gives the proportion of tertiary educated who have followed a general program.

TABLE 1
TABLE 2

Tables 1 and 2 show substantial cross-section heterogeneity. They also display time and space information, which allows us to examine how cross-section heterogeneity varies over time. This information is displayed in Figures 3 and 4, which depict country-specific patterns by age group. These figures show that between country heterogeneity does not fall over time, and this seems true both for the proportion of tertiary educated and the proportion of tertiary educated endowed with a general education. However, the proportion of tertiary educated grows over time, which should be taken into account. In Figure 5, the proportion of tertiary educated of each age group is divided by the cross-country average of the same group. Figure 6 results from a similar computation. Figure 5 shows that cross-section heterogeneity in educational attainment actually falls over time. This means that there is convergence in the proportion of tertiary educated, even though there is still considerable heterogeneity for the youngest generation (25-34). Figure 6 exhibits a very different pattern, because there is no convergence at all between the different countries. Such persistence in cross-section heterogeneity has a major implication. Country-specific factors are more likely to alter the skill divide (horizontal component) rather than the distribution of educational attainment (vertical component).

FIGURE 3
FIGURE 4
FIGURE 5
FIGURE 6

2. There are no clear European and Anglo-Saxon models

Table 3 gives the proportion of graduates in the 25-64 population who have followed a general education. This proportion is disaggregated by schooling level, e.g. upper-secondary schooling and tertiary level.

TABLE 3

This table fails to identify a European pattern and an Anglo-Saxon pattern. On the one hand, focusing on upper-secondary schooling reveals spectacular differences. While France and Germany have fairly low proportions of generally educated, things are drastically different in the US. Actually, there is no separate stream of vocational education at the secondary level in the US. However, such difference does not generalize to other Anglo-Saxon and European countries. On the other hand, the skill divide in secondary schooling is not correlated at all with the skill divide in tertiary education. Figure 7 reveals that fact.

FIGURE 7

In the subset of Anglo-Saxon and European countries, this phenomenon is even more striking as Table 4 shows: if European secondary educated tend to acquire more specific skills than in the US, European tertiary educated tend to acquire more general skills than in the US. Overall, the proportion of graduates with a general education irrespective of educational level is about the same in the two groups of countries.

TABLE 4

3. Relationships with other papers

Krueger and Kumar (2004) and Mukoyama and Sahin (2006) also display some statistics to motivate their papers. They mostly emphasize enrollment rates in vocationnal upper-secondary schooling. Without surprise, these figures highlight the German and US cases as two extreme situations. Even though these statistics do not contradict what we say in this Appendix, we believe that it is better to consider graduates rather than enrollment rates. Graduates provide with a clear picture of the divide of educational investment, because they have completed their education. By contrast, enrollment rates may be misleading. Individuals who decide to follow a general secondary education may then decide to follow a vocational tertiary education. From that perspective, the enrollment rate in vocational upper-secondary education is an index of the schooling duration rather than a proxy of the schooling divide. It is fair to recognize that Krueger and Kumar (2004) as well as Mukoyama and Sahin (2006) know that fact. In their view, general education is associated to longer studies. It is implicit in Krueger and Kumar, who also consider cross-country differences in the entry rate into universities, "where general education is primarily imparted" (their words). It is explicit in Mukoyama and Sahin in which choosing a general education means paying more than choosing a vocational education. Our paper clearly separates the level of education from the type of education, which motivates the use of data on graduates.

TECHNICAL APPENDIX – NOT TO BE PUBLISHED

In this Appendix, we provide all the technical details required to follow sub-section 4.3.

Workers' value functions are

$$rW(s,g,\varepsilon) = w(s,g,\varepsilon) + \lambda\left[\int_{\varepsilon^d(s,g)}^{\varepsilon_0} W(s,g,\widetilde{\varepsilon})dG(\widetilde{\varepsilon}) + G(\varepsilon^d(s,g))U(s) - W(s,g,\varepsilon)\right] \quad (38)$$

$$rW^0(s,g) = w^0(s,g) + \lambda\left[\int_{\varepsilon^d(s,g)}^{\varepsilon_0} W(s,g,\widetilde{\varepsilon})dG(\widetilde{\varepsilon}) + G(\varepsilon^d(s,g))U(s) - W^0(s,g,\varepsilon)\right] \quad (39)$$

$$rU(s,g) = \mu H(g)\left[W^0(s,g) - U(s,g)\right] \quad (40)$$

Firms' value functions are

$$rJ(s,g,\varepsilon) = f(s) + \varepsilon - w(s,g,\varepsilon) + \lambda\left[\int_{\varepsilon^d(s,g)}^{\varepsilon_0} J(s,g,\widetilde{\varepsilon})\,dG(\widetilde{\varepsilon}) - (T-V)\,G\left(\varepsilon^d(s,g)\right) - J(s,g,\varepsilon)\right] \quad (41)$$

$$rJ^0(s,g) = f(s) + \varepsilon - w^0(s,g,\varepsilon) + \lambda\left[\int_{\varepsilon^d(s,g)}^{\varepsilon_0} J(s,g,\widetilde{\varepsilon})\,dG(\widetilde{\varepsilon}) - (T-V)\,G\left(\varepsilon^d(s,g)\right) - J^0(s,g)\right] \quad (42)$$

Match surplus are given in the text. We reproduce them here:

$$S^0(s,g) = W^0(s,g) - U(s,g) + J^0(s,g) - V \quad (43)$$

$$S(s,g,\varepsilon) = W(s,g,\varepsilon) - U(s,g) + J(s,g,\varepsilon) - V + T \quad (44)$$

Nash bargaining implies that

$$W^0(s,g) = \beta S^0(s,g) \quad (45)$$

$$W(s,g,\varepsilon) = \beta S(s,g,\varepsilon) \quad (46)$$

Finally, the productivity threshold derives from

$$S\left(s,g,\varepsilon^d\right) = 0 \quad (47)$$

Mixing the different conditions leads to the following equation for match surplus

$$(r+\lambda)\,S(s,g,\varepsilon) = f(s) + \varepsilon - r\left[U(s,g) - T\right] + \frac{\lambda}{r+\lambda}\int_{\varepsilon^d(s,g)}^{\varepsilon_0}\left[1 - G(\widetilde{\varepsilon})\right]d\widetilde{\varepsilon} \quad (48)$$

Using (i) $S^0(s,g) = S(s,g,\varepsilon_0) - T$, (ii) equations (40), (45) and (46), we finally obtain the equations given in the text, that is

$$S^0(s,g) = \frac{\varepsilon_0 - \varepsilon^d(s,g) - (r+\lambda)T}{r+\lambda} \quad (49)$$

$$\varepsilon^d(s,g) = \beta\mu H(g)\,S^0(s,g) - f(s) - rT - \frac{\lambda}{r+\lambda}\int_{\varepsilon^d(s,g)}^{\varepsilon_0}\left[1 - G(\widetilde{\varepsilon})\right]d\widetilde{\varepsilon} \quad (50)$$

The equation defining initial match surplus is very standard (see for instance the analogous equation in Wasmer, 2006). The second equation is also standard, even though we have written it a bit differently to get a more compact equation in our framework. The reader can check that these equations can also be written in a less elegant way:

$$S^0(s,g) = \frac{f(s) + \varepsilon_0 - \lambda T + \frac{\lambda}{r+\lambda}\int_{\varepsilon^d(s,g)}^{\varepsilon_0}\left[1 - G(\widetilde{\varepsilon})\right] d\widetilde{\varepsilon}}{r + \lambda + \beta\mu H(g)} \tag{51}$$

$$\varepsilon^d(s,g)\left[r + \lambda + \beta\mu(\theta)H(g)\right] + \lambda \int_{\varepsilon^d(s,g)}^{\varepsilon_0}\left[1 - G(\widetilde{\varepsilon})\right] d\widetilde{\varepsilon} = \beta\mu H(g)\varepsilon_0 \tag{52}$$
$$- (r+\lambda)\left\{f(s) + T\left[r + \beta\mu(\theta)H(g)\right]\right\}$$

Both initial match surplus and threshold productivity level go down with firing costs T.

The foc to the maximization program writes down:

$$H'(g)\, S^0(I-g,g) = H(g)\left[\frac{\partial S^0(I-g,g)}{\partial s} + \frac{\partial S^0(I-g,g)}{\partial g}\right] \tag{53}$$

Using the facts that

$$\frac{\partial S^0(s,g)}{\partial s} = \frac{f'(s)}{r + \beta\mu H(g) + \lambda G(\varepsilon^d(s,g))} \tag{54}$$

$$\frac{\partial S^0(s,g)/\partial g}{S^0(s,g)} = -\frac{H'(g)}{H(g)}\frac{\beta\mu H(g)}{r + \beta\mu H(g) + \lambda G(\varepsilon^d(s,g))} \tag{55}$$

We finally get the equation given in text:

$$\frac{H'(g)}{H(g)} S^0(I-g,g) = \frac{f'(I-g)}{r + \lambda G(\varepsilon^d(I-g,g))} \tag{56}$$

To understand general equilibrium implications, let us highlight the dependence of the different variables in an explicit way. Hence, initial match surplus is $S^0(\theta, s, g, T)$, while the equilibrium is a duple (θ^*, g^*) satisfying the following conditions:

(i) Initial match surplus and threshold productivity value

$$S^0(\theta, I-g, g, T) = \frac{\varepsilon_0 - \varepsilon^d(\theta, I-g, g, T) - (r+\lambda)T}{r+\lambda} \tag{57}$$

$$\varepsilon^d(\theta, I-g, g, T) = \beta\mu(\theta) H(g) S^0(\theta, I-g, g, T) \tag{58}$$
$$-f(I-g) - rT - \frac{\lambda}{r+\lambda}\int_{\varepsilon^d(\theta, I-g, g, T)}^{\varepsilon_0}\left[1 - G(\widetilde{\varepsilon})\right] d\widetilde{\varepsilon}$$

(ii) Optimal divide of skills

$$\frac{H'(g)}{H(g)} S^0(\theta, I-g, g, T) = \frac{f'(I-g)}{r + \lambda G(\varepsilon^d(\theta, I-g, g, T))} \tag{59}$$

(iii) Equilibrium tightness

$$c\frac{\theta}{\mu(\theta)} = (1-\beta) H(g) S^0(\theta, I-g, g, T) \tag{60}$$

Equations (57) and (58) define initial match surplus and threshold productivity as functions of tightness, general skills and firing costs. After simple computations, it comes

$$\frac{\partial S^0(\theta, I-g, g, T)/\partial\theta}{S^0(\theta, I-g, g, T)} = -\frac{\alpha(\theta)}{\theta}\frac{\beta\mu(\theta)H(g)}{r+\beta\mu(\theta)H(g)+\lambda G(\varepsilon^d(I-g,g))} < 0 \quad (61)$$

$$\frac{\partial\varepsilon^d(\theta, I-g, g, T)/\partial\theta}{S^0(\theta, I-g, g, T)} = -(r+\lambda)\frac{\lambda G(\varepsilon^d(I-g,g))}{r+\beta\mu(\theta)H(g)+\lambda G(\varepsilon^d(I-g,g))} < 0 \quad (62)$$

$$\frac{\partial S^0(\theta, I-g, g, T)}{\partial T} = -\frac{\lambda G(\varepsilon^d(I-g,g))}{r+\beta\mu(\theta)H(g)+\lambda G(\varepsilon^d(I-g,g))} < 0 \quad (63)$$

$$\frac{\partial\varepsilon^d(\theta, I-g, g, T)}{\partial T} = -(r+\lambda)\frac{r+\beta\mu(\theta)H(g)}{r+\beta\mu(\theta)H(g)+\lambda G(\varepsilon^d(I-g,g))} < 0 \quad (64)$$

Equations (59) and (60) jointly determine the equilibrium pair (g^*, θ^*). There exists a unique equilibrium. Consider the following functions

$$\phi_1(g,\theta,T) = \frac{H'(g)}{H(g)}S^0(\theta, I-g, g, T) - \frac{f'(I-g)}{r+\lambda G(\varepsilon^d(\theta, I-g, g, T))} \quad (65)$$

$$\phi_2(g,\theta,T) = c\frac{\theta}{\mu(\theta)} - (1-\beta)H(g)S^0(\theta, I-g, g, T) \quad (66)$$

Let $\mathbf{J}$ denote the Jacobian matrix of function $\Phi \equiv (\phi_1, \phi_2)$ evaluated in equilibrium.

$$\mathbf{J} = \begin{bmatrix} \partial\phi_1/\partial g & \partial\phi_1/\partial\theta \\ \partial\phi_2/\partial g & \partial\phi_2/\partial\theta \end{bmatrix} \quad (67)$$

where partial derivatives are computed by use of equations (61) and (62). It can be shown that[7]

$$\partial\phi_1/\partial g < 0 \quad (68)$$

$$\frac{H'}{H}\frac{\partial S^0}{\partial\theta} < \partial\phi_1/\partial\theta < 0 \quad (69)$$

$$\partial\phi_2/\partial g \equiv 0 \quad (70)$$

$$\partial\phi_2/\partial\theta \equiv (1-\beta)\frac{HS^0}{\theta}\frac{(1-\alpha)(r+\lambda G)+\beta\mu H}{r+\beta\mu H+\lambda G} > 0 \quad (71)$$

By the implicit function theorem,

$$\begin{bmatrix} dg^*/dT \\ d\theta^*/dT \end{bmatrix} = -\mathbf{J}^{-1}\begin{bmatrix} \partial\phi_1/\partial T \\ \partial\phi_2/\partial T \end{bmatrix} \quad (72)$$

where

$$\partial\phi_1/\partial T < \frac{H'}{H}\frac{\partial S^0}{\partial T} < 0 \quad (73)$$

$$\partial\phi_2/\partial T \equiv -(1-\beta)H\frac{\partial S^0}{\partial T} > 0 \quad (74)$$

[7]The fact that $\partial\phi_1/\partial\theta < 0$ derives from uniqueness of equilibrium.

and

$$\mathbf{J}^{-1} = \frac{1}{\det \mathbf{J}} \begin{bmatrix} \partial\phi_2/\partial\theta & -\partial\phi_1/\partial\theta \\ -\partial\phi_2/\partial g & \partial\phi_1/\partial g \end{bmatrix} \tag{75}$$

with $\det \mathbf{J} = (\partial\phi_1/\partial g)(\partial\phi_2/\partial\theta) < 0$. Therefore,

$$\frac{d\theta^*}{dT} \overset{sign}{=} (\partial\phi_1/\partial g)(\partial\phi_2/\partial T) < 0 \tag{76}$$

Hence, tigthness is strictly decreasing in firing costs as in the Mortensen-Pissarides model. Similarly,

$$\begin{aligned} \tfrac{dg^*}{dT} \overset{sign}{=} \; & (\partial\phi_2/\partial\theta)(\partial\phi_1/\partial T) - (\partial\phi_1/\partial\theta)(\partial\phi_2/\partial T) \\ & < (1-\beta)\, \tfrac{H'}{H} \tfrac{\partial S^0}{\partial T} \tfrac{HS^0}{\theta} \tfrac{(1-\alpha)(r+\lambda G)+\beta\mu H}{r+\beta\mu H+\lambda G} + (1-\beta)\, \tfrac{H'}{H} \tfrac{\partial S^0}{\partial T} H \tfrac{\partial S^0}{\partial\theta} \\ & = (1-\beta)\, H' \tfrac{\partial S^0}{\partial T} S^0 \tfrac{1-\alpha}{\theta} < 0 \end{aligned} \tag{77}$$

Thus, firing costs are detrimental to general skills, even though tightness is strictly decreasing in firing costs.

Fig. 3: Proportion of tertiary educated by age group in 2003 (in %)

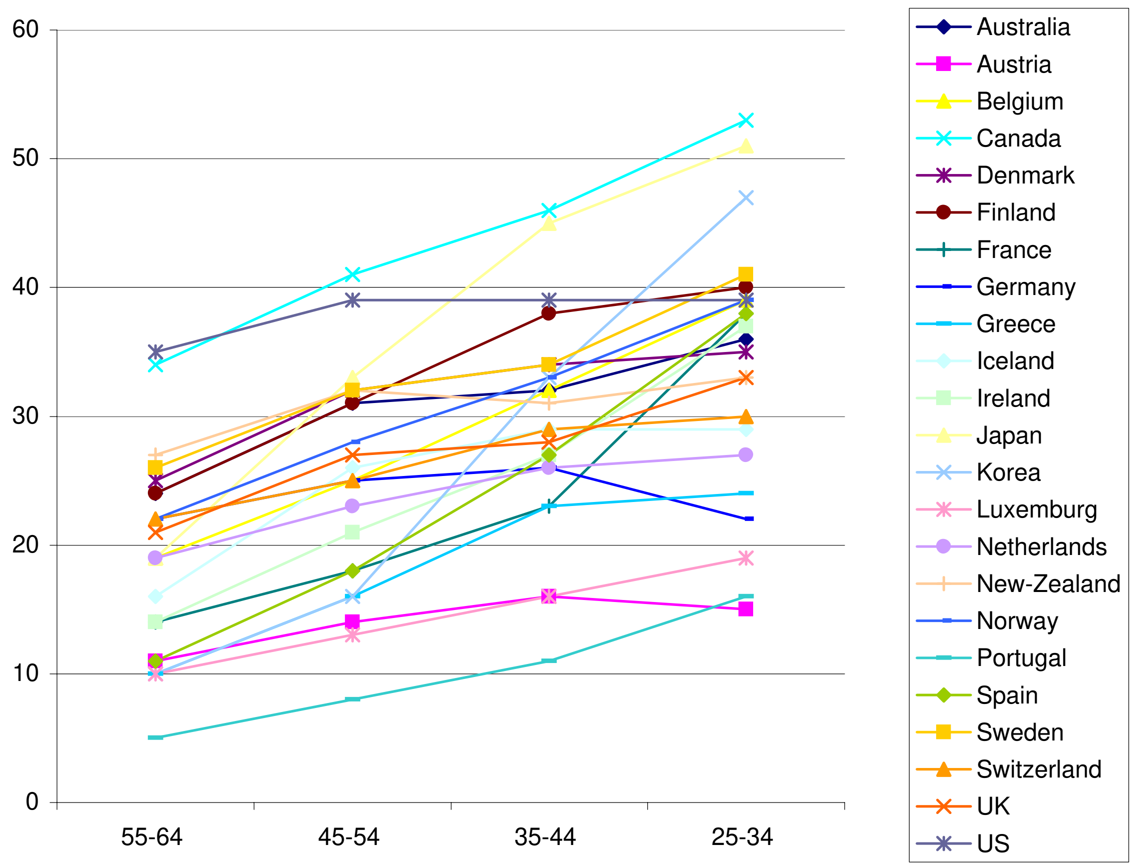

Fig. 4: Proportion of general among the tertiary educated by age group in 2003 (in %)

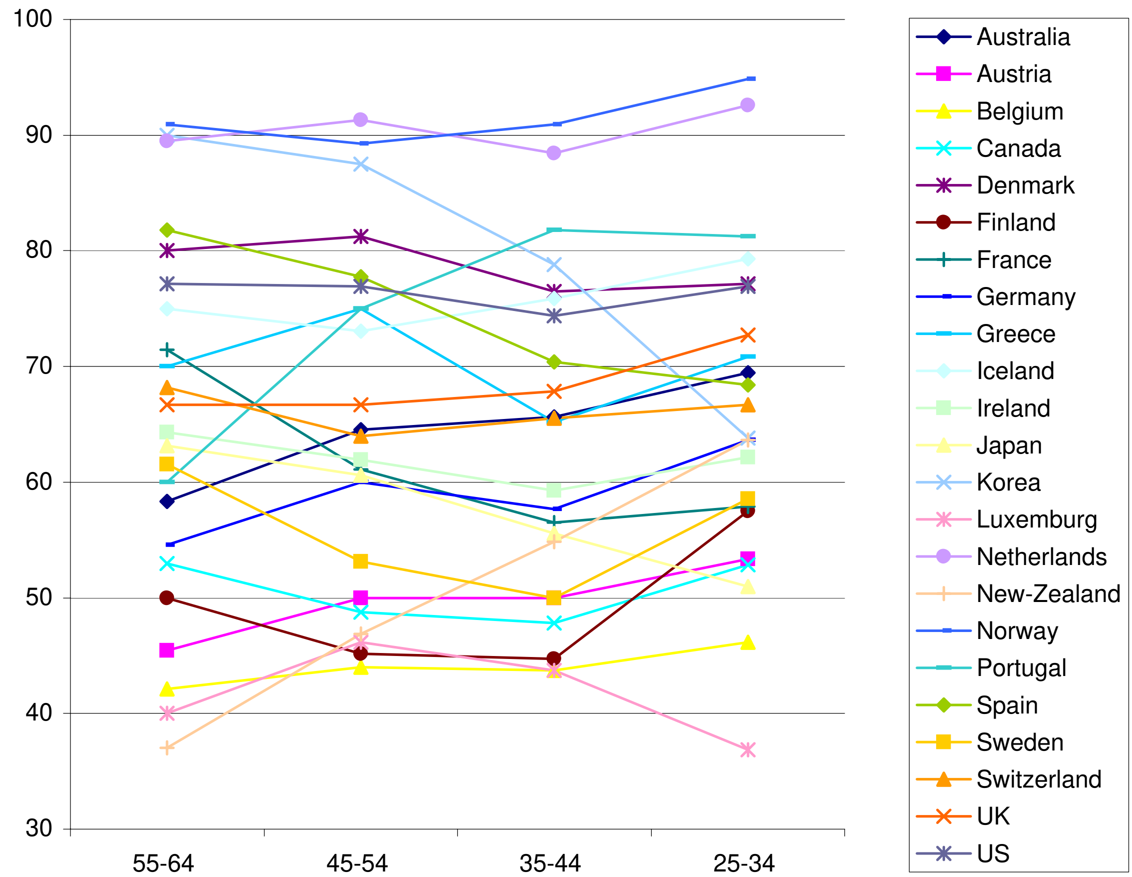

Fig.5: Adjusted proportion of tertiary educated by age group in 2003

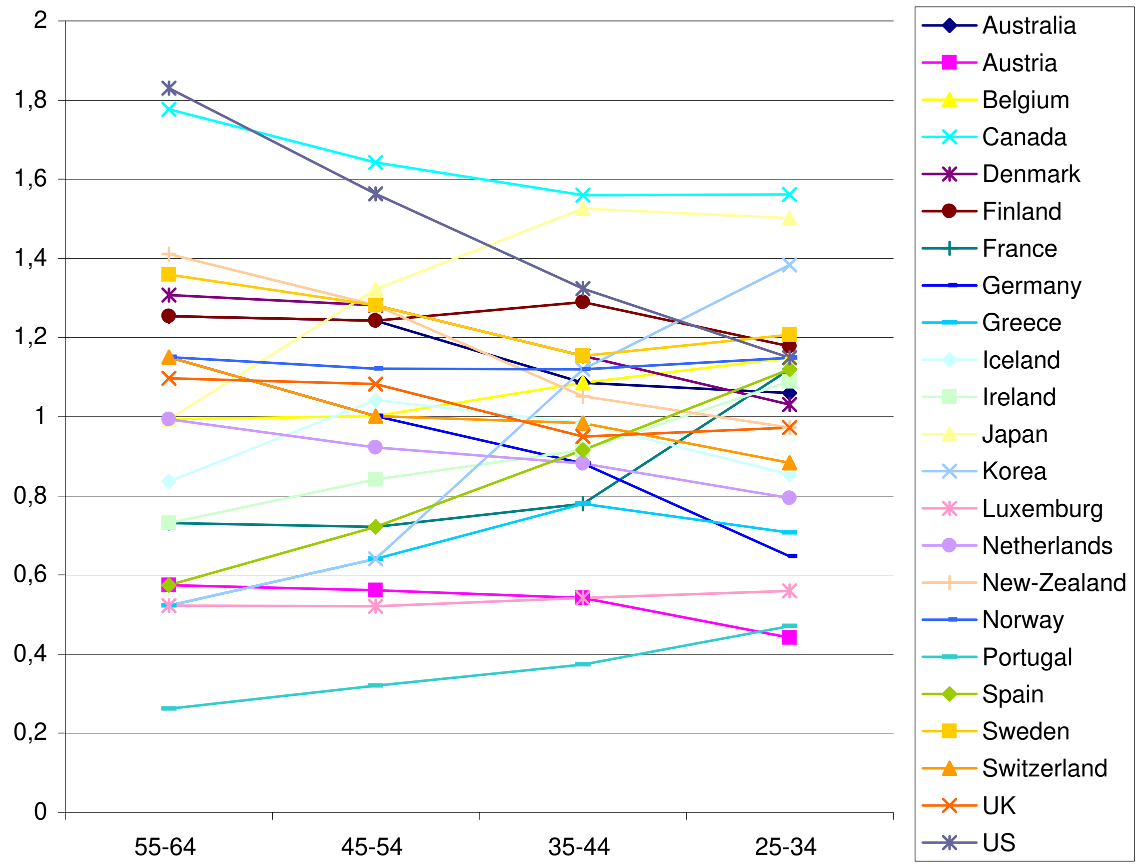

Fig.6: Adjusted proportion of general among tertiary educated by age group in 2003

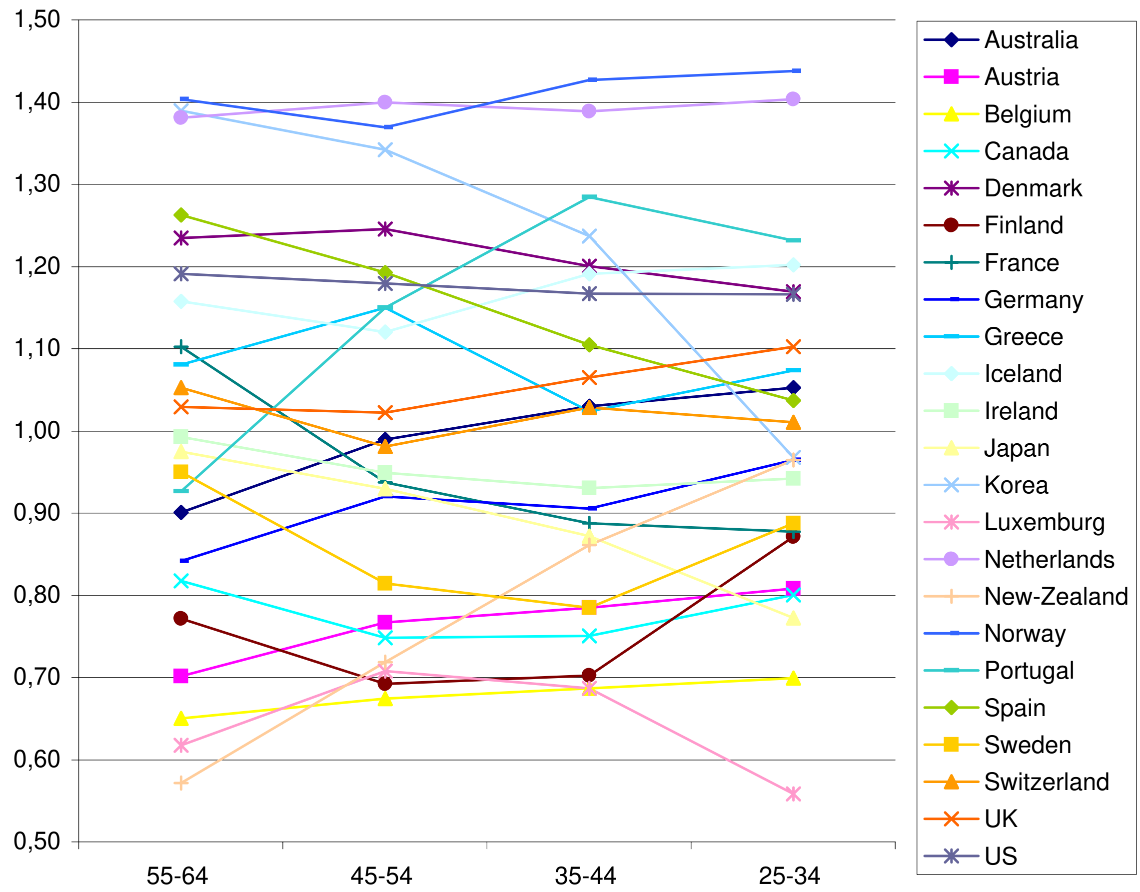

Fig.7: % general among secondary and tertiary educated, 2003

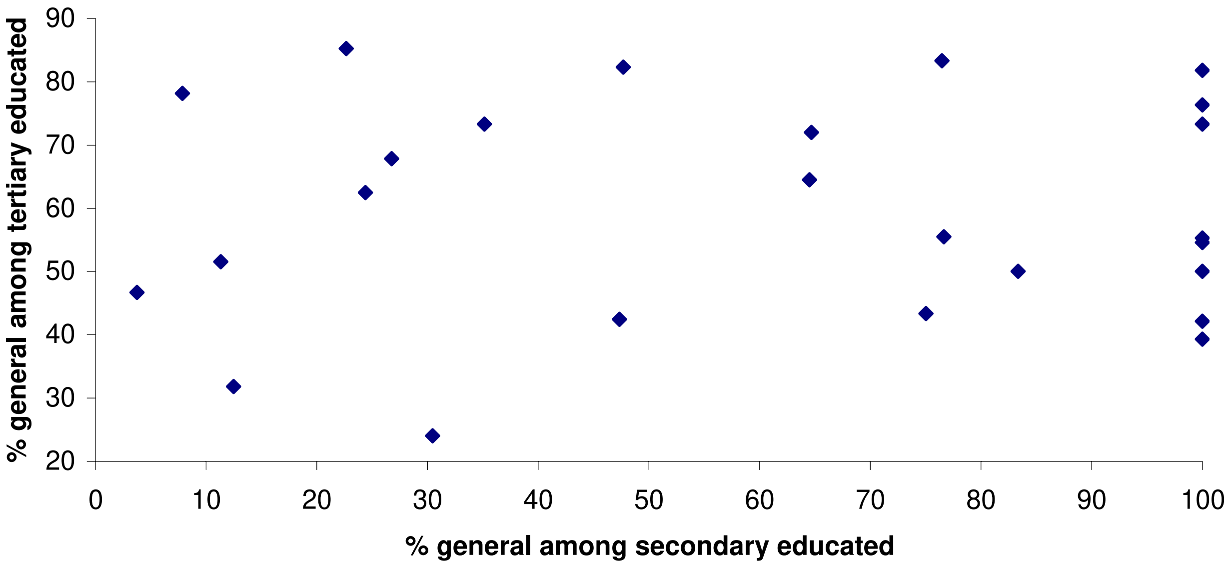

Table 1: Proportion of tertiary educated by age group

	55-64	45-54	35-44	25-34
Australia	24	31	32	36
Austria	11	14	16	15
Belgium	19	25	32	39
Canada	34	41	46	53
Denmark	25	32	34	35
Finland	24	31	38	40
France	14	18	23	38
Germany	22	25	26	22
Greece	10	16	23	24
Iceland	16	26	29	29
Ireland	14	21	27	37
Japan	19	33	45	51
Korea	10	16	33	47
Luxemburg	10	13	16	19
Netherlands	19	23	26	27
New-Zealand	27	32	31	33
Norway	22	28	33	39
Portugal	5	8	11	16
Spain	11	18	27	38
Sweden	26	32	34	41
Switzerland	22	25	29	30
UK	21	27	28	33
US	35	39	39	39

Source: Computations from Education at a glance (2006)

Table 2: Proportion of general between tertiary educated by age group

	55-64	45-54	35-44	25-34
Australia	58	65	66	69
Austria	45	50	50	53
Belgium	42	44	44	46
Canada	53	49	48	53
Denmark	80	81	76	77
Finland	50	45	45	58
France	71	61	57	58
Germany	55	60	58	64
Greece	70	75	65	71
Iceland	75	73	76	79
Ireland	64	62	59	62
Japan	63	61	56	51
Korea	90	88	79	64
Luxemburg	40	46	44	37
Netherlands	89	91	88	93
New-Zealand	37	47	55	64
Norway	91	89	91	95
Portugal	60	75	82	81
Spain	82	78	70	68
Sweden	62	53	50	59
Switzerland	68	64	66	67
UK	67	67	68	73
US	77	77	74	77

Source: Computations from Education at a glance (2006)

Table 3: Proportion of general between secondary and tertiary educated in 2003

	% secondary educated	% tertiary educated	Country type
Australia	65	65	AS
Austria	13	32	
Belgium	75	43	CE
Canada	100	39	AS
Denmark	8	78	
Finland	100	50	
France	24	63	CE
Germany	4	47	CE
Greece	83	50	CE
Iceland	77	56	
Ireland	100	42	AS
Italy	76	83	CE
Japan	100	55	
Korea	100	73	
Luxemburg	30	24	
Netherlands	35	73	
New-Zealand	47	43	AS
Norway	23	85	
Poland	48	82	
Portugal	100	82	CE
Spain	65	72	CE
Sweden	100	55	
Switzerland	11	52	
UK	27	68	AS
US	100	76	AS

Source: computations and Education at a glance (2006)
AS and CE stands for, resp., Anglo-saxon and Continental European.
Secondary stands for upper-secondary.

Table 4: Proportion of general within secondary and tertiary educated in 2003

	Secondary educated	Tertiary educated	Overall
Anglo-saxon	0,73	0,55	0,61
European	0,61	0,63	0,61

Source: computations and Education at a glance (2006)
Secondary stands for upper-secondary.

Table A3: Numbers used to draw Figure 5

	55-64	45-54	35-44	25-34
Australia	1,25	1,24	1,09	1,06
Austria	0,58	0,56	0,54	0,44
Belgium	0,99	1,00	1,09	1,15
Canada	1,78	1,64	1,56	1,56
Denmark	1,31	1,28	1,15	1,03
Finland	1,25	1,24	1,29	1,18
France	0,73	0,72	0,78	1,12
Germany	1,15	1,00	0,88	0,65
Greece	0,52	0,64	0,78	0,71
Iceland	0,84	1,04	0,98	0,85
Ireland	0,73	0,84	0,92	1,09
Japan	0,99	1,32	1,53	1,50
Korea	0,52	0,64	1,12	1,38
Luxemburg	0,52	0,52	0,54	0,56
Netherlands	0,99	0,92	0,88	0,80
New-Zealand	1,41	1,28	1,05	0,97
Norway	1,15	1,12	1,12	1,15
Portugal	0,26	0,32	0,37	0,47
Spain	0,58	0,72	0,92	1,12
Sweden	1,36	1,28	1,15	1,21
Switzerland	1,15	1,00	0,98	0,88
UK	1,10	1,08	0,95	0,97
US	1,83	1,56	1,32	1,15

Each cell is computed as follows.
First, we take country-specific proportion of tertiary educated for each age group.
Second, we divide it by the between-country average proportion for such group.

Table A4: Numbers used to draw Figure 6

	55-64	45-54	35-44	25-34
Australia	0,90	0,99	1,03	1,05
Austria	0,70	0,77	0,78	0,81
Belgium	0,65	0,67	0,69	0,70
Canada	0,82	0,75	0,75	0,80
Denmark	1,23	1,25	1,20	1,17
Finland	0,77	0,69	0,70	0,87
France	1,10	0,94	0,89	0,88
Germany	0,84	0,92	0,91	0,96
Greece	1,08	1,15	1,02	1,07
Iceland	1,16	1,12	1,19	1,20
Ireland	0,99	0,95	0,93	0,94
Japan	0,97	0,93	0,87	0,77
Korea	1,39	1,34	1,24	0,97
Luxemburg	0,62	0,71	0,69	0,56
Netherlands	1,38	1,40	1,39	1,40
New-Zealand	0,57	0,72	0,86	0,96
Norway	1,40	1,37	1,43	1,44
Portugal	0,93	1,15	1,28	1,23
Spain	1,26	1,19	1,10	1,04
Sweden	0,95	0,81	0,78	0,89
Switzerland	1,05	0,98	1,03	1,01
UK	1,03	1,02	1,07	1,10
US	1,19	1,18	1,17	1,17

Each cell is computed as follows.
First, we take country-specific proportion of general
among tertiary educated for each age group.
Second, we divide it by the between-country average proportion for such group.