Employment protection and unemployment benefits: On technology adoption and job creation in a matching model

Kjell Erik Lommerud* Odd Rune Straume† Steinar Vagstad‡

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Abstract

We analyse the effects of different labour market policies – employment protection, unemployment benefits and payroll taxes – on job creation and technology choices in a model where firms are randomly matched with workers of different productivity and wages are determined by ex-post bargaining. In this setting, unemployment benefits are unambiguously detrimental both to job creation and technology adoption while the effects of employment protection are mixed, as higher firing costs stifle job creation but stimulate technology investments. This suggests that a 'flexicurity' policy, with low employment protection and high unemployment benefits, might have the adverse effect of slowing down technological progress and job growth. Indeed, our analysis of the optimal policy solution suggests that flexicurity is often not optimal, and may be optimal only in conjunction with payroll subsidies.

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*Corresponding author. Department of Economics, University of Bergen, Fosswinckels gate 14, N-5007 Bergen, Norway. E-mail: kjell-erik.lommerud@econ.uib.no

†Department of Economics/NIPE, University of Minho, Campus de Gualtar, 4710-057, Braga, Portugal. E-mail: o.r.straume@eeg.uminho.pt

‡Department of Economics, University of Bergen, Fosswinckels gate 14, N-5007 Bergen, Norway. E-mail: steinar.vagstad@econ.uib.no

1 Introduction

The factor price equalisation theorem[1] in international economics presents scaring prospects for many workers in the rich part of the word. One implication of the theorem is that under some assumptions free and unimpeded trade of goods will bring labour of the same quality to be priced equally in all countries. To quote Richard Freeman[2], our wages will be set in Beijing. As downward adjustment of wages can be a slow and painstaking process, competition from newly industrialised countries can be an important factor behind the persistently high unemployment rates many Western economies experience today. With this as a backdrop, it becomes extremely important that labour market institutions help to promote productivity growth, sectoral reallocation and quick adoption of technology - rather than the opposite. With intense competition from billions of low-paid workers, the only way to keep wages high in the developed world is for each and every worker to maintain a productivity edge.

Labour market institutions vary considerably among the rich countries of the world. While the US often is presented as a flexible and productivity-promoting labour market, Europe - and especially the Mediterranean rim - is characterised as suffering from 'eurosclerosis'.[3] The latter is taken to mean that insiders are well protected, outsiders find it hard to enter the labour market, while technological progress and job creation are hurt. Among policy makers 'flexicurity' has become something of a buzzword. Can one make relatively rigid labour markets in parts of Europe more prone to change, while still preserving the economic safety net which to some extent is absent in the US? The concrete idea is to build down employment protection, but at the same time provide economic security outside the original firm by supplying generous unemployment benefits and retraining support. Denmark and the Netherlands are countries where flexicurity purportedly exists, and these countries have over the last years experienced smaller unemployment problems than many other Western economies.

The purpose of the present paper is theoretically to investigate optimal labour market policies in a matching-type model of the labour market. More precisely, we set up an optimal taxation problem with three choice variables; an unemployment benefit, a tax that can regulate firing costs

[1] Samuelson (1948).

[2] Freeman (1995).

[3] Bentolila and Bertola (1990). An updated comparison of labour market institutions in various rich countrise can be found in Kahn (2012).

up or down, and a payroll tax (or subsidy) on labour earnings. Flexicurity is then a combination of policies that reduce firing costs but at the same time provide generous unemployment benefits.

Matching models have many features that seem interesting in the present context. Sunk investments are necessary to install a job, and firm and worker bargain over the division of the surplus. How will public policies affect the distribution of income between capital owners and workers? When workers capture quasi-rents from sunk investments, this can reduce firms' incentives to create jobs and install technology. Can public policy be used to mitigate these problems?

We will not preview all our results here, but focus on one finding. Flexicurity does not seem to be a particularly good idea in the present environment. True, there exist parameter combinations where optimal policy can be characterised as a flexicurity package. But in general terms flexicurity is not good for job creation and technology investments. A generous unemployment benefit will drive up the bargained wage that firm and worker arrive at after they are matched and locked in a relationship. High wages spell trouble for job creation: firms hesitate to open jobs when they know that after lock-in workers will be able to extract much of the quasi-rent from the relationship. At the same time, low firing costs imply that many firm-worker matches will be terminated after true productivity is revealed, which creates disincentives for technology investments. If firms knew they would have to retain also the less able workers, they could just as well invest in increasing their productivity. On the positive side for flexicurity, it does provide workers with higher income both while employed and unemployed. We find, though, that with a somewhat strict definition of flexicurity, such a policy will always be used in combination with a negative payroll tax, which is used to correct for the distorted job creation and technology incentives shaped by the flexicurity package. However, this only makes sense when the government has access to 'other income', for example resource rents. If a government must tax labour income (here through a payroll tax) to finance itself, it would therefore abstain from flexicurity policy.

The literature both on employment protection and unemployment insurance abound.[4,5]

[4] Work on sectoral reallocation and/or employment protection include Lazear (1990), Dixit and Rob (1994), Bertola and Rogerson (1997), Ljungqvist (2002), Bertola (2004), Rogerson (2005), Piccirilli (2010) and Karabay and McLaren (2011).

[5] Examples from the literature on unemployment insurance are Baily (1978), Shavell and Weiss (1979), Hansen and Imrohorogulu (1992), Hopenhayn and Nicolini (1997, 2009), Acemoglu and Shimer (2000), Chetty (2006),

Much less attention has been paid to how these policy instruments should be combined. An exception is Blanchard and Tirole (2008). They study the optimal combination of employment protection and unemployment insurance in a matching model that is not fully dynamic in the sense that rematching after one employment relationship has been terminated, is abstracted from.[6] It is know to be notoriously difficult to study optimal policy in fully dynamic matching models without assuming linear utility.[7] But risk-neutrality and equal marginal utility of income for capital owners, employed workers and the unemployed also appear as an unattractive starting point for analysis. We therefore use much the same model as Blanchard and Tirole; more precisely, we see our paper as an extension of that version of the Blanchard-Tirole model which includes ex-post wage bargaining.[8] The extension lies in the added focus on job creation and technology choice.

Many authors have investigated flexicurity – or the two constituent parts of that policy, employment protection and unemployment benefits – in frameworks different from the current matching framework.[9] When these authors sometimes have arrived at more positive evaluations of flexicurity, we do not mean to claim that they are wrong, but simply that for a full picture one also should investigate the consequences of different labour market regimes in a context with matching and locked-in employment relationships. We would like to suggest a delineation between external and internal flexibility of the labour market. The original eurosclerosis debate painted a picture of lacking sectoral reallocation. This we would refer to as 'external' (lack of) flexibility. If the problem is that workers are unwilling to quit ailing industries in order (hopefully) to be reemployed in the sunrise part of the economy, lower employment protection combined with unemployment insurance would probably improve that economy's 'flexibility'. However, a very important source of productivity growth is the adoption of new technology

Shimer and Werning (2007), Hassler and Mora (2008) and Landais, Michaillat and Saez (2010).

[6] The combined choice of employment protection and unemployment insurance is also studied by Anesi and De Donder (2012), but in a political economy context where the equilibrium policy package is a result of coalition formation.

[7] Mortensen and Pissarides (2003) study the joint determination of a series of taxes and subsidies in a matching model, but resorted to the assumption of risk-neutral workers. Pissarides (2001) studies employment protection in a matching model with non-linear utility. Alvarez and Veracierto (2000) study payroll and layoff taxes and severance payments with non-linear utility, while results largely are given as numerical simulations.

[8] Belot, Boone and van Ours (2007) also use a 'one-shot' matching model as ours to analyse employment protection.

[9] Literature on flexicurity include Andersen and Svarer (2007), Cockx and van der Linden (2010), Boeri, Conde-Ruiz and Galasso (2012) and Andersen (2012).

in the industries where the workers already are employed. We dub this 'internal' flexibility. Will flexicurity policy also improve an economy's track record when it comes to this type of flexibility?

In previous work[10] we investigated how flexicurity affected the adoption of labour-saving technology in a context with trade unions. In this set-up better technology makes some workers more productive while others lose their job. Good unemployment insurance softens the consequences of job loss and makes the union more favourably inclined towards technological change, and this is partly the reason why we find that flexicurity policy works well also in this context.[11] The current matching model is quite different. Firstly, technological innovation is not labour-saving. Technology is installed after a job is opened up and can only increase a worker's chance of retaining a job.[12] Secondly, there is no institution like a trade union that weighs the interests of winners and losers from better technology. In a matching model of the labour market flexicurity can backfire, since policies meant to increase sectoral readjustment also prop up wages for the employed and reduce incentives both for technology improvement and job creation.

No labour market model captures the full complexity of the real world. In reality, there are probably both instances of labour-saving and labour-augmenting technological change, lacking sectoral reallocation as well as problems with technology adoption, some workers are represented by unions, others are not. The point of the current work is not to claim that flexicurity never works, but only to caution that a policy which has been heavily recommended as a tool for productivity improvement while retaining some kind of economic security for workers, in some instances actually can be quite problematic exactly for productivity growth.

Our interest is the joint determination of employment protection, unemployment insurance and a payroll tax. We proceed in steps. Section 2 presents the basic model and also contains comparative static exercises for the choice variables, in order to get a grip of some of the main mechanisms. Section 3 contains first an optimal tax analysis, which maps the pros and cons of using the various policy instruments, taking direct and indirect effects into account. To gain some further understanding, we also perform a policy reform analysis, that is, we investigate if a

[10] Lommerud and Straume (2012).

[11] See also Dowrick and Spencer (1994) and Lommerud, Meland and Straume (2006) for theoretical studies of union opposition to labour-saving technological change.

[12] Moreover, the produced good is sold at a given fixed market price, so there is no saturation of the demand for the product.

small increase in one policy variable is welfare beneficial, starting from a point where all choice variables are set to zero. Lastly, we solve the model numerically to come to grips with how the various exogenous parameters of the model influence the combination of policy choices. In this light, we discuss if flexicurity is a sensible policy package in a matching model. Section 4 offers some concluding remarks.

2 Model

Consider an economy that consists of a continuum of workers and entrepreneurs, each with a total mass of 1. Entrepreneurs are risk-neutral and heterogeneous with respect to the cost of starting up a firm. We assume that the start-up cost is kI, where $k > 0$ and $I \sim U[0,1]$. An entrepreneur that decides to start up a firm has to install costly technology that affects labour productivity. After deciding on the level of technology, each firm hires one worker. The productivity of the match is given by

$$y = \phi\varepsilon, \tag{1}$$

where $\phi > 0$ reflects the technology of the firm and ε reflects the productivity of the worker. Workers are heterogeneous with respect to their productivity, which is only revealed after the match is formed. More specifically, we assume that ε is randomly distributed on $[0,1]$ with a density function $f(\varepsilon)$ and a corresponding cumulative distribution function $F(\varepsilon) = \int_0^\varepsilon f(s)\,ds$. Since all workers draw their productivity from the same distribution, they are ex ante identical.

We consider the following sequence of events:

Stage 0: A welfare-maximising policy maker chooses the following policy variables: A layoff tax $c \geq 0$, a payroll tax/subsidy $t \lesseqgtr 0$, and an unemployment benefit $b \geq 0$.

Stage 1: Each entrepreneur decides whether or not to pay kI in order to start up a firm.

Stage 2: Each entrepreneur who decided to start a firm chooses how much to invest in technology. Achieving a technological level ϕ costs $\frac{\psi}{2}\phi^2$, where $\psi > 0$.

Stage 3: Workers are randomly (and instantaneously) matched with firms. Those workers that are not offered a job become unemployed and receive unemployment benefit b.

Stage 4: Worker productivity is revealed and each firm decides whether to keep the worker or lay him off. At this stage, entry and technology costs are sunk. If the firm decides to break up the match, it has to pay the layoff tax c. A dismissed worker becomes unemployed and receives unemployment benefit b.

Stage 5: Each worker that is not laid off bargains with its employer over the wage rate, w, and production takes place.

The number of entrepreneurs who decide to start up a firm is given by $\widehat{I} \leq 1$. Since the mass of workers, by assumption, is equal to 1, this means that there are two potential sources of unemployment in the model. In equilibrium, the unemployed consist of those workers who did not get a job offer in the first place (the unlucky ones), if $\widehat{I} < 1$, and those who were initially hired but subsequently laid off (the less productive ones).

2.1 Wage bargaining

After productivity is revealed, we assume that each worker that is not laid off obtains a share β of the joint surplus from the match, implying that the wage is given by

$$w = (1 - \beta)(b + v) + \frac{\beta(y + c)}{1 + t}, \tag{2}$$

where $v > 0$ is the disutility of working (measured in monetary terms).[13] The parameter $\beta \in (0, 1)$ can thus be thought of as representing the relative bargaining power of workers.[14] The corresponding profit for the firm from this match is given by

$$\pi = y - w(1 + t) = (1 - \beta)[y - (1 + t)(v + b)] - \beta c. \tag{3}$$

[13] Alternatively, we can think of v as the rent that an unemployed worker could earn in the informal sector.

[14] As suggested by Blanchard and Tirole (2008), this wage would also result from a simple two-stage game where the worker proposes a wage in the first stage that the employer can either accept or reject. If the proposal is rejected, the wage is set in the second state by the worker (with probability β) or the firm (with the remaining probability). In equilibrium, the worker would propose the wage given by (2) and the firm would accept.

2.2 Dismissals

The worker and the firm will separate only if the joint net surplus from production is negative. Thus, a worker whose productivity satisfies the condition

$$y \geq \widehat{y} := (1+t)(v+b) - c \tag{4}$$

will not be laid off.[15] Using the definition of $\widehat{y}$, the bargained wage can be rewritten as

$$w = v + b + \frac{\beta (y - \widehat{y})}{1+t}. \tag{5}$$

The main determinants of the bargained wage are intuitive. Higher unemployment benefits will improve workers' outside options and therefore lead to higher wages. For a given level of worker productivity, better technology will generate a larger surplus with a correspondingly higher wage (if workers have some bargaining power). On the other hand, a higher payroll tax will reduce the joint net surplus and cause a wage drop, although the wage drop is not large enough to prevent the firm's labour cost after tax from rising.

The condition (4) defines a lower threshold in terms of worker productivity, given by

$$\widehat{\varepsilon} := \frac{\widehat{y}}{\phi} = \frac{(1+t)(v+b) - c}{\phi}. \tag{6}$$

Hired workers with productivity $\varepsilon < \widehat{\varepsilon}$ will be dismissed, while the remaining hired workers will be retained. Thus, $\widehat{\varepsilon}$ determines the expected dismissal rate in the economy.

Proposition 1 *For a given level of technology, the expected dismissal rate is decreasing in the level of technology and the firing cost, and increasing in the level of unemployment benefit and the payroll tax.*

2.3 Technology choice

Before the firm is matched with a worker, investments in technology are made. The optimal technological level is chosen to maximise expected profits, which, using (2), (3) and (6), are

[15] It is easily confirmed that the condition $\pi \geq -c$ is equivalent to the condition $w \geq b + v$. Thus, the firm and the worker will always agree on when to separate. This is due to the assumption of efficient bargaining.

given by

$$\pi^e = -cF(\widehat{\varepsilon}) + \int_{\widehat{\varepsilon}}^{1} [(1-\beta)(y-(1+t)(v+b)) - \beta c] f(\varepsilon)\, d\varepsilon - \frac{\psi}{2}\phi^2. \tag{7}$$

The optimal level of technology installed by each firm is implicitly given by[16]

$$\phi^* = \frac{(1-\beta)}{\psi} \int_{\widehat{\varepsilon}(\phi^*)}^{1} \varepsilon f(\varepsilon)\, d\varepsilon. \tag{8}$$

By the Implicit Function Theorem, the effects of marginal changes in the different labour market policy instruments (c, b, t) on optimal technology choices are given by

$$\frac{\partial \phi^*}{\partial j} = -\frac{\partial^2 \pi^e / \partial \phi \partial j}{\partial^2 \pi^e / \partial \phi^2}, \quad j = c, b, t, \tag{9}$$

where

$$\frac{\partial^2 \pi^e}{\partial \phi \partial c} = \frac{(1-\beta)\widehat{\varepsilon} f(\widehat{\varepsilon})}{\phi} > 0, \tag{10}$$

$$\frac{\partial^2 \pi^e}{\partial \phi \partial b} = -\frac{(1-\beta)(1+t)\widehat{\varepsilon} f(\widehat{\varepsilon})}{\phi} < 0 \tag{11}$$

and

$$\frac{\partial^2 \pi^e}{\partial \phi \partial t} = -\frac{(1-\beta)(v+b)\widehat{\varepsilon} f(\widehat{\varepsilon})}{\phi} < 0. \tag{12}$$

Proposition 2 *Unemployment benefits and payroll taxes contribute to reducing the optimal level of technology investments, while firing costs have a positive effect on technology incentives.*

The intuition for these results is fairly straightforward. The effect of labour market policy on technology incentives is determined by how the expected dismissal rate is affected. Notice that a higher dismissal rate increases the probability that technology investments are wasted. Thus, once an entrepreneur has sunk the cost of starting up a firm, any policy that increases (reduces) the expected dismissal rate will reduce (increase) the incentives for investing in technology in order to make the hired worker more productive.

[16] The second-order condition is satisfied if

$$\psi > \frac{(1-\beta)\widehat{\varepsilon}^2 f(\widehat{\varepsilon})}{\phi}.$$

2.4 Job creation

An entrepreneur will choose to start up a firm if the entry cost, kI, is lower than the expected profits of running a firm, π^e. Thus, all entrepreneurs with $I < \widehat{I}$ will start a firm, where $\widehat{I} = \frac{\pi^e}{k}$. Since I is assumed to be uniformly distributed on $[0, 1]$, total job creation is therefore given by

$$\widehat{I} = \frac{\pi^e(\phi^*)}{k}, \tag{13}$$

implying that there is a monotonic correspondence between expected profits and total job creation. Notice also that, since π^e is increasing in ϕ, a higher level of technology increases the expected profits of running a firm and thus stimulates job creation.

From (7), the effects of labour market policies on total job creation are given by[17]

$$\frac{\partial \widehat{I}}{\partial c} = -\left[\frac{F(\widehat{\varepsilon}) + \beta(1 - F(\widehat{\varepsilon}))}{k}\right] < 0, \tag{14}$$

$$\frac{\partial \widehat{I}}{\partial b} = -\frac{(1-\beta)(1+t)[1 - F(\widehat{\varepsilon})]}{k} < 0, \tag{15}$$

$$\frac{\partial \widehat{I}}{\partial t} = -\frac{(1-\beta)(v-b)[1 - F(\widehat{\varepsilon})]}{k} < 0. \tag{16}$$

Proposition 3 *The amount of job creation is decreasing in the level of firing costs, unemployment benefits and payroll taxes.*

The negative relationship between firing costs and job creation is due to two factors. Higher firing costs mean that not only does it become more costly for the firm to lay off workers, but it also becomes more costly to retain them, since retained workers are in a better position to negotiate higher wages. Both these effects, which are represented, respectively, by the first and second term in (14), contribute to reducing the expected profits of running a firm and therefore lead to less job creation.

The effects of unemployment benefits and payroll taxes work only through the equilibrium wage. Higher unemployment benefits and/or payroll taxes will increase the wage and therefore hamper job creation. Obviously, a payroll subsidy will have the opposite effect.

[17] Notice that, by considering marginal changes in the policy parameters, indirect effects on job creation through technology choices are eliminated by the Envelope Theorem.

2.5 Total employment

Equilibrium total employment is given by

$$L = \widehat{I}\left[1 - F(\widehat{\varepsilon})\right]. \tag{17}$$

Labour market policies (layoff taxes, unemployment benefits and payroll taxes/subsidies) affect total employment through job creations and dismissal rates. The comparative statics effects are given by

$$\frac{\partial L}{\partial c} = -\frac{(1 - F(\widehat{\varepsilon}))\left[F(\widehat{\varepsilon}) + \beta(1 - F(\widehat{\varepsilon}))\right]}{k} + \frac{f(\widehat{\varepsilon})\widehat{I}}{\phi} \gtrless 0, \tag{18}$$

$$\frac{\partial L}{\partial b} = -\frac{(1 - F(\widehat{\varepsilon}))^2(1 - \beta)(1 + t)}{k} - \frac{(1 + t) f(\widehat{\varepsilon})}{\phi} < 0, \tag{19}$$

$$\frac{\partial L}{\partial t} = -\frac{(1 - F(\widehat{\varepsilon}))^2(1 - \beta)(v + b)}{k} - \frac{(v + b) f(\widehat{\varepsilon})}{\phi} < 0. \tag{20}$$

Proposition 4 *Unemployment benefits and payroll taxes reduce total employment while the effect of firing costs is ambiguous.*

While the total employment effect of firing costs is a priori ambiguous due to less job creation but lower dismissal rates, the effect of unemployment benefits and payroll taxes are unambiguously negative due to the compound effect of less job creation and higher dismissal rates.

Parametric example

Let us see if we can go some way towards resolving the ambiguous employment effect of firing costs by applying a parametric example. Suppose that $\varepsilon \sim U[0,1]$, implying that $f(\varepsilon) = 1$ and $F(\varepsilon) = \varepsilon$. The optimal technology choice is then implicitly given by

$$\phi^* = \frac{(1 - \beta)(1 + \widehat{\varepsilon})(1 - \widehat{\varepsilon})}{2\psi}. \tag{21}$$

Expected profits are given by

$$\pi^e = \frac{(1 - \beta)^2(1 + \widehat{\varepsilon})(1 - 3\widehat{\varepsilon})(1 - \widehat{\varepsilon})^2}{8\psi} - c. \tag{22}$$

Notice that in an interior solution, i.e., $\widehat{I} \in (0,1)$, the expected dismissal rate must be less than 33% in equilibrium. Using (21)-(22) in (18), the effect of firing costs on total employment is given by

$$\frac{\partial L}{\partial c} = -\frac{\left[4\left(\widehat{\varepsilon} + \beta\left(1-\widehat{\varepsilon}\right)\right) - k\left(1-\beta\right)\left(1-3\widehat{\varepsilon}\right)\right]\left(1-\widehat{\varepsilon}\right)}{4k} - \frac{c}{\phi^{*}}. \tag{23}$$

If the relative bargaining power of workers (β) is sufficiently high, or if the entry cost parameter k is sufficiently low, the numerator of the first term in (23) is positive, implying that both terms are unambiguously negative. In this case, higher firing costs always have a detrimental effect on total employment. Thus, a positive relationship between firing costs and total employment is possible only if workers' relative bargaining power is sufficiently low. The less bargaining power workers have, the stronger are the incentives for job creation, an effect that is reinforced by stronger incentives for technology investments (notice the negative relationship between β and ϕ^{*}), and the more likely it is that higher firing costs will increase total employment. A positive relationship between firing costs and total employment is also more likely if these costs are small to begin with. Consider, for example, the introduction of an infinitesimally small layoff tax. If workers have no bargaining power (i.e., $\beta = 0$), such a policy will increase total employment if $k > \frac{4\widehat{\varepsilon}}{1-3\widehat{\varepsilon}}$.

2.6 Flexicurity

A labour market policy that combines low employment protection with a relatively generous income support to unemployed workers has come to be known as *flexicurity*. In our model, a policy reform towards more flexicurity would correspond to a simultaneous reduction in c and increase in b. How would this affect technology choices and job creation? The answer follows directly from Propositions 2 and 3:

Corollary 1 *A policy reform towards more flexicurity would lead to less technology investments while the effect on job creation is a priori ambiguous.*

Since flexicurity has an ambiguous effect on job creation, the effect of this type of labour market policy on total employment is correspondingly ambiguous. While lower investment in technology reduces total employment (all else equal), the overall employment effect could nevertheless be positive if job creation is sufficiently stimulated due to less employment protection.

Notice that the effects of flexicurity on technology investments depend crucially on whether technology is labour-saving or not.[18] In the present model, a firm may want to lay off a worker not because new technology makes him redundant but because his productivity turns out to be too low. The firm can increase the probability that a worker surpasses the productivity threshold by installing better technology, but, clearly, the incentives for such technology investments weaken if it becomes less costly to fire low-productivity workers. In the same vein, higher unemployment benefits – the other element in the flexicurity package – have qualitatively different effects on firms' incentives for technology investments, depending on whether new technology is labour-saving or not. This illustrates the importance of considering the *nature* of technological change when assessing how flexicurity affects the rate of technological progress.

3 Welfare

We assume that workers are risk averse with the utility of income given by a strictly concave function $u(\cdot)$. Social welfare is defined as the sum of expected worker utility and firm profits, net of public expenditures. Before analysing optimal labour market policies, let us first derive the socially optimal first-best solution.

3.1 The first-best solution

Suppose that revenues can be transferred in a lump-sum manner between firms and workers, and that the social planner can directly choose the income to employed and unemployed workers, the dismissal rate, the technology level and the number of active firms. Using the above-stated definition of social welfare, the first-best outcome is given by the solution to the following maximisation problem:

$$\begin{aligned} \max_{w,b,\widehat{\varepsilon},\phi,\widehat{I}} W &= \widehat{I}\left[F(\widehat{\varepsilon})\,u(v+b) + (1 - F(\widehat{\varepsilon}))\,u(w)\right] + \left(1-\widehat{I}\right)u(v+b) \\ &\quad + \widehat{I}\left[\int_{\widehat{\varepsilon}}^{1}[\phi\varepsilon - w]\,f(\varepsilon)\,d\varepsilon - \frac{\psi}{2}\phi^2 - F(\widehat{\varepsilon})\,b\right] - \left(1-\widehat{I}\right)b - k\int_0^{\widehat{I}} I\,dI, \end{aligned} \tag{24}$$

[18] See Lommerud and Straume (2012) for an analysis of the effect of flexicurity on labour-saving technology adoption.

subject to a resource constraint,

$$\widehat{I}\left[\int_{\widehat{\varepsilon}}^{1}\left[\phi\varepsilon - w\right] f\left(\varepsilon\right) d\varepsilon - \frac{\psi}{2}\phi^{2} - F\left(\widehat{\varepsilon}\right) b\right] - \left(1-\widehat{I}\right) b - k\int_{0}^{\widehat{I}} I dI \geq K, \tag{25}$$

where K is to be interpreted as an exogenously given requirement that the part of the economy studied has to deliver a surplus to the rest of the economy. A negative K may be interpreted as a subsidy. Let λ denote the multiplier associated with the constraint. We assume throughout the analysis that $u'(v) > 1+\lambda$, implying that, in the absence of unemployment benefits, an income transfer towards unemployed workers is welfare improving (all else equal). Notice also that the above formulation of social welfare imposes the same wage for all employed workers, which implies that income can be costlessly transferred among workers with different productivities.

The first-order conditions of the maximisation problem are given by

$$\frac{\partial W}{\partial w} = \widehat{I}(1 - F\left(\widehat{\varepsilon}\right))\left[u'\left(w\right) - \left(1+\lambda\right)\right] = 0, \tag{26}$$

$$\frac{\partial W}{\partial b} = \left(1 - \widehat{I}\left[1 - F\left(\widehat{\varepsilon}\right)\right]\right)\left[u'\left(v+b\right) - \left(1+\lambda\right)\right] = 0, \tag{27}$$

$$\frac{\partial W}{\partial \widehat{\varepsilon}} = \widehat{I} f\left(\widehat{\varepsilon}\right)\left[u\left(v+b\right) - u\left(w\right) - \left(1+\lambda\right)\left(\widehat{y} - w + b\right)\right] = 0, \tag{28}$$

$$\frac{\partial W}{\partial \phi} = \left(1+\lambda\right)\widehat{I}\left[\int_{\widehat{\varepsilon}}^{1}\varepsilon f\left(\varepsilon\right) d\varepsilon - \psi\phi\right] = 0, \tag{29}$$

$$\frac{\partial W}{\partial \widehat{I}} = \left[1 - F\left(\widehat{\varepsilon}\right)\right]\left[u\left(w\right) - u\left(v+b\right)\right] - \left(1+\lambda\right)\begin{pmatrix} \left[\int_{\widehat{\varepsilon}}^{1}\phi\varepsilon f\left(\varepsilon\right) d\varepsilon - \frac{\psi}{2}\phi^{2}\right] - k\widehat{I} \\ -(w-b)(1-F\left(\widehat{\varepsilon}\right)) \end{pmatrix} = 0. \tag{30}$$

From (26)-(30), we can characterise the first-best optimal solution as follows:

Proposition 5 *The socially optimal first-best solution is characterised by*

(i) $w = v + b$,

(ii) $u'\left(v+b\right) = u'\left(w\right) = 1+\lambda$,

(iii) $\widehat{\varepsilon} = \frac{v}{\phi}$,

(iv) $\phi = \frac{1}{\psi}\int_{\widehat{\varepsilon}}^{1}\varepsilon f\left(\varepsilon\right) d\varepsilon$,

(v) $\widehat{I} = \frac{1}{k}\left(\int_{\widehat{\varepsilon}}^{1}\left(y - v\right) f\left(\varepsilon\right) d\varepsilon - \frac{\psi}{2}\phi^{2}\right)$.

Due to a positive opportunity cost of public funds ($\lambda > 0$) and the assumption of $u'(v) >$

$1 + \lambda$, the first-best solution implies that the government extracts all profits and redistribute parts of it to workers. Furthermore, with risk averse workers, the first-best outcome has workers fully insured against unemployment. That is, workers receive the same utility regardless of whether they are unemployed or not.

In the absence of any labour market policies, how does the market equilibrium derived in the previous section compare with the first-best outcome? Setting $b = c = t = 0$, a comparison of the first-best outcome with the equilibrium levels of wage, dismissal rate, technology and job creation, given respectively by (2), (6), (8) and (13), reveals the following:

Proposition 6 *In the absence of labour market policies:*

(i) If $\beta = 0$, the first-best levels of technology, dismissal rate and job creation are achieved in equilibrium, but worker income is at a suboptimal level and profits are positive.

(ii) If $\beta > 0$, the equilibrium outcome is characterised by underinsured workers, too high dismissal rates, too low technology level, too little job creation and too high profits.

Due to the possibility of hold-up through ex post bargaining, the first-best technology, dismissal and job creation can only be achieved if workers have no bargaining power. And even in that case, the first-best outcome is not achieved, as the marginal utility of income is lower for entrepreneurs than both for workers and for the government, implying that it is socially suboptimal to let the firms keep the entire surplus of the economy.

If workers have some bargaining power ($\beta > 0$), they are able to capture parts of the surplus from production ex post. This reduces the expected marginal revenue of technology investments and therefore leads to a suboptimally low technology level in equilibrium. This, in turn, leads to an equilibrium dismissal rate that is suboptimally high. A lower level of technology and a higher expected dismissal rate also reduces job creation, as well as total employment, below the first-best level. Furthermore, $\beta > 0$ implies $w > v + b$, which means that workers are underinsured compared with the first-best outcome. Notice, however, that this is true for any value of b, implying that full insurance against unemployment cannot be achieved by labour market policies as long as workers have some ex post bargaining power.

3.2 The second-best solution

In a second-best world, entry, technology and dismissal choices are decided by firms (and not by the welfare-maximising social planner). Thus, using (6)-(8) and (13), the equilibrium values of $\widehat{\varepsilon}$, ϕ and $\widehat{I}$ are given by

$$\widehat{\varepsilon}\phi = (1+t)(v+b) - c, \tag{31}$$

$$\phi\psi = (1-\beta)\int_{\widehat{\varepsilon}}^{1} \varepsilon f(\varepsilon)\, d\varepsilon, \tag{32}$$

$$\widehat{I} = \frac{1}{k}\left(\int_{\widehat{\varepsilon}}^{1} \left((1-\beta)\left(y - (1+t)(v+b)\right) - \beta c\right) f(\varepsilon)\, d\varepsilon - cF(\widehat{\varepsilon}) - \frac{\psi}{2}\phi^2\right). \tag{33}$$

These three equilibrium conditions implicitly define $\widehat{\varepsilon}, \phi$ and $\widehat{I}$ as functions of (c, b, t), where the signs of the partial derivatives are given by[19]

$$\frac{\partial\phi}{\partial t} < 0,\ \frac{\partial\phi}{\partial b} < 0,\ \frac{\partial\phi}{\partial c} > 0,\ \frac{\partial\widehat{\varepsilon}}{\partial t} > 0,\ \frac{\partial\widehat{\varepsilon}}{\partial b} > 0,\ \frac{\partial\widehat{\varepsilon}}{\partial c} < 0,\ \frac{\partial\widehat{I}}{\partial t} < 0,\ \frac{\partial\widehat{I}}{\partial b} < 0,\ \frac{\partial\widehat{I}}{\partial c} < 0.$$

Aggregate expected worker utility is given by

$$U := \widehat{I}\left[F(\widehat{\varepsilon})\, u(v+b) + \int_{\widehat{\varepsilon}}^{1} u(w) f(\varepsilon)\, d\varepsilon\right] + \left(1 - \widehat{I}\right) u(v+b), \tag{34}$$

aggregate expected profits are

$$\Pi := \widehat{I}\left[\int_{\widehat{\varepsilon}}^{1} [y - w(1+t)]\, f(\varepsilon)\, d\varepsilon - \frac{\psi}{2}\phi^2 - F(\widehat{\varepsilon})\, c\right] - k\int_{0}^{\widehat{I}} I\, dI, \tag{35}$$

while expected net revenues for the government are given by

$$G := t\widehat{I}\int_{\widehat{\varepsilon}}^{1} w f(\varepsilon)\, d\varepsilon + c\widehat{I}F(\widehat{\varepsilon}) - \left(1 - \widehat{I}[1 - F(\widehat{\varepsilon})]\right) b. \tag{36}$$

Social welfare is then defined as

$$W = U + \Pi + (1+\lambda)\, G, \tag{37}$$

where we take the shadow price of public funds, λ, to be given outside the model.

[19] Details are provided in the Appendix.

The second-best policy is then characterised by a system of three first-order conditions:

$$\frac{dW}{dj} = \frac{\partial W}{\partial j} + \frac{\partial W}{\partial \widehat{I}}\frac{d\widehat{I}}{dj} + \frac{\partial W}{\partial \widehat{\varepsilon}}\frac{d\widehat{\varepsilon}}{dj} + \frac{\partial W}{\partial \phi}\frac{d\phi}{dj} = 0, \quad j = t, b, c, \tag{38}$$

where

$$\frac{\partial W}{\partial t} = \widehat{I}\left[\begin{array}{c} (1+\lambda)\int_{\widehat{\varepsilon}}^{1}\left(v + b + \frac{\beta\phi(\varepsilon-\widehat{\varepsilon})}{(t+1)^2}\right) f(\varepsilon)\, d\varepsilon \\ -\int_{\widehat{\varepsilon}}^{1} u'(w)\frac{\beta\phi(\varepsilon-\widehat{\varepsilon})}{(1+t)^2} f(\varepsilon)\, d\varepsilon - (1 - F(\widehat{\varepsilon}))(v+b) \end{array}\right] \gtrless 0, \tag{39}$$

$$\begin{aligned} \frac{\partial W}{\partial b} &= \widehat{I}\int_{\widehat{\varepsilon}}^{1} u'(w) f(\varepsilon)\, d\varepsilon + \left(1 - \widehat{I}[1 - F(\widehat{\varepsilon})]\right) u'(v+b) - \widehat{I}(1+t)(1 - F(\widehat{\varepsilon})) \\ &\quad + (1+\lambda)\left[t\widehat{I}(1 - F(\widehat{\varepsilon})) - \left(1 - \widehat{I}[1 - F(\widehat{\varepsilon})]\right)\right] \\ &\gtrless 0, \end{aligned} \tag{40}$$

$$\frac{\partial W}{\partial c} = \lambda\widehat{I}F(\widehat{\varepsilon}) > 0, \tag{41}$$

$$\frac{\partial W}{\partial \widehat{I}} = \int_{\widehat{\varepsilon}}^{1}[u(w) - u(v+b)] f(\varepsilon)\, d\varepsilon + (1+\lambda)\left(t\int_{\widehat{\varepsilon}}^{1} w f(\varepsilon)\, d\varepsilon + cF(\widehat{\varepsilon}) + (1 - F(\widehat{\varepsilon}))b\right) > 0, \tag{42}$$

$$\frac{\partial W}{\partial \widehat{\varepsilon}} = -\widehat{I}\left[\frac{\beta\phi}{1+t}\int_{\widehat{\varepsilon}}^{1} u'(w) f(\varepsilon)\, d\varepsilon + (1+\lambda)\left(\frac{t\beta\phi}{1+t}[1 - F(\widehat{\varepsilon})] + f(\widehat{\varepsilon})(t(v+b) + b - c)\right)\right] \gtrless 0, \tag{43}$$

$$\frac{\partial W}{\partial \phi} = \widehat{I}\int_{\widehat{\varepsilon}}^{1}[u'(w) + (1+\lambda)t]\frac{\beta(\varepsilon - \widehat{\varepsilon})}{1+t} f(\varepsilon)\, d\varepsilon > 0, \tag{44}$$

and[20]

$$\frac{d\widehat{I}}{dt} < 0,\ \frac{d\widehat{I}}{db} < 0,\ \frac{d\widehat{I}}{dc} < 0,\ \frac{d\widehat{\varepsilon}}{dt} > 0,\ \frac{d\widehat{\varepsilon}}{db} > 0,\ \frac{d\widehat{\varepsilon}}{dc} < 0,\ \frac{d\phi}{dt} < 0,\ \frac{d\phi}{db} < 0,\ \frac{d\phi}{dc} > 0. \tag{45}$$

The total welfare effect of using a tax instrument (t, b or c) is the sum of direct and indirect effects. In addition to the direct welfare effects for given values of $\widehat{I}$, $\widehat{\varepsilon}$ and ϕ, there are also indirect effects of taxation via changes in job creation, dismissal rates and technology choices.[21] Below we discuss these effects separately, for each of the three tax instruments.

[20] Complete expressions for the partial derivatives of $\widehat{I}$, $\widehat{\varepsilon}$ and ϕ, with respect to the three different tax instruments, are given in Appendix.

[21] Notice that, by considering marginal changes in $\widehat{I}$, $\widehat{\varepsilon}$ or ϕ, the welfare effects via changes in aggregate profits are zero (i.e., $\partial\Pi/\partial\widehat{I} = \partial\Pi/\partial\widehat{\varepsilon} = \partial\Pi/\partial\phi = 0$). Thus, the indirect welfare effects work through changes in worker utility and net tax revenues.

First, consider a marginal increase in the payroll tax, t. The direct welfare effect is given by (39) and consists of three components. Since the increase in government revenue (1. term) is counteracted by a reduction in worker utility (2. term) and a reduction in aggregate profits (3. term), the direct welfare effect of a higher payroll tax is qualitatively ambiguous. Notice that a payroll tax increase leads to lower wages, and that this effect is stronger the more bargaining power workers have (cf. (2)). Thus, an increase in the relative bargaining strength of workers (β) increases the tax revenues collected from payroll taxation (due to higher wages) but also increases the utility loss of such taxation (due to a stronger wage-reducing effect of payroll taxes).

An increase in t also leads to lower job creation, higher dismissal rates and less technology investment. The welfare effect of lower job creation is unambiguously negative. Since workers are able to capture part of the surplus from production, lower job creation reduces expected aggregate worker utility (1. term in (42)). Furthermore, government revenues are reduced due to a smaller tax base and more unemployed workers (2. term in (42)). Less technology investments also unambiguously reduce welfare, since the corresponding wage drop implies a reduction in workers' utility as well as lower payroll tax revenues (1. and 2. term, respectively, in the square brackets in (44)). Notice that these two effects require that workers have some bargaining power. Otherwise, if $\beta = 0$, better technology would not translate into higher wages. Finally, payroll taxation affects welfare indirectly through higher dismissal rates. Since wages are bargained as a mark-up on $(\varepsilon - \widehat{\varepsilon})$, a higher dismissal rate implies a wage reduction, with a corresponding reduction in worker utility (1. term in (43)). Higher dismissal rates also affect government net revenues (2. term in (43)). Due to lower wages and higher unemployment, payroll tax revenues are reduced while unemployment benefit payments are increased. However, more dismissals also imply increased revenues from layoff taxes. From (43), we see that, if t and b are sufficiently small to begin with, the net effect of higher dismissal rates on net tax revenues is actually positive.

Second, consider a marginal increase in unemployment benefits, b. The direct welfare effect is given by (40) and consists of five components. Since higher unemployment benefits increase wages, utility is higher for both employed (1. term) and unemployed (2. term) workers. This is counteracted by lower profits (3. term). The direct effect on net tax revenues is qualitatively ambiguous, since higher expenditures on unemployment benefits (2. term in the square brackets in (40)) are compensated by increased payroll tax revenues due to higher wages (1. term in the square brackets in (40)). The indirect effects are qualitatively similar to the effects of payroll taxation discussed above. Higher unemployment benefits unambiguously reduce welfare due to lower job creation and less technology investments, while the effect via higher dismissal rates is a priori ambiguous.

Third, consider a marginal increase in layoff taxes, c. In this case, the direct welfare effect is positive and consists only of the value increase of revenues that are transferred from private to public hands, due to $\lambda > 0$ (cf. (41)). Similarly to other tax increases, the indirect welfare effect through changes in job creation is unambiguously negative. An increase in the layoff tax reduces job creation, which lowers social welfare (all else equal). However, the indirect welfare effects through changes in dismissal rates and technology choices are qualitatively different for the layoff tax than for the other tax instruments. An increase in the layoff tax induces firms to invest more in technology, which unambiguously increases social welfare. The effect via higher dismissal rates is qualitatively ambiguous, but since layoff taxes reduce the number of dismissals, the welfare effect is negative only in the rather special case where the loss in layoff tax revenues outweighs the revenue increase stemming from a higher payroll tax base and lower unemployment.

3.2.1 Marginal introduction of tax policies

In order to derive further qualitative results of the different tax policy options, let us consider the effects a marginal change in each of the three tax instruments, where this change is evaluated in the 'no policy' benchmark: $t = b = c = 0$. This gives us the welfare effect of introducing each of the tax instruments *separately*, using the 'no policy' case as a benchmark.

Substituting (39) and (42)-(44) into (38), for $j = t$, and setting $t = b = c = 0$, the welfare effect of introducing a small payroll tax is given by

$$
\begin{aligned}
\left.\frac{dW}{dt}\right|_{t=b=c=0} &= \widehat{I}\lambda\int_{\widehat{\varepsilon}}^{1} wf(\varepsilon)\,d\varepsilon+\widehat{I}\int_{\widehat{\varepsilon}}^{1}\left[1-u'(w)\right](w-v)\,f(\varepsilon)\,d\varepsilon \\
&+\int_{\widehat{\varepsilon}}^{1}\left[u(w)-u(v)\right]f(\varepsilon)\,d\varepsilon\frac{d\widehat{I}}{dt}-\widehat{I}\beta\phi\int_{\widehat{\varepsilon}}^{1}u'(w)\,f(\varepsilon)\,d\varepsilon\frac{d\widehat{\varepsilon}}{dt} \\
&+\left[\widehat{I}\int_{\widehat{\varepsilon}}^{1}u'(w)\,\beta(\varepsilon-\widehat{\varepsilon})\,f(\varepsilon)\,d\varepsilon\right]\frac{d\phi}{dt}, \qquad (46)
\end{aligned}
$$

where the first term is positive, the second may be positive or negative, while the remaining terms are negative. Consequently, for a sufficiently small value of λ, introducing a negative payroll tax (i.e., a payroll subsidy) unambiguously improves welfare as long as $u'(w)\geq 1$. Since, by assumption, $u'(v)>1+\lambda$, there exists a sufficiently low $w>v$ such that $u'(w)\geq 1$.[22] The wage will be below this threshold level if β is sufficiently low. A higher β will reduce the utility gain of redistributing income towards employed workers through a payroll subsidy, possibly making it negative (if $u'(w)<1$). On the other hand, a higher β makes payroll subsidies a more potent instrument for reducing welfare distortions due to suboptimal levels of job creation, dismissal rates and technology choices. With reasonable assumptions on $u(\cdot)$, it seems entirely likely that the latter effects will be the dominant ones, implying that the introduction of a payroll subsidy is welfare improving, unless the opportunity cost of public funds is too high.

By a similar procedure, the introduction of a small unemployment benefit has the following effect on social welfare:

$$
\begin{aligned}
\left.\frac{dW}{db}\right|_{t=b=c=0} &= \widehat{I}\int_{\widehat{\varepsilon}}^{1}\left[u'(w)-1\right]f(\varepsilon)\,d\varepsilon+\left(1-\widehat{I}\left[1-F(\widehat{\varepsilon})\right]\right)\left[u'(v)-1\right] \\
&-\lambda\left(1-\widehat{I}\left[1-F(\widehat{\varepsilon})\right]\right)+\int_{\widehat{\varepsilon}}^{1}\left[u(w)-u(v)\right]f(\varepsilon)\,d\varepsilon\frac{d\widehat{I}}{db} \\
&-\widehat{I}\beta\phi\int_{\widehat{\varepsilon}}^{1}\left[u'(w)\right]f(\varepsilon)\,d\varepsilon\frac{d\widehat{\varepsilon}}{db}+\widehat{I}\int_{\widehat{\varepsilon}}^{1}\left[u'(w)\right]\beta(\varepsilon-\widehat{\varepsilon})\,f(\varepsilon)\,d\varepsilon\frac{d\phi}{db}. \qquad (47)
\end{aligned}
$$

The first term has an ambiguous sign, the second term is positive, while the remaining terms are negative. The overall effect is positive if β is sufficiently small, making the sum of the first three

[22] Notice that $u'(w)\geq 1$ is a sufficient but not necessary condition for the second term in (46) to be non-positive.

terms positive while making last three terms arbitrarily close to zero.[23] Thus, the introduction of unemployment benefits is more likely to be welfare improving if workers' bargaining power is low. This may appear somewhat counterintuitive, since a low β implies a low income difference between employed and unemployed workers, which reduces the need to insure against unemployment. The main implication of this result is that unemployment benefit is not primarily an instrument to redistribute income from employed to unemployed workers, but rather an instrument to redistribute income from firms to workers (employed and unemployed). The reason is that higher unemployment benefits not only increase the income of unemployed workers, but also lift the wages of employed workers proportionally (cf. (5)). Introducing unemployment benefits to redistribute income from firms to workers is welfare improving if workers have low bargaining power, since in this case the utility gain of redistribution is large while the distortions of job creation, dismissal rates and technology choices due to unemployment benefits are small.

Finally, the welfare effect of introducing a small layoff tax is given by

$$\begin{aligned}\left.\frac{dW}{dc}\right|_{t=0,b=0,c=0} &= \lambda\widehat{I}F(\widehat{\varepsilon}) + \left[\int_{\widehat{\varepsilon}}^{1}[u(w)-u(v)]\,f(\varepsilon)\,d\varepsilon\right]\frac{d\widehat{I}}{dc} \\ &\quad - \left[\widehat{I}\beta\phi\int_{\widehat{\varepsilon}}^{1}u'(w)\,f(\varepsilon)\,d\varepsilon\right]\frac{d\widehat{\varepsilon}}{dc} + \left[\widehat{I}\int_{\widehat{\varepsilon}}^{1}u'(w)\,\beta(\varepsilon-\widehat{\varepsilon})\,f(\varepsilon)\,d\varepsilon\right]\frac{d\phi}{dc}. \quad (48)\end{aligned}$$

Due to a positive opportunity cost of public funds, this expression will be positive for a sufficiently small value of β. In the limit $\beta \to 0$, the introduction of a (small) layoff tax will have a purely fiscal effect (which is welfare-positive for $\lambda > 0$) without creating any welfare distortions. However, even for high values of β we cannot unambiguously conclude that the welfare effect of introducing layoff taxes is negative, since such a tax will reduce distortions caused by suboptimal technology choices and dismissal policies, while increasing the welfare distortion caused by suboptimal job creation.

We summarise the above analysis as follows:

Proposition 7 *If workers' bargaining power is sufficiently small, the introduction of a small*

[23] Notice that the first three terms in (47) can be rewritten as

$$\widehat{I}\int_{\widehat{\varepsilon}}^{1}[u'(w)-(1+\lambda)]\,f(\varepsilon)\,d\varepsilon + \left(1-\widehat{I}+\widehat{I}F(\widehat{\varepsilon})\right)[u'(v)-(1+\lambda)] + \lambda\widehat{I}(1-F(\widehat{\varepsilon})).$$

For a sufficiently low β, w is sufficiently close to v such that the assumption $u'(v) > 1+\lambda$ ensures that all three terms are positive.

unemployment benefit or a small layoff tax will always be welfare improving. If, in addition, the opportunity cost of public funds is sufficiently small, the introduction of a small payroll subsidy will also be welfare improving.

3.2.2 Numerical simulations of the optimal policy

Due to the complexity of the model, we must resort to numerical simulations in order to explicitly describe the second-best policy. Suppose that worker productivity is distributed according to $\varepsilon \sim U[0,1]$, implying $f(\varepsilon) = 1$ and $F(\varepsilon) = \varepsilon$. Suppose further that a worker's utility of income x is given by $u(x) = a\sqrt{x}$, where $a > 0$. With these assumptions, aggregate utility, profits and net government revenue (all in expected terms) are given by

$$U = \frac{2a\widehat{I}(1+t)}{3\beta\phi}\left[\left(v+b+\frac{\beta\phi(1-\widehat{\varepsilon})}{1+t}\right)^{\frac{3}{2}} - (v+b)^{\frac{3}{2}}\right] + \left(1-\widehat{I}(1-\widehat{\varepsilon})\right)a(v+b)^{\frac{1}{2}}, \tag{49}$$

$$\Pi = \widehat{I}\left[\frac{(1-\beta)\phi(1-\widehat{\varepsilon}^2)}{2} + [\beta\phi\widehat{\varepsilon} - (v+b)(1+t)](1-\widehat{\varepsilon}) - \frac{\psi}{2}\phi^2 - \widehat{\varepsilon}c\right] - \frac{k}{2}\widehat{I}^2, \tag{50}$$

$$G = t\widehat{I}\left[\frac{\beta\phi(1-\widehat{\varepsilon}^2)}{2(1+t)} + \left(v+b-\frac{\beta\phi\widehat{\varepsilon}}{1+t}\right)(1-\widehat{\varepsilon})\right] + c\widehat{I}\widehat{\varepsilon} - \left(1-\widehat{I}(1-\widehat{\varepsilon})\right)b. \tag{51}$$

In Table 1 we report the optimal solution simulated for 21 different parameter configurations.[24] As a base case we use the configuration $a = 1.5$, $\lambda = 0.5$, $\psi = 0.3$, $k = 0.21$, $\beta = 0.3$ and $v = 0.1$. This base case is shown in the horizontal lines with bold types in the table. In each of the 5 sections of the table, one of the key parameters (a, λ, ψ, k and β) is varied (shown in bold type) around the base case value.[25] In addition to the optimal tax variables (t^*, c^* and b^*), equilibrium values (in the second-best solution) are shown for technology (ϕ), dismissal rate ($\widehat{\varepsilon}$), job creation ($\widehat{I}$) and total employment (L).[26]

[Table 1 about here]

[24] The simulations are made using the General Algebraic Modeling System (GAMS). Further details are available upon request.

[25] All parameter configurations are chosen to make sure that the assumption of $u'(v) > 1+\lambda$ is satisfied. With our chosen utility function, this condition reduces to $\frac{a}{2\sqrt{v}} > 1+\lambda$.

[26] In line with our model assumptions, we impose the restrictions $b \geq 0$ and $c \geq 0$ in the numerical simulations of the second-best solution.

Some general patterns can be detected from these simulations. For a large subset of the parameter configurations, the optimal policy involves payroll subsidies rather than payroll taxes. The exceptions are cases with a sufficiently low value of a, ψ or k, or a sufficiently high value of λ. Recall that the use of payroll subsidies leads to higher employment (due to more job creation and fewer dismissals) and higher worker income (due to more technology investments and higher bargained wages). A low a implies a low welfare weight on worker utility, which consequently reduces the planner's incentive to use payroll subsidies in order to increase worker income. Furthermore, if the opportunity cost of public funds (λ) is sufficiently high, it is too costly to subsidise employment and the optimal policy involves a positive payroll tax instead. Finally, low costs of technology investments or job creation (i.e., low values of ψ or k) imply that job creation is high in equilibrium. This means that the welfare gain of stimulating (further) job creation by using payroll subsidies is correspondingly low. However, in all other cases, the optimal second-best policy implies that payroll subsidies are used to stimulate technology investments and job creation, and to secure a higher income level for workers.

Another observation we can make is that the use of a layoff tax is part of the optimal policy only for a quite small subset of all parameter configurations. More specifically, $c^* > 0$ only for sufficiently low values of ψ, k or β. Notice that in all of these cases, incentives for job creation are sufficiently strong to induce a corner solution with $\widehat{I} = 1$. Thus, if the cost of technology or job creation is sufficiently low, or if workers' bargaining power is sufficiently low, layoff taxes can be used to stimulate technology investments without harming job creation. Otherwise, the detrimental effect of layoff taxes on job creation outweighs the positive effect on technology investment and it is better, in terms of social welfare, to stimulate technology investments only by using payroll subsidies.

We can also identify the cases where the optimal policy package is characterised by *flexicurity*, which we here define as the combination of $c^* = 0$ and $b^* > 0$. This occurs for a sufficiently high value of a, ψ, k or β, or a sufficiently low value of λ. The most interesting cases are the ones where either technology investment or job creation is very costly (i.e., where ψ or k is high), or where the relative bargaining power of workers (β) is high. These cases are all associated with high levels of unemployment in equilibrium, which increases the welfare gain of unemployment benefits. At the same time, the strong welfare incentives to stimulate job creation in these cases preclude the use of layoff taxes as part of the optimal policy. Consequently, the optimal policy is a flexicurity package, where unemployment benefits are given in order to raise the income level of unemployed workers, while firing costs are kept at the minimum level in order to stimulate job creation.

Notice, however, that a flexicurity policy is always optimally combined with payroll subsidies. The major drawback of flexicurity is that it provides relatively weak incentives for technology investments. This drawback applies to both elements of the flexicurity package, as higher unemployment benefits and lower employment protection both contribute to worsening firms' incentives for technology investments (cf. Proposition 2). A flexicurity policy is therefore optimally combined with payroll subsidies, which stimulate technology investments and thus (partly) correct for the above-mentioned negative effect of flexicurity. Thus, in our setting it seems that the scope for flexicurity as an optimal policy is limited to cases where the government has access to other income, for example resource rents, in order to finance the full policy package.

4 Concluding remarks

Our basic framework has been one of labour market matching and ex post wage bargaining. Differently from Blanchard and Tirole (2008) we have emphasised the role of job creation and technology adoption. The normative question has been how a government jointly should decide on labour market institutions, such as a tax to regulate firing costs and unemployment insurance, in conjunction with a tax on labour earnings, more precisely a payroll tax. A basic problem in such a setting is that there is underinvestment in job creation and technology.[27] A low payroll tax or perhaps even jobs subsidies can to some extent alleviate this problem.

Flexicurity policy is often taken to imply that firing costs are reduced while unemployment insurance is generous. When it comes to reducing a possible layoff tax, this could or could not be part of optimal policy. Low firing costs mean that the productivity cut-off to be retained in the firm goes up - and this reduces incentives to invest in technology. Low firing costs, though,

[27] This is akin to Manning's (1987) well-known argument that even when union bargaining is so-called efficient (meaning that one bargains both over wage and employment level) this can still lead to underinvestment when investment decisions are taken before the bargaining process opens.

is also shown to be beneficial for job creation. The effect on total employment is ambiguous: more jobs are created, but a lower percentage of workers are retained due to lower technology investments that upgrade productivity. Lowering layoff taxes also use up public funds, and public funds are scarce. An alternative use of public funds is to lower the payroll tax, something which directly attacks the underlying problem of job creation and also stimulates technology investments. Whether or not optimal policy in our model contains low layoff taxes depends on parameter values. A tax on layoffs is optimal if there are already sufficiently strong incentives for job creation and technology investments in the economy, for example if workers' bargaining strength is relatively low.

Unemployment insurance is problematic in the current context. Workers are risk-averse, so to provide some insurance against low income is of value. But unemployment insurance is not a particularly good instrument to even out income between employed and unemployed workers. This is because good unemployment insurance betters the bargaining situation of employed workers and drive up their wages as well. What unemployment insurance does, though, is to redistribute from entrepreneurs to the entire working population. This might sound fine if one is not an entrepreneur, but the problem is that job creation is hurt and technological progress is slowed down.

The model is quite rich and optimal policy depends on a whole array of parameters. But we start to realise why optimal policy often does not resemble what policy-makers refer to as flexicurity. If we define flexicurity as the case where the layoff tax is zero while unemployment benefits are positive, this only occurs when a jobs subsidy replaces the payroll tax. The main problem is the unemployment insurance leg of flexicurity. Unemployment insurance insures, but also creates disincentives for job creation and technology adoption, and costs public money. This money could alternatively have been used to bring down labour taxation. Especially, when the alternative cost of public funds is high, flexicurity is not optimal. Our results are complex, so we should refrain from oversimplification. But one could perhaps still hint that in situations where firms and workers are locked into employment relationships and bargain over the division of a jointly created surplus, job creation policy (that is, low taxes on the employed) could be equally important as flexicurity policy.

Appendix

The equilibrium values of job creation, dismissal rates and technology choices are given by

$$\widehat{\varepsilon}\phi = (1+t)(v+b) - c, \tag{A1}$$

$$\phi\psi = (1-\beta)\int_{\widehat{\varepsilon}}^{1} \varepsilon f(\varepsilon)\, d\varepsilon, \tag{A2}$$

$$\widehat{I} = \frac{1}{k}\left(-cF(\widehat{\varepsilon}) + \int_{\widehat{\varepsilon}}^{1}((1-\beta)(y-(1+t)(v+b)) - \beta c) f(\varepsilon)\, d\varepsilon - \frac{\psi}{2}\phi^2\right). \tag{A3}$$

These three equilibrium conditions implicitly define $\widehat{\varepsilon}, \phi$ and $\widehat{I}$ as functions of (c, b, t). From the (A1) and (A2) we obtain

$$\begin{aligned}
\frac{d\phi}{dt} &= \frac{(v+b)(1-\beta)\widehat{\varepsilon} f(\widehat{\varepsilon})}{(1-\beta)\widehat{\varepsilon}^2 f(\widehat{\varepsilon}) - \phi\psi} < 0, && \text{(A4)}\\
\frac{d\phi}{db} &= \frac{(1+t)(1-\beta)\widehat{\varepsilon} f(\widehat{\varepsilon})}{(1-\beta)\widehat{\varepsilon}^2 f(\widehat{\varepsilon}) - \phi\psi} < 0, && \text{(A5)}\\
\frac{d\phi}{dc} &= \frac{-(1-\beta)\widehat{\varepsilon} f(\widehat{\varepsilon})}{(1-\beta)\widehat{\varepsilon}^2 f(\widehat{\varepsilon}) - \phi\psi} > 0, && \text{(A6)}\\
\frac{d\widehat{\varepsilon}}{dt} &= \frac{-\psi(v+b)}{(1-\beta)\widehat{\varepsilon}^2 f(\widehat{\varepsilon}) - \phi\psi} > 0, && \text{(A7)}\\
\frac{d\widehat{\varepsilon}}{db} &= \frac{-\psi(1+t)}{(1-\beta)\widehat{\varepsilon}^2 f(\widehat{\varepsilon}) - \phi\psi} > 0, && \text{(A8)}\\
\frac{d\widehat{\varepsilon}}{dc} &= \frac{\psi}{(1-\beta)\widehat{\varepsilon}^2 f(\widehat{\varepsilon}) - \phi\psi} < 0, && \text{(A9)}
\end{aligned}$$

while from (A3) we get (using the fact that $\frac{\partial \widehat{I}}{\partial \widehat{\varepsilon}} = \frac{\partial \widehat{I}}{\partial \phi} = 0$):

$$\begin{aligned}
\frac{d\widehat{I}}{dt} &= -\frac{1}{k}(1-\beta)(v+b)[1-F(\widehat{\varepsilon})] < 0, && \text{(A10)}\\
\frac{d\widehat{I}}{db} &= -\frac{1}{k}(1-\beta)(1+t)[1-F(\widehat{\varepsilon})] < 0, && \text{(A11)}\\
\frac{d\widehat{I}}{dc} &= -\frac{1}{k}(F(\widehat{\varepsilon}) + \beta[1-F(\widehat{\varepsilon})]) < 0. && \text{(A12)}
\end{aligned}$$

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Table 1: Optimal labour market policies

	a	λ	ψ	k	β	t^*	c^*	b^*	ϕ	$\widehat{\varepsilon}$	$\widehat{I}$	L
	1.00	0.5	0.3	0.21	0.3	0.14	0	0	1.16	0.10	0.61	0.55
	1.25	0.5	0.3	0.21	0.3	−0.04	0	0	1.16	0.08	0.67	0.61
(1)	**1.50**	**0.5**	**0.3**	**0.21**	**0.3**	**−0.22**	**0**	**0**	**1.16**	**0.07**	**0.72**	**0.67**
	1.75	0.50	0.3	0.21	0.3	−0.40	0	0.03	1.16	0.07	0.73	0.68
	2.00	0.50	0.3	0.21	0.3	−0.53	0	0.10	1.16	0.08	0.68	0.62
	1.50	**0**	0.3	0.21	0.3	−0.64	0	0.11	1.16	0.06	0.73	0.69
	1.50	**0.25**	0.3	0.21	0.3	−0.44	0	0.01	1.16	0.05	0.78	0.74
(2)	**1.50**	**0.5**	**0.3**	**0.21**	**0.3**	**−0.22**	**0**	**0**	**1.16**	**0.07**	**0.72**	**0.67**
	1.50	**0.75**	0.3	0.21	0.3	−0.04	0	0	1.16	0.08	0.67	0.61
	1.50	**1.00**	0.3	0.21	0.3	0.11	0	0	1.16	0.10	0.62	0.57
	1.50	0.5	**0.1**	0.21	0.3	2.28	0.35	0.01	3.50	0.03	1.00	0.98
	1.50	0.5	**0.2**	0.21	0.3	0.39	0.01	0	1.74	0.08	1.00	0.92
(3)	**1.50**	**0.5**	**0.3**	**0.21**	**0.3**	**−0.22**	**0**	**0**	**1.16**	**0.07**	**0.72**	**0.67**
	1.50	0.5	**0.4**	0.21	0.3	−0.41	0	0.06	0.86	0.11	0.43	0.38
	1.50	0.5	**0.5**	0.21	0.3	−0.51	0	0.10	0.69	0.15	0.28	0.24
	1.50	0.5	0.3	**0.09**	0.3	0.20	0.06	0.02	1.16	0.08	1.00	0.92
	1.50	0.5	0.3	**0.15**	0.3	−0.20	0	0	1.16	0.07	1.00	0.93
(4)	**1.50**	**0.5**	**0.3**	**0.21**	**0.3**	**−0.22**	**0**	**0**	**1.16**	**0.07**	**0.72**	**0.67**
	1.50	0.5	0.3	**0.27**	0.3	−0.26	0	0.03	1.16	0.08	0.52	0.48
	1.50	0.5	0.3	**0.33**	0.3	−0.29	0	0.05	1.16	0.09	0.40	0.36
	1.50	0.5	0.3	0.21	0	−0.16	0.11	0.15	1.67	0.06	1.00	0.94
	1.50	0.5	0.3	0.21	**0.1**	−0.17	0.04	0.07	1.49	0.06	1.00	0.94
(5)	**1.50**	**0.5**	**0.3**	**0.21**	**0.3**	**−0.22**	**0**	**0**	**1.16**	**0.07**	**0.72**	**0.67**
	1.50	0.5	0.3	0.21	**0.5**	−0.38	0	0.07	0.82	0.13	0.27	0.23
	1.50	0.5	0.3	0.21	**0.7**	−0.57	0	0.14	0.48	0.21	0.05	0.04

In all simulations: $v = 0.1$