Employment Protection, Investment in Job-Specific Skills, and Inequality Trends in the United States and Europe*

Matthias Doepke
Northwestern University

Ruben Gaetani
University of Toronto

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Abstract

Since the 1980s, the United States has experienced a sharp rise in the college wage premium. In contrast, in a number of European economies such as Germany and Italy the return to education stayed roughly the same. In this paper, we argue that differences in employment protection can account for a substantial part of these diverging trends. In our model, firms and workers can invest in relationship-specific capital: firms can create jobs that are complementary to experienced workers with long tenure, and workers can make corresponding investments in firm-specific skills. The incentives to undertake such investments are stronger when employment protection creates an common expectation of long-lasting firm-worker matches. Firms and workers also invest in relationship-specific capital in a calm economic environment where match-specific shocks are small. The diverging inequality patterns between the United States and Europe emerge from different levels of employment protection combined with an increase in "turbulence" (Ljungqvist and Sargent 1998) in the economy starting in the 1980s.

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1 Introduction

Since the 1980s, in the United States economy has experienced a sharp rise in education premia in the labor market, with the gap between the average wages of college-educated and less-educated workers going up by more than 30 percent. A similar trend is observed in other Anglo-Saxon economies, including Canada and the United Kingdom. During the same period, the relative supply of highly educated labor has also risen in these countries, suggesting a long-term upward shift in the demand for education. Other industrialized countries also experienced a rise in the supply of educated workers, but education premia did not follow the Anglo-Saxon trend. Specifically, most European economies witnessed only a small rise in the return to education since the 1980s.

The different trends in education premia suggests that it is not just global technological trends, but also country-specific factors that drive the return to education. In this paper, we argue that differences in employment protection can account for a substantial part of these diverging trends. In particular, we argue that firing restrictions affect the incentives to invest in job-specific skills. If there is a systematic difference in the extent to which workers with different education can transfer experience across different jobs, firing restrictions and between-group inequality can be tightly related. We also argue that restrictions for firing older workers are particularly relevant, which is where differences between Europe and the United States are the largest.

We start by documenting a strong negative correlation between the increase in the education premium since the 1980s and strength of employment protection legislation in a sample of OECD countries. Using data from the Panel Study of Income Dynamics for the United States and the Socio-Economic Panel for Germany, we show that the share of old, non-college educated workers with long-term tenure has declined substantially in the U.S. since the 1980s, but has remained unchanged in Germany. For college-educated workers, in contrast, the share of employees with long-term tenure has declined significantly both in the U.S. and Germany. In the spirit of Ljungqvist and Sargent (1998), we interpret the overall decline in the share of workers with long-term tenure as being due to increased "turbulence" in the economy. In our model, turbulence takes the form of a rise in the variance of firm-specific shocks that can lead to separations. We take the view that firing restrictions in Germany have provided unskilled workers with some insurance against higher turbulence.

We develop a model of the labor market in which workers can invest in skills while employed. Firm-worker matches are subject to productivity shocks that may lead to separation. The central assumption that we maintain is that transferability of skills depends on education. Skills acquired on the job by college-educated workers are transferrable across different employment spells. By contrast, non-college educated workers acquire mostly job-specific skills that are lost upon separation. The model offers a novel perspective on changes in the skill premium. Namely, if college education gives an advantage in transferring skills across jobs, an increase in the rate of separation will have a first-order effect on the education premium.

We calibrate the model to match salient labor market facts in the United States and Germany. In our quantitative exercise, we infer the turbulence shock from the U.S. labor market variables, and calibrate the firing cost to match the corresponding variables in the German data. In low-turbulence times there is low probability of separation even in the absence of firing restrictions. As a result, most workers invest in skills regardless of regulation. In turbulent times, investment choices crucially depend on firing restrictions. In the absence of firing restrictions (i.e. in the U.S.) only educated workers continue to invest in skill at a high rate, generating a high wage premium. However, in an environment with firing restrictions for experienced workers (i.e. in Europe) most workers continue to invest. This produces a lower education premium compared to the unconstrained economy. Our quantitative analysis implies that the mechanism explains 46 percent of the overall increase in the college premium in the United States, while also explaining why the college premium rose much less in Germany.

The idea that differences in labor market regulation lead to diverging labor market outcomes in Europe and the United States has a long history. Blanchard and Summers (1986) argue that European hysteresis can be due to labor market institutions that favor “insiders”versus “outsiders.”This fact generates persistent, long-term shifts in the rate of unemployment. They document the following empirical facts:

(1) Unemployment increased substantially in Europe (Germany, France and the UK) since the 1970s, less so in the United States and (2) Unemployment is highly persistent both in Europe and the US –slightly more so in Europe. The theoretical mechanism they suggest is that only insiders matter for setting the wage: If there is a shock that decreases the number of insiders, the remaining ones will set the wage in a way that keeps them employed, but will not care about outsiders re-entering employment. Hence, a shock to the unemployment rate can have high persistence. The theory is consistent with evidence on unionization in Europe and the US. Bentolila and Bertola (1990) study a partial equilibrium setting in which a firm takes hiring and firing decision under linear adjustment costs. Bertola and Ichino (1995) put forth the idea that shocks to the returns to skills (including trade shocks with developing countries) translate into higher wage dispersion in the US and higher unemployment rate in Europe. Nickell (1997) observes that there is large variation in labor market outcomes not only between Europe and the US, but also within Europe. He reports several cross-country correlations between various measures of unemployment and labor market participation and labor market institutions (e.g. unemployment benefits and labor protection). He finds no effect of labor protection or "well-designed"unemployment benefits and large effects of "badly-designed"unemployment benefits, unionization and labor taxes.

This paper contributes to the literature on the relationship between skills, technological adoption and labor market rigidities. Aghion, Howitt, and Violante (2002) argue that information technology is "general purpose": for educated workers, it increases the transferability of skills across sectors, and it makes physical capital less sector-specific and hence allows for a faster reallocation of capital to growing sectors. Both effects lead to an increase in inequality in response to the introduction of information technology. Our paper also builds on the notion that educated workers are characterized by higher transferability of human capital (here across employment spells), but focuses on other driving forces for changing inequality. On the empirical side, Gathmann and Schönberg (2010) estimate to what degree human capital acquired on the job can be thought of as task-specific. They use the German Employee Panel to test the following predictions: (1) tasks required in the "source" occupation are "close"to the tasks in the landing occupation; (2) the "distance"between source and landing occupation is negatively related to labor market experience; (3) the wage in the landing occupation is higher if the source occupation was "close"; (4) the current wage is positively related to "tenure"in tasks that are close to the current occupation. They also show that these patterns are typically strongest for the high-skilled, suggesting that task-specific skills are especially important for this education group. Wasmer (2006) develops a model to connect labor market rigidities with the incentives to invest in job-specific skills. High search frictions and firing costs increase the value of an existing match compared to separation. This leads to a lower rate of separation and increases the incentives to invest in match-specific skills compared to generic skills.

Acemoglu (2003) offers a direct analysis of the different experiences in terms of inequality between the United States and Europe that emphasizes the demand, rather than the supply, of skills. He decomposes the change in the skill premium in a given country as the change in technology and change in supply of skills. He then infers the change in technology by applying the decomposition to the United States, and uses the resulting estimate to compare the "actual"and the "predicted"change in the skill premium for a variety of countries. He finds significant differences between predicted and realized skill premium for several countries. He then formulates the following hypothesis: demand for skills changes endogenously and, if institutions are such that relative wage of skilled relative to unskilled workers is compressed, firms will have an incentive to invest in technologies complementary to low-skill workers. The reason is that an increase in the productivity of a worker whose wage is above his marginal product will not require a wage increase even if his marginal product increases.

The following section describes the main empirical patterns that motivate this study. Our quantitative model is described in Section 3, and in Section 4 we explain how we calibrate the model to the data. In Section 5 we describe our results, and and Section 6 concludes.

2 Empirical Patterns

In this section, we document empirical facts on the evolution of key labor market variables for the United States and Germany since the early 1980s. For the United States, we use the waves of the Panel Study of Income Dynamics (PSID) from 1981 to 2013. For Germany, we use the Socio-Economic Panel (SOEP) from its first wave (1984) to 2013. Those datasets allow to perform a reliable comparative analysis of the US and German experiences, and provide individual-level information on job tenure, wages and education, that are the key dimensions used in the analysis.

For the PSID, we focus on male family heads of age 25-64, with at least 12 years of education. We identify employment switches as observations in which the recorded job tenure is smaller than the distance between consecutive interviews, and use this definition of switches to construct consistent employment histories throughout the panel. For the SOEP, we focus on males of age 25-64, with at least 10.5 years of recorded education or training. We assign minimum wage to those observations in which the recorded wage is below minimum wage.

We discard yearly observations in which the individual is self-employed. We define a unique educational attainment variable for each individual, based on the highest number of years of education recorded in the panel for that individual. Finally, we construct a system of weights that keeps the age distribution by education fixed at the first year of the sample (1981 for the PSID and 1984 for the SOEP). All the statistics in this section are constructed using this system of weights.

2.1 Education premia and share of college graduates in the United States and Europe

As widely documented by the existing literature (Heathcote, Storesletten, and Violante 2010), over the last three decades, the US economy has witnessed a sharp rise in the college wage premium. The blue line in Figure 1 shows the coefficients of a series regressions of log real wages on a college education dummy, based on a moving three-year window around the focal year. The estimated coefficients, that can be interpreted as unconditional college wage premia, display a sharp increase since the early 1980s, peaking at twice of its original value in the second half of the 2000s and stabilizing thereafter (Valletta 2016).

This increase in the returns to education coincided with a contemporaneous increase in the relative supply of college educated workers. The blue line of Figure

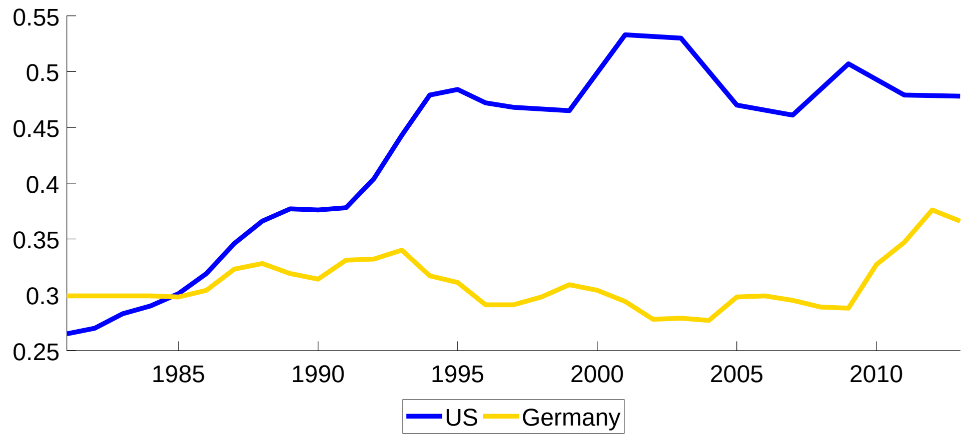

Figure 1: The college wage premium in the United States and Germany, 1980 to 2014.

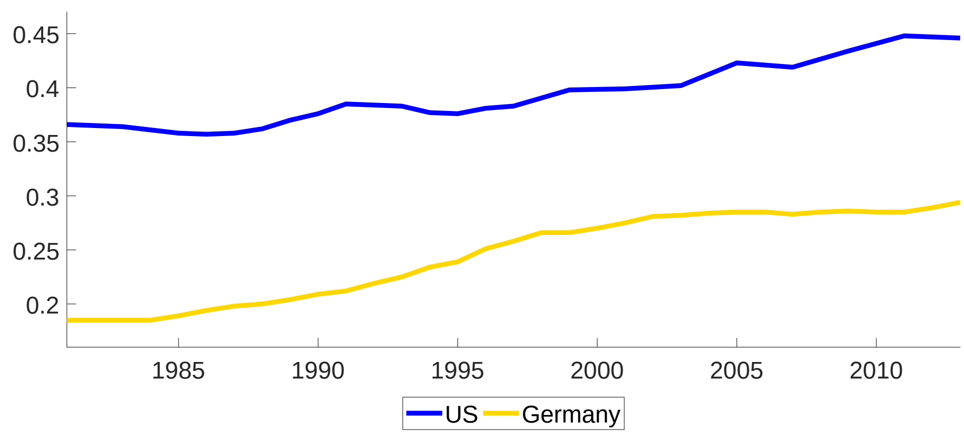

Figure 2: Share of college graduates in the United States and Germany, ages 25-64

2 displays the evolution in the share of college graduates in the US labor force since 1981, revealing a steady upward trend from 37% in 1981 to 45% in 2010.

A sizeble literature since (Katz and Murphy 1992; Krusell et al. 2000) has attempted to rationalize the contemporaneous increase in the market price and the relative supply of skilled workers in the United States by proposing that technological advances in recent decades have favored disproportionately college educated workers. According to Acemoglu (2002a) the skill-biased nature of recent technological change is itself an outcome of the increase in the supply of skilled workers in the labor market.

An important limitation of the skill-biased technical change explanation is that the supply of college educated workers has risen in all industrialized countries, whereas there is no uniform pattern in changes in the college wage premium. Notably, Germany experienced a pattern in the relative supply of college educated workers that closely tracks the one observed in the US, but did not witness a comparable increase in the returns to education. The yellow line of Figure 2 shows the steady increase in the fraction of college educated workers in Germany since 1984, which followed a path parallel to the US one. On the contrary, the yellow line of Figure1 shows the evolution of the college wage premium in Germany: The premium was in line with the US level in the early 1980s, but displays no evident upward trend over the last three decades, despite the modest increase in the late portion of the sample.

This observation suggests that there are additional country-specific factors that have a substantial impact on the college premium. Our study is motivated by the observation that changes in the education premium across countries are empirically related to measures of labor protection. Figure 2 displays the percentage change in the college premium in the years 1980-2006 in a sample of OECD countries, plotted against the OECD labor protection index. The data on education premia are taken from Krueger et al. (2010), while the OECD employment protection index is taken from Nickell (1997). The picture shows a strong negative correlation between the two. The United States, the United Kingdom and Canada have experienced a substantial increase in the return to education. In contrast, Germany, Italy and Spain - economies characterized by significantly stronger employment protection legislation - have experienced a flat or declining return to college.

In this paper, we analyze a specific mechanism that can account for the empirical relationship between employment protection and changes in the college premium. In particular, we argue that employment protection can increase the incentives for workers and firms to make relationship-specific investments that pay off if workers stay with the same firm for a long time. These investments take

Figure 3: Labor protection and change in education premium. Data from Krueger et al. (2010) and Nickell (1997).

the form of investment in firm-specific skills for workers, and the creation of jobs that employ such firm-specific skills on the part of firms. In addition to employment protection, the incentive to make relationship-specific investments depends also on the size and frequency of shocks to the productivity of a worker-firm match. We argue that employment protection is especially important when there are frequent shocks. This suggests that when there is an increase in economic turbulence, relationship-specific investments should decline in countries with little employment protection, but not in countries where employment protection creates an expectation of worker-firm matches of long duration. If high and low education workers differ in their ability to transfer skills across employment spells, these differences will be reflected in the evolution of education premium in response to changes in economic turbulence.

2.2 The fall in long-term tenure

This paper argues that part of the increase in the education premium in the United States can be attributed to a combination of higher labor market turbulence and the fact that skills acquired on the job by low-education workers are less transferrable across different employment spells. Our mechanism linking employment regula-

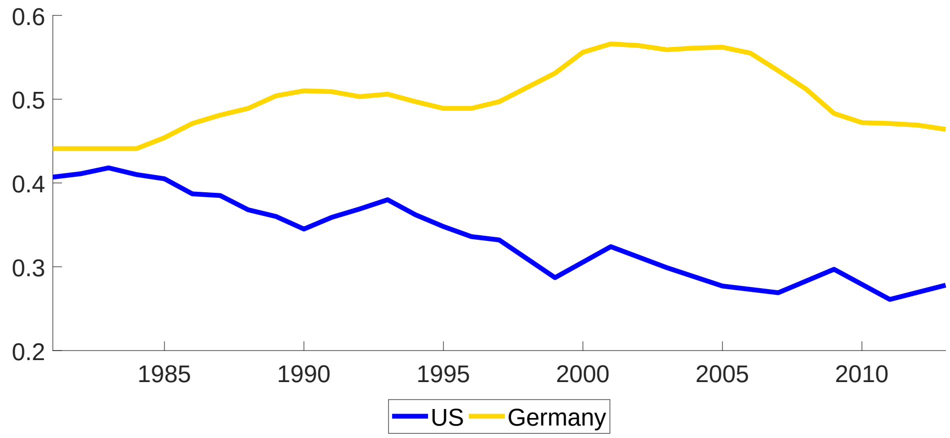

Figure 4: Share of workers with long-term tenure (20+ years) among high school graduates aged 45–55 in the United States and Germany

tion, labor market turbulence and inequality relies on the notion that in economies with more employment protection workers experience less job turnover and hence are more likely to achieve long-term tenure with a given employer. The PSID and the German SOEP can be used to directly verify whether this is true in the data.

For both the US and Germany, we compute the share of workers of age 45 to 54 who have been with the same employer for at least 20 years (hereafter, "long-term tenure" workers). Figure 4 displays the evolution of this share for the sub-sample of high-school educated workers. The share displays a clear downward trend in the United States: It declines from 41% in 1981 to 29% in 2013. The pattern for Germany is strikingly different. While in 1984 the share is comparable in magnitude to the U.S. one (about 44%) there is no downward trend in the following decades, with the share of high-school educated workers with long-term tenure remains roughly stable throughout the sample.

In contrast, the difference in these patterns is observed to a much lesser extent for college-educated workers (Figure 5), where the share of long-term tenure workers declines by similar amounts in the United States and Germany. This observation suggests that labor protection legislation may not be uniformly binding in preventing a decline in long-term tenure after an increase in labor market turbulence. For example, if college educated workers enjoy a higher degree of skill transferrability

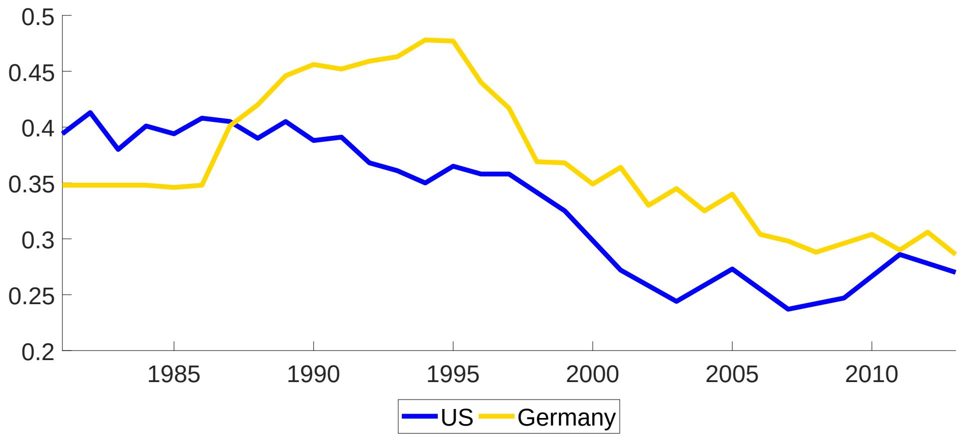

Figure 5: Share of workers with long-term tenure (20+ years) among high college graduates aged 45–55 in the United States and Germany

across consecutive employment spells compared to high-school educated workers, the former will have stronger incentives to respond to match-specific shocks by moving to a different employer, even in the presence of stringent labor market policies.

2.3 Skill transferrability for college and non-college graduates

The mechanism proposed in this paper highlights a novel source behind the wage difference between education groups, namely, the different intensity at which workers in those education groups can accumulate skills on the job, and the extent to which these skills are dispersed following a separation. Crucially, this source of wage differential strongly responds to changes in labor market turbulence and labor protection legislation.

In the model of Section 3, we formalize differences in skill transferrability through the parameters of a simple transition function, that controls the amount of skills lost by any individual worker upon separation from her current employer. The parameters of such transition function depends on the educational group, and will be set to match the empirical returns to long-term tenure. In our setting, higher returns to tenure are unambigously linked to lower skill transferrability, or, through a transition function that penalizes the individual level of skills more

	Log of hourly wage, age 45-54 USA (PSID)			
	1981-1995		1996-2013	
Tenure >= 20, High-school	.235***		.236***	
	(.045)		(.033)	
Tenure >= 20, College		.129***		.156***
		(.061)		(.044)
Exper. 3rd degree pol.	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
# Obs.	1,875	1,278	2,561	1,961
R^2	0.10	0.04	0.06	0.05

Table 1: Returns to tenure for college- and non-college-educated workers in the United States. Standard errors clustered at individual level in parentheses.

severely after a separation event.

In what follows, we show that returns from long-term tenure are significantly higher for high-school workers compared to college educated workers. This heterogeneity, that we interpret as a higher transferrability of skills accumulated on the job by high-education workers, is consistent over time and holds both in the US and the German data. This observation motivates us to treat the degree of skill-specificity as a model primitive, which does not change over time or across institutional settings. In the remainder of this section, we quantify this heterogeneity in a form that is readily comparable to the outcomes of the quantitative model.

Table 1 reports the estimated coefficients of individual-level regressions of log hourly wages on a set of year fixed effects, and a dummy variable that takes value one if the worker has been with the same employer for at least 20 years, for the sample of PSID individuals of age 45 to 54. We run these regressions separately for high-school and college educated workers, and split the sample into an early period (1981-1995) and a late period (1996-2013). Standard errors are clustered at the individual level. The estimated coefficients are significantly smaller for college

	Log of hourly wage, age 45-54			
	Germany (SOEP)			
	1984-1995		1996-2013	
Tenure >= 20, High-school	.098***		.143***	
	(.021)		(.022)	
Tenure >= 20, College		-.035		-.075*
		(.051)		(.041)
Exper. 3rd degree pol.	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
# Obs.	4,008	1,066	3,817	1,247
R^2	0.11	0.13	0.10	0.07

Table 2: Returns to tenure for college- and non-college-educated workers in Germany. Standard errors clustered at individual level in parentheses.

educated workers, and remain consistent across time periods.

Table 2 reports results of an analogous set of regressions performed on the German SOEP sample. Although average returns to tenure are smaller than the ones estimated with the PSID, the differences across education groups are strongly in line with the ones in the US sample. Returns are significantly higher for high-school educated workers, and the results remain constistent across time periods.

To further validate the consistency of the PSID results in Table 1 with the SOEP ones in Table 2, we run, separately for the PSID and the SOEP, a pooled regression that includes all the workers of age 45 to 54, and regress the log hourly wage on a set of year fixed effects, college attainment and long-term tenure dummy variables, and the interaction between the two. The results are reported in Table 3. The coefficients of the interaction terms are negative and statistically significant in both samples, as well as consistent in magnitude. The size of the estimates implies that the premium of long-term tenure workers with high-school education is 12.3 percentage points higher than the premium enjoyed by college educated workers in the United States, and 16.3 percentage points higher in Germany.

Log of hourly wage, age 45-54		
	US	DE
Tenure >= 20	.249***	.121***
	(.035)	(.016)
College graduate	.470***	.464***
	(.038)	(.037)
Interaction	-.123**	-.163***
	(.052)	(.038)
Exper. 3rd degree pol.	yes	yes
Year FE	yes	yes
# Obs.	7,675	10,138
R^2	0.23	0.39

Table 3: Returns to tenure for college- and non-college-educated workers in Germany. Standard errors clustered at individual level in parentheses.

3 A Labor Search Model with Skill Upgrading

In this section, we develop a quantitative dynamic model of job creation and on-the-job accumulation of human capital that can replicate the facts described in Section 2. We calibrate the model to match salient features of the U.S. labor market between 1980 and 2010. We use the calibrated model to quantify the extent to which the mechanism can account for the evolution of average worker tenure by education and tenure and education wage premia. We also explore how labor protection regulation can help explain the different reactions of the U.S. and European economies to rising turbulence starting in the 1980s.

One challenge for modeling is that if both firm and worker can make relationship-specific investments, complicated strategic interactions may arise. We will address this by considering a setting where the firm decides ex-ante what type of vacancy to open: only some vacancies allow for high returns to effort. The model will generate a shift towards vacancies that do not reward investment in job-specific skills when there is an increase in the separation rate.

3.1 Demographics

Consider an environment in which mass M^H of young college-educated workers and mass M^L of less-educated workers enter the labor market every year. Workers enter the labor market at age 25 and retire at age 64.

Workers are risk neutral and discount future periods with a yearly discount factor $\beta < 1$. A worker's instantaneous utility is given by their wage or home production, minus the cost of effort e exerted on acquiring skills on the job. After retirement, workers' continuation utility is independent of their skill accumulation. The continuation utility therefore does not affect decisions and hence we normalize this utility to zero.

Each worker of type $s \in \{H, L\}$ enters the labor market with a productivity level $h \in \{h_1^s, \ldots, h_n^s\}$ drawn from a probability distribution $F^s(\cdot)$.

3.2 Matching and Vacancies

There are separate labor markets for college-educated and less-educated workers. Within each market, all workers (irrespective of age or skill) face the same job-finding probability. Likewise, firms can target vacancies to either the college-educated or less-educated market, but they cannot target specific sub-groups.[1] Given u_s workers looking for jobs in market $s \in \{L, H\}$ and v_s firms posting vacancies in this market, the number of matches is generated by the matching function $m_s(u_s, v_s)$, which is increasing in both arguments, satisfies constant returns to scale, and satisfies $m_s(0, v_s) = m_s(u_s, 0) = 0$. Let the job finding probability be $\lambda_s = m_s(u_s, v_s)/u_s$ and the probability of filling a vacancy is $\theta_s = m_s(u_s, v_s)/v_s$.

The cost of posting a vacancy in market $s \in \{L, H\}$ is given by k_s. There are two types of jobs that can be created: those that allow for the accumulation of skills on the job (type A), and those that do not (type N). Vacancies for college-educated workers in market $s = H$ are always of type A. In contrast, firms posting vacancies for less-educated workers can decide which type of vacancy to post. Jobs that allow for skill accumulation are more profitable, but also more costly to create.

[1]The mechanism does not depend on this and the assumption of pooling within each market could be relaxed, at the cost of additional complexity in notation and computation.

There is heterogeneity across firms in the cost of creating an accumulation-type job, which makes the supply of these jobs responsive to relative profitability. Specifically, after paying the initial vacancy posting cost k_L, the firm draws a cost k_A for creating an accumulation-type vacancy from a uniform distribution with limits $\left[c_0 E\left[J_N^L\right], c_1 E\left[J_N^L\right]\right]$, where $c_1 > c_0$ and $E\left[J_N^L\right]$ is the expected profitability of N-type jobs. This scaling of the cost guarantees that proportional shifts to the profitability of all jobs (say, through an increase in overall productivity) do not affect the fractions of type-A and N jobs created. Given this cost, the firm will open a A vacancy if and only if the cost k_A is lower than the difference between the expected returns from the two types of vacancies:

$$k_A \leq E\left[J_A^L\right] - E\left[J_N^L\right].$$

Hence, the share v_A^L of A vacancies will be equal to:

$$v_A^L = \min\left\{ \max\left\{ \frac{E\left[J_A^L\right] - E\left[J_N^L\right]}{(c_1 - c_0)E\left[J_N^L\right]} - \frac{c_0}{c_1 - c_0}, 0 \right\}, 1 \right\}. \tag{1}$$

There is free entry for firms, so that vacancy creation is governed by a zero-profit condition. Given the number of posted vacancies and unemployment rates in each market, the matching function pins down the job finding rates λ_s. However, given that we are primarily interested in the steady-state education premium rather than fluctuations in unemployment, for most of our analysis we will choose the job finding rates λ_s and the parameters c_0 and c_1 governing the creating of type-A vacancies directly. From these choices, it is straightforward to back out vacancy creation costs and matching functions that generate the same job finding rates as an equilibrium outcome.

3.3 Production and Turbulence Shocks

Once matched, the firm and the worker start producing. Under normal conditions, a match between a firm and worker of education s, skill level h, and (potential) experience x (where $x = 1$ at age 25 and $x = 40$ at age 64) produces output $y^s(h, x) = a^s(x)h$. For a given match, this regular output level evolves over time for two reasons: a change in the experience-specific productivity component $a^s(x)$

and a change in the skill level h through on-the-job accumulation of skills, of the job type allows for accumulation.

In addition, the output level can also be affected by turbulence shocks. These shocks never hit in the first period of a firm-worker relationship. Subsequently, before production takes place in any period, the match is hit by a turbulence shock with probability γ^s. If the shock hits, productivity of the match is reduced to a fraction $\epsilon \sim$ Uniform $(0, \bar{\epsilon})$ of the regular productivity. During a turbulence shock of magnitude $\hat{\epsilon}$, with probability γ^s a more severe negative shock can hit the match, reducing the productivity of the match again to a fraction $\epsilon \sim$ Uniform $(0, \hat{\epsilon})$. A turbulence shock lasts until separation, or until a positive shock hits the match, bringing productivity back to normal. This probability of this reversal shock is ϵ, capturing the idea that more severe shocks (lower ϵ) have a lower probability of reversal.

3.4 Wage Setting and Separations

Wage bargaining between firm and worker in continuing matches takes place every period. Wages are set via Nash bargaining, but with a downward wage rigidity that imposes a floor on the wage that can be paid. If the wage floor is not binding, Nash bargaining takes place such that the worker retains a share α of the resulting surplus. For a employment match that has not been hit by a turbulence shock, we denote the resulting wage by $w_p^s(x, h)$, where $s \in \{L, H\}$ and $p \in \{T, N\}$.

The wage rigidity takes the form of a prevailing wage law that states that for given worker characteristics x and h, firms cannot pay a wage lower than a fraction $\delta < 1$ of the regular wage for the corresponding matches in normal conditions, $w_p^s(x, h)$. Hence, the rigidity can only bind of the match is subject to a turbulence shock. In the calibrated model, we set $\bar{\epsilon}$ sufficiently small so that the downward rigidity is always binding when a turbulence shock hits. Hence, if the match is subject to turbulence and is not dissolved, the wage will be $\tilde{w}_p^s(x, h) = \delta w_p^s(x, h)$.

The match is dissolved when the continuation value of the firm falls below an education-specific firing cost, $-f^s$. The firing cost is redistributed to the rest of the agents as a lump-sum payment. Separation is determined by the firm because worker and firm either share surplus, in which case they agree on separation decisions, or the wage rigidity is binding, in which case the firm may have a negative continuation value even though the worker would like to continue.

The assumption of a downward wage rigidity can be motivated with an information friction if the firm has private information about the turbulence shock. The wage rigidity rules out empirically implausible large downward wage adjustments in continuing matches. Without the wage rigidity, the model still yields similar results in terms of explaining changes in education wage premia. However, the wage rigidity has a larger impact on welfare implications, because it can lead to inefficient separations in the presence of turbulence shocks.

3.5 Skill Accumulation and Skill Loss

Workers in jobs that allow for skill accumulation choose how much effort to exert in accumulating skills. A worker of type $s \in \{H, L\}$, experience x, and current productivity level h_i^s can exert effort e at cost $a^s(x)h_i^s e^2$, and improve her skills with probability $\bar{e}\frac{e}{e+1}$. If effort is successful, a worker with skill level h_i^s upgrades her skills to h_{i+1}^s. Skill accumulation cannot happen during turbulence shocks.

Upon separation from any job, workers suffer a downgrading of their skills, so that a worker of education $s \in \{H, L\}$ and skill level h_i^s transitions to skill level h_j^s with probability $Q^s(i,j)$. We assume that Q is such that $Q^s(i,j) = 0$ for each $j > i$, so that separation always leads (weakly) to a loss of skills. We define Q^s recursively as follows:

$$Q^s(i,j) = \sigma^s Q^s(i,j+1), \qquad j < i$$
$$\sum_{j=1}^{i} Q^s(i,j) = 1$$

where the parameter $\sigma^s > 0$ captures the job-specificity of the accumulated skills. A lower value of σ^s induces a distribution of $Q^s(i,\cdot)$ that first-order stochastically dominates the corresponding distribution with a higher value of σ. A value of $\sigma = 1$ induces a uniform distribution over the skill levels smaller than or equal to the current one, whereas a value of σ close to zero implies that the expected loss of skills upon separation is almost null.

3.6 Bellman Equations

We now present the Bellman equations for a generic worker of type $s \in \{H, L\}$, experience x, and current skill level h, and her corresponding matched firm. We present separate Bellman equations for vacancies of type A that allow for on-the-job accumulation of skills and of type N that do not.

First, consider the Bellman equation for a worker in a vacancy of type N who is not currently experiencing a turbulence shock:

$$V_N^s(x,h) = w_N^s(x,h) + \beta\left[(1-\gamma^s)V_N^s(x+1,h) + \gamma^s E\left(\tilde{V}_N^s(x+1,h',\epsilon)\right)\right].$$

Here $\tilde{V}_N^s(\cdot,\cdot,\epsilon)$ is the value of being in an employment relationship with current turbulence shock ϵ, which can potentially be equal to the expected value of unemployment in the case ϵ is sufficiently low to induce separation. We define this term formally below.

The Bellman equation for a worker in a vacancy that allows for accumulation of skills (type A) needs to account for the optimal choice of effort and, given the effort choice, for the probability of skill upgrade:

$$\begin{aligned} V_A^s(x,h) = \max_e \Big\{ & w_A^s(x,h) - a^s(x)he^2 \\ & + \beta\left[(1-\gamma^s)E\left(V_A^s(x+1,h')\right) + \gamma^s E\left(\tilde{V}_A^s(x+1,h',\epsilon)\right)\right]\Big\}. \end{aligned}$$

In order to formally define the value of a worker in a current turbulence state ϵ, it is useful to start with the value of a matched firm with no turbulence shock:

$$J_N^s(x,h) = a_x^s h - w_N^s(x,h) + \beta\left[(1-\gamma^s)J_N^s(x+1,h) + \gamma^s E\left(\tilde{J}_N^s(x+1,h',\epsilon)\right)\right].$$

$$J_A^s(x,h) = a^s(x)h - w_A^s(x,h) + \beta\left[(1-\gamma^s)E\left(J_A^s(x+1,h')\right) + \gamma^s E\left(\tilde{J}_A^s(x+1,h',\epsilon)\right)\right].$$

Next, consider the value of a matched firm currently experiencing a turbulence shock ϵ. Since we assume that skill accumulation does not occur during turbulent times, the Bellman equation can be defined for a generic type of vacancy $p \in \{N, T\}$. Given the downward wage rigidity, the wage cannot fall below $\delta w_p^s(x, h)$, and we assume that $\bar{\epsilon}$ is sufficiently low to make the wage floor binding. If the value of the firm conditional on continuation is negative, separation occurs. Hence, the value of the firm with turbulence shock ϵ is:

$$\tilde{J}_p^s(x, h, \epsilon) = \max\Big\{a^s(x)h\epsilon - \delta w_p^s(x, h) + \beta\Big[\gamma^s E\left(\tilde{J}_p^s(x+1, h, \epsilon')\right) + (1-\gamma^s)(1-\pi^s)\tilde{J}_p^s(x+1, h, \epsilon) + (1-\gamma^s)\pi^s J_p^s(x+1, h)\Big], -f^s\Big\}$$

Now, the value of a worker facing a turbulence shock ϵ that does not induce separation can be written as:

$$\tilde{V}_p^s(x, h, \epsilon) = \delta w_p^s(x, h) + \beta\Big[\gamma^s E\left(\tilde{V}_p^s(x+1, h, \epsilon')\right) + (1-\gamma^s)(1-\pi^s)\tilde{V}_p^s(x+1, h, \epsilon) + (1-\gamma^s)\pi^s V_p^s(x+1, h)\Big].$$

If the worker faces a turbulence shock ϵ that is sufficiently low to induce separation (i.e. $\tilde{J}_p^s(x, h) < 0$), then the continuation value for the worker is equal to the expected value of uneployment, where expectations are taken with respect to the probability distribution over skill losses, $Q^s(i, j)$:

$$\tilde{V}_p^s(x, h, \epsilon) = E_{Q^s}\left[U^s(x, h')\right].$$

Finally, the value of an unemployed worker can be written as:

$$U^s(x, h) = a^s(x)h\bar{b} + \beta\Big\{\lambda\left[v_A^s V_A^s(x, h) + (1 - v_A^s)V_N^s(x, h)\right] + (1-\lambda)U^s(x, h)\Big\},$$

where the share of A-type vacancies for H workers, v_A^H, is always equal to 1.

After retirement, the value of the firm and the utility of the worker are both normalized to zero and do not depend on the level of skills. As a result, the optimal choice of effort in the last period before retirement is equal to zero.

4 Model Calibration

We want to examine the ability of our model to quantitatively account for the increase in the college wage premium between 1980 and 2010, and the potential role of labor protection laws in mitigating this increase. Since our framework emphasizes the accumulation and loss of skills over the life cycle, the results will crucially depend on the choice of the parameters that control the accumulation and loss of such skills.

To get at the value for those parameters, we perform a calibration exercise to replicate some key features of the US data between 1980 and 2010. In the quantitative analysis, we will treat a subset of the paramaters to be time-invariant, and the remaining parameters to vary between 1980 and 2010. We will not allow any of the structural parameters to be different in the United States and Germany, and we will use differences in firing costs to match the different levels of long-term tenure observed in the two countries.

Our calibration exercise is divided into four steps. First, we assign values to a subset of parameters that are less central to our analysis, either by setting them to standard values in the literature or by calibrating them externally. Second, we calibrate the remaining structural parameters of the model to match a set of specific moments in the US data in the 1980s. In this step, our calibration procedure is explicit on which parameter is responsible for matching each moment, and delivers an exact match between the target moments and the model-generated counterparts. This step calibrates all the remaining time-invariant parameters, as well as the time-variant parameters that concern the 1980 steady state. Third, given the time-invariant parameters estimated up to this point, we calibrate the time-variant parameters in the 2010 steady-state to match the relevant moments in the US 2010 data. Again, this step is explicit in identifying each parameter with the moment that is relevant for its identification, so that the calibration delivers an exact fit. Lastly, we set the type-specific firing costs to match the data on long-term tenure for Germany in the 2010 steady state.

Step 1: Assigned parameters We set the model period to be one year. The discount factor is $\beta = 0.95$, which implies a net yearly interest rate of 5.26%. The

Assigned parameters			
	Parameter	Value	Source-Target
Discount rate	β	0.95	Yearly $r = 5.25\%$
Job finding rate	λ	0.8	Ave un. 3mths
Bargaining weight	α	0.5	Gertler and Trigari (2009)
Non-market prod	b	0.2	50% repl. 0.4
Wage rigidity	δ	0.8	20% wage cut

Table 4: Model calibration: Step 1

bargaining weight of the worker is set to $\alpha = 0.5$, consistently with Gertler and Trigari (2009). The wage floor upon turbulence shock is set to $\delta = 0.8$, which implies a wage cut of 20% in turbulent times. The job finding rate is set to $\lambda = 0.8$, implying an average duration of unemployment of 3 months. The coefficient of the flow value of unemployment is set to $\bar{b} = 0.2$, which reproduces an average ratio of non-market to market production of 20%, consistently with an average replacement ratio of 40% for half of the currently unemployed labor force.

A summary of the assigned parameters can be found in Table 4.

Step 2: Matching the 1980 steady state Before computing the 1980 US steady state, we impose a set of normalizations and simplifying assumptions that facilitate the calibration and make the steady state comparison more intuitive. First, we assume that in 1980 all the vacancies for L workers are of type A, i.e. $v^L_{A,80} = 1$. Second, we impose that the productivity term $a^s(x)$ varies across types but not across experience groups. In other words, we normalize these terms to a constant and attribute the wage-experience profile in the 1980 steady state to the endogenous process of skill accumulation on the job. To this end, we set $a^L_{80}(x) = 1$, and $a^H_{80}(x) = A^H_{80}$ for all experience levels x, and we calibrate A^H_{80} to match the education premium in 1980 in the United States.[2] These normalizations leave

[2]We can think of A^H as capturing all the residual factors that affect the college premium, including skill-biased technological change.

Calibration: 1980 US Steady State					
	Parameter	Value	Moment	Data	Model
L skill specificity	σ^L	0.44	L Tenure premium	0.27	0.27
H skill specificity	σ^H	0.15	H Tenure premium	0.11	0.11
Prob. skill upgrade	$\bar{e}$	0.34	H Exp. premium	0.36	0.36
Skill-biased tech.	A^H_{80}	1.12	1980 College premium	0.28	0.28
L freq. of turbulence	γ^L_{80}	0.095	L long-term ten, 1980	0.36	0.36
H freq. of turbulence	γ^H_{80}	0.079	H long-term ten, 1980	0.40	0.40
Pareto initial skills	η	1.67	SD log-wage age 25	0.30	0.30
Prod. loss in turb.	$\bar{\epsilon}$	0.6	Var. of match prod.	0.05	0.05

Table 5: Model calibration: Step 2

eight parameters that are left to estimate to compute the steady state in the 1980 US economy.

The distribution of skills for workers entering the labor market, $F(\cdot)$, is assumed to be a Pareto with shape parameter η, whose value is set to match the standard deviation of overall hourly wages at age 25 in the PSID in 1981, which is equal to 0.30. The resulting value for η is 1.67. The parameter that controls the accumulation of skills on the job, $\bar{e}$, is set to match the average wage growth for college educated workers between the age of 25-34 and the age 45-54. The PSID delivers a figure of 35.9%, which is matched exactly by setting $\bar{e} = 0.34$.

The choice of $\bar{\epsilon}$ has implications for the volatility of match-specific shocks. Although it is not possible to directly measure this quantity in the PSID, the literature has estimated the standard deviation of the process for match productivity to be between 0.04 and 0.06 (Postel Vinay and Turon, 2010). To quantify the volatility of match-specific productivity generated by our model, we simulate a panel of 20,000 individuals and record the underlying productivity of the match. We then run a regression of this form:

$$a_{i,j,t} = \bar{a}_j + \rho a_{i,j,t-1} + \zeta_{i,j,t}$$

where $a_{i,j,t}$ is the logarithm of the underlying productivity of match i of individual j at time t, and $\bar{a}_j$ is a fixed effect for individual j. To generate a variance of the error term, $\zeta_{i,j,t}$, equal to 0.05, we set $\bar{\epsilon} = 0.6$.

There are four key parameters that have no immediate counterpart in the existing literature. First of all, we need to calibrate the parameters that control the frequency of turnulence shocks, γ^H_{80} and γ^L_{80}. We set these parameters to match the share of workers of age 45-54, by education group, with current tenure between 20 and 30 years. These shares in the PSID are 36.2% and 40%, respectively, implying $\gamma^H_{80} = 0.078$ and $\gamma^L_{80} = 0.094$.[3]

Finally, we need to calibrate the parameters that control the loss of skills upon separation, σ^H and σ^L. These parameters are identified by the tenure premium enjoyed by H and L workers, respectively, in the 1980 US steady state. We choose to target the wage premium that workers of age 45-54 and current tenure 20-30 years enjoy against workers of the same age range, but with current tenure between 0-10 years. This premium is equal to 10.9% for college graduates and 26.9% for high-school graduates.[4] These figures imply a significantly higher loss of skills for L workers compared to H workers: σ^L is calibrated to be 0.44, compared to a significantly lower value for σ^H, which is set to 0.15. These calibrated values imply that high-school workers acquire less trasferrable skills on the job compared to college graduates.

The assumption that the share of accumulation-type jobs for high-school graduates in the 1980 steady state is equal to 100% provides one condition that allows us to pin down both c_0 and c_1 at a later stage of the calibration. A summary of the parameters for the 1980 US steady state and the associated targeted moments can be found in Table 5.

Step 3: Matching the 2010 Steady State A subset of the parameters calibrated in Step 2 are time-invariant (η, $\bar{e}$, σ^H, σ^L, $\bar{\epsilon}$). The remaining parameters (γ^H, γ^L,

[3]To compute these shares, we take the average shares in the PSID between the years 1981 and 1986.

[4]To gain power in the estimation of the tenure premia in the 1980 steady state, we estimate them by pooling all the observations between 1981 and 1993.

Calibration: 2010 US Steady State					
	Parameter	Value	Moment	Data	Model
Returns to exp.	g_{10}	0.005	H Δ Exp. premium	0.08	0.08
Fraction of A jobs	$v^L_{A,10}$	0.63	L Δ Exp. premium	-0.02	-0.02
Skill-biased tech.	A^H_{10}	1.24	2010 College premium	0.48	0.48
L freq. of turbulence	γ^L_{10}	0.128	L long-term ten, 2010	0.23	0.23
H freq. of turbulence	γ^H_{10}	0.115	H long-term ten, 2010	0.25	0.25

Table 6: Model calibration: Step 3

A^H) are time variant, and are calibrated for the 2010 steady state, jointly with the function that controls overall returns to experience, $a^s(x)$, and the share of A-jobs of type L. Since Step 2 and Step 3 deliver two separate values for the 1980 and 2010 steady states, $v^L_{A,80}$ and $v^L_{A,10}$, the time invariant parameters c_0 and c_1 can be backed up uniquely. Hence, we can treat $v^L_{A,10}$ as an exogenous parameter and calibrate its value directly at this stage.

For the 2010 steady state, we set γ^H and γ^L again to match the share of workers between the age of 45 and 54, with tenure of 20-30 years. In the United States, this share is significantly lower in 2010 than it was in 1980: 23.3% for high-school graduates and 24.5% for college graduates. This increase in the frequency of labor market turbulence gives as calibrated values $\gamma^H = 0.113$ and $\gamma^L = 0.128$.

The 2010 value of A^H_{10} is set to match the 2010 unconditional education premium, which is equal to 0.48. The experience shifter, $a_{10}(x)$, is chosen to match the increase in the experience-wage profile of college educated workers. Specifically, we match a 8 percentage point increase in the experience premium enjoyed by H workers of age 45 to 54, compared to young workers (age 25-34) of the same education group. This experience premium is equal to 35.9% in 1980 and increases to 43.9% in 2010. We normalize $a_{10}(1) = 1$, and postulate a functional form of $a(x)$ that grows exponentially with experience at a constant rate, g_{10}:

$$a_{10}(x) = (1 + g_{10})^x \qquad x > 1.$$

We calibrate g_{10} to generate an experience premium of 43.9% for H workers. We assume that $a_{10}(x)$ applies uniformly across worker types (up to the constant shifter A^H_{10}) and finally calibrate the share of jobs for L workers that allow for accumulation of skills, $v^L_{A,10}$ to match the decline in the wage-experience profile of low-education workers between 1980 and 2010, which is equal to 2 percentage points in the PSID.

This procedure yields $g_{10} = 0.55\%$, and $v^L_{A,10} = 0.61$. Once the resulting equilibrium is computed, combining the values of J^L_N and J^L_A for both steady states through equation (1) yields unique values for the structural parameters c_0 and c_1, which can then be used in producing the counterfactuals.

Parameter values and corresponding targeted moments for the 2010 steady state are summarized in Table 6.

Step 4: Calibrating the firing cost for Germany The last step of the calibration requires to set values for the education-specific firing cost that will be used to assess to what extent labor protection legislation can be responsible for the different evolution of the college premium in Germany compared to the US experience.

We set the firing cost for the 2010 German steady state so that, given the change in the frequency of turbulence shocks, γ^H_{10} and γ^L_{10}, the change in the share of workers with long-term tenure replicates the figures delivered by the SOEP. This implies setting $f^L_{D,10}$ to 115% of the average 1980 wage of L workers, which induces a perfectly flat share of long-term tenure L workers between 1980 and 2010. Analogously, we set $f^H_{D,10}$ to 60% of the average 1980 wage for H workers, inducing a decrease in the share of long-term tenure among college educated workers equal to 6 percentage points.

Results for this step are summarized in Table 7.

5 Findings from the Quantitative Model

We now would like to examine the extent to which the model can account for changes in the college wage premium over time, and what the model implies

Calibration: Firing cost for Germany, 2010					
	Parameter	Value	Moment	Data	Model
F-cost to 1980 w, L	$f_{D,10}^{L}$	1.15	L long-term ten 2010D	0.36	0.36
F-cost to 1980 w, H	$f_{D,10}^{H}$	0.6	H long-term ten 2010D	0.34	0.34

Table 7: Model calibration: Step 4

for the implications of employment protection on the evolution of the college premium. Consider, first, the impact of increase turbulence in the US calibration.

5.1 Comparing the 1980 and 2010 Steady States

Figure 6 provides a snapshot of the main mechanism through which labor turbulence affects the college premium on our model. What is displayed is the annual probability that a worker's skill level will be upgraded to a higher level, by age and education. Across ages, the probability of upgrading skills declines with age, which reflects the shorter investment horizon of workers who are closer to retirement. Comparing college-educated and less-educated workers, in the 1980 calibration the probability of accumulating skills is broadly similar but slightly higher for the college-educated workers, which is because the higher transferability of skills for these workers.

Now consider, in the same figure, the dashed lines that correspond to the 2010 calibration. For the less-educated workers, we observe a much lower probability of skill upgrading. This is due to the higher level of turbulence shocks: both worker and firm are aware that matches are less likely to be long lived, which reduces the incentive to invest in match-specific capital. In contrast, for college-educated workers the decline in investment in skill is minimal; given that these workers primarily accumulate transferable skills, their investment is much less dependent on the level of turbulence and hence on the longevity of matches.

The decline in skill upgrading for the less-educated workers reflects investment from both sides: firms create fewer vacancies that allow for the accumulation of skill, and conditional on having a job that allows for accumulation, workers invest

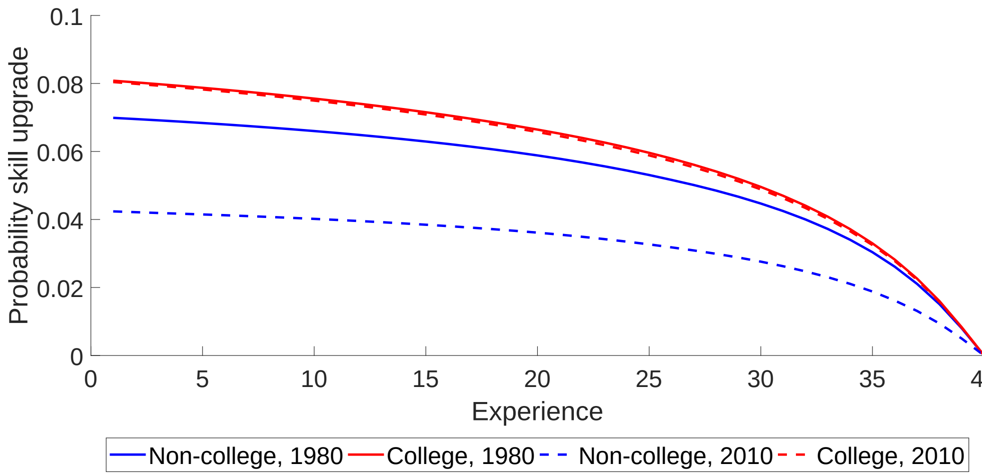

Figure 6: Probability of skill upgrading by experience for college-educated and less-educated workers, US calibration for 1980 and 2010

less. In the calibrated model, the firm investment turns out to be more important: more than 80 percent of the decline in the probability of skill upgrading is due to fewer accumulation-type vacancies being created.

The decline in the investment in relationship-specific capital among less-educated workers results in a decline in the average human capital of less-educated workers, and hence in a rise in the measured college wage premium. Figure 7 shows that the skill distribution shifts left (i.e., down) for both types of workers, but much more so for the less-educated workers.

Setting	College Premium
1980 data/model	0.287
2010 data/model with turbulence, SBTC	0.485
2010 model with turbulence	0.378
2010 model with turbulence (fixed job composition)	0.293

Table 8: The College wage premium in model and data

Table 8 breaks down how these changes affect the college wage premium in the model economy. The first two rows describe the college premia in 1980 and 2010

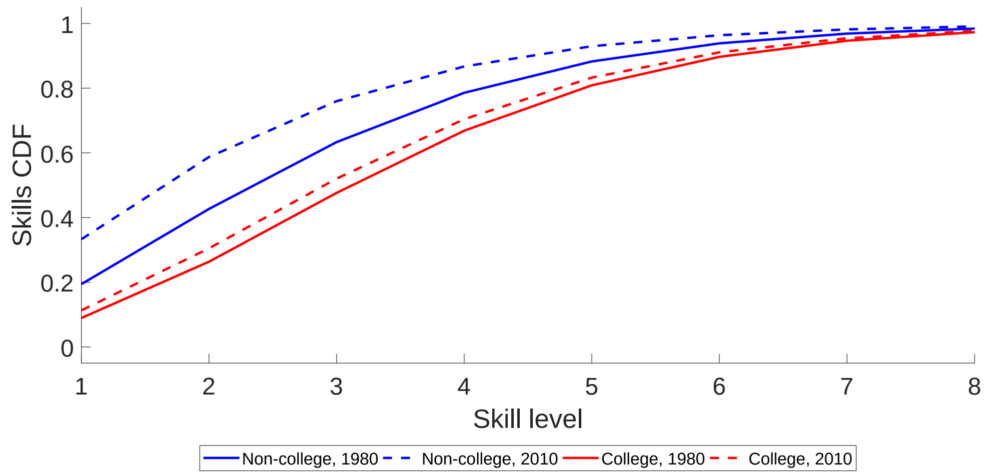

Figure 7: Distribution of skills of college-educated and less-educated workers, US calibration for 1980 and 2010

in the data and also in the model calibrations matched to these years, which match the premia exactly. In the model, the college premium rises in part due to the mechanism of on-the-job investment in skill that we focus on, and in part due to the rise in the overall skill bias parameter. The third row shows the college premium that the model generates in 2010 if we only feed in larger turbulence shocks but leave the overall skill bias unchanged. We see that this mechanism alone still leads to a large rise in the college premium from 29 to 38 log points, or about 46 percent of the total rise in the skill premium. Hence, the quantitative model implies that our mechanism can account for a substantial fraction of the rise in the skill premium.

In the model, higher turbulence shocks increase the skill premium in part because firms create fewer jobs that allow for the accumulation of skills, and in part because even when having such a job workers have less incentives to accumulate skills. The last row of Table 8 shows how much the skill premium changes if we fix the composition of job types, and hence isolate only the effect of the worker investment in skills. In this case, the skill premium rises but only a little, implying that a change in the creation of accumulation-type jobs by firms accounts for most of the effect of rising turbulence on the college premium (more than 90 percent of the total).

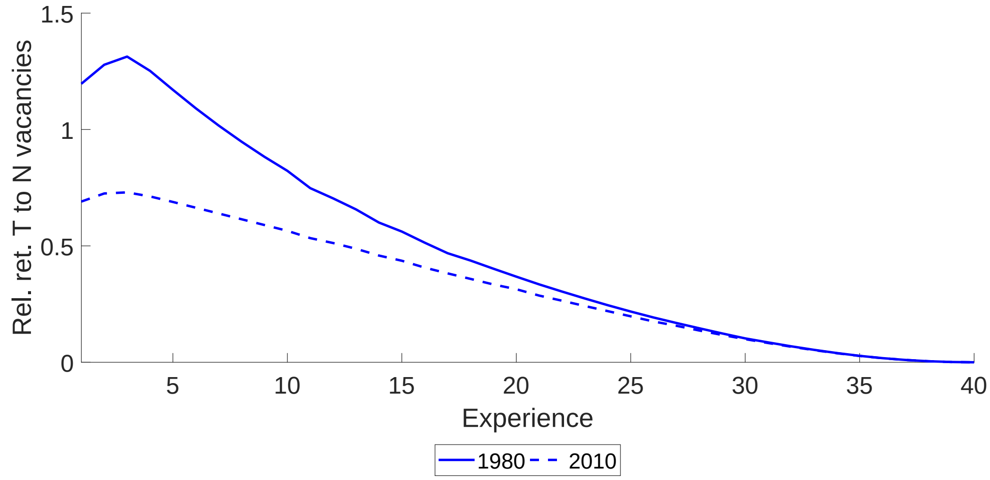

Figure 8: Profitability gap between jobs that do and do not allow for skill accumulation (A versus N vacancies)

Figure 8 shows why the fraction of jobs that allow for skill accumulation declines. What is displayed is the gap in expected profitability between jobs that allow for skill accumulation versus those that do not, as a function of the experience of the worker that gets hired. Accumulation-type jobs are always more profitable, especially when matched with younger workers who potentially will be matched for a long time. However, the increase in turbulence reduces the profitability advantage of accumulation-type jobs, primarily because of the higher likelihood of shocks that will lead to separation. Given that these jobs are more costly to create, this shift in profitability has a large effect on equilibrium job composition.

5.2 The Impact of Labor Protection

Next, we examine the extent to which labor protection legislation can contribute to explaining why the college premium rose much less in Germany compared to the United States over the period from 1980 to 2010. We view the US and German economy as subject to the same overall technological shifts, and hence the increase in turbulence applies equally to both economies. However, we consider the possibility that the impact of these changes was mitigated in Germany due to stronger employment protection. As already described in Section 4, we model labor protection as a firing cost, and we set the level of this firing cost for the 2010

Germany calibration to match the observation that long-term tenure in Germany declined for college-educated workers but not for less-educated workers.

Setting	College Premium
1980 data/model	0.287
2010 data/model with turbulence, SBTC	0.485
2010 model with turbulence, SBTC, employment protection	0.433
2010 model with turbulence	0.378
2010 model with turbulence, employment protection	0 .339

Table 9: The College Wage Premium in Data and in Model with Employment Protection

Table 9 shows how labor protection affects the evolution of the skill premium in the model economy. The first two rows reproduce the findings from Table 8 for the model without employment protection. The third row shows that when employment protection is introduced, the rise in the college premium is smaller by close to 30 percent. The last two rows isolate the effect of employment protection in the model with only turbulence shocks but without additional skill-biased technological change. Here, the rise in the skill premium is more than 40 percent smaller. Hence, the quantitative analysis shows that when we calibrate the model to match the different evolution of long-term job tenure in the US and Germany, the theory can account for a substantial portion of the diverging patterns in the college wage premium in these two countries.

Figures 9 and 10 illustrate the economics behind these findings. Figure 9 displays the gap in expected profitability between jobs that allow for skill accumulation versus those that do not, as in Figure 8. With the firing cost imposed, the profitability of accumulation-type still declines, but only about half as much as without the firing cost. The main effect of the cost is to lower separations and hence increase expected job tenure. The longer job tenure increases the horizon over which job-specific investments accrue returns, which increases the relative profitability of jobs that allow for such investments. Figure 10 displays the probability of skill upgrading for less-educated workers, parallel to Figure 6. The decline in the

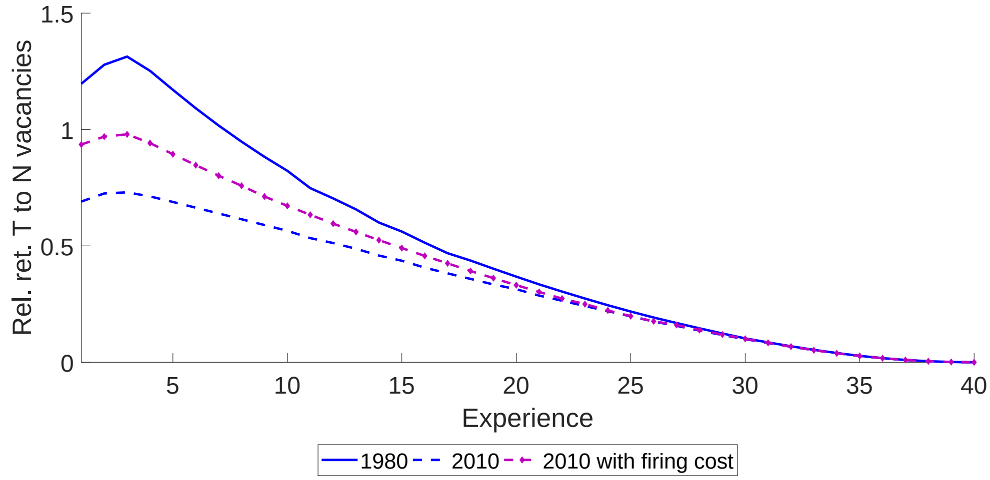

Figure 9: Profitability gap between jobs that do and do not allow for skill accumulation (A versus N vacancies) with employment protection

probability of skill upgrading in response to the increase in turbulence is roughly cut in half when the firing cost is imposed.

Setting	Output	Welfare
2010 model with turbulence (fixed job composition)	0.964	0.964
2010 model with turbulence	0.870	0.877
2010 model with turbulence, employment protection	0.886	0.893

Table 10: Output and Welfare in Model relative to 1980

Table 10 describes how imposing employment protection affects output and welfare in the economy. Compared to the 1980 benchmark, the turbulence shocks on their own lower output and welfare, because they lead to more frequent separation and hence a greater destruction of job-specific capital. Employment protection lowers these losses both in terms of output and welfare. This result obtains because in our model some of the separations that occur in response to turbulence shocks are inefficient, and employment protection can prevent some of these separations and also induce a greater accumulation of job-specific skills.

Figure 11 maps out how welfare depends on the fixed cost imposed on job separa-

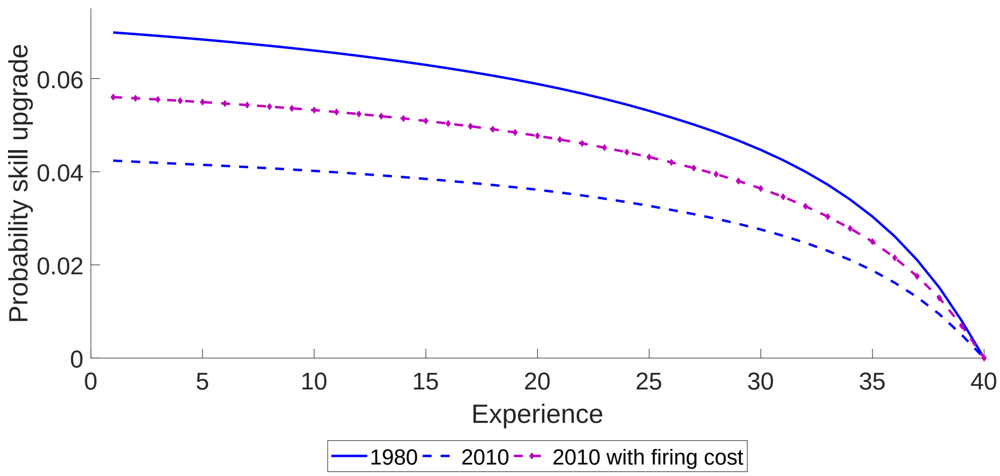

Figure 10: Probability of skill upgrading by experience for less-educated workers, US calibration for 1980 and 2010, and 2010 calibration with employment protection

tions. The welfare effects of employment protection are not unambiguous; some inefficient separations may be prevented, but it may also preserve matches that for efficiency reasons should be split up. The figure shows that the welfare-improving effect of the policy is primarily due to inducing firms to create more jobs that allow for the accumulation of skill. Once this fraction hits the upper bound (i.e., all jobs allow for accumulation), welfare decreases if the firing cost is raised even more. This result suggests that an intermediate level of employment protection that prevents inefficient separations of matches with a lot of relationship-specific capital but otherwise does not impose too many additional distortions may yield the best results.

5.3 Education Premia Across Cohorts Along the Transition Path

So far, we have focused on a comparison of steady states. Given the life-cycle structure, our model also generates rich transitional dynamics. While we do not want to take a strong stand on the exact timing of the change in economic turbulence, a robust implication of our theory for transitional dynamics is that there are important cohort effects. When economic turbulence rises, the workers who are initially most affect are young workers who just enter the labor market. These workers have not yet accumulated any relationship-specific skills, and

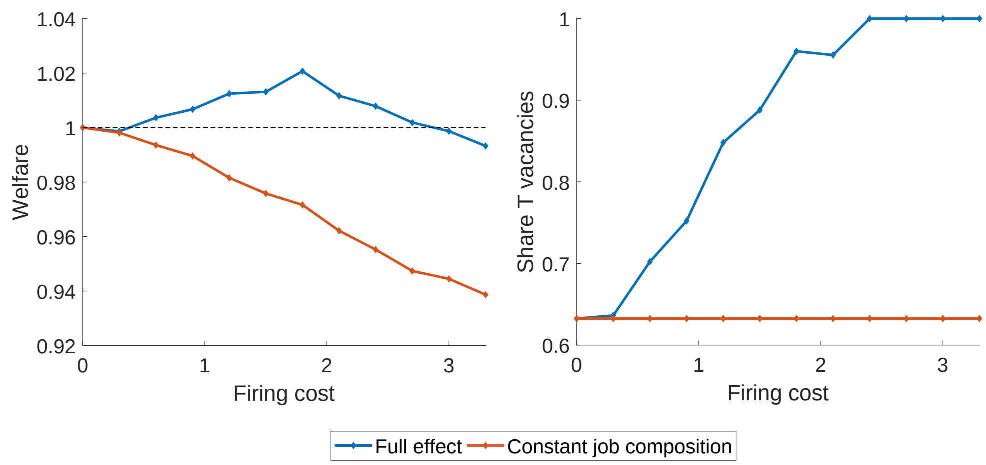

Figure 11: Welfare and fraction of jobs for less-educated workers that allow for accumulation of skill as a function of the firing cost

the composition of jobs available to them (in terms of the possibility of skill accumulation) will immediately reflect the change in turbulence. In contrast, older workers benefit for some time from the skills they have already accumulated, and also from the fact that many of them already have jobs that allow for the accumulation of skill that were created in the past.

Figure 12 illustrates the implications of these transitional dynamics for how the college wage premium evolves differentially for younger and older workers. The picture shows the college premium relative to 1980 separately for younger (25 to 39) and older (40 to 64) workers. In the simulation, we impose a permanent change in turbulence to the level calibrated for 2010 in 1981. Hence, there is a one-time change in the economic environment, and all transitional dynamics are due to the endogenous evolution of state variables. The picture shows that by 1990, the college premium among younger workers is already substantially higher, whereas there is little change for the older workers. This reflects that in 1990 a substantial fraction of older workers are still in jobs that were created before the shock took place in 1981. The next panels show that by 2000, the impact on younger and older workers has evened out, and by 2010 it is the older workers who are more affected. This reflects that in the steady state, older workers are more strongly affected by the lower availability of jobs that allow for skill accumulation, because

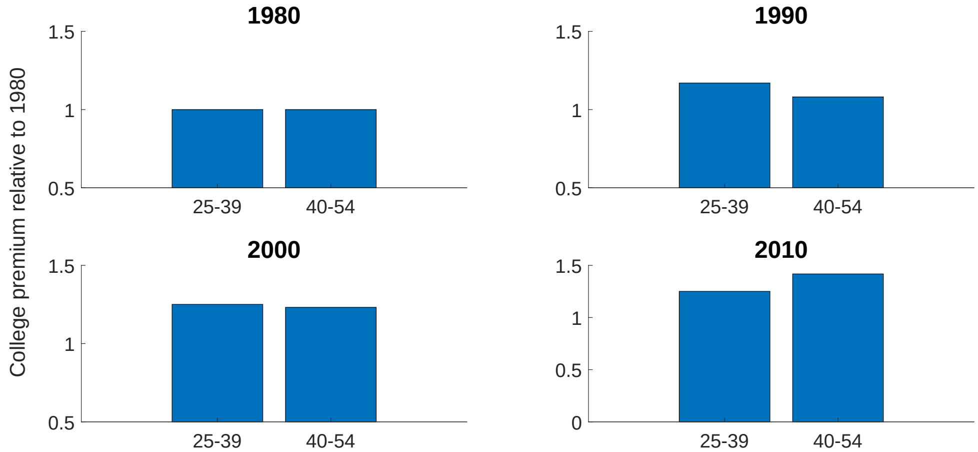

Figure 12: The college premium by age over time after one-time increase in turbulence (model)

accumulated skills are more important for older workers.

Figure 13 presents the same information in the data. The changes in the college premium are quantitatively larger in the data, because the dynamic model simulation only focuses on the turbulence channel. Qualitatively, however, the pattern in the data is exactly the same as in the model: in the first decade the college premium rises primarily for the young, in the second decade the impact evens out, and in the long run the old workers are more affected.[5].

6 Conclusion

There are large differences in employment protection across countries. In Europe, insider-outsider labor markets and protection of senior workers at the expenses of junior and temporary workers are common. In this paper, we argue that this dimension has important implications for investment in job-specific skills. This fact can help explain the diverging inequality trends between countries with tight labor market regulation and countries with low levels of employment protection.

In our analysis, we have focused on match-specific investments that improve the productivity of a given worker-firm pair. An interesting extension would

[5]The fact that the risk in the skill premium first affected younger workers was first pointed out by Card and Lemieux (2001)

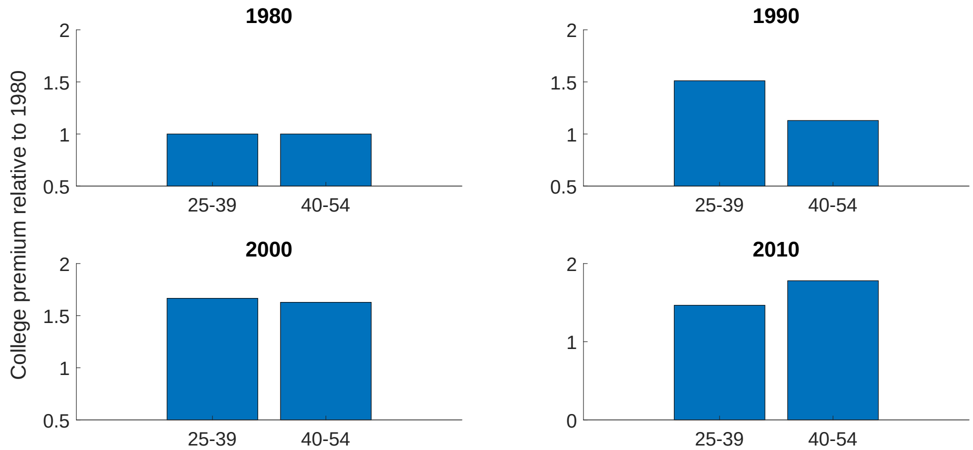

Figure 13: The college premium by age over time (data)

be to also consider more general investment by firms in technologies that are complementary to workers' accumulated firm-specific skills. That is, some firms' production technology relies on having experienced workers, whereas other technologies work equally well with inexperienced workers. In a model of directed technological change along the lines of Acemoglu (2002b), the incentive to develop technologies that work well with experienced workers would be higher if (because of labor regulation) the firm is more likely to have many such workers in the future. The direction of technical change in the context of a search model has previously been considered by Michelacci and Lopez-Salido (2007), but not from the perspective of the skill premium in the labor market. Considering the role of labor market regulations in models of endogenous directed technological change is an important challenge for future research.

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