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Schumpeterian Growth and the Political Economy of Employment Protection

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This paper analyzes the differing attitudes concerning political support for employment protection between skilled and unskilled workers in a quality-ladder growth model. Creative destruction through innovation results in "Schumpeterian unemployment" of unskilled workers. By voting on firing costs, unskilled workers consider a trade-off between the benefit of fewer unemployment spells and the cost of lower quality growth of consumer goods. Skilled workers, although not threatened by unemployment, may vote for even larger firing costs. Alleviating one labor market rigidity by increasing the matching efficiency between firms and unskilled workers aggravates another rigidity by creating political support for additional firing costs.

Keywords: Non-Scale Growth, Schumpeterian Unemployment, Firing Costs

JEL classification: J63, O33, E24, D72

1 Introduction

Employment protection is often considered to be excessive in many European countries, resulting in involuntary unemployment.[1] More specifically, firing costs are set to maintain workers in dying industries.

[1] The OECD (1999, Chapt. 2) provides an extensive summary of employment protection legislation (EPL) for 27 OECD countries and analyses its effects on employment. No significant effect of the strictness of EPL on *overall* unemployment is found. However, the problem of long-term unemployment tends to be aggravated by stricter EPL because job turnover is dampened significantly.

Instead of simply advising politicians to remove these firing costs, serious economists need to understand the underlying political economics of employment protection legislation. This seems to be even more important since rigid European labor markets are often claimed to cause a long-run growth slowdown in addition to creating unemployment. Therefore, this paper aims at analyzing the driving forces behind the demand for employment protection of different groups of workers within a simple and by now standard Schumpeterian endogenous growth model.

As argued in a stimulating paper by Saint-Paul (2002) within a vintage model of *exogenous* growth, incumbent workers form a majority and vote for a specific level of employment protection by considering the trade-off between the costs and benefits of it. The benefits are due to a longer job duration at a wage strictly above the alternative income set by the social security net (opportunity costs of working). The difference between the wage rate and the opportunity costs of working is a rent that exists because of the assumption of match-specific human capital - workers of a specific vintage have larger productivity than unemployed. The costs of employment protection consist of staying in a less productive firm at a wage below the level that could be paid in the leading-technology firm. Saint-Paul shows that in his model, these costs increase with the growth rate (rate of creative destruction), thereby reducing the political support for firing costs. Firing costs are set according to the single-peaked preferences of the median (employed) voter.

Our growth framework is borrowed from the seminal paper of Dinopoulos and Segerstrom (1999). They build a two-country Schumpeterian quality ladder growth model without scale effects that is used to analyze the effects of North-North trade liberalization on wage inequality. More precisely, we apply the PEG ("permanent effects on growth") version of that model, which results in a steady-state innovation and growth rate that can be influenced by public policies. The basic quality-ladder framework builds on the model of Grossman and Helpman (1991), where consumers only buy goods with the lowest quality-adjusted price.[2]

We will restrict the analysis to a closed economy, but introduce labor market frictions. This is done through the use of Şener's (2001) matching model of "Schumpeterian unemployment", where the flow into the pool of unemployed workers is determined by the endogenous innovation rate that forces technologically-backward firms to shut down and lay off their (unskilled) production workers. In that setting, jobs are created by new innovative firms, and R&D is only performed by skilled workers who do not face the risk of becoming unemployed. However, a

[2] Other pioneering contributions to neo-Schumpeterian growth theory include most notably Segerstrom et al. (1990) and Aghion and Howitt (1992).

successful match between the technology of a new quality leader and an unemployed worker only takes place after a search period of given exogenous length, which results in matching unemployment. Contrary to the model of Şener, the exit of old quality leaders overtaken by new innovators is costly in our model, and all workers as well as the unemployed vote on the level of firing costs. Due to the assumption of perfect unemployment insurance, unskilled employed and unemployed workers have the same preferences.

Contrary to the model of Saint-Paul (2002), we have no further need for the assumption of a productivity differential between employed and unemployed workers that creates the rent for incumbent workers, which in turn provides incentives to vote for employment protection. Here, productivities of employed and unemployed workers are identical. However, the time spent for a successful match with an unemployed worker involves costs for an incumbent firm (forgone profit during search period), which results in an unskilled wage rate strictly above the level of unemployment benefits.

The steady-state unemployment rate of unskilled workers increases in proportion to the (endogenous) innovation rate. An increase in firing costs is shown to reduce the steady-state innovation rate and to increase the proportion of unskilled workers. The latter follows from the declining unemployment rate which raises expected wage earnings of unskilled workers, thereby reducing education incentives. We also derive a critical level of the innovation rate below (above) which an increase in firing costs raises (reduces) the skilled wage rate. We assign empirically 'plausible' values to the parameters of our model and find that for most of the parameter ranges, the innovation rate will stay below this critical level. Hence in most cases, after a change in firing costs, the steady-state innovation rate and the skilled wage rate move in opposite directions.

When considering a vote for a specific level of firing costs, both worker groups take into account a trade-off between the benefit of rising per capita consumption quantity (due to a higher expected wage income) and the cost of a declining growth rate of consumer goods quality, both in terms of the individual discounted lifetime utility of a given household. Workers do not have to take into account the effects on firm profits, because we assume (as does Saint-Paul, 2002) that workers do not own firms, and profits go to a small group of capitalists whose political power can be neglected for the sake of simplicity. This will allow us to concentrate on the political conflict between skilled and unskilled workers, instead of mixing it up with a conflict between shareholders and workers. However, we will also discuss how our results are affected when accounting for workers' firm ownership.

The unique preferred level of firing costs is explicitly derived for the unskilled. It depends positively on the (exogenous) efficiency of the matching function. Since a more efficient matching technology is shown to increase the steady-state innovation and growth rate, we can conclude the following: in the case of a more flexible labor market with a higher turnover that accelerates economic growth, unskilled workers ceteris paribus favor stricter employment protection. If this vote turns into actual economic policy, it slows down product quality growth but reduces unskilled unemployment. The latter raises expected lifetime earnings and thereby increases consumption quantity of any unskilled worker. Furthermore, if the innovation rate is below the critical level, skilled workers would favor even stricter employment protection of the unskilled workers than the unskilled themselves (because of the positive effect on the skilled wage rate).[3] Our results shed light on the questions of whether a high-growth or a low-growth environment tends to create more support for policies to make the labor market more flexible, and whether cross-country growth differentials can be attributed to differences in specific aspects of labor market flexibility.

The remainder of this paper is organized as follows: Sect. 2 presents the building blocks of our model, which comprises household and firm behavior as well as a description of how unemployment is created in our model. Sect. 3 derives the unique steady-state equilibrium of our model with endogenous growth and a positive unemployment rate of unskilled workers. In addition, we analyze in detail the various steady-state effects of rising firing costs. Sect. 4 derives the preferences for firing costs of skilled and unskilled workers. Sect. 5 discusses the interaction of different aspects of labor market flexibility and the trade-off between growth and employment protection. It is established that the link between labor market flexibility and growth may be more complex than is usually supposed. In addition, we place our findings in the context of important contributions of Saint-Paul (2002) and Arnold (2002) on this topic. In Sect. 6, after discussing the results and possible limitations, our analysis is extended in several dimensions. In particular, we cover the case of a net negative effect of firing costs on hiring, and we discuss the case of repeated voting on firing costs. Sect. 7 provides our conclusions.

[3] If public opinion polls revealed a stronger support for strict EPL among less-skilled than among skilled workers, this must not necessarily be viewed as empirical evidence against our theoretical results. Actual voting behavior may be short-sighted, or voters may lack rational expectations. Our results refer to the case of fully rational workers as members of dynastic families with a bequest motive who vote on the level of firing costs for an infinite horizon.

2 The Model

2.1 Household Behavior and Skill Acquisition

The household side of the model is almost identical to Dinopoulos and Segerstrom (1999) and repeated by Şener (2001), hence we can be brief. There is a continuum of households indexed by ability $\theta \in [0,1]$ with all members of household θ having the same ability level equal to θ that is common knowledge for the individual member himself and all potential employers. Furthermore, all households have the same number of members at each point in time, and the total population is growing exogenously according to $N(t) = N_0 e^{nt}$ with normalization $N_0 \equiv 1$. The optimization problem of a dynastic family with ability θ and a constant subjective time preference rate $\rho > 0$ is to maximize its discounted utility

$$Z_\theta = \int_{t=0}^{\infty} e^{-(\rho-n)s} \log z_\theta(s) ds \tag{1}$$

by choice of the allocation of labor income across consumer goods that enter the instantaneous utility function $z_\theta(s)$ at each point in time s, by the evolution of consumption expenditure over time, and by the decision whether to become skilled or not. There is a continuum of vertically differentiated goods Q, each produced at a single industry out of a continuum $\omega \in [0,1]$. We denote by $q_\theta(j,\omega,s)$ the quantity of vertically differentiated goods with j improvements of its quality (each improvement being of size $\lambda > 1$) in industry ω at time s consumed by an individual with ability θ. Since the goods produced in each industry just differ in their quality, and λ units of quality j are a perfect substitute for one unit of quality $j+1$, only goods with the lowest quality-adjusted price p are consumed. As is usual in quality-ladder growth models (see Grossman and Helpman, 1991), it follows that there is a unit-elastic demand function $q_\theta(j,\omega,s) = c(s,\theta)/p$ in each industry ω, where $c(s,\theta)$ is the consumption expenditure per capita. Thus, we can define the instantaneous utility function of each household member as

$$\log z_\theta(s) = \int_0^1 \log\left[\lambda^{j(\omega,s)} \frac{c(s,\theta)}{p}\right] d\omega. \tag{2}$$

Utility maximization is subject to an intertemporal budget constraint

$$W_\theta(t) = \int_t^{\infty} e^{ns} e^{-[R(s)-R(t)]} c(s,\theta) ds \tag{3}$$

where $W_\theta(t)$ denotes the family's discounted wage income from time t on, and $R(t) \equiv \int_0^t r(s)ds$ is the market discount factor with $\dot{R}(t) = r(t)$ denoting the instantaneous interest rate at time t. Note that we do not need to rule out savings altogether. Households can borrow and lend with each other or with the capitalists at the market interest rate. The only necessary additional assumption in (3) is that we do not allow workers to own firms (firm ownership *by the capitalists* yields revenues in this type of model because quality leaders earn monopoly profits). Therefore, the value of firms - that will be affected by the level of firing costs - does not affect the workers' welfare.

As is usual, the steady-state interest rate is determined by the optimal saving decision of workers and capitalists (where in the capitalists' problem, the accumulation of financial assets is accounted for in the budget constraint replacing (3)). This yields the usual Keynes-Ramsey rule $\dot{c}/c = r_t - \rho$ for the optimal path of per-capita consumption expenditure of workers and capitalists. In a steady state with a constant nominal wage rate, per-capita consumption of all individuals must be constant, which implies $r_t = \rho$. We assume $\rho > n$ to have finite lifetime utility for all households.

Each individual lives for an exogenously given period of time $D > 0$. He can choose either to remain unskilled for his entire lifetime, earning the wage rate w_L regardless of his ability if employed or zero if unemployed (unemployment benefits are normalized to zero), or to spend an exogenously given period $T < D$ on education in order to become a skilled worker. This second possibility yields zero income during the period of education and an ability-dependent wage income θw_H during the period of employment of length $D - T$ without any unemployment risk. Therefore, an individual with ability θ invests in education if and only if

$$\int_0^D e^{-\rho t} w_L(s)(1-u)ds < \int_T^D e^{-\rho t} \theta w_H(s)ds \tag{4}$$

holds.[4] Setting (4) to hold as an equality and normalizing $w_L \equiv 1$, we get the unique steady-state threshold ability level as

$$\theta_0 = \frac{(1-u)w_L}{w_H} \frac{1-e^{-\rho D}}{e^{-\rho T} - e^{-\rho D}} \equiv \frac{1-u}{w_H}\sigma, \quad \sigma > 1. \tag{5}$$

Individuals with ability below $\theta_0 \in]0,1[$ choose to remain unskilled whereas those with ability $\theta \geq \theta_0$ invest in education.

[4] Writing the unskilled discounted wage income this way assumes implicitly the existence of perfect unemployment insurance - these workers only care about the *expected* lifetime income, not about length or frequency of unemployment spells in particular, and the wage income $(1-u)w_L$ is certain. This will simplify our analysis later on since it means identical policy preferences for unskilled employed and unemployed workers.

2.2 Production and R&D

The production side of the model is a closed-economy version of Şener (2001). In any industry $\omega \in [0,1]$, the production function is simply $Q_t = (1-u)L_t = (1-u)\theta_0 N_t$, irrespective of the corresponding quality level. Hence, output equals the amount of *employed* unskilled labor, where $L_t = \theta_0 N_t$ is the unskilled labor supply as a fraction θ_0 of total population.

The R&D process specified below results in a unique quality leader in each industry who is protected by an exclusive patent on his production technology. Once another innovation (that is, an improvement of the quality of consumer goods of size $\lambda > 1$) occurs in the same industry, this patent expires and becomes common knowledge. The current quality leader in each industry reaps all profits by engaging in limit pricing: Since consumers only buy goods with the lowest quality-adjusted price, the quality leader charges the price $p = \lambda - \epsilon, \epsilon \to 0$, that drives all quality followers (who produce one-step inferior goods and can do no better than charging the unit-cost price 1) out of the market. Given a unit-elastic demand function $q = c/\lambda$, marginal production costs $w_L = 1$ and a total of N consumers, this strategy yields monopoly profits of $\pi = (\lambda - 1)cN/\lambda$. Total consumption cN/λ equals total output Q and thus total unskilled labor demand, hence it follows:

$$c = \lambda(1-u)\theta_0. \tag{6}$$

This establishes a one-to-one relationship between per-capita consumption quantity $q = c/\lambda$ and the employed unskilled workforce.

There are sequential and stochastic R&D races in each industry $\omega \in [0,1]$. There is free entry in R&D, and all participating firms are using the same technology in discovering the next higher quality of consumer goods. Skilled labor is the only input used to carry out R&D in any industry ω and is assumed to be perfectly mobile across industries. Any R&D firm i that hires h_i units of skilled labor in industry ω at time t is successful in discovering the next higher quality product with instantaneous probability $\eta h_i / X(\omega,t)$, where $X(\omega,t)$ is an R&D difficulty index and $\eta > 0$ is a given technology parameter. Therefore, $\eta h_i / X(\omega,t)$

> "[...] is the probability that the firm will innovate by time $t + dt$ conditional on not having innovated by time t, where dt is an infinitesimal increment of time" (Segerstrom, 1998, p. 1297).

Since we assume that R&D returns are independently distributed across firms, across industries and over time, the industry-wide instantaneous probability of innovation at time t is

$$I(\omega,t) = \eta H(\omega,t)/X(\omega,t) \tag{7}$$

with $\sum_i h_i(\omega) = H(\omega)$ as the industry-wide employment of skilled labor in R&D.[5] R&D difficulty is assumed to be proportional to the size of the market:[6]

$$X(\omega, t) = kN_t,\ k > 0. \tag{8}$$

Next, we will consider the stock market. Usually in this type of model, consumer savings are lent to firms investing in R&D. However, since we will have consumers voting on firing costs which ultimately affects unemployment, the skilled wage rate, the education decision and growth, we want to avoid considering effects on share values simultaneously. Therefore, we follow Saint-Paul (2002) in assuming that savings *in R&D funds* (however, not savings altogether) come from a small class of capitalists who do not play a significant role in the political process to be discussed later. In Sect. 6.1 we will argue that this assumption does not affect our main results qualitatively.

As is standard in quality-ladder growth models, efficiency in the stock market requires that the expected rate of return of a stock issued by a successful R&D firm must be equal to the riskless rate of return r (since capitalists can completely diversify the industry-specific risk of unsuccessful R&D expenditure by holding shares of all existing firms). Defining $\vartheta(\omega, t)$ as the expected discounted profits of a monopolist, the *no-arbitrage condition in the stock market* states

$$\frac{\pi}{\vartheta}dt + \frac{\dot{\vartheta}}{\vartheta}dt(1 - Idt) - \left(\frac{\vartheta + F}{\vartheta}\right)Idt = rdt. \tag{9}$$

The first term on the LHS is the dividend per share during the time interval dt, the second term on the LHS denotes share appreciation during this time interval (due to increasing consumption demand because of population growth). This only takes place when there is no further innovation in this industry within dt (the probability of this is given in brackets). The third term on the LHS denotes full capital loss for share owners of this particular firm when there is further innovation during dt which is often called the "*creative-destruction effect*". In addition,

[5] This means that the arrival of innovations in each industry ω is governed by a Poisson process with arrival rate $I(\omega, t)$ which in turn depends on R&D employment in a linear way.

[6] Dinopoulos and Segerstrom (1999, p. 459) call this the "permanent-effects-on-growth" (PEG) specification, because it implies a steady-state innovation and growth rate that can permanently be affected by various economic policies. The intuition behind this specification is that the larger the market, the higher are marketing costs to introduce a new technology and the higher are the replacement costs in the case of flaws in newly invented products (Dinopoulos and Thompson, 1996, p. 399). The main purpose of rising R&D difficulty over time is to remove counterfactual scale effects from the growth model. See Jones (1995, 1999) and Segerstrom (1998) for detailed discussions of scale effects and different ways to avoid them.

this term contains the new variable $F_t \equiv BN_t, B > 0$, denoting firing costs that are indexed to the size of the economy, and that the previous quality leader has to bear in case innovation by a competitor drives him out of the market. It is assumed that F_t does not include redundancy payments to the laid-off worker. The indexing is necessary in order to prevent firing costs becoming negligible in a growing economy. Later on, we will introduce the voting of all workers on B.

All three terms on the LHS of (9) together denote expected returns per share of any firm investing in R&D during dt, and this must equal the return r of a riskless asset during the same time period given on the RHS. In the limit $dt \to 0$, we obtain

$$\vartheta(\omega,t) = \frac{\pi(t) - FI(\omega,t)}{r(t) + I(\omega,t) - \frac{\dot{\vartheta}(\omega,t)}{\vartheta(\omega,t)}}, \tag{10}$$

which gives us the appropriately discounted "*reward for innovating*" with $\pi = (\lambda - 1)cN/\lambda$. In order not to discourage innovation activity completely, firing costs have to satisfy

$$BI < \frac{\lambda - 1}{\lambda} c. \tag{11}$$

Note that (10) gives the reward for innovating only if the firm immediately starts producing after having innovated the leading technology. However, following Şener (2001), we assume a frictional labor market for unskilled workers which requires that the new quality leader searches for an exogenously given time period $y > 0$ for the appropriate unskilled worker to be matched with the new vacancy. Thus, given the interest rate r, the reward for innovating needs to be discounted by the factor e^{-yr}.

A firm i chooses its R&D intensity $I_i(\omega, t)$ by maximizing the *expected* reward for innovating (since innovation success is not certain but occurs with instantaneous probability I_i) minus costs at each point in time. Hence, it maximizes $e^{-yr}\vartheta I_i - w_H h_i$, with $I_i = \eta h_i / X$, through the optimal choice of h_i. Due to free entry into the R&D sector, these expected profits are competed away, and in equilibrium we must have the skilled wage rate defined by the "*R&D equilibrium condition*"

$$w_H = e^{-yr}\frac{\eta\vartheta}{X} = \frac{e^{-yr}\eta}{k}\frac{c(1-1/\lambda) - IB}{r + I - \frac{\dot{\vartheta}}{\vartheta}}, \tag{12}$$

which is valid in any industry ω by symmetry of the model.

2.3 Job Matching and Unemployment

The details of our model concerning matching and unskilled "Schumpeterian" unemployment are a slightly changed, closed-economy version of those in Şener (2001) who in turn builds on Aghion and Howitt (1994). Unskilled workers are continuously engaged in an on-the-job search, while firms can only start searching for the appropriate unskilled worker to use the new production technology after having innovated. Thus, they start producing and reaping monopoly profits with an exogenously given delay of length $y > 0$. The matching process is deterministic, and the successful matching of technology leaders with unskilled workers follows a "well-behaved" matching function $Am(V_t, L_t)$, where $A > 0$ is a constant efficiency parameter.[7] This matching function is concave, homogenous of degree one and increasing both in vacancies V_t created by innovating firms and the total unskilled workforce L_t. The aggregate job-finding rate (per efficiency unit A of the matching function) $p(\nu_t)$ measures the rate at which a worker who starts search at any day finds a new job. This rate is defined as $p(\nu_t) = m(\nu, 1) > 0 \; \forall \; \nu_t > 0$ with the vacancy rate $\nu_t = V_t/L_t$, and we assume that $p(0) = 0$ and $p(\infty) = \infty$ holds.[8] The aggregate recruiting-success rate (per efficiency unit A of the matching function) $q(\nu_t)$ measures the rate at which a firm that has just innovated successfully matches a worker with the new technology. This rate is defined as $q(\nu_t) = m(\nu_t, 1)/\nu_t > 0 \; \forall \; \nu_t > 0$, and we assume that $q(\infty) = 0$ and $q(0) = \infty$ holds. $q(\nu_t)$ and y are closely related as will be discussed in Sect. 3 below.

The aggregate rate of change in the number of vacancies V within a time interval $[t, t + dt]$ is given by

$$\dot{V}_t dt = \frac{c_{t+y} N_{t+y}}{\lambda} I_t dt + \frac{c_{t+y} N_{t+y}}{\lambda} \beta dt - Am(V_t, L_t) dt. \qquad (13)$$

The first expression on the RHS of (13) gives the flow of newly posted vacancies at time t equal to the expected unskilled labor demand at time $t + y$ that occurs with the innovation probability I_t. This term follows from the production function that assumes a one-to-one relationship between unskilled labor input and consumer goods output, and the unit-elastic consumption demand. Furthermore, it takes into account that positions can only be filled after a matching time y, when

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[7] In order to avoid the problem that workers may be matched while still being employed, we have to assume that (deterministic) matching time is long enough, as in Aghion and Howitt (1998, p. 126, fn. 7).

[8] The only difference to Şener (2001) is that he considers the special case $A = 1$. Here, we introduce the matching-productivity parameter A in order to have an *exogenous* parameter that allows us to perform a comparative static exercise with respect to the efficiency of the matching process (in Sect. 5.1 below).

total consumption has changed. The second expression on the RHS of (13) takes into account the change of the market size within the time interval $[t+y, t+y+dt]$, that is, for the growing unskilled labor demand *after* production of the new leading-quality goods begins. In that interval, population grows at the exogenous rate $n = \beta - \delta > 0$ (with β and δ denoting the birth rate and the death rate, respectively), and positions of dying employed unskilled workers must be filled. The third expression on the RHS of (13) denotes outflow of vacancies due to successful matching during dt. Note that vacancy creation at time t is determined by additional labor demand at time $t + y$, but it is determined by the value of the matching function at time t.

Similarly, the aggregate rate of change in the unemployment level $U \equiv uL$ within a time interval $[t, t + dt]$ is given by

$$\dot{U}_t dt = \frac{c_t N_t}{\lambda} I_t dt + \beta L_t dt - \delta u_t L_t dt - Am(V_t, L_t)dt. \tag{14}$$

The four terms on the RHS of (14) denote, respectively, layoffs by the current quality leader in any industry ω in the case of innovation by a competing firm, newly born individuals who decide not to take education before they enter the labor market, dying unemployed workers, and outflow of unemployment due to successful matching, all measured during the time interval dt.

Thus, the total unemployment level consists of Schumpeterian and demographic unemployment. Firing costs do not *directly* affect vacancy creation or unemployment flows, but they will have indirect effects via the endogenous variables I_t, c_t and u_t.

3 Steady State and Rising Firing Costs

We define the steady state of our model as the long-run equilibrium with market clearing and constant values for our variables θ_0, w_H, I, c, v and u, given the level $B = F/N$ of firing costs to be determined later by the majority-winning preferences of workers.

We begin by deriving the steady-state unemployment rate, following Şener (2001). Dividing (14) by dt, using $m(V, L) = p(\nu)L$, $L = \theta_0 N$, $U/L = u$ and (6) yields

$$\frac{\dot{U}}{U} = \frac{(1-u)I + \beta - \delta u - Ap(\nu)}{u} = \beta - \delta = n, \tag{15}$$

where the second equality follows from imposing the restriction of a constant steady-state unemployment rate. Equation (15) can easily be solved for

$$u = 1 - \frac{Ap(\nu^*)}{I + \beta} \tag{16}$$

with ν^* denoting the steady-state vacancy rate.[9] This can be derived in a similar fashion from (13), using $\frac{\dot{V}}{V} = \beta - \delta,\ c_{t+y} = c_t = c,\ N_{t+y} = N_t e^{ny}$ and the result in (16):

$$\nu^* = \frac{Ap(\nu^*)(e^{ny} - 1)}{n}. \tag{17}$$

The aggregate recruiting-success rate q and the matching time y are related as follows (cf. Şener, 2000, pp. 579-80):

$$Aq(\nu_t) = \frac{Am(\nu_t, 1)}{\nu_t} = \frac{Ap(\nu_t)}{\nu_t} = \frac{n}{e^{ny} - 1} \tag{17a}$$

where the first two equations follow from our definitions of $q(\nu)$ and $p(\nu)$, and the last equation follows from (17). Whereas $Aq(\nu_t)$ is a monotonically decreasing function of ν_t, $n/(e^{ny} - 1)$ is a positive constant, which defines uniquely the steady-state value ν^* as a function of exogenous parameters. In the limit $n \to 0$, we obtain $Aq(\nu_t) = 1/y$ by applying L'Hôpital's rule. This is the special case (for $A = 1$) considered in Aghion and Howitt (1994): with no population growth, the matching time y is simply the inverse of the aggregate recruiting-success rate $1/q$, which is the *instantaneous* expected matching time for a fixed pool of searching workers. With $n > 0$, however, it holds $y < 1/q$ since firms can choose from a continuously growing pool of searching workers (note that $n/(e^{ny} - 1)$ decreases in n). In Sect. 5.1 we will conduct comparative statics on A with keeping ν^* constant, so that the value of y is adjusted accordingly.

The only endogenous variable affecting (positively) the unskilled unemployment rate u in (16) is the innovation rate I: more frequent innovations reduce the expected incumbency period $1/I$ of current quality leaders in any industry ω, thereby reducing the duration of employment spells of unskilled workers and raising their unemployment rate by increased labor market turnover.[10] Note that the finding of

[9] Similar to Şener (2001, p. 136), we note that the additional assumption $Ap(\nu) > \beta$ is needed to rule out that "biological turnover" alone suffices to produce a positive unemployment rate.

[10] There are two reasons for why in addition to this positive "creative destruction effect" of growth on unemployment, there is no negative "capitalization effect". First, as argued by Aghion and Howitt (1998, p. 127), since the quality leader does not upgrade its own technology, the capitalized value of each innovation does not grow with higher labor productivity (in terms of consumer goods quality), hence no *additional* incentives of follower firms to create vacancies arise. Second, unlike in the model of Aghion and Howitt (1994, p. 483; 1998, p. 135), the capitalization effect does not enter when considering forward-looking behavior of firms. This is because in (10), the instantaneous expected income from innovating is growing with the size of the market (n) which does not depend on the rate of innovation. Therefore, a higher growth and innovation rate does not reduce (actually, it increases) the net discount rate at which quality leaders capitalize their expected profits.

an unambiguously positive long-run relationship between growth and unemployment hinges crucially on the fact that we are only considering the quality dimension of growth (increasing quality of consumer goods), while neglecting the quantity dimension. The latter could be introduced e.g. by accounting for human capital accumulation, with the level of human capital entering the production function of goods. Then, growth in the quantity dimension would raise production and hence the unskilled labor demand for any given innovation rate, thereby working toward a reduction in unemployment.

Next, we will determine the steady-state values for both I and θ_0. To this end, we solve (12) for I, use (6) to replace c, (5) to replace w_H, (16) to replace u, and use $r_t = \rho$. Proceeding in this manner, we get

$$I = \frac{\eta e^{-\rho y} Ap(\nu^*)\theta_0^2(\lambda - 1) - (\rho - n)\sigma Ap(\nu^*)k}{\sigma Ap(\nu^*)k + (\beta + I)\eta e^{-\rho y}\theta_0 B}. \tag{18}$$

In Appendix A we prove by use of the implicit function theorem that $dI/d\theta_0 > 0$ holds in (18). A second equation in the variables I and θ_0 is derived by the skilled labor market equilibrium condition. Whereas skilled labor demand equals IkN/η from (7) and (8), skilled labor supply can be derived as $(1-\theta_0^2)\phi N/2$ with $\phi \equiv [e^{n(D-T)}-1]/(e^{nD}-1) < 1$ (see Dinopoulos and Segerstrom, 1999, p. 456). Putting both together, the skilled labor market clearing condition is

$$\theta_0 = \sqrt{1 - \frac{2kI}{\eta\phi}}. \tag{19}$$

Equations (18) and (19) together determine the unique steady-state combination (I, θ_0) as depicted in Fig. 1 (next page).[11] There, we also illustrate the following (formal proof is provided in Appendix B):

Proposition 1. *A rise in firing costs reduces unambiguously both the steady-state innovation rate and the proportion* $1-\theta_0$ *of skilled workers.*

It will prove useful to derive the steady-state equilibrium also in (w_H, I)-space. This is done in Fig. 2 (page 91). To derive Fig. 2, we first solve (12) for I, use (6) to substitute for c, (5) to substitute for $1 - u$, and (19) to substitute for θ_0. This yields

$$I = \frac{\frac{\eta}{\sigma}e^{-\rho y}(\lambda - 1) - (\rho - n)k}{k\left[1 + \frac{2e^{-\rho y}(\lambda-1)}{\sigma\phi}\right] + \frac{\eta e^{-\rho y}B}{w_H}}, \tag{20}$$

[11] Şener (2001, p. 138, Fig. 1) studies the steady-state effects of trade-liberalization using exactly the same graph.

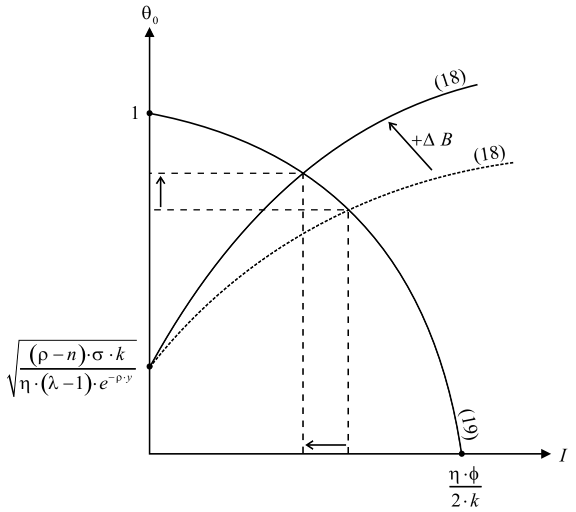

Fig. 1. Steady-state effects of rising firing costs in (θ_0, I)-space

which is unambiguously decreasing in B. Then, we use (5), (16) and (19) to write w_H as a function of I alone:

$$w_H = \frac{\sigma A p(\nu^*)}{(\beta + I)(1 - \frac{2kI}{\eta\phi})^{1/2}}. \tag{21}$$

In (21), w_H is decreasing in I for $I < (\theta_0^2 \eta\phi/k) - \beta$ and rising for larger I. Equations (20) and (21) together determine the unique steady-state combination (I, w_H) as depicted in Fig. 2.

Equation (20) captures the R&D equilibrium with skilled labor market clearing. Its positive slope indicates that the higher the innovation rate in equilibrium, the higher the skilled wage rate will be due to the rising demand for skilled workers. Equation (21) accounts for the equilibrium education decision of individuals, the steady-state unemployment rate and the skilled labor market clearing condition. It gives for each level of the equilibrium innovation rate (that implies an equilibrium unemployment rate via (16)) the required skilled wage rate that makes the individual with threshold ability θ_0 indifferent with respect to his educational decision, given skilled labor market clearing. This curve is U-shaped. For low levels of I, on the one hand, unskilled unemployment is relatively low, hence expected unskilled wage income is relatively high, which raises the required skilled wage rate ("*education equilibrium effect*"). On the other hand, skilled labor market clearing would call for a low level of w_H ("*skilled labor demand effect*") because

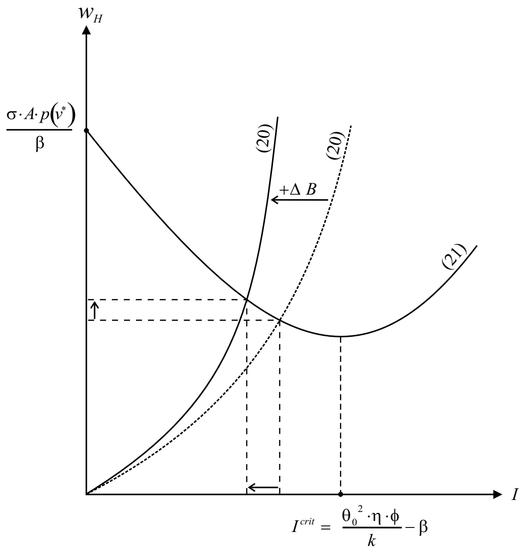

Fig. 2. Steady-state effects of rising firing costs in (w_H, I)-space

demand for R&D labor is low. For low I, the *education equilibrium effect* dominates the *skilled labor demand effect*, and this is why the required w_H is high in this case. For high levels of I, unskilled unemployment is high, thus expected unskilled wage income is low. Ceteris paribus, this yields a low required w_H. However, this *education equilibrium effect* is dominated by the *skilled labor demand effect*: a high I creates a large demand for skilled workers that drives up w_H. This is why the required w_H is high for large I. For $I = (\theta_0^2\eta\phi/k) - \beta$, both effects together imply the minimum level of w_H consistent with (5), (16) and (19). In addition to this, Fig. 2 also illustrates the following:

Proposition 2. *An increase in firing costs raises the skilled wage rate for* $I < I^{crit} \equiv (\theta_0^2\eta\phi/k) - \beta$ *and reduces it for* $I > I^{crit}$.

Proposition 2 simply follows from the fact that an increase in firing costs raises unambiguously the denominator of (20), thus this curve shifts to the left in Fig. 2 without affecting the curve for (21). As drawn, the initial steady-state innovation rate is below the critical value $I^{crit} = (\theta_0^2\eta\phi/k) - \beta$. To see whether this assumption is plausible, we assign the following benchmark simulation values to our parameters, taken from Dinopoulos and Segerstrom (1999, p. 467): a population growth rate of $n = 0.01$, a time preference rate $\rho = 0.03$ to get a 3-percent steady-state real interest rate $r = \rho$, a working life of $D = 40$

years[12], a duration of college education of $T = 4$ years[13] (implying $\sigma = 1.193$ and $\phi = 0.881$), and a 35-percent improvement in product quality through each innovation ($\lambda = 1.35$). As noted by Steger (2003, p. 4), average estimates about the monopolists' percentage markup over marginal costs $\lambda - 1$ lie in the interval $[0.1, 0.4]$, hence reasonable values for λ are in the range $[1.1, 1.4]$. In addition, we also follow Dinopoulos and Segerstrom (1999) by imposing a 2-percent steady-state utility growth rate[14] $\dot{z}/z = I \log \lambda = 0.02$, from which we get $I = 0.0666$. It remains to derive a parameter value for η/k and a value for θ_0. The latter is determined endogenously by (18) and (19). Even for a given $I = 0.0666$, this yields θ_0 as a function of $y, A, p(\nu^*)$ - all of which are unknown and not straightforward to derive - and of B which will be derived endogenously in Sect. 4 below. Therefore, we prefer to choose θ_0 from the data in order to derive a 'plausible' value for η/k.[15] The OECD (2003, Table A2.4) reports trends in educational attainment at the tertiary level from 1991 to 2001, which corresponds to $1 - \theta_0$ in our model. We take the most recent values from 2001 for the US, Germany and Italy, where the percentage of the population of 25 to 34-year-old males that have attained tertiary education equaled 36, 23 and 10, respectively. This implies that the threshold ability level for the US (Germany, Italy) is $\theta_0 = 0.64$ $(0.77, 0.90)$.[16] Given this, a value for

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[12] This yields a birth rate of $\beta = ne^{nD}/(e^{nD} - 1) \approx 0.03$. See Dinopoulos and Segerstrom (1999 p. 454) for a derivation.

[13] Hence, a "skilled worker" is defined as having taken four years of college, whereas unskilled workers only have a high-school degree.

[14] As is usual in quality-ladder growth models, this steady-state growth rate is found by noting that the expected number of innovations up to time t equals $\int_0^1 j(w, s) d\omega = \int_0^s I(t) dt$. Using this in the instantaneous utility function (2) and differentiating with respect to time gives the result.

[15] Hence, our procedure is explained by help of Fig. 1 as follows: first, we impose a fixed value for the innovation rate I that follows from the assumption of a two percent steady-state utility growth rate, depending on a particular value for λ. This means that we draw a vertical line for a specific I instead of the curve for (18). The intersection of this vertical line with the curve for (19) defines θ_0, but this depends on the value for η/k. Second, we impose a value for θ_0 as suggested by the data. Given I and θ_0, a "plausible" value for η/k follows from (19), which defines the position of this curve in Fig. 1. Note that our only purpose of assigning specific values to θ_0 from the data is to derive values for η/k. In Sect. 4 below, we will use a specific value for η/k and derive both I and θ_0 *endogenously.*

[16] From Table A2.4 in OECD (2003), we derive the following threshold ability levels of other major OECD countries for males in 2001: $\theta_0 = 0.54$ in Japan, $\theta_0 = 0.55$ in Canada, $\theta_0 = 0.66$ in Sweden, $\theta_0 = 0.68$ in France, $\theta_0 = 0.70$ in the UK, and $\theta_0 = 0.74$ in the Netherlands. In 1991, the lowest values for males available in the OECD dataset were $\theta_0 = 0.70$ for Canada and $\theta_0 = 0.71$ for the US.

Table 1. Robustness check for the comparison of I and I^{crit}

	I	η/k	I^{crit}	I^{max}
$\underline{\lambda = 1.4}$:	0.0594			
$\theta_0 = 0.64$		0.2285	**0.0521**	0.1007
$\theta_0 = 0.77$		0.3314	0.1428	0.1460
$\theta_0 = 0.90$		0.7101	0.4765	0.3128
$\theta_0^{crit} = 0.6559$		0.2368	0.0594	0.1043
$\underline{\lambda = 1.35}$:	0.0666			
$\theta_0 = 0.64$		0.2562	**0.0621**	0.1129
$\theta_0 = 0.77$		0.3716	0.1638	0.1637
$\theta_0 = 0.90$		0.7962	0.5379	0.3508
$\theta_0^{crit} = 0.6490$		0.2614	0.0666	0.1152
$\underline{\lambda = 1.3}$:	0.0762			
$\theta_0 = 0.64$		0.2931	**0.0754**	0.1291
$\theta_0 = 0.77$		0.4251	0.1917	0.1873
$\theta_0 = 0.90$		0.9107	0.6196	0.4012
$\theta_0^{crit} = 0.6414$		0.2940	0.0762	0.1295
$\underline{\lambda = 1.25}$:	0.0896			
$\theta_0 = 0.64$		0.3446	0.0940	0.1518
$\theta_0 = 0.77$		0.4998	0.2307	0.2202
$\theta_0 = 0.90$		1.0708	0.7339	0.4717
$\theta_0^{crit} = 0.6332$		0.3396	0.0896	0.1496
$\underline{\lambda = 1.2}$:	0.1097			
$\theta_0 = 0.64$		0.4218	0.1219	0.1858
$\theta_0 = 0.77$		0.6117	0.2892	0.2695
$\theta_0 = 0.90$		1.3106	0.9050	0.5774
$\theta_0^{crit} = 0.6242$		0.4080	0.1097	0.1797
$\underline{\lambda = 1.15}$:	0.1431			
$\theta_0 = 0.64$		0.5502	0.1682	0.2424
$\theta_0 = 0.77$		0.7979	0.3865	0.3515
$\theta_0 = 0.90$		1.7096	1.1898	0.7531
$\theta_0^{crit} = 0.6143$		0.5217	0.1431	0.2298
$\underline{\lambda = 1.10}$:	0.2098			
$\theta_0 = 0.64$		0.8068	0.2608	0.3554
$\theta_0 = 0.77$		1.1701	0.5809	0.5154
$\theta_0 = 0.90$		2.5070	1.7588	1.1044
$\theta_0^{crit} = 0.6033$		0.7489	0.2098	0.3299

η/k follows for given I from (7) and (8): $I = \eta(1-\theta_0^2)\phi/(2k)$. Table 1 above provides a robustness check for the comparison of I and I^{crit}.[17]

[17] Note from Fig. 1 that the maximum feasible innovation rate consistent with an interior steady-state equilibrium is below $I^{max} = \eta\phi/(2k)$. In Table 1, $I^{crit} > I^{max}$ holds in the case of Italy ($\theta_0 = 0.90$) for the whole range $\lambda \in [1.1, 1.4]$, and in the case of Germany ($\theta_0 = 0.77$) for all λ except $\lambda = 1.4$.

Table 1 indicates for each λ the critical threshold ability level θ_0^{crit} for which $I = I^{crit}$ holds. The table shows that our implicit assumption $I < I^{crit}$ in Fig. 2 does (not) hold in the case of the US for low (high) values of λ (the bold numbers indicate a violation of this condition; for $\lambda = 1.2912,\ I = I^{crit}$ holds for given $\theta_0 = 0.64$). For the cases of Germany ($\theta_0 = 0.77$) or Italy ($\theta_0 = 0.90$), the condition $I < I^{crit}$ is fulfilled over the whole range $\lambda \in [1.1, 1.4]$. Thus, in countries with a relatively high proportion of people who have attained tertiary education (e.g. Japan, Canada), an increase in firing costs reduces the skilled wage rate, i.e., the *skilled labor demand effect* dominates the *education equilibrium effect*. This implies that the skilled wage rate and the innovation rate move in the same direction after a change in firing costs. In countries with a relatively low proportion of people who have attained tertiary education (e.g. France, UK, Germany), the skilled wage rate and the innovation rate move in opposite direction after a change in firing costs.

In all cases, after an increase in firing costs, the declining innovation rate implies a decrease in the unskilled unemployment rate because of slower labor market turnover (see (16)), which ceteris paribus induces fewer individuals than before to invest in education since the expected unskilled wage income increases. In the case of $I < I^{crit}(I > I^{crit})$, the rise (decline) in the skilled wage rate works in the opposite (same) direction. In any case, the net effect on θ_0 is positive as depicted in Fig. 1. However, the net effect on the *aggregate* unemployment rate $u_a = \theta_0 u$ in principle is ambiguous.[18] Finally, the decline in unskilled unemployment and the rise in the proportion of unskilled workers both increase effective unskilled labor supply, which increases goods production and thus consumption quantity $q = c/\lambda$, see (6).

4 Preferences Regarding Firing Costs

In this Section we derive the preferences regarding firing costs of skilled and unskilled workers in a once-and-for-all vote on $B = F/N$, while taking into account that with forward-looking agents, all individuals decide concurrently about their education and their vote on B. This requires three steps of procedure: First, we consider the education decision of a household by comparing the two corresponding discounted lifetime

[18] Using (19) and (16), with I as given in (18) and $dI/dB < 0$ from Proposition 1, it is straightforward to derive the following condition for a rise in firing costs to *reduce* the aggregate unemployment rate: $I < \frac{1}{2-u}[\frac{\eta\phi}{k}(1-u) - \beta u]$. Given our benchmark values (implying $I = 0.0666$) and the intermediate case of Germany with $\eta/k = 0.3716$ (derived from setting $\theta_0 = 0.77$), this condition is fulfilled for unskilled unemployment rates up to $u < 0.6676$.

utility streams. This comparison reveals that all households with ability $\theta^i < \theta_0(I)$ ($\theta^i > \theta_0(I)$) prefer to stay unskilled (to become skilled). Second, we maximize separately the discounted (expected) lifetime utility of a skilled and an unskilled household with respect to B under the assumption of a given skill choice. Third, we show that those households who lose the ballot under majority voting (i.e., the skilled) can do no better than staying with their educational decision, even if they perfectly foresee that they would lose the ballot. The level of per-capita firing costs demanded by the majority of unskilled households will be implemented, which results unambiguously in a particular "desired" innovation rate. Depending on this innovation rate, the threshold ability level $\theta_0(I)$ adjusts according to (19).

We will restrict the analysis to a steady-state welfare comparison. This somewhat limits the scope of our analysis, because when assuming a particular starting value B_0 of per-capita firing costs, the welfare comparison should take the transitional period into account.[19] At the end of this section we argue that the implied imprecision is unlikely to change our results qualitatively. Since all individual members of a given household are identical, maximizing discounted lifetime utility of a representative household member is the same as maximizing it for the whole household. Since finitely living household members behave like a dynastic family, this maximization is done over an infinite horizon. Therefore, the particular age of the (unskilled) median voter does not matter. Due to the assumption of perfect unemployment insurance, the employment status of an unskilled voter also does not matter.

Let us consider first the voting problem of a household in case its members decide to stay unskilled under a given level of firing costs that results from majority voting. Inserting instantaneous utility (2)

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[19] Since the transitional dynamics are analytically intractable in this kind of model, *one* way is to rely on numerical simulations similar to, e.g., Joseph and Weitzenblum (2003). In a model of unemployment, moral hazard and precautionary savings, they simulate the transitional welfare effects of a cut of the replacement rate, financed by a tax and paid to unemployed workers. Such an analysis is beyond the scope of our paper. *Another* way out is to focus on "stationary political equilibria" as suggested by Saint-Paul (2002, pp. 687-88). This type of equilibrium has two properties: first, we start in a (unique) steady-state equilibrium for a given level of per-capita firing costs B. Second, this initial level of per-capita firing costs equals the majority-winning level, which in our case will be the level preferred by all individuals who choose to stay unskilled under these firing costs. Starting from there, a once-and-for-all vote on the level of B would affirm the current equilibrium. Saint-Paul considers this

> "[...] as the limit steady state of a repeated voting equilibrium as the frequency of voting goes to zero" (ibid, p. 687).

In Sect. 6.4 we will argue that in our particular case, the frequency of voting is irrelevant for the steady-state level of firing costs that we obtain.

into total discounted utility (1), and using $p = \lambda$ and $\int_0^1 j(w,s)d\omega = \int_0^s I(t)dt$ yields

$$Z(\theta^i < \theta_0) = [1/(\rho - n)][\log(1-u) - \log\lambda + I\log\lambda/(\rho - n)] \quad (22)$$

as discounted lifetime utility of an unskilled household with ability $\theta^i < \theta_0$ for all of its members. Since workers do not own firms, the expected consumption expenditure per period of this household is simply $(1-u)w_L = 1-u$. Using this and (16) in (22) gives:

$$Z(\theta^i < \theta_0) = \frac{1}{\rho - n}\left\{\log\left[\frac{Ap(\nu^*)}{\beta + I(B)}\right] - \log\lambda + \frac{I(B)\log\lambda}{\rho - n}\right\}. \quad (23)$$

Differentiating (23) with respect to B yields the f.o.c.

$$\frac{dZ(\theta^i < \theta_0)}{dB} = \frac{1}{\rho - n}\left\{\frac{\beta + I(B)}{Ap(\nu^*)}\left[-\frac{Ap(\nu^*)dI/dB}{[\beta + I(B)]^2}\right] + \frac{dI}{dB}\frac{\log\lambda}{\rho - n}\right\} = 0,$$

from which we derive the aggregate innovation rate desired by all unskilled workers:

$$\hat{I}(\theta^i < \theta_0) = [(\rho - n)/\log\lambda] - \beta. \quad (24)$$

This is the innovation rate that optimally balances the unskilled workers' conflicting interests in rising consumption quantity versus rising growth of consumer goods quality. Any slightly faster rate of technical progress would result in a net utility loss because the marginal utility gain of faster quality growth (increase in the third term in curly brackets in (23)) would be more than offset by the marginal utility loss of lower consumption quantity (decrease in the first term in curly brackets in (23)). The argument for the case of a slightly lower rate of technical change is analogous. Using our benchmark parameter values, (24) implies $\hat{I}(\theta^i < \theta_0) = 0.0363$ which is well below the innovation rate used above $I = 0.0666$ to generate a 2-percent steady-state utility growth rate. Inserting (24) into (18) and (19) allows us to solve the model for the unique per-capita firing costs preferred by all unskilled workers:

$$\hat{B}(\theta^i < \theta_0) = Ap(\nu^*)\left\{\frac{\rho - n}{\log\lambda}\eta\theta_0[\hat{I}(\theta^i < \theta_0)]\left(\frac{\rho - n}{\log\lambda} - \beta\right)\right\}^{-1}$$
$$\{\eta(\lambda - 1)\theta_0[\hat{I}(\theta^i < \theta_0)]^2 - \sigma k e^{\rho y}[(\rho - n)(1 + 1/\log\lambda) - \beta]\}, \quad (25)$$

where $\theta_0[\hat{I}(\theta^i < \theta_0)]$ denotes the threshold ability level that results after inserting (24) in (19).[20] If $\theta_0 > 0.5$ holds, (25) would also give the

[20] For our benchmark parameter values and $\eta/k = 0.3716$ from the intermediate case of Germany, we derive $\theta_0[\hat{I}(\theta^i < \theta_0)] = 0.8821$. Then (25) implies

level of per-capita firing costs preferred by the majority of all workers.[21] Given equal participation rates of skilled and unskilled workers in a vote on B, the median voter will be unskilled, hence (25) will be realized. In Sect. 5.1 we will exploit the fact that $\hat{B}(\theta^i < \theta_0)$ is rising in the matching efficiency parameter A to analyze effects of a change in the exogenous (A) on the endogenous (B) component of labor market flexibility.

Let us now consider the voting problem of a household in case its members decide to become skilled under a given level of firing costs that results from majority voting. The discounted lifetime utility of a skilled household with ability $\theta^i \geq \theta_0$ of all its members is

$$Z(\theta^i \geq \theta_0) = [1/(\rho - n)][\log(\theta^i w_H) - \log \lambda + I \log \lambda/(\rho - n)]. \quad (26)$$

The expected consumption expenditure per period of this household is simply $\theta^i w_H$. Using this and (21) for the skilled wage rate in (26) gives

$$Z(\theta^i \geq \theta_0) = \frac{1}{\rho - n}\left\{\log\left[\frac{\theta^i A p(\nu^*)}{[\beta + I(B)]\sqrt{1 - 2kI(B)/(\eta\phi)}}\right] - \log \lambda + \frac{I(B)\log\lambda}{\rho - n}\right\}. \quad (27)$$

The comparison of (27) and (23) immediately reveals that only those households with ability $\theta^i > \theta_0(I)$ have the incentive to invest in education in order to realize $Z(\theta^i \geq \theta_0) > Z(\theta^i < \theta_0)$, where $\theta_0(I)$ is given by (19), with $I = \hat{I}(\theta^i < \theta_0)$ under majority voting for given

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a positive value of firing costs (and $\partial\hat{B}(\theta^i < \theta_0)/\partial A > 0$ which will be used later) for a matching time up to $y \leq 13.4$ years. Finally, in order to check whether the inequality (11) is fulfilled, we have to assign additional specific parameter values for $y, p(\nu^*)$ and A. A value for $p(\nu^*)$ is imposed by assigning an empirically 'plausible' value for the unskilled unemployment rate in (16). According to Reinberg and Hummel (2003, Table 1b), the average unemployment rate among West German males aged 15-64 with no finished vocational education has been 20.1% within the period 1987 to 2002. Given $\hat{I}(\theta^i < \theta_0) = 0.0363$ and imposing an unskilled unemployment rate $u = 0.2$ and $A = 1$, (16) yields $p(\nu^*) = 0.0533$. Using this and a matching time as low as $y = 0.1$ (note that $\hat{B}(\theta^i < \theta_0)$ is decreasing in y for all $\lambda \in [1.1, 1.4]$), we verify by using (6) that $\hat{B}(\theta^i < \theta_0)\hat{I}(\theta^i < \theta_0) \approx 0.0825 < c(\lambda - 1)/\lambda = (\lambda - 1)(1 - u)\theta_0 \approx 0.2467$.

[21] Since θ_0 is endogenous, we need to state the assumption $\theta_0 > 0.5$ in terms of the exogenous parameters. Inserting (24) into (19), this assumption is equivalent to $\frac{3}{8} > \frac{[(\rho-n)/\log\lambda]-\beta}{(\eta/k)\phi}$. For the whole range of parameter values for λ and η/k that is covered by Table 1, this assumption is clearly satisfied (given our benchmark parameter values for ρ, n, β and ϕ). Moreover, the empirical evidence given in OECD (2003, Table A2.4) suggests threshold ability levels between $\theta_0 = 0.54$ (Japan) and 0.90 (Italy) for males in 2001.

$\theta_0 > 0.5$. Actually, this means that the minority of skilled workers has to take $\hat{I}(\theta^i < \theta_0)$ and thus $\theta_0[\hat{I}(\theta^i < \theta_0)]$ as given. Finally, even when $I = \hat{I}(\theta^i < \theta_0)$ is perfectly foreseen by all skilled households, they still prefer to become skilled and lose the vote on B rather than working as unskilled and joining the winning majority. Differentiation of (27) with respect to B yields the f.o.c.

$$\frac{dZ(\theta^i \geq \theta_0)}{dB} = \frac{1}{\rho - n}\left[\frac{\frac{(\beta+I)k}{\theta_0 \eta \phi} - \theta_0}{(\beta + I)\theta_0}\frac{dI}{dB} + \frac{dI}{dB}\frac{\log \lambda}{\rho - n}\right] = 0, \qquad (28)$$

where (19) and (21) have been used. We see that the individual characteristic θ^i cancels out, hence all skilled workers have identical preferences with regard to B. An optimum satisfying this f.o.c. only exists if the first term in square brackets is negative (since $dI/dB < 0$), which is fulfilled if and only if $I < I^{crit}$ holds. From (28) we can derive the aggregate innovation rate desired by all skilled workers in implicit form:[22]

$$\hat{I}(\theta^i \geq \theta_0) = \frac{(\rho - n)(\eta\phi - 2kI)}{(\log \lambda)(\eta\phi - 2kI) + (\rho - n)k} - \beta \qquad (29)$$

with $I < \eta\phi/(2k)$ from Fig. 1. Comparison of (29) with (24) gives our first main result:

Proposition 3. *For $I < I^{crit}$, skilled workers (i.e., those individuals who decide to become skilled after a majority decision on the level of firing costs is reached), although not threatened by unemployment risk,* **(i)** *prefer unambiguously a lower steady-state innovation rate, and* **(ii)** *vote for a higher level of firing costs than unskilled workers.*
For $I \geq I^{crit}$, skilled workers vote for zero firing costs.

Given part (i) of Proposition 3, part (ii) follows immediately from $dI/dB < 0$ as stated in Proposition 1. The intuitive reasoning for the surprising finding in part (i) of Proposition 3 is as follows. By voting on the level of firing costs, both worker groups face a trade-off between rising consumption quantity and a slower growth rate of consumer goods quality. On the one hand, larger firing costs reduce the aggregate innovation rate - the growth rate of the quality of consumer goods slows down, which reduces the discounted lifetime utility of both worker groups by the same amount (third term in (23) and (27)). On

[22] Using the benchmark parameters with the intermediate case of Germany ($\eta/k = 0.3716$), (29) can be transformed into the quadratic equation $I^2 - 0.233337I + 0.004934 = 0$. This has two solutions: the larger one $\hat{I}(\theta^i \geq \theta_0) = 0.2098 > I^{max} = 0.1637$ is not feasible, whereas the smaller one $\hat{I}(\theta^i \geq \theta_0) = 0.0235 < \hat{I}(\theta^i < \theta_0) = 0.0363 < I^{max}$ is feasible.

the other hand, larger firing costs increase labor input in goods production by reducing the unskilled unemployment rate u and increasing the proportion θ_0 of unskilled workers available. Each unskilled worker individually benefits from the decline in u through the increase in expected wage income $w_L(1-u)$ for the given wage rate $w_L \equiv 1$. This effect also benefits skilled workers: a lower unskilled unemployment rate implies higher per-capita consumption expenditure c and thus a larger market for the output of the current quality leader, which raises the reward for innovating ϑ and thus w_H. However, as argued when discussing Fig. 2, an increase in firing costs triggers an *education equilibrium effect* and a *skilled labor demand effect*, and the former dominates the latter if and only if $I < I^{crit}$ holds. Thus, demand for skilled workers declines due to the lower innovation rate, but this is more than offset by the required increase in w_H in order to make the individual with ability $\theta^i = \theta_0$ (with θ_0 now being higher than before) indifferent with respect to his educational choice. Hence, skilled workers benefit from an *additional* gain through stricter employment protection relative to the unskilled. For $I > I^{crit}$, however, both terms in the square brackets in (28) are negative, hence no interior solution exists. Since in this case a decrease in firing costs raises both the growth rate of the quality of consumer goods and the skilled wage rate, skilled workers would vote for zero firing costs (corner solution).

Since skilled workers are still in the minority, the importance of Proposition 3 is not that it explains the observed cross-country variation in firing costs, depending on the proportion of skilled workers in each country.[23] However, the result may nevertheless be relevant in the following sense: as long as $I < I^{crit}$ holds, it offers an argument for why we *should not expect* that the massive increase in the percentage of skilled workers that has been observed in most OECD countries over the last decades, induces political pressure to reduce employment protection levels for less-skilled workers. However, continuous skill upgrading reduces I^{crit} (as shown in Table 1 above), and once $I \geq I^{crit}$ holds, the (relatively large) proportion of skilled workers would vote or lobby for zero firing costs.

At the beginning of this section we argued that in principle, a complete welfare comparison should take into account the transitional period. However, at least when starting from $B_0 < \hat{B}(\theta^i < \theta_0)$, we are confident that taking account for transitional effects would not change our results qualitatively for three reasons. First, a rise in per-capita fir-

[23] This conclusion may not hold anymore when considering the different rates of influence held by skilled and unskilled workers in the political process. For instance, voter turnout is usually found to increase with income and, in particular, with education (Wolfinger and Rosenstone, 1980). Moreover, costly lobbying (campaign contributions) may rise with income which is positively related to skills.

ing costs (e.g., from B_0 to the level preferred by the unskilled workers) implies an increase in θ_0 (see Fig. 1). Since *fewer* individuals decide to become educated, the education period of length T does not matter for the transition in this case. The required drop in the proportion of skilled workers H/L is achieved by the death of skilled workers, by the birth of unskilled workers who enter immediately the labor market, and by the immediate drop in the innovation rate, which results in declining unskilled unemployment. Second, the immediate decline in the unskilled unemployed rate raises production and consumption quantity of both skilled and unskilled workers. This positive welfare effect dominates in the short run, whereas the negative welfare effect (lower quality growth) arises mainly in the long run. Hence, in this case we do not face the problem that a negative short-run welfare effect more than outweighs possible long-run welfare gains. In the opposite case of $B_0 > \hat{B}(\theta^i < \theta_0)$, this problem arises and could prevent the majority of workers from voting in favor of a reform proposal aimed at reducing firing costs, similar to the failure of the proposal to cut the replacement rate in the model of Joseph and Weitzenblum (2003) that we mentioned earlier. Third, the short-run effect on consumption quantities works in the same direction for skilled and unskilled workers. Hence, there is no reason to believe that due to transitional effects, our result in Proposition 3 should not continue to hold.

5 Determinants of the Level of Firing Costs

5.1 Interactions between Different Types of Labor Market Rigidities

When discussing possible reasons for the persistently higher unemployment rates in many European countries compared to the US, Siebert (1997) stressed the importance of taking account of interactions between different types of labor market rigidities, instead of performing a ceteris-paribus analysis for each friction only:

> "Looking at single institutional characteristics one at a time is never very promising, because the effect of a single institutional arrangement can only be understood in its interaction with other institutional rules. [...] Consequently, the cumulative effect of rules is relevant determining their total impact." (ibid, p. 39).

We therefore analyze the effects of a more efficient matching technology from the viewpoint of both employers and employees, modeled as an increase in the exogenous matching productivity parameter A, on the steady-state equilibrium before and after a response of $\hat{B}(\theta^i < \theta_0)$, respectively. As is obvious from (17a), for given ν^* an increase in A implies the simultaneous reduction of the matching time y.

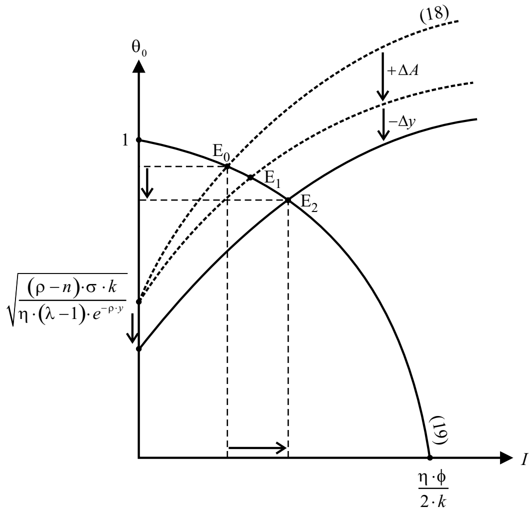

Fig. 3. Steady-state effects of more efficient matching for fixed B in (θ_0, I)-space.

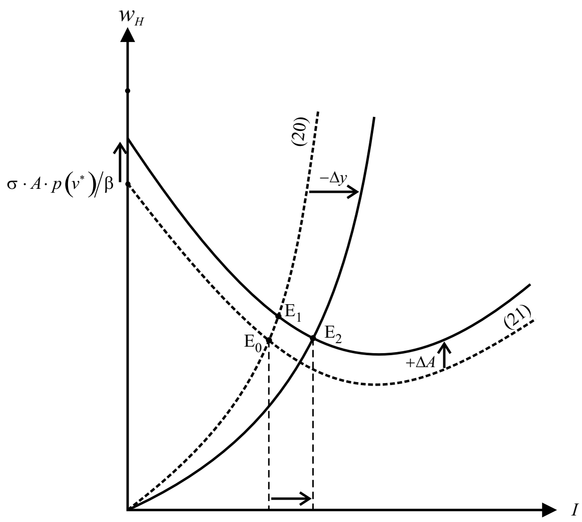

Fig. 4. Steady-state effects of more efficient matching for fixed B in (w_H, I)-space

As shown in Fig. 3 (page 101), for a given level of per-capita firing costs B, an increase in A first rotates the curve for (18) clockwise downward. Formally, this follows immediately from (18) when dividing both nominator and denominator by A. Then the resulting decrease in y shifts the entire curve for (18) further downward, including the ordinate intercept (proof for $dI/dy < 0$ is given in Appendix C). The innovation rate increases unambiguously, which implies a decline in θ_0, since more skilled workers are needed for R&D.

The initial positive impact of a rise in A on the innovation rate comes from the reduction in unskilled unemployment, thus u determined in (16) decreases for a given level of I. Lower unemployment implies higher output and thus a larger market for innovating firms. More efficient matching leads to a decrease in the matching time y. This also affects positively the innovation rate because it implies a smaller discount rate on the innovators' future monopoly profits (production can start earlier) at any given value of the reward for innovating ϑ. The net effect on unskilled unemployment is ambiguous since the increase in the innovation rate tends to raise u.

The points $\{E_0, E_1, E_2\}$ in Fig. 4 (page 101) correspond to those in Fig. 3. Initially, the skilled wage rate increases with rising A due to the drop in unskilled unemployment that raises the profitability of doing R&D (move from E_0 to E_1). The resulting decrease in matching time y triggers an *education equilibrium effect* and a *skilled labor demand effect*, and the former dominates the latter for $I < I^{crit}$. Thus, demand for skilled workers rises due to the larger innovation rate, but this positive effect on w_H is more than offset by the required decrease in w_H in order to make the individual with ability $\theta^i = \theta_0$ (with θ_0 now being lower than before) indifferent with respect to his educational choice. The required decrease in w_H comes from the fact that an increase in I raises u which reduces $w_L(1-u)$. Hence, a lower w_H is needed to induce all individuals with $\theta^i > \theta_0$ to become educated (move from E_1 to E_2 in Fig. 4). The net effect on w_H is ambiguous for $I < I^{crit}$, and unambiguously positive for $I > I^{crit}$.

Since the matching time is reduced, the increase in A can be interpreted as an increase in labor market flexibility. This raises unambiguously the level of firing costs preferred by the unskilled workers who form the majority. Formally, $\partial\hat{B}(\theta^i < \theta_0)/\partial A > 0$ follows from (25) whenever $\hat{B}(\theta^i < \theta_0) > 0$ holds. This could be illustrated by help of Fig. 3 as follows: suppose that $I = \hat{I}(\theta^i < \theta_0)$ holds at the initial steady-state equilibrium E_0. After the (unexpected) change in A and y, unskilled workers (i.e., those who decide not to invest in education under the new B) vote for a new value for $\hat{B}(\theta^i < \theta_0)$ such that the curve for (18) rotates counterclockwise around its ordinate intercept until $I = \hat{I}(\theta^i < \theta_0)$ is reestablished at E_0 again. Hence our second main result follows:

Proposition 4. *An exogenous increase in labor market flexibility, ceteris paribus accelerating innovation and economic growth, increases the political support for larger firing costs of unskilled workers (i.e., of those individuals who decide not to become skilled after a majority decision on the level of firing costs is reached for the given new value of A), thereby reducing innovation and growth again.*

Hence, a more flexible labor market with more efficient matching has two effects: first, it induces an increase in the aggregate innovation and growth rate for a given level of firing costs. Second, it increases the level of per-capita firing costs preferred by the majority-winning unskilled workers, which in turn reduces the steady-state innovation and growth rate.[24] The intuition for this result is as follows: for the optimal decision on B, the net effect of an increase in matching efficiency A on the unskilled workers' unemployment rate (which is ambiguous for given B) does not matter. The welfare-maximizing choice of per-capita firing costs B results in the *unique* desired innovation rate (24) that is independent of A and y - the marginal effects of a change in B on the lifetime utility derived from consumption quantity and quality growth do not change. Since the increase in A raises the steady-state innovation rate, optimal behavior of the unskilled (as of the skilled) workers is to restore the welfare-maximizing path of I, which requires that firing costs increase accordingly. A positive effect on the level of discounted lifetime utility of all workers will remain after $I = \hat{I}(\theta^i < \theta_0)$ is restored again. This is because it remains the increase in A in the first term in curly brackets of (23) and (27), respectively, and with fixed $I = \hat{I}(\theta^i < \theta_0)$, an increase in A reduces u unambiguously.

Hence, given that the economy starts at $I = \hat{I}(\theta^i < \theta_0)$, an increase in matching efficiency would not change the steady-state innovation and growth rate at all if a once-and-for-all vote on the level of B took place thereafter. In Sect. 6.4 we will argue that $I = \hat{I}(\theta^i < \theta_0)$ is preserved even with repeated voting.

The result presented in this section serves as an example for the interaction of labor market frictions as stressed by Siebert (1997) cited above. Here, one rigidity of the labor market is the non-instantaneous matching of unemployed workers with producing firms as defined by

[24] Suppose that $I < I^{crit}$ holds. Then, skilled workers (i.e., those individuals who would still decide to become skilled under the new $\hat{B}(\theta^i < \theta_0)$) vote for a level of firing costs that exceeds the one preferred by the unskilled by a constant 'markup' as is obvious from comparing (29) and (24). Hence they also increase their demand for firing costs after a rise in A. The intuition is similar to that given for the unskilled workers.

the matching function $Am(V, L)$. More efficient matching works toward an alleviation of this rigidity. However, this intensifies a second labor market rigidity, namely the level of requested firing costs: alleviating one (exogenous) rigidity aggravates the other (endogenous) one.

5.2 The Trade-off between Growth and Employment Protection

In his vintage model of exogenous growth, Saint-Paul (2002) finds that the workers' gains from employment protection are smaller the higher the growth rate, i.e., the faster the rate of creative destruction.[25] The reasoning for his finding is as follows. Employment protection keeps a certain fraction of the workforce in vintages with productivity below that of the most recent vintage, because in his model, firms determine endogenously the optimal exit date which is postponed by larger firing costs.[26] Faster growth enlarges the productivity gap between old and new vintages, whereas the opportunity costs of working (that is, the value of being unemployed) are increasing at the current growth rate. Hence, the value of keeping the current employment (and reaping the rent that arises by assumption of match-specific human capital) deteriorates faster with higher economic growth, which reduces support for employment protection by the decisive median voter.

Since the growth rate is endogenous in our model, the comparative static exercise is less straightforward than in Saint-Paul's model. However, to analyze workers' attitudes toward employment protection in a

[25] This may be viewed as a contrast to his own empirical findings (Saint-Paul, 1996, pp. 283-86). There, he finds the empirical regularity present in EU countries that, since the 1960s, governments reduced (increased) firing costs at times of low (high) growth. Given that the government did follow the workers' demand for employment protection, two explanations for this apparent contradiction seem plausible. Either the sign of the (theoretical) correlation between growth and requested firing costs should be positive as is found in Saint-Paul's data, or his empirical findings reflect only short-sighted motivation of workers when voting on firing costs. Our model takes a long-run perspective.

[26] More precisely, the optimal exit date is determined by equalizing the marginal loss per unit of time (wage minus productivity) to the annuity equivalent of the firing costs. Thus, in Saint-Paul's model, production takes place with several technologies simultaneously, and technical progress improves the efficiency of the production process without affecting the quality of consumer goods. Therefore, the consumption side of the economy can be (and actually is) neglected in his framework. In our model, by contrast (that explains 'creative destruction' *endogenously*), technical progress involves product innovations that result in rising consumer goods quality over time. Since we assume limit pricing behavior of the quality leader, and consumers only buy goods with the lowest quality-adjusted price, consumer goods of different quality levels do not coexist in our framework. Hence, rising firing costs do not extend the lifetime of *old* firms but only the expected incumbency period $1/I$ of the *current* quality leader.

faster growing economy, we can look at the effects of changes to the exogenous parameters closely related to growth, namely a rise in the size of innovations λ and a rise in the R&D productivity parameter η. The marginal effect of a larger size of innovations on the steady-state utility growth rate $\dot{z}/z = I \log \lambda$ is positive for fixed B:

$$\begin{aligned}\frac{\partial(\dot{z}/z)}{\partial\lambda} &= \frac{\partial I_1}{\partial\lambda}(\log\lambda) + \frac{I_1}{\lambda} \\ &= \frac{1}{2}\left[\left(\frac{P}{2}\right)^2 - Q\right]^{-1/2}\frac{Ap(\nu^*)}{B}\theta_0(\log\lambda) + \frac{I_1}{\lambda} > 0, \qquad (30)\end{aligned}$$

where

$$I_1 \equiv -P/2 + \sqrt{((P/2)^2 - Q)} > 0$$

with $P > 0$ and $Q < 0$ as defined in Appendix B. Due to $\frac{\partial I_1}{\partial\lambda} > 0$, an increase in λ shifts the curve for (18) downward in Fig. 1 without affecting the curve for (19). Hence, for given B, a larger size of innovations speeds up innovation and growth. However, differentiation of (25) shows that $\partial\hat{B}(\theta^i < \theta_0)/\partial\lambda > 0$ holds.[27] Therefore, the results of an increase in λ are similar to that of an increase in the matching efficiency (Proposition 4). The only difference in this case is that the growth rate desired by unskilled workers (i.e., by those individuals who do not invest in education under the new $\hat{B}(\theta^i < \theta_0)$) is affected: $\partial\hat{I}(\theta^i < \theta_0)/\partial\lambda = -(\rho - n)/[(\log\lambda)^2\lambda] < 0$. If each innovation raises product quality to a larger extent, workers would adjust their vote on firing costs as to reduce the desired expected frequency of innovations. This is easily understood by looking at (23): on the one hand, a larger size of innovations raises the marginal utility gain of a slightly increasing innovation rate in terms of higher quality growth (third term in curly brackets of (23)). On the other hand, the marginal utility loss of a rise in I in terms of declining consumption quantity is unaffected (first term in curly brackets of (23)). Therefore, equality between marginal gains and losses is reached through a lower "desired" innovation rate, which requires to vote for a higher B.[28] Hence the steady-state utility growth rate $\dot{z}/z = I \log \lambda$ with voting on firing costs declines:

$$\frac{\partial(\dot{z}/z)}{\partial\lambda}\Big|_{I=\hat{I}(\theta<\theta_0)} = \frac{\partial(\rho - n - \beta\log\lambda)}{\partial\lambda} = -\frac{\beta}{\lambda} < 0, \qquad (31)$$

[27] Whereas the nominator of (25) increases unambiguously with rising λ, a *sufficient* condition for that the denominator of (25) declines with rising λ is $1 \geq [k/(\eta\phi)]\{3[(\rho - n)/\log\lambda] - 2\beta\}$. For our benchmark parameter values, the RHS of this inequality takes a value of 0.4254. Moreover, this inequality is satisfied for *any* possible values for λ and η/k considered in Table 1.

[28] By the second term in curly brackets of (23), consumption quantity is reduced due to higher markup pricing. This, however, does not affect the optimal decision about B.

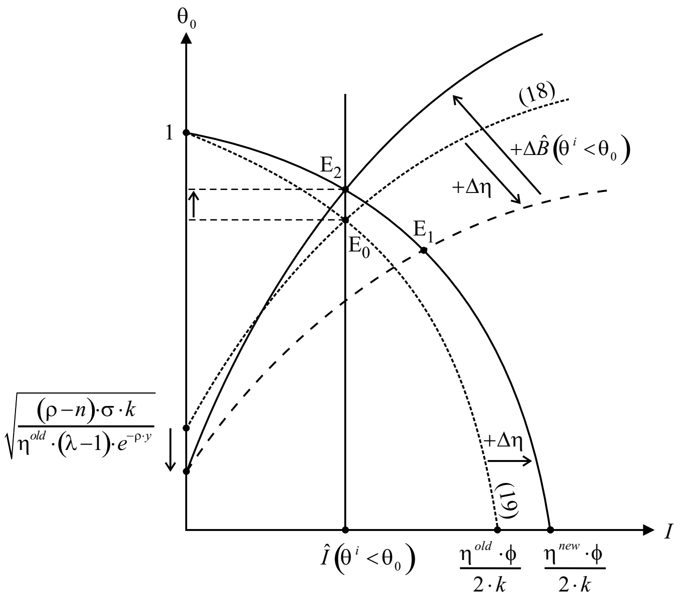

Fig. 5. Steady-state effects of rising *R&D* productivity with voting response.

and $\theta_0[\hat{I}(\theta^i < \theta_0)]$ increases according to (19).

We now discuss the effects of an increase in R&D productivity η. Fig. 5 (above) illustrates what happens in this case, both before and after unskilled workers (i.e., those who still remain unskilled after a vote on B for the new value of η) react by adjusting their desired level of firing costs.

The economy starts in the steady-state equilibrium E_0 at which the resulting aggregate innovation rate happens to equal the innovation rate desired by unskilled workers (the majority), $I = \hat{I}(\theta^i < \theta_0)$. A positive R&D-technology shock $+\Delta\eta$ (which was unexpected in the previous vote on B) shifts both the skilled labor full employment curve (19) and the R&D equilibrium curve (18) to the right, with the ordinate (abscissa) intercept of the latter (former) declining (rising). Without voting on firing costs thereafter, the steady-state equilibrium would shift from E_0 to E_1 where the innovation rate has risen unambiguously, whereas the net effect on the threshold ability level is ambiguous. The curve for (19) shifts outward since with a higher R&D productivity, any positive given amount $(1-\theta_0^2)\phi N/2$ of skilled workers can produce more R&D output than before (formally, θ_0 rises for any given $I > 0$ in (19)). The downward shift of (18) is explained by the fact that expected

R&D benefits increase for given skilled labor input (these additional benefits will be transferred to a higher skilled wage rate because of free entry in the R&D race).[29] However, since the welfare-maximizing innovation rate given in (24) is unaffected, unskilled workers (i.e., those individuals who decide not to invest in education under a vote on B for the given new η) raise their demand for employment protection in order to restore this level.[30] Hence with voting on B, the curve for (18) rotates counterclockwise around its ordinate intercept like in Fig. 1, and the steady-state equilibrium moves from E_1 to E_2. Relative to the old steady state at E_0, the proportion of unskilled workers has risen because fewer skilled workers than before are needed to produce the same aggregate innovation rate $\hat{I}(\theta^i < \theta_0)$. Hence, in our different framework, Saint-Paul's (2002, p. 699) conclusion that

> "[...] periods of high growth may be a more appropriate time for increasing labor market flexibility [...]"

no longer holds. Instead, we state our third main result:

Proposition 5. *Given $I < I^{crit}(I > I^{crit})$, an exogenous positive growth shock – taking the form of a larger size of innovations λ or a higher R&D productivity η – increases political support of all workers (of the individuals who decide to stay unskilled under the new B) for larger firing costs, and raises the proportion of unskilled workers in the new steady-state. In the case of a larger λ, the new desired innovation rate $\hat{I}(\theta^i < \theta_0)$ is lower than before, whereas this rate does not change in the case of a larger η.*

The results of this section could also be viewed as a caveat to the findings of Arnold (2002). He shows that in a North-South model of intraindustry trade with innovation and endogenous growth in the North and (exogenous) imitation by the South, the growth effects of increased Southern imitation depend on Northern labor market flexibility. The latter is modeled by an exogenous parameter denoting the outflow rate from unemployment which equals our job-finding rate $p(\nu)$. In the case of high (low) labor market flexibility (i.e., large (low) $p(\nu)$), increased Southern imitation stimulates (impedes) Northern economic growth. That is, alleviating the (only) labor market distortion in his model tends to support growth-enhancing effects of a change to another exogenous parameter, in that case a rise in the Southern imitation

[29] The formal proof is similar to Appendix A. Applying the implicit function theorem to (18) shows that $dI/d\eta > 0$ if and only if condition (11) is fulfilled, which holds necessarily for any positive R&D investment. Therefore, the R&D equilibrium curve shifts downward at any given level of θ_0.

[30] Formally, $\partial \hat{B}(\theta^i < \theta_0)/\partial \eta > 0$ holds not only for our benchmark parameter values but for the whole range of all possible parameter values that result in an interior steady-state solution with $\theta_0 \in]0,1[$ and $\hat{B}(\theta^i < \theta_0) > 0$.

rate.[31] In our model, by contrast, alleviating the exogenous component of labor market rigidity (increase in A) creates political support for another, growth-retarding distortion of the labor market (an increase in firing costs).[32] This effect offsets any potentially growth-enhancing exogenous shocks (as discussed above) or policies like those related to international trade and imitation that could be added to our model: the steady-state utility growth rate with voting on firing costs is fixed at $\dot{z}/z = \hat{I}(\theta^i < \theta_0) \log \lambda = \rho - n - \beta \log \lambda$. Therefore, there is no systematic link anymore in our framework between one particular element of *exogenous* labor market flexibility and the innovation and growth rate.

6 Qualifications and Extensions

6.1 Accounting for Firm Ownership of Workers

Neglecting firm ownership of workers influences obviously our results concerning the level of requested firing costs. Like in Saint-Paul (2002), this assumption is made mainly because it allows us to concentrate on the conflicting interests *among* workers, instead of adding a political conflict between workers and shareholders (which may be identical to workers). Moreover, it allows us to solve our model explicitly for $\hat{B}(\theta^i < \theta_0)$ and to provide a clear discussion of its determinants. As in Saint-Paul's model, taking account of firm ownership of workers would weaken political support for firing costs (the optimal balance between quality growth and consumption quantity is found at a higher desired innovation rate), depending on the relative importance of labor and capital income. This is because the value of firms (thus, $e^{-yr}\vartheta$) depreciates with higher firing costs. If the fraction of financial assets in total income were higher for skilled workers than for the unskilled, this would decrease the demand for firing costs among the former by more than

[31] In Arnold's model, the negative effects of rising Southern imitation on Northern growth consist of a shortening of product life cycles (harming monopolists' profits and thus innovation incentives) and a rise in frictional unemployment (because imitation reallocates production to the South due to lower marginal labor costs). The positive effect on Northern growth is rooted in the efficiency gain in Southern production, which raises world demand for Northern monopolists' goods and thus their profits, which stimulates innovation incentives.

[32] A notable similarity between Arnold (2002) and our model is that more efficient matching ceteris paribus (that is, for a given level of firing costs in our case) raises the long-run growth rate. However, this result hinges crucially on the presence of scale effects in Arnold's model (a higher total number of employed workers implies an increase in the innovation rate), whereas our model is free of scale effects (I is independent of the size of the total workforce).

among the latter. However, accounting for equal share ownership among skilled and unskilled workers affects our results in (24) and (29) only quantitatively, without having any impact on Proposition 3. Moreover, Propositions 4 and 5 are not affected at all, even when taking account of an unequal distribution of share ownership across worker types. Finally, since share ownership among workers is much more common in the US than in West European countries, this may provide one explanation for the much lower level of firing costs observed in the US.

6.2 R&D Incentives of Industry Leaders

One may wonder whether introducing firing costs should provide an incentive for quality leader firms to improve their own products. By gaining a quality advantage of size λ^2 instead of λ, they could try to avoid the risk of having to pay the firing costs once being overtaken by an innovating follower firm. However, it turns out that this idea conflicts with the R&D process put forward in Sect. 2.2 above, which is taken from Segerstrom (1998) and Dinopoulos and Segerstrom (1999): it is assumed that *all* firms have the *same* R&D technology, and once a new innovation occurs, the patent attached to the previous leading technology expires and becomes common knowledge. Therefore, quality followers do not have to "catch up before they can pass" (i.e., they do not have to copy the current state-of-the-art product before being able to improve it), contrary to the R&D setup in Aghion et al. (2001).[33] This means that even if quality leader firms improved their own products, the instantaneous probability of a further quality-augmenting innovation by followers would not change, hence the leader's probability of having to pay the firing costs does not change. The intuition follows Grossman and Helpman (1991):

> "[...] we implicitly suppose that potential entrants can, via inspection of the goods on the market, learn enough about the state of knowledge to mount their own research efforts, even if the patent laws (or the lack of complete knowledge about best production methods) prevent them from manufacturing the current generation products. This specification captures in part the often noted, public-good characteristics of technology"(ibid, p. 47).

[33] As noted by Segerstrom (2004), this assumption made by Aghion et al. (2001) has the counterfactual implication that small firms do not innovate.

Hence, the "Arrow effect" still ensures that industry leaders find it more profitable to direct their R&D investments toward other industries in which they are quality followers (see Grossman and Helpman, 1991, p. 47, for proof), irrespective of the firing costs. To capture the empirical fact of significant R&D expenditure of industry leaders, it would be necessary either to introduce R&D cost advantages for them relative to follower firms, as in Segerstrom and Zolnierek (1999) and Segerstrom (2004), or to assume Stackelberg behavior of industry leaders, as in Etro (2004). Both approaches, however, would complicate the Schumpeterian unemployment mechanism described in Sect. 2.3 considerably, which is beyond the scope of this paper (but might provide a fruitful subject for future research).

6.3 The Effects of Firing Costs on Hiring

A basic principle of labor economics is that higher firing costs tend to decrease both hiring and firing of firms, such that the net effect on unemployment becomes ambiguous. This accords with empirical evidence referred to in footnote 1 above. At first sight, it seems that this paper does not indicate the negative effect of firing costs on hiring: in (17), the steady-state vacancy rate is independent of B, and a higher level of B reduces unambiguously unskilled unemployment due to lower labor market turnover (declining "Schumpeterian unemployment"). Inspection of equation (13) that describes the process of vacancy creation reveals that actually, we did account for the negative effect of firing costs on hiring: larger firing costs reduce the aggregate innovation rate (since firms anticipate expected costs of layoffs when deciding on the optimal level of R&D investment), which tends to reduce the number of vacancies posted. However, this effect is completely offset by the induced increase in market size: since the unskilled unemployment rate declines and the proportion of unskilled workers rises with larger firing costs, aggregate production must also increase, which raises unskilled labor demand of innovating firms. That is, larger firing costs reduce the frequency of vacancy postings but once innovation occurs, the number of posted vacancies is higher, reflecting the larger market size for each incumbent monopolist.

This is a knife-edge result that hinges crucially on the assumption of a linear production function

$$Q_t = (1 - u)\theta_0 N_t.$$

Assume now that households use part of their savings to finance the accumulation of a physical capital stock K with $K_t = K_0 e^{nt}$. Note that the capital stock must grow at the population growth rate in order to ensure constant per-capita consumption expenditure, similar to (6), that we need because of constant wage rates. With a Cobb-Douglas production function

$$Q_t = [(1-u)\theta_0 N_t]^\alpha K_t^{1-\alpha}, \quad 0 < \alpha < 1,$$

the market-size effect of a declining u and a rising θ_0 would be alleviated, and a positive (negative) relationship between the steady-state vacancy rate and the aggregate innovation rate (the level of firing costs) would result. To show this, we first use the new production function (that equals total consumption) in (14) and solve this equation for the new steady-state unskilled unemployment rate in implicit form:

$$u = \frac{(1-u)^\alpha K_0^{1-\alpha} I}{\beta \theta_0^{1-\alpha}} + 1 - \frac{Ap(\nu^*)}{\beta}. \tag{32}$$

In (32), θ_0 is determined by a new R&D equilibrium condition replacing (18), and by (19) for skilled labor full employment. Equation (32) reduces to (16) for $\alpha = 1$, and it still implies a positive long-run relationship between innovation and unskilled unemployment. Then, using (32) and the new production function in (13) gives the new steady-state vacancy rate

$$\nu^* = \frac{\frac{(1-u)^\alpha e^{ny}(I+\beta)}{\theta_0^{1-\alpha}} - Ap(\nu^*)}{\beta - \delta} K_0^{1-\alpha}, \tag{33}$$

which reduces again to (17) for $\alpha = 1$. Now, an increase in firing costs has two effects on ν^*. First, by reducing the innovation rate, ν^* declines which is the expected negative effect on hiring that vanishes in the linear-production case. Second, by reducing the unskilled unemployment rate, ν^* somewhat rises again. This second effect is weakened indirectly, however, by the first: a lower vacancy rate reduces the job-finding rate $p(\nu^*)$ due to the monotonous matching function and therefore tends to raise u according to (32) again. Overall, a net negative effect of rising firing costs on the steady-state vacancy rate will prevail, which somewhat weakens the market-size effect referred to above. Hence, after a rise in firing costs, the reduction (increase) in u (θ_0) is alleviated, with the extent depending on the size of α.

It turns out that this extension of the model does not affect our main results qualitatively. The crucial point in the logic of Proposition 3 is that for $I < I^{crit}$, skilled workers realize additional benefits from higher firing costs relative to the unskilled because the *education equilibrium effect* dominates the *skilled labor demand effect*. This reasoning and thus Proposition 3 still hold. Proposition 4 also remains valid since $dI/dA > 0$ and $dI/dB < 0$ continue to hold. All workers still face the same trade-off between consumption quantity and consumption quality growth. However, with the new production function, the increase in consumption quantity after a marginal rise in firing costs is smaller than before. This is because the negative effects of firing costs on hiring alleviate the net reduction in unskilled unemployment. Since the negative effect of a marginal reduction in the innovation rate on workers' utility in terms of quality growth is unchanged, they vote for a lower level of B than in the linear-production case. Hence, for a given output level, the innovation rate $\hat{I}(\theta^i < \theta_0)$ that is realized after the vote on B is larger than with the old production function. Finally, by a similar argument, the logic of Proposition 5 is also not affected qualitatively by this extension of our model.

6.4 Accounting for Repeated Voting

In general, with repeated voting on a policy issue, there may be important general-equilibrium feedback effects that affect voting behavior in the future, which, with forward-looking voters, can influence voting behavior today. In particular, rational voters will take into consideration that their vote today may change the distribution of workers tomorrow, which could induce strategic voting. This in turn could lead to situations of multiple politico-economic equilibria. In their introductory section, Hassler et al. (2003) provide a broad overview over the relevant literature on these issues.

Fortunately, things are much simpler in our framework. First of all, since all unskilled and all skilled workers have the same preferences about firing costs, respectively, there are only two possible political outcomes, namely $\hat{B}(\theta^i < \theta_0)$, given in (25), and

$$\hat{B}(\theta^i \geq \theta_0) > \hat{B}(\theta^i < \theta_0)$$

(or, alternatively, $\hat{B}(\theta^i \geq \theta_0) = 0$ if $I > I^{crit}$). Second, these two desired levels of per-capita firing costs are unique, respectively. Third, the proportion θ_0 of unskilled workers is a smoothly increasing function of B as can be seen from Fig. 1. Then, all we need to ensure $B = \hat{B}(\theta^i < \theta_0)$ as the unique political outcome with repeated voting (irrespective of the frequency of voting) is to assume that $\theta_0 > 0.5$ holds (which can be stated in terms of fundamental parameters, see footnote 21).

7 Conclusions

This paper contributes to the literature on the growth effects of labor market flexibility from a political economy point of view within the setup of a standard Schumpeterian endogenous growth model without scale effects. Given the rigidity of non-instantaneous matching of unskilled workers with vacancies posted by new quality leader firms, we analyze both general equilibrium consequences of and political demand for firing costs. We find that although firing costs reduce the steady-state innovation and growth rate, all workers vote for positive firing costs (if the innovation rate falls short of a critical level) by evaluating a trade-off between the quantity of consumption and the growth of the quality of consumer goods. If the innovation rate is below the critical level, skilled workers (i.e., those individuals who still invest in education after the majority-winning unskilled workers have decided on firing costs) even vote for larger firing costs than unskilled workers, although only the latter can become unemployed. Moreover, we find that workers increase their demand for firing costs in the case of more efficient matching on the labor market. Hence, alleviating a labor market rigidity that is exogenous to our framework aggravates the rigidity that is determined endogenously by majority voting.

We can derive two major insights from our analysis. First, contrary to the conclusion of Saint-Paul (2002), our results do not support the view that employment protection is likely to be lower in fast growing economies. Once the aggregate innovation and growth rate is made endogenous in a neo-Schumpeterian framework, all workers have an individually 'optimal' rate of creative destruction. The median voter's (single-peaked) preferences for this rate of innovation are realized by adjusting the endogenous labor market rigidity accordingly. If the exogenous component of labor market rigidity or other exogenous parameters change in a way to increase innovation and long-run growth, workers vote for *more* employment protection. Second, our results suggest that the interplay between labor market flexibility and economic growth tends to be more complicated than reflected in popular statements like 'a flexible labor market tends to support economic growth'. This may well hold for all defining elements of labor market flexibility taken as an aggregate (hence it holds in the model of Arnold, 2002, where there is just one type of labor market rigidity). However, because some of those elements are endogenous to the political process and interact with other elements as illustrated for example by our model, it seems to be questionable to explain cross-country variations in economic growth by differences in a single aspect of labor market rigidity.

Our results are unlikely to change qualitatively once one extends the analysis to cover the case of incomplete unemployment insurance. This would introduce unemployed workers' preferences for firing costs that differ from those of unskilled employed workers. However, it seems justifiable to assume that the median voter is still an unskilled employed worker who mainly cares about expected wage earnings.[34]

An interesting extension of our analysis would be to add the possibility for firms to escape firing costs by outsourcing the production of consumer goods to a foreign country. Alternatively, instead of firing costs, one could also analyze the preferences of different worker groups for unemployment benefits within our dynamic setting.

Appendix

A. The Proof of $dI/d\theta_0 > 0$ in (18)

To prove that the curve for (18) is upward sloping in Fig. 1, we write

$$f(I,\theta_0) \equiv I - \frac{\eta e^{-\rho y} Ap(\nu^*)\theta_0^2(\lambda-1) - (\rho-n)\sigma Ap(\nu^*)k}{\sigma Ap(\nu^*)k + (\beta+I)\eta e^{-\rho y}\theta_0 B} = 0 \quad \text{(A. 1)}$$

and apply the implicit function theorem:

$$\begin{aligned}\frac{dI}{d\theta_0} &= -\frac{\partial f/\partial\theta_0}{\partial f/\partial I}\\ &= -\frac{-[2\eta e^{-\rho y}Ap(\nu^*)\theta_0(\lambda-1)]den + nom(\beta+I)e^{-\rho y}\eta B}{den^2 + nom\ e^{-\rho y}\theta_0\eta B},\end{aligned} \quad \text{(A. 2)}$$

where *nom* and *den* denote nominator and denominator of (18), respectively. Using $den/nom = 1/I$, (A.2) takes a positive value if and only if

$$2Ap(\nu^*)\theta_0(\lambda-1) > I(\beta+I)B \quad \text{(A. 3)}$$

is fulfilled. By using $\beta+I = Ap(\nu^*)/(1-u)$ from (16) and subsequently $\theta_0(1-u) = c/\lambda$ from (6), condition (A.3) can be restated as follows:

$$2c(\lambda-1)/\lambda > IB. \quad \text{(A. 4)}$$

This is fulfilled because of our assumption (11).

[34] Saint-Paul (1996) distinguishes five groups of individuals (skilled workers, unskilled and semi-skilled workers, short-term unemployed, long-term unemployed, and capitalists) and argues that

> "typically, the decisive voter will be considered as a member of [the] group [of] unskilled and semi-skilled employed workers. This is meant to be a relatively broad group, including workers without a college degree, who make up more than 70% of the workforce in most European countries" (ibid, p. 275).

B. Proof of Proposition 1

Equation (18) can be solved for

$$I^2 + \underbrace{\left[\frac{\sigma A p(\nu^*) k}{e^{-\rho y}\eta\theta_0 B} + \beta\right]}_{\equiv P} I + \underbrace{\frac{Ap(\nu^*)}{B}\left[\frac{(\rho - n)\sigma k}{e^{-\rho y}\eta\theta_0} - \theta_0(\lambda - 1)\right]}_{\equiv Q} = 0. \quad \text{(A. 5)}$$

This quadratic equation yields two roots

$$I_{1,2} = -P/2 \pm \sqrt{(P/2)^2 - Q},$$

of which only

$$I_1 = -P/2 + \sqrt{(P/2)^2 - Q}$$

is positive. Moreover, there are no complex solutions since $Q < 0$ immediately follows from looking at the ordinate intercept of (18) in Fig. 1. Thus, I_1 is the only feasible solution. Differentiating this with respect to B gives

$$\frac{dI_1}{dB} = \frac{P - \beta}{2B} + \frac{1}{2}[(P/2)^2 - Q]^{-\frac{1}{2}}\left(P\frac{\beta - P}{2B} + \frac{Q}{B}\right). \quad \text{(A. 6)}$$

The derivative in (A.6) is negative if and only if

$$[(P/2)^2 - Q]^{-\frac{1}{2}}\left[\frac{P(P-\beta)}{2} - Q\right] > P - \beta,$$

which can be rewritten as

$$\frac{P}{2} - \frac{Q}{P - \beta} > [(P/2)^2 - Q]^{\frac{1}{2}} = I + \frac{P}{2}, \quad \text{(A. 7)}$$

where the equality on the RHS follows from our definition in (A.5). Simplifying and substituting for P and Q in (A.7) finally gives the condition

$$I < \frac{e^{-\rho y}\eta\theta_0^2(\lambda - 1)}{\sigma k} - (\rho - n). \quad \text{(A. 8)}$$

Note that the RHS of (A.8) equals (18) for $B = 0$. Since (18) can be written as

$$I = \frac{\frac{e^{-\rho y}\eta\theta_0^2(\lambda-1)}{\sigma k} - (\rho - n)}{1 + \frac{(\beta+I)e^{-\rho y}\eta\theta_0 B}{\sigma A p(\nu^*) k}}, \quad \text{(A. 9)}$$

(A.8) follows immediately. Hence, we have shown that an increase in firing costs reduces the value for the innovation rate I defined implicitly in (18), given any feasible value for θ_0. Thus, the curve for (18) shifts to the left as depicted in Fig. 1, whereas the curve for (19) is not affected. This proves Proposition 1.

C. The Proof of $dI/dy < 0$ in (18)

In order to show that the curve for (18) shifts downward again after the induced decline in the matching time y as shown in Fig. 3, we use (A.1) and implicit differentiation:

$$\frac{dI}{dy} = \frac{\partial f/\partial y}{\partial f/\partial I}$$
$$= -\frac{-[-\rho\eta e^{-\rho y} Ap(\nu^*)\theta_0^2(\lambda - 1)]den + nom[-\rho(\beta + I)\eta e^{-\rho y}\theta_0 B]}{den^2 + nom\ e^{-\rho y}\theta_0\eta B}. \qquad \text{(A. 10)}$$

Using $den/nom = 1/I$, (A.10) takes a negative value if and only if $c(\lambda-1)/\lambda > IB$ is satisfied, which is our assumption in (11). Therefore, a reduction in y shifts the curve for (18) downward in Fig. 3, whereas the curve for (19) is not affected. Thus, $dI/dy < 0$ follows immediately.

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