How labor regulation affects innovation and investment: A *neo*-Schumpeterian approach.

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Abstract

Theoretical and empirical models provide ambiguous responses on the relationship between labor regulation, innovation and investment. Labor regulation tends to raise firms' adjustment costs. But, also, labor regulation stimulates firms to make innovations and investment to recover productivity in the long-run. In this paper we present a neo-Schumpeterian endogenous growth model, which explains how these opposite forces operate over time, and why a stricter labor regulation may positively affect innovation and investment.

Key words: Endogenous growth model; Labor regulation; Innovation, Investment.

JEL Code: O4; J5.

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1 Introduction

In this paper we address the question of how labor regulation affects innovation and investment in the long-run. This issue is not new in the economic literature. The current debate identifies two main opposite effects (Acemoglu, 1998; Nickell and Layard, 1999; Blanchard, 2000; Alesina et al., 2014; Pessoa and Van Reenen, 2014; Griffith and Macartney, 2014). On the one hand, labor regulation increases the firms' adjustment costs of labor and capital, depressing innovation. On the other hand, a stricter labor regulation may stimulate firms to innovate and invest to recover productivity and profits in the long-run. We focus on the economic impacts of these opposite forces and attempt to identify the favorable conditions which enable firms to enhance innovation and investment in the long run.

In the present model, innovation, investment and labor regulation are not regarded as distinct casual factors but as three aspects of the same process. An important share of innovation is embodied in new investment goods and labor regulation determine the costs to invest and innovate. Further, labor regulation may increase firing costs, but may also stimulate firms to innovate in order to recover productivity in the long run. Our aim is to explain how these forces influence each other. Specifically, following Romer (1990, 2006), Grossman and Helpman (1991) and Aghion and Howitt (1992, 2009), we build up an *augmented neo-Schumpeterian* model of economic growth: since any change in labor regulation modifies the costs and the incentives in doing innovations and investments, the pattern of economic growth crucially depends on how labor policies and firm's decisions interact over time. With this integrated approach in mind, we attempt to highlight the mechanisms whereby a stricter employment protection legislation (EPL) either depresses or stimulates the accumulation of innovation and capital.[1]

Our paper is also related to a recent literature that connects labor policies with measured total factor productivity (TFP) differences across countries (Lagos, 2006; Chari *et al*, 2008; Saltari and Travaglini, 2008) or within a country (Pessoa and Van Reenen, 2014). In the former literature, the selection effect – i.e., firms with lower productivity stay in the market when firing is costly – implies that firing costs make less efficient matches, reducing average TFP. However, while our model preserves the negative impact

[1] The EPL is an index computed by OECD which measures the procedures and costs involved in dismissing individuals or groups of workers, and the procedures involved in hiring workers on fixed-term or temporary work agency contracts.

of EPL on firms' adjustment costs, which may lead to underinvestment, a higher EPL may have the opposite effect to stimulate innovation, making the comparison of the relationship between TFP and EPL across countries less straightforward (Chari *et al.*, 2008).[2]

Empirical evidence about this issue seems rather inconclusive. Figure 1 shows the scatter between the level of measured TFP (relative to U.S.) and the EPL index for the main European countries, in 1992 and 2013, that is before and after deregulation in labor market. The comparison of the two graphs reveal the existence of a either positive or negative unconditional correlation (if any) between the variables. Looking at the pictures we are tempted to interpret the observed correlation as the result of the interaction between changes in labor regulation and in technology progress. This controversial evidence opens the question of whether labor market rigidity tends either to reduce or to increase the incentives to innovate and invest in the long-run. Our aim is to shed some new light on this crucial issue.

Our model has three distinctive features. First, we use a two sector model where a share of capital and labor is employed to make innovation. Second, labor regulation affects both the firing cost of labor and the adjustment costs of capital. Third, the reservation productivity at which firms decide to innovate, and which affects the TFP growth rate, depends on labor regulation.

We show that the resolution of this trade-off – that is a higher adjustment cost *versus* a greater incentive to innovate – depends on the parameters capturing the firm's rents generated by innovation relative to the additional costs induced by labor regulation. When the cost of labor regulation is small enough *relative* to productivity, that is, below some endogenous threshold, there is great scope to innovate and to enhance investment. In the opposite case, where the cost of labor regulation is above the critical endogenous threshold, the firms cut innovation and investment shifting economy towards a less productive steady state. Mainly, a crucial implication of our model is that a stricter EPL can stimulate innovation just as more innovation stimulates output by raising the productivity growth. The two processes are strictly related. Therefore, in our model there are scenarios where a *more* flexible labor market can depress innovation (and investment) slowing down technology progress in the long run.

[2]In a within-country perspective, Pessoa and Van Reenen (2014) analyze the fall of UK productivity from 2008, and address as possible reason for poor productivity the low growth in the effective capital-labour ratio, which was likely occurred because there has been a fall in real wages and increases in the cost of capital due to the financial crisis

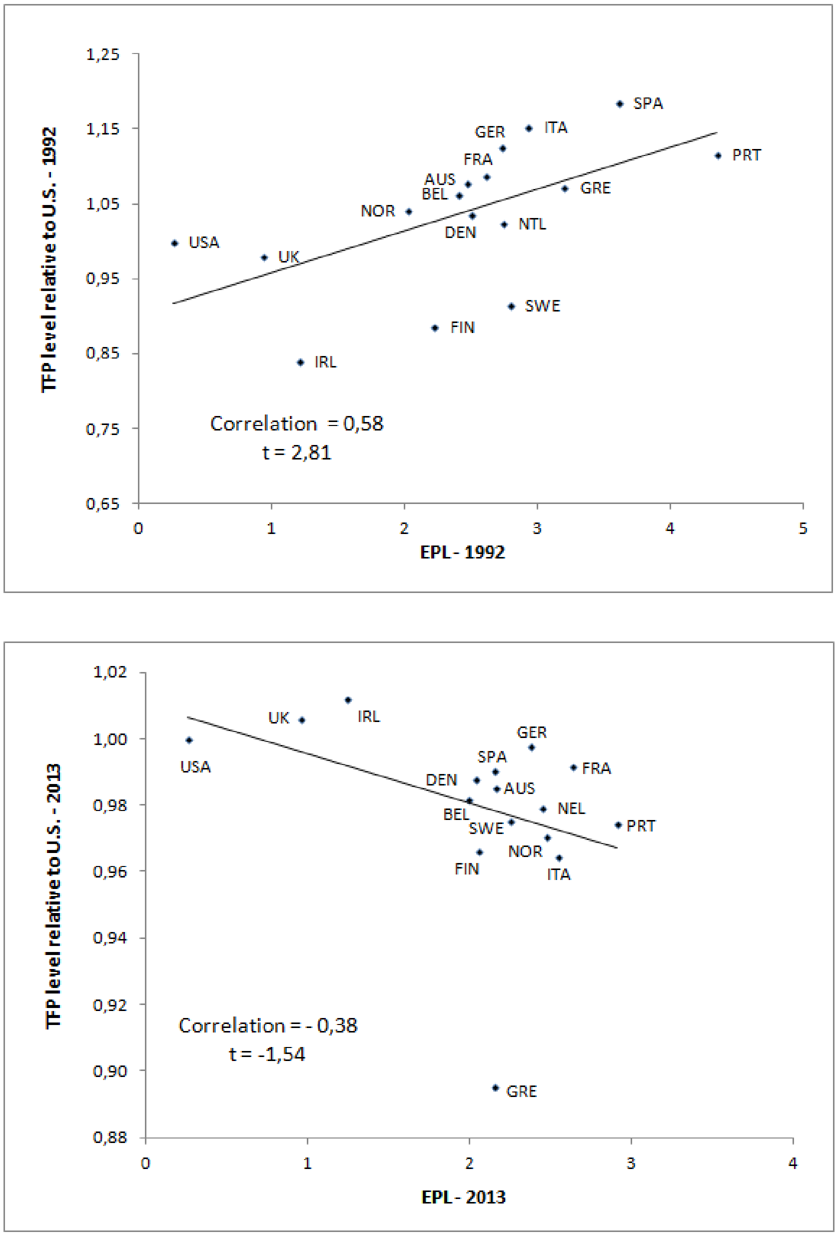

Figure 1: Employment Protection and Measured TFP.

In the second part of the paper we evaluate the robustness of the model running a VAR analysis to test how changes in labor regulation, investment and innovation affect the short and long-run dynamics of the economy. The impulse responses of Italy, Germany and France are studied. The baseline evidence show that investment and innovation can be either complements or substitutes, and that changes in labor regulation have heterogeneous impacts on investment and innovation of the three economies. In Italy, the effect of a milder labor regulation is substantially *negative* for investment and innovation at all horizons. In Germany, it is *positive* for investment and *negligible* for innovation in the long run. In France, it is basically *positive* both in the short and long run. Therefore, the deeper significance of our theoretical and empirical analysis is that how labor regulation affects (the growth rate of) innovation and investment depends crucially on the ability of the economic system to extract productivity from technology, and ultimately on the relationship between *all* costs and *all* revenues of economic activity not only those resulting from the use of labor.

The paper is organized as follows. Section 2 presents the current literature on the issue. Section 3 lays down the foundations of the model whose dynamic properties, and some important implications of the model, are studied in Section 4. Section 5 presents the VAR model and the analysis of the impulse response functions. Section 6 concludes.

2 Literature

Four types of arguments are usually advanced to argue in favor of a *negative correlation* between labor regulation, innovation and investment. Firstly, labor rigidity reduces the capacity of firms to reallocate workers after adverse shocks from declining sectors to new and more dynamic ones (Bentolila and Bertola, 1990; Hopenhayn and Rogerson, 1993; Nickell and Layard, 1999), and this stickiness can slowdown economic activity (Denny and Nickell, 1992; Calcagnini et al. 2009, 2014). Recent estimates show that stricter EPL leads to lower innovation intensity in industries with a higher job reallocation propensity, and that the use of temporary contracts has a stronger impact on innovation intensity than the strictness of employment protection for regular contracts (Griffith and Macartney, 2014). Secondly, the firing costs can hamper the decisions of firms to invest in new labor-saving innovations, pushing either an industry or a firm toward sectors where technology advances slowly and demand is stable (Bassanini and Ernest, 2002; Scarpetta and Tressel, 2004; Saint-Paul, 2002). Interestingly, theoretical models on labor regulations and international specialization also suggest that countries with lower labor flexibility specialize in incremental innovation ,while new products are mainly produced in countries with higher labor flexibility (Saint-Paul, 1996, 2002). Thirdly, there is the possibility that in a rigid labor market workers tend to appropriate rents generated by innovative process, thus reducing the incentive of firms to adopt new technology and take new investment risks (James and Malcolmson, 1997; Metcalf, 2002). Among these, some authors (Ichino and Riphahn, 2005) assert that a lower EPL may positively affect labor productivity, but not innovation, through the reduction of absenteeism. Finally, labor rigidity can reduce, at country level, the skill premium of workers (Acemoglu, 1998), and, if innovations are labor-saving, economies with more stringent labor regulation, which are binding for low skilled workers, become less technologically advanced in their high-skilled sectors, and more technologically advanced in their low-skilled sectors (Alesina *et al.* 2014). Altogether these contributions assert that labor regulation and innovation move in the opposite direction, i.e. there is a negative correlation between them.

This result is however not conclusive, and many other studies reveal the existence of a *positive correlation* between labor regulation and innovation. A broad literature exists. A traditional explanation regards the possibility that a higher labor cost (also induced by a stricter labor regulation) stimulates firms to adopt labor-saving innovations (Sylos Labini 1984, 1993, 1999). According to this literature, the dynamic substitution between capital and labor differs from static substitution and provides a way to explain how technology advancement passes through new capital goods (Kaldor, 1957; Saltari and Travaglini, 2006, 2009; Calcagnini G, G. Giombini e G. Travaglini, 2015). Further, in a *neo*-Schumpeterian perspective "the flexibilitation of the wage-formation process will give an extra competitive option to non-innovative firms" (Kleinknecht, 1998, p.394). Indeed, wage flexibility tends to increase the chance of less innovative firms to survive in a competitive market paying a lower wages (Antonucci and Pianta, 2002). But, while in the short run their survival is favorable for employment, it will depress productivity and innovation with eventually a negative impact on employment. In addition, it can be shown that wage moderation tends to slowdown the replacement of old capital with new one, depressing productivity as time passes (Naastepad and Kleinknecht, 2004). Finally, flexible labor and wage moderation can depress aggregate demand. This is the well known Verdoon–Kaldor law which links demand growth to productivity growth (Verdoon 1949; Kaldor, 1957, 1966).

Notice that these traditional explanations do not exhaust the reasons for a positive correlation between labor regulation and innovation. One additional explanation regards the impact of flexibility on training and human capital. When (expected) labor duration is short "firms have little incentives to invest in workforce training, simply because the payback period is too short" (Lucidi and Kleinknecht, 2010). Similar incentives render workers reluctant to acquire skills since they anticipate the absence of any commitment with the employers (Belot *et al.*, 2007). Therefore, a high flexibility may cause under-investment in training with negative impacts on innovation and productivity. According to this view, labor flexibility in the form of temporary workers display on average a lower level of general and firm specific human capital. Firms with a high labor turnover may lack of knowledge of markets and this could weaken their innovation. Similar phenomenon of lack in workplace cooperation, and subsequent non cooperative relationship between workers and management may negatively affect innovative activities and firm performance (Buchele and Christiansen 1999; Huselid, 1995; Lorenz, 1999; Naastepad and Storm, 2005). Asymmetric information can induce further problems when the effort of workers is not perfectly observable. In this case, fixed term workers can be particularly prone to exert low level of effort if they expect to be fired at the end of their contract (Bentolila and Dolado, 1994).

Finally, an interesting implication is emphasized by Acharya *et al.* (2013). They observe that "innovation and firm creation are indeed fostered by laws that limit firms' ability to *ex post* discharge their employees at will. Thus, we surmise that employment protection laws present a trade-off: while they may cause *ex post* inefficiencies in the labor market [. . .], they can have positive *ex ante* effects by fostering innovation and entrepreneurship" (Acharya et al., 2013, p.5). They conclude that labor regulation is an important part of the "policy toolkit for promoting innovation and possibly economic growth" (p.42). Similar empirical results, but for other countries, are also find by Michie and Sheehan (2003), Boeri and Garibaldi (2007), Pieroni and Pompei (2008), Antonioli et al. (2010), Acharya et al. (2012) and Pini (2014).

In the next Section, we will contribute to this debate presenting a model of endogenous growth in which the correlation between labor regulation and innovation may be positive in the long-run.

3 The model

The present model builds on the *neo*-Schumpterian growth model of Romer (1990, 2006), Grossman and Helpman (1991) and Aghion and Howitt (1992, 2009). There is much evidence that capital accumulation improves technology progress and productivity (DeLong and Summers, 1991; Aghion and Howitt, 1992). Also there is evidence that the innovative sector of the economy is highly capital intensive (Jones, 1998), and that labor regulation affects innovation and investment (Kleinknecht, 1998; Saltari and Travaglini, 2006, 2009; Griffith and Macarteney 2014; Vindigni *et al.*, 2015). Therefore, it is important to extend previous innovation-based Schumpeterian growth models to include the effect of changes in labor regulation on innovation and investment.

To study this issue we introduce in the present model a shift parameter called z, that captures variations in the degree of rigidity in the labor market. We may think to this parameter as the EPL index. Our aim is to study the long run effects of changes in z on innovation and investment.

3.1 Output

We use a two-sector model. In one sector, output is produced; in the other, innovation is done. We assume that the saving rate is given, and that innovations depend on both current technology and capital per worker used in the innovative sector. Finally, we assume that the share of capital and labor employed to produce output and innovation are exogenous and constant.

The aggregate output produced at time t is

$$Y_t = [(1 - b_K) K_t]^{\alpha} [A_t (1 - b_L) L_t]^{1-\alpha} \tag{1}$$

with $0 < \alpha < 1$. The fractions $(1 - b_K) < 1$ and $(1 - b_L) < 1$ define the quantity of capital and labor used to produce output. A_t is the stock of innovation (technology) at the time t. We may think to this parameter as the TFP index.

Our model incorporates both the possibility of positive and negative correlation. We assume that: (i) a stricter labor regulation may encourage firms to innovate and invest in order to recover productivity; (ii) a stricter labor regulation may increase the firing costs of labor and the adjustment costs of investment, undermining the firm's rents which come out from new investments. The combination of these opposite forces determines the effective pattern of innovation in the long-run.

3.2 Innovation

Let's start with innovation. In any period t, its growth rate $\dot{A}_t = \frac{dA_t}{dt}$ depends on the quantity of capital and labor engaged to this aim, and on the share of innovative activities which becomes obsolete as new ones arrive. This relationship can be written as

$$\dot{A}_t = \frac{\left[(b_K K_t)^{\beta} (b_L L_t)^{\gamma} A_t^{\theta}\right]^{1+z}}{\omega A^m} \tag{2}$$

We call this equation Schumpeterian because it embodies the force that Schumpeter (1934) called "creative destruction": the innovations that drive economic growth by creating new technologies also destroy previous innovations (and their output) by making them obsolete (Aghion and Howitt, 2009).

In equation (2), the numerator can be seen as a production function of innovation. It has two special characteristics (Romer, 1990). First, it is not assumed to have constant return of scale in capital and labor since $\beta + \gamma \lesseqgtr 1$. Second, the parameter θ captures the effect of the existing technology stock A_t on its current variations. Since, in principle, it may be $\theta \lesseqgtr 1$, the existing stock of innovation has very different impacts on its future production (and costs) and on the long-run properties of the economy.

One crucial respect in which our model departs from its predecessors is that it eschews any distinction between changes in labor regulation and those induced by innovation and investment: a change in z inevitably affects both capital intensity and innovation. We assume that $0 \leqslant z \leqslant 1$: when $z = 0$ labor market is perfectly flexible, while if $z = 1$ it is perfectly rigid. Equation (2) formalizes our *neo*-Schumpeterian viewpoint that a strict labor market regulation gives an extra competitive incentive to firms for creating innovations to enhance productivity. (Schumpeter, 1936; Sylos Labini, 1967; Kleinknecht, 1998; Lucidi and Kleinknecht, 2009; Antonucci and Pianta, 2002; Palley, 2014; Griffith and Macartney, 2014).

Then, in equation (2) the destruction mechanism is captured by the denominator ωA^m, where $0 < \omega < 1$ is the *destruction rate* of innovation. Precisely, ωA^m measures the implicit cost of any creative destruction: the higher is $m > 0$ the higher is the productivity cost coming from destruction of obsolete innovations (and output). This happens because any technology advancement entails a new mix of *quasi*-fixed inputs. We assume that the rate of destruction ω and the coefficient m are constants. However, by making ω and m a positive function of z, the flow of innovation (creation and destruction) strictly depends on the rigidity of labor.

3.3 Investment

We assume that investment follows the rule

$$\dot{K}_t = \frac{sY_t}{\varkappa \left(L_t/K_t\right)^z} \tag{3}$$

where $\dot{K}_t = \frac{dK_t}{dt}$. In equation (3) $\dot{K}_t$ is the growth rate of capital, s the exogenous saving rate, $\left(L_t/K_t\right)^z$ the adjustment cost of capital caused by labor regulation, and $0 < \varkappa < 1$ the parameter that measures the impact of the adjustment cost on investment (Nickell 1986, Saint-Paul 1997, Nickell and Layard 1999, Denny and Nickell 1992, and Calcagnini *et al.* 2009). Depreciation is set to zero for simplicity.

To interpret the adjustment cost, let's assume that a firm uses L_t units of labor and K_t units of capital. Labor regulation causes the firing cost L_t^z. But, this cost is mitigated by the abatement effect K_t^{-z} of capital since an increase in capital intensity K_t/L_t also increase the labor productivity Y_t/L_t (see equation 1), so reducing the *effective* cost of labor regulation. Hence, $\left(L_t/K_t\right)^z$ is the adjustment cost of investment caused by the *quasi*-fixity of labor (Oi, 1962), while $\varkappa \left(L_t/K_t\right)^z$ is the *impact* of the adjustment cost on current investment.

Finally, we close the model assuming that population grows at the exogenous rate

$$\dot{L}_t = nL_t \tag{4}$$

with $n > 0$, and $\dot{L}_t = \frac{dL_t}{dt}$.

4 The steady state equilibrium

Substituting equation (1) in (3) yields

$$\dot{K}_t = \frac{CK_t^{\alpha}\left(A_t L_t\right)^{1-\alpha}}{\varkappa\left(L_t/K_t\right)^{z}} \tag{5}$$

where $C = s\left(1-b_K\right)^{\alpha}\left(1-b_L\right)^{1-\alpha}$. Dividing both sides by K_t we get

$$g_K = \frac{C\left(\frac{A_t L_t}{K_t}\right)^{1-\alpha}}{\varkappa\left(L_t/K_t\right)^{z}} \tag{6}$$

where $g_K \equiv \frac{1}{K_t}\frac{dK_t}{dt}$, and taking logs of both sides, and differentiating with respect to time gives

$$\frac{\dot{g}_K}{g_K} = (1-\alpha)\left(g_A + n - g_K\right) - z\left(n - g_K\right) \tag{7}$$

or

$$\dot{g}_K = \left[(1-\alpha)\left(g_A + n - g_K\right) - z\left(n - g_K\right)\right] g_K \tag{8}$$

where $g_A = \frac{1}{A_t}\frac{dA_t}{dt}$. Thus, g_K is rising if $(1-\alpha)\left(g_A + n - g_K\right) > z\left(n - g_K\right)$, that is if the growth rate of labor intensity in effective units is higher than its adjustment cost. For the same reasons, g_K is decreasing in the opposite case, and constant if $\dot{g}_K = 0$. Notice that, the last addendum of equation (7) directly depends on the parameter z, so the higher is z the smaller is the growth rate $\dot{g}_K$ of investment.

The locus of points where g_K is constant ($\dot{g}_K = 0$) is

$$g_K = n + \frac{1-\alpha}{1-\alpha-z} g_A \tag{9}$$

where $\frac{1-\alpha}{1-\alpha-z}$ is the slope. We have two cases: if $z < 1-\alpha$ then $\frac{1-\alpha}{1-\alpha-z} > 1$; if $z > 1-\alpha$ then $\frac{1-\alpha}{1-\alpha-z} < 0$, while $z = 1-\alpha$ is an indeterminate case. All information are summarized in Figure 2.

When, in the (g_A, g_K) space, the slope is bigger than 1 the locus (9) is an increasing straight line (panel (a) of Figure 2). Above the locus $\dot{g}_K < 0$, whereas $\dot{g}_K > 0$ below of it.

But, when $\frac{1-\alpha}{1-\alpha-z} < 0$ the locus of points where $\dot{g}_K = 0$ has a negative slope. This case is shown in panel (b) of Figure (2), which also shows the dynamics of g_K out of the locus $\dot{g}_K = 0$.

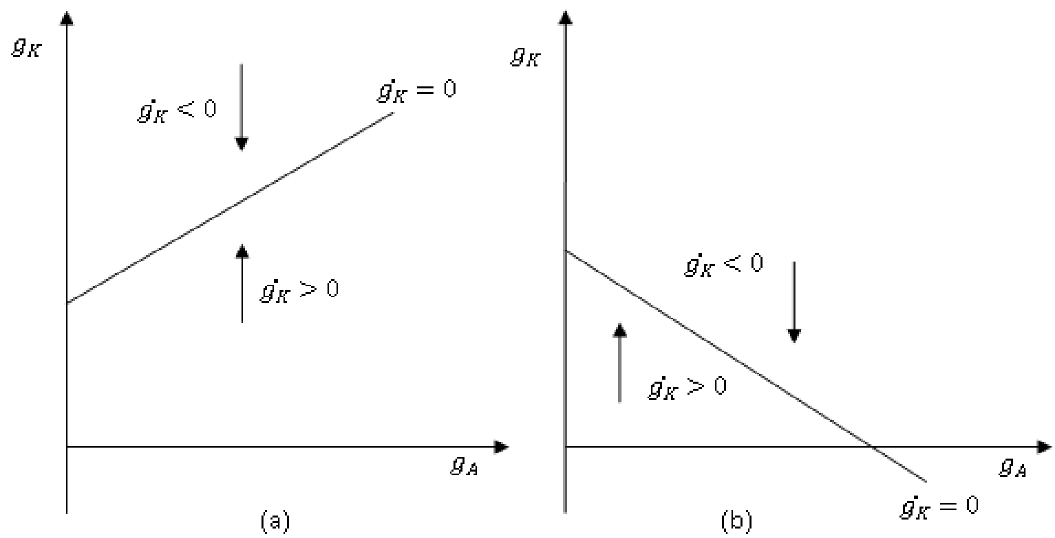

Figure 2: The dynamic of the capital growth rate.

4.1 Innovation

The growth rate of innovation is obtained by equation (2). Dividing it by A_t we get the corresponding growth rate

$$g_A = \frac{DK_t^{\beta(1+z)}L_t^{\gamma(1+z)}A_t^{\theta(1+z)-1}}{\omega A^m} \tag{10}$$

where $g_A \equiv \frac{1}{A_t}\frac{dA_t}{dt}$ and $D = \left(b_K{}^{\beta}b_L{}^{\gamma}\right)^{1+z}$. Taking logs and differentiating with respect to time yields

$$\frac{\dot{g}_A}{g_A} = \beta\,(1+z)\,g_K + \gamma\,(1+z)\,n + [\theta\,(1+z) - 1 - m]\,g_A \tag{11}$$

or

$$\dot{g}_A = [\beta\,(1+z)\,g_K + \gamma\,(1+z)\,n]\,g_A + [\theta\,(1+z) - 1 - m]\,g_A^2 \tag{12}$$

Now, $\frac{\dot{g}_A}{g_A}$ is increasing if the right-hand side of (11) is positive, decreasing if it is negative, and constant if it is zero. This is shown in Figure 3. Precisely, from the condition $\dot{g}_A = 0$ we get the locus

$$g_K = -\frac{\gamma n}{\beta} + \left[\frac{1+m}{\beta\,(1+z)} - \frac{\theta}{\beta}\right]g_A \tag{13}$$

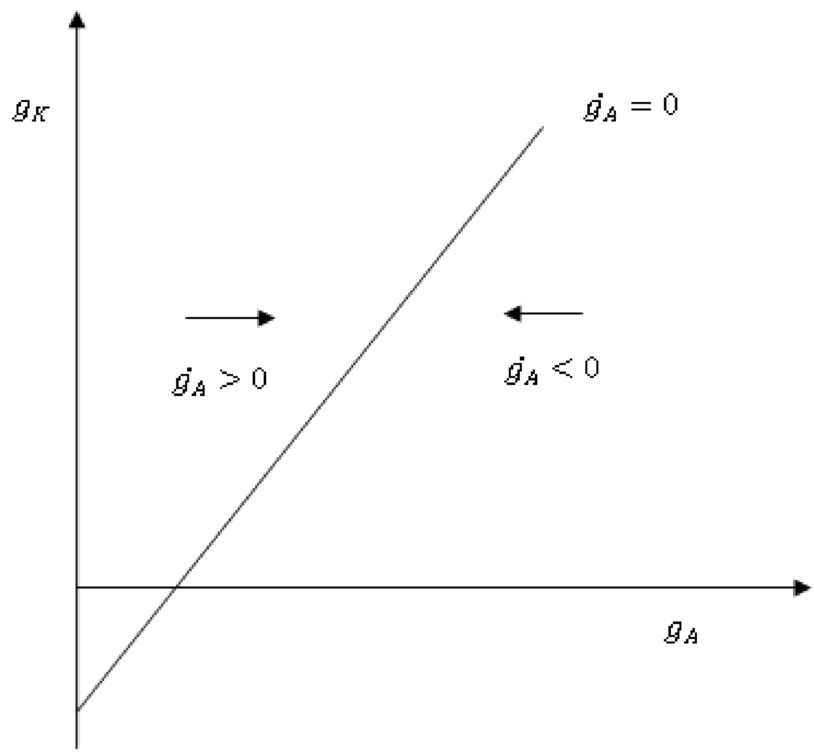

Figure 3: The dynamics of the innovation growth rate when $(\beta + \theta)(1 + z) < 1 + m$

which is a straight line with negative constant $-\frac{\gamma n}{\beta}$ and positive slope $\frac{1+m}{\beta(1+z)} - \frac{\theta}{\beta} > 1$ under the assumption that $(\beta + \theta)(1 + z) - m < 1$. This latter condition must be clarified.

In our model the presence of constant, increasing or decreasing returns to scale depends on the characteristics of equation (2). Indeed, the stock of capital and innovation are the only inputs *made* in the economy, and the first term in equation (2) states that the degree of returns to scale to K_t and A_t is $(\beta + \theta)(1 + z)$. Note that the same condition states that the marginal (destruction) cost of any obsolete innovation is $1 + m$. Therefore, if $(\beta + \theta)(1 + z) - m < 1$ the innovation has decreasing returns; if $(\beta + \theta)(1 + z) + m = 1$ it has constant returns; if $(\beta + \theta)(1 + z) - m > 1$ it has increasing returns to scale. As we will see, this condition determines the stationary property of the model.

To begin with, we start our analysis from the case $(\beta+\theta)(1+z)-m<1$ which assures converge towards the steady state equilibrium.

4.2 Case 1: $(\beta+\theta)(1+z)-m<1$ and $z<1-\alpha$

Our dynamic system is given by equations (8) and (12), and its steady state is

$$\begin{cases} \dot{g}_K=0: \; g_K=n+\frac{1-\alpha}{1-\alpha-z}g_A \\ \dot{g}_A=0: \; g_K=-\frac{\gamma n}{\beta}+\left[\frac{1+m}{\beta(1+z)}-\frac{\theta}{\beta}\right]g_A \end{cases} \tag{14}$$

As said above, under the assumption $(\beta+\theta)(1+z)-m<1$ we get $\frac{1+m}{\beta(1+z)}-\frac{\theta}{\beta}>1$ and the slope of the locus $\dot{g}_A=0$ is positive. Further, we know that along the locus $\dot{g}_K=0$ the slope is positive when $z<1-\alpha$. Thus, convergence requires that $\frac{1+m}{\beta(1+z)}-\frac{\theta}{\beta}>1>\frac{1-\alpha}{1-\alpha-z}$, that is the $\dot{g}_A=0$ locus must be steeper than the locus where $\dot{g}_K=0$. The corresponding phase diagram is shown in Figure 4.

With decreasing returns to scale, the dynamics of the system is globally stable: regardless the value of the initial growth rates of innovation and capital, they converge to the steady state values g_A^* and g_K^* in E in Figure 4

$$g_A^*=\frac{(1+z)(\beta+\gamma)(1-\alpha-z)}{[1+m-\theta(1+z)](1-\alpha-z)-\beta(1+z)(1-\alpha)}n \tag{15}$$

and

$$g_K^*=\frac{(1-\alpha)(1+z)(\beta+\gamma)+(1-\alpha-z)[1+m-\theta(1+z)]-\beta(1+z)(1-\alpha)}{[1+m-\theta(1+z)]-\beta(1+z)(1-\alpha)}n \tag{16}$$

Notice that the steady state values (15) and (16) imply that the growth rates of innovation and capital depend on z, and that, under the assumption $(\beta+\theta)(1+z)-m<1$, the long-run growth rate of innovation is an increasing function of z. Indeed, deriving by z the slopes of the two loci of system (14) we get

$$\frac{\partial \; (slope \; of \; g_K)}{\partial z}=\frac{1-\alpha}{(1-\alpha-z)^2}>0 \tag{17}$$

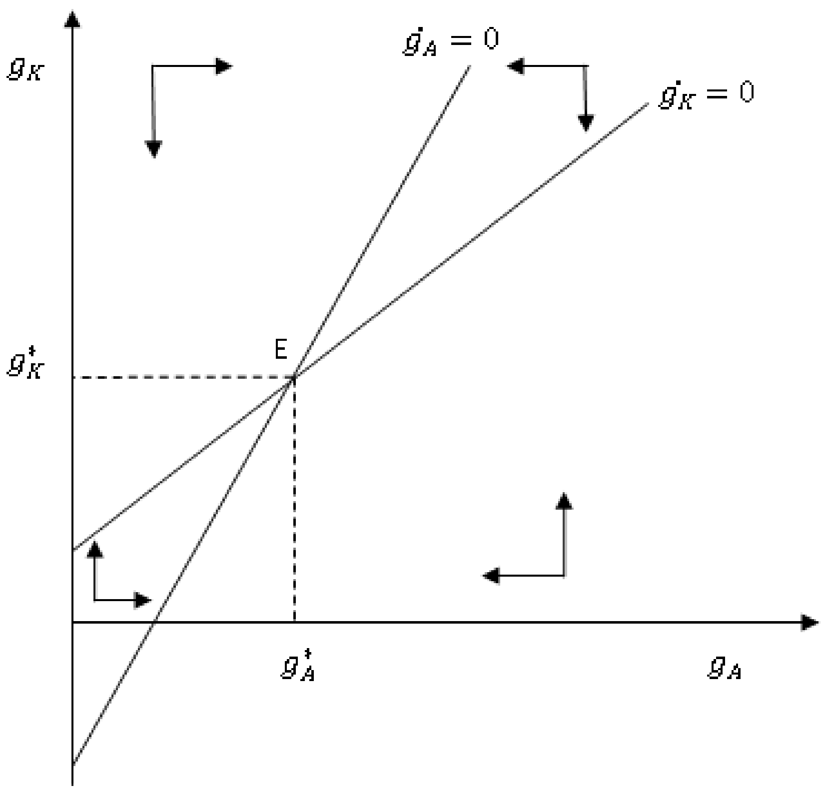

Figure 4: The dynamics of the model when $z < 1 - \alpha$ and $(\beta + \theta)(1 + z) - m < 1$.

and

$$\frac{\partial \ (slope \ of \ g_A)}{\partial z} = -\frac{(1+m)}{\beta (1+z)^2} < 0 \tag{18}$$

Figure (5) is the graphical counterpart of this analytical result. After an increase in z (a stricter labor regulation) the rotation of both the loci shifts the equilibrium from E to E' where both the values of g_K and g_A increase in steady state. Hence, a *positive correlation* between EPL and TFP characterizes the convergence of the effective economy towards the long-run equilibrium. Further, note that in this scenario both g_K and g_A reduce when z decreases. As a consequence, a more flexible labor market while allows for a job recovery in the short-run also has the unexpected downside to decrease the growth rate of innovation and capital in the long-run. Eventually, this process may result in a slowdown of capital intensity, technology stock and labor productivity.

Therefore, the effect of a higher z illustrates our point that innovation and investment may be *complementary* processes: a stricter labor regulation stimulates innovation and investment by raising their long-run equilibrium values, just as more innovation stimulates output per worker raising the productivity growth. This complementary proposition runs counter to the conventional beliefs that the long-run growth rate of technology progress is not affected by labor regulations.

4.3 Case 2: $(\beta+\theta)(1+z) - m < 1$ and $z > 1-\alpha$

The previous result depends on the relative magnitude of the parameters which drive g_A and g_K towards the steady state. Therefore, let's now assume $z > 1-\alpha$, which means that the marginal cost z of labor regulation is greater than the marginal productivity $1-\alpha$ of an additional unit of labor.

In this scenario, while in the space (g_A, g_K), the $\dot{g}_A = 0$ locus does not change its slope, the $\dot{g}_K = 0$ locus turns on itself because of the slope $\frac{1-\alpha}{1-\alpha-z} < 0$. In words, the investment growth rate is *negatively* affected by labor regulation whose implicit cost is too high *relative* to productivity growth. This fact modifies the long-run property of the economy: now an increase in z (a stricter labor regulation) has an *ambiguous* effect on the steady state values.

To explain this point, look at point E in Figure (6). On the one hand, a higher z raises the negative slope of $\dot{g}_K = 0$ moving the initial steady state

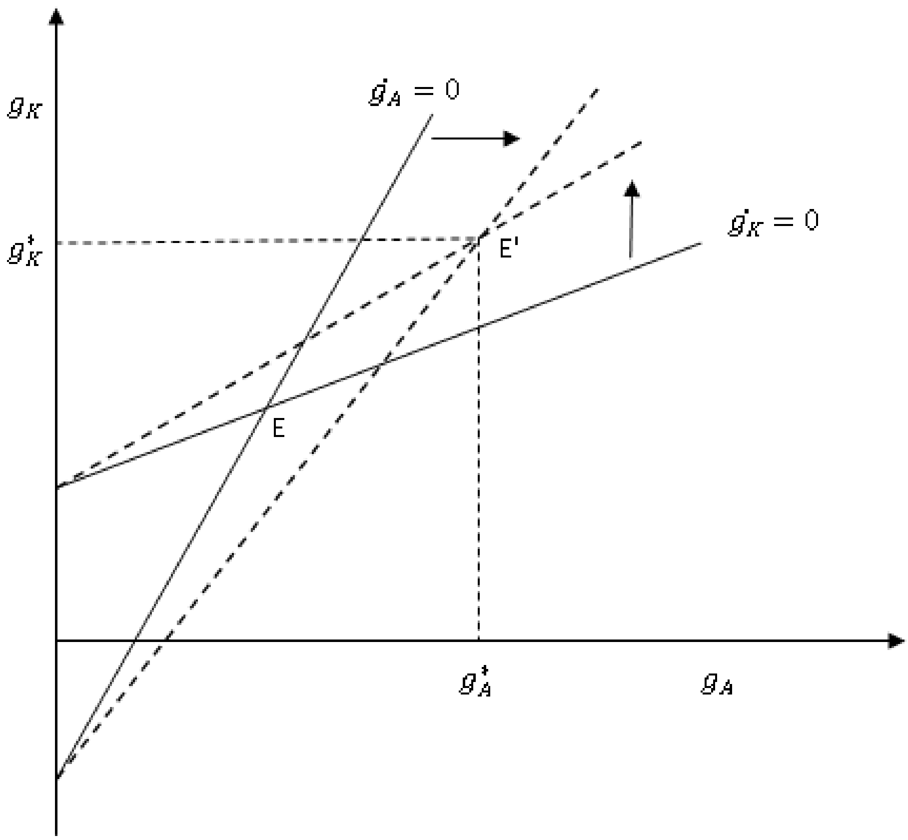

Figure 5: The effect of a stricter labor regulation ($\Delta z > 0$) on investment and innovation when $(\beta + \theta)(1 + z) - m < 1$ and $z < 1 - \alpha$.

E on the left along the $\dot{g}_A = 0$ locus. On the other hand, a greater z reduces the slope of the $\dot{g}_A = 0$ locus moving the point E on the right along the locus $\dot{g}_K = 0$. The steady state shifts downwards, but in an unpredictable direction: g_K^* is certainly smaller than its initial value, but the value of g_A^* will depend on the relative magnitude of the parameters which drive the process of "creative destruction".

Thus, for the case $(\beta + \theta)(1 + z) + m < 1$ our model provides two alternative scenarios: (i) when $z < 1 - \alpha$ the *complementary* proposition prevails and innovative sector tackles the *global* cost of labor boosting innovation and investment; alternatively, (ii) when $z > 1 - \alpha$ an ambiguous result emerges: innovation and investment may be either *complements* or *substitutes*. In one case, a stricter labor regulation implies less innovation, less productivity and less investment in steady state. In the other case, a stricter labor regulation implies less investment *but* higher innovation. Hence, economy converges to steady states where the innovation rate may be either greater or smaller than its initial value.

4.4 Case 3: $(\beta + \theta)(1 + z) - m > 1$ and $z < 1 - \alpha$

From our previous analysis, we know that the condition $(\beta + \theta)(1 + z) - m > 1$ implies increasing returns to scale and that the slope of the $\dot{g}_A = 0$ locus is smaller than 1. Further, we know that the locus $\dot{g}_K = 0$ where $z < 1 - \alpha$ has a slope greater than 1. In this scenario the two loci diverge and never cross each other. Therefore, starting from a point between the two loci both g_A and g_K will increase for ever and the economy exhibits ever-increasing growth rather than converge towards an endogenous balanced growth path. This is a consequence of the increasing returns to scale. Intuitively, here, innovation and capital are so useful in the *creation* of new innovation that each additional increase in their level results in so much more productivity that the growth rates of innovation and capital accelerate the growth rate of innovation rather than decrease it. In other words, the marginal productivity of innovation is always greater than its marginal *destruction* cost and the economy embarks on a path of ever-increasing growth. Importantly, in this scenario (that is $z < 1 - \alpha$) a stricter labor legislation does not change the property of the system because innovation and capital are just productive enough that the increase in A is self-sustaining.

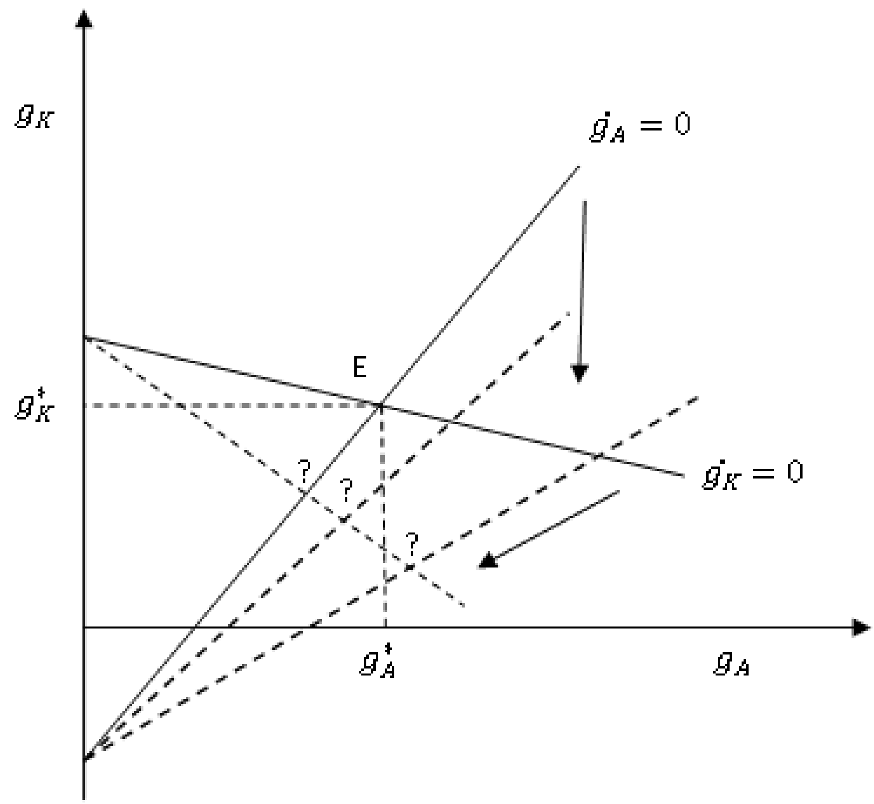

Figure 6: The effect of a stricter labor regulation ($\Delta z > 0$) on investment and innovation when $(\beta + \theta)(1 + z) - m < 1$ and $z > 1 - \alpha$.

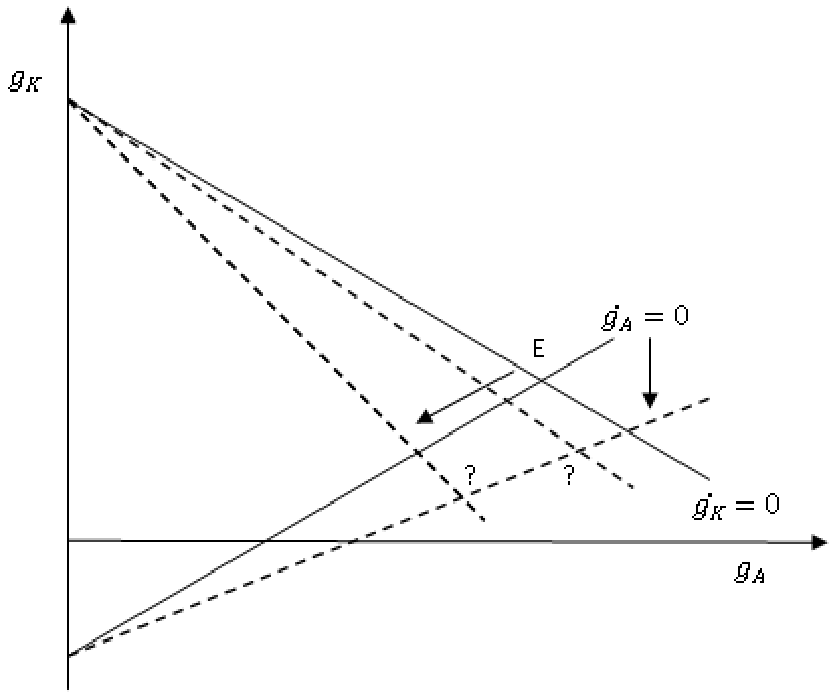

Figure 7: The dynamics of the system when $(\beta + \theta)(1 + z) - m > 1$ and $z > 1 - \alpha$.

4.5 Case 4: $(\beta + \theta)(1 + z) - m > 1$ and $z > 1 - \alpha$

We have seen that when $z > 1 - \alpha$ the locus $\dot{g}_K = 0$ has a negative slope. What happens to the long run equilibrium when $(\beta + \theta)(1 + z) - m > 1$? This is shown in Figure (7).

As the Figure (7) shows, regardless of the increasing returns to scale the additional cost of labor rigidity is so high that any further rise in z reduces the growth rate of capital. However, the impact of this change on innovation is *ambiguous*. Indeed, the final effect depends, as in the case 2 discussed above, on the relative magnitudes of the slope's parameters of the $\dot{g}_A = 0$ locus.

4.6 Case 5: $(\beta+\theta)(1+z)-m=1$, $z=0$ and $n=0$

Finally, when $(\beta+\theta)(1+z)=1+m$ and $n=0$ the system (14) reduces to

$$\begin{cases} \dot{g}_K = 0: \;\; g_K = \frac{1-\alpha}{1-\alpha-z} g_A \\ \dot{g}_A = 0: \;\; g_K = g_A \end{cases} \tag{19}$$

Notice that for $\frac{1-\alpha}{1-\alpha-z} \gtrless 1$ the system is satisfied only for $g_K = g_A = 0$ which means that the economy is in a stationary state without economic growth. Alternatively, if $z=0$ both expressions simplify to $g_K = g_A$ that is the two loci lie directly on top of each other, and both are given by the 45-degree line. Further, when $z=0$ also $(\beta+\theta) = 1+m$ and existing capital and innovation are just productive enough that "creative destruction" is proportional to current stocks. Hence, in this scenario the phase diagram does not tell us what balanced growth path converge to. Nonetheless, it says that with constant return to scale and zero population growth, whatever the growth rate, it requires $z=0$ which means a flexible labor market.

Therefore, our model provides an articulated explanation of the unconditional correlation between labor regulation investment and innovation. In principle, this correlation can be either positive or negative depending on how the economy reacts to changes in labor regulation. In the innovative sector the productivity created by technology advancements may overcome the cost induced by labor regulation so stimulating the firms to invest and innovate. As discussed above, under the assumption of decreasing returns to scale, this result requires that the marginal revenue of innovation is greater than the adjustment cost of capital caused by labor regulation. This result is particularly important since it implies that the way the innovation evolves in response to a change in labor regulation may be strikingly asymmetric. This outcome is broadly consistent with the stylized facts of Figure (1), and provides a novel explanation of the controversial correlation between TFP and EPL observed in the main European countries in the recent years.

We conclude this section by remarking that our results question to some degree the validity of the argument that labor flexibility is a necessary precondition for innovation and investment. Reducing labor market regulation, that is decreasing in our scheme the value of z, may be an important prerequisite to relaunch the spending on technology progress and capital accumulation. But, such changes do not have clear-cut consequences for the political feasibility of a labor reform aimed at making innovative processes more productive.

5 An empirical illustration

In this section we discuss the dynamic implications of our model by estimating the impulse response functions for a trivariate VAR model in investment, TFP and temporary employment. All three variables are measured in growth rates (of total economy) and denoted by g_k, g_A and g_f, where k is capital stock, A is TFP and f the *incidence* of temporary employment on standardized age group 15–24.[3] Our analysis focuses on Italy, Germany and France to measure how different European economies respond to changes in one of the three variables. All data are annual, from 1980 to 2015, seasonal adjusted and provided by Eurostat and OECD.

While the growth rates of measured capital and TFP are the empirical counterpart of two of the main variables of the theoretical model, less clear may appear our choice of using the *incidence* of temporary employment with standardized age group 15–24 to measure (the effects of) changes in labor regulation, instead of using the changes in the EPL index. To clarify the point, let's have a look at Figures (8) and (9). They display the patterns of the EPL, for both temporary and permanent workers, among the European countries until 2014. It emerges a plain decrease in EPL, capturing the long lasting deregulation of the European labor market. However, its variation is too discontinuous to be usefully employed in a VAR analysis. Thus, to overcome this problem the *incidence* of temporary employment for young people is used to proxy the effect of changes in labor regulation. Precisely, we assume that a more (less) flexible labor market increases (decreases) the share of temporary employment, affecting both investment and innovation in the long run. Figure (10) displays the increase of temporary employment for young workers in Italy, Germany and France from 1980 to 2015.

Using the time series of investment, TFP and temporary employment we get a reduced form VAR representation of our economy. Then, once the moving average representation of it is obtained, we compute the impact

[3] The OECD statistics clarify that "A job may be regarded as temporary if it is understood by both employer and the employee that the termination of the job is determined by objective conditions such as reaching a certain date, completion of an assignment or return of another employee who has been temporarily replaced. In the case of a work contract of limited duration the condition for its termination is generally mentioned in the contract. To be included in these groups are: a) persons with a seasonal job, b) persons engaged by an employment agency or business and hired out to a third party for the carrying out of a "work mission" (unless there is a work contract of unlimited duration with the employment agency or business), c) persons with specific training contracts".

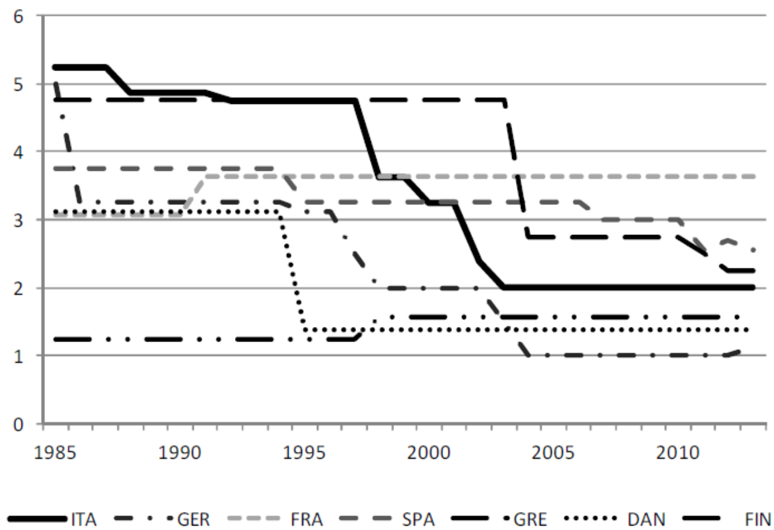

Figure 8: EPL - Temporary workers. Main European countries (OECD).

of one-unit shock in the variables to study how the economy responds to (unexpected) shocks.

Importantly, we have no *a priori* about the magnitude and the direction of the shocks generating the impulse responses because, as it is discussed above, our model provides alternative predictions on the conditional correlation among the three variables. Hence, we do not impose any theoretical restrictions to identify the structural shocks. We only limit our analysis to use the type of the recursive system proposed by Sims (1980) that is decomposing the VAR residuals in a triangular fashion. This recursive technique is called Cholesky decomposition. However, this technique may introduce a potentially important asymmetry on the system, and there is no simple way to resolve the problem. Fortunately, from our empirical analysis emerges that for all countries the patterns of the impulse responses do not depend on the ordering of the variables, and that the qualitative results are similar across alternative treatments of the deterministic components. So we can consider the reduced VAR residuals as structural shocks (Enders, 2015). As we will see, the dynamic responses of the three variables are suggestive of the presence of a *neo*-Schumpeterian endogenous mechanism which link together

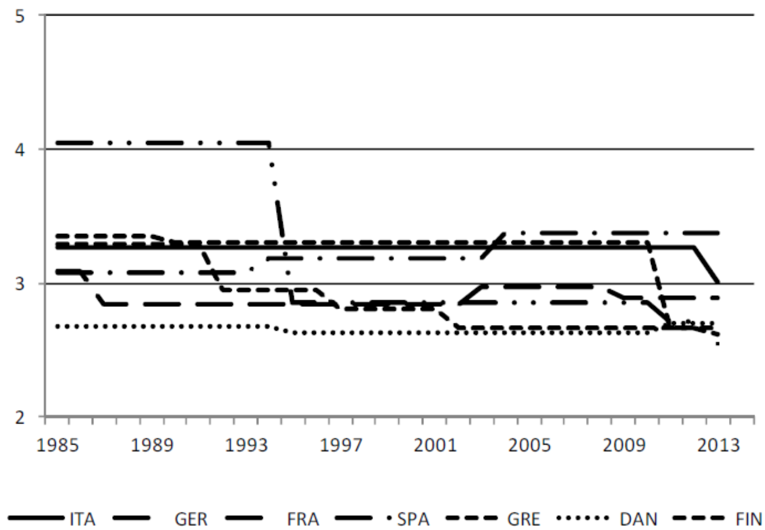

Figure 9: EPL - Permanent workers. Main European countries (OECD).

changes in labor regulation with those in investment and innovation.

5.1 Estimates for Italy

Figures (11)–(13) display the estimated impulse responses of the three variables for Italy, together with their 90 percent bootstrap confidence interval.[4]

Labor shocks. Figure (11) displays the response functions of temporary employment, investment and TFP to a positive one-unit shock in the incidence of temporary employment g_f. We label this change as institutional shock in labor market. In response to an initial labor shock (the first panel of Figure (11), g_f experiences an increase of about 0.2 percent. Following this increase, the effect is reversed after one year, and temporary employment returns steadily to its original value. Notice that the responses of the other two variables are suggestive of an endogenous mechanism linking temporary

[4] In the base model presented here, VAR includes the growth rates of capital, TFP and temporary employment, with a constant and two lags. We use AIC, SC and HQ tests to compute the optimal number of lags. The visual analysis of the three time series, their correlogram and the unit root tests augmented ADF and KPSS provide robust inference about the stationary property of the series.

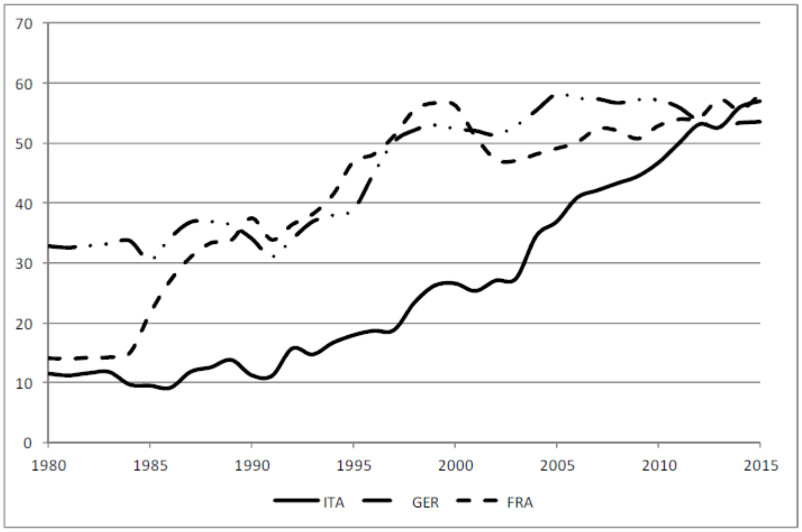

Figure 10: Share of temporary employment - age 15 to 24 in Italy, Germany and France.

employment to investment and innovation. Interestingly, the *positive* shock in labor market has a long lasting *negative* impact on both investment (-0.1 percent) and TFP (0.04 percent in the long run, with a negative peak of 0.2 percent after two years). For Italy, these responses provide clues that a higher labor flexibility has only transitory effects on the employment rate of young cohorts. These responses shed critical lights on the optimist view that a flexible labor market is a necessary pre-condition to relaunch investment and innovation in the long-run. Notice that the slowdown

Investment shock. We have a hump-shaped permanent effect on investment and TFP. Their effects peak after one to two years. Precisely, the effect of a positive investment one-unit shock moves economy from one equilibrium to another, after about six to eight years. Notice that in response to an initial investment shock, g_K experiences a raise of about 0.2 percent, with a positive long lasting effect. This is displayed in the first panel of Figure (12). The response of the TFP, in the second panel in the same figure, is the mirror image of investment. After an initial decrease, the growth rate of g_A experiences an increase for 4 years, but the magnitude of the final change appears to be smaller than the one of investment. Hence, while a strong *substitution* effect prevails in the short run, a (slight) *complementary* effect prevails in the long-run. For Italy, we interpret this pattern as determined by its productive structure specialized in the traditional sectors where a high share of micro and small firms, with low technology content, prevails on large and more specialized ones. In this perspective, the response of temporary employment to an investment shock is positive. Initially, it raises, but, as time passes, the incidence of temporary employment tends to decrease steadly (-0.1 percent). Overall, and as expected from the theory (Belot et al., 2007; Lucidi and Kleinknecht, 2010), the advanciament of investment affects positively the TFP. Therefore, the responses suggest that investment and technology progress are *substitutes* in the short run, and *complementaries* in the long run. Mainly, an increase in investment and innovation affects positively the share of permanent employment.

Technology shock. Figure (13) displays the effect of a positive one-unit technology shock to the three variables. The impulse responses detect an immediate positive response in TFP, and a steadly adjustment of investment and temporary employment. The investment rate increases for about one to eight years. Note that the dynamic response of temporary employment is different: a positive technology shock decreases the share of temporary employment as time passes, so improving the composition of labor market which raises the number of permanent workers. Similar pattern is followed by the TFP: initially it increases in response to the shock, but this expansionary effect is reversed after about one years, to be positive in the long run. The qualitative results are similar across all alternative treatments of lags and time trends. The only significance difference appears when the VAR is estimated with time trends: in this case the response of investment and TFP display a shorter lasting effect.

In our view, the response of TFP and investment are suggestive of the presence a *neo*-Schumpeterian endogenous mechanism between the variables. *Complementarity* can explain why increase in TFP can lead to an increase in investment which persists over time until the new equilibrium is obtained. *Substitution* can explain why in response to a technology shock investment increases steadly to match the decrease in temporary employment needed to maintain constant productivity.

All in all, the responses of the Italian economy to the shocks are also consistent with a traditional view of the dynamic effects of aggregate demand on investment and employment, in which, after an initial investment increase, movements in aggregate demand build up until the adjustments of prices and wages leads the economy back to equilibrium (Blanchard and Quah, 1989;

Gamber and Joutz, 1993; Blanchard and Wolfer, 2000). In other words, investment seems to deplete its role of demand shock in the short run, to become a supply shock in the long run.

5.2 Relative contribution of shocks

Having shown the dynamic effect of each type of shocks, the next step is to assess their relative contribution to fluctuations in investment, innovation and temporary employment. To this aim, we start by comparing the stochastic components of the three variables by means of their historical decomposition. In a way, historical decomposition shows what the history of any single variable would have been, if the *jth* disturbance (shock) has been the only one affecting the system. To this aim, we compute the stochastic components of the three series starting from the identification of the reduced VAR model. These components are the time path of the three variables that would have been obtained in absence of deterministic components. By construction these series are stationary.

The outcome of this exercise is displayed in Figures (14)-(16). The fluctuation of g_f is largely explained by shocks in labor market; the fluctuations of g_k are caused by both investment and technology shocks; while the fluctuations of g_A are mainly caused by shocks in technology with a significant contribution of investment shocks.

A formal statistical assessment of these suggestive evidence can be given by computing the forecast error variance decomposition for our variables, at various horizons. Table 2.a – 2.c gives the decomposition for Italy. The data in the tables have the following interpretation. Define the forecast error in one of the variable as the difference between the actual value and its forecast from the moving average representation of the reduced VAR model. The error variance decomposition tells us the proportion of the fluctuations in a sequence due to its "own" shocks *versus* shocks to the other variables. If *jth* shocks explain none of the forecast error variance of a single variable, at all forecast horizons, we can say that the variable is exogenous. At the other extreme, if *jth* shocks explain all of the forecast error variance in the variable at all forecast horizons, we can say that the variable is entirely endogenous.

Two principal conclusions emerge. First, the relative contribution of technology shocks (TFP) to investment fluctuations, g_k, is initially about zero (Table 2.a), but it raises and after 5 years arrives at 22 percent. Then, it further increases to 50 percent after 10 years stabilizing at these level in the

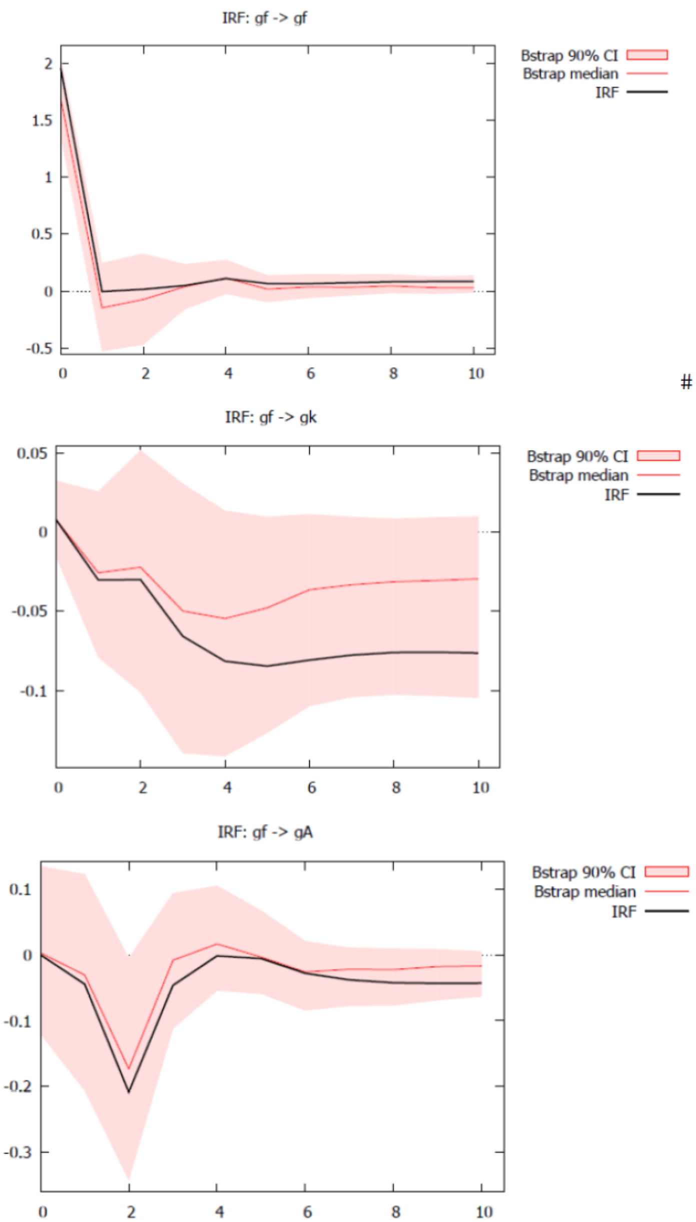

Figure 11: Responses to shocks in labor market - Italy.

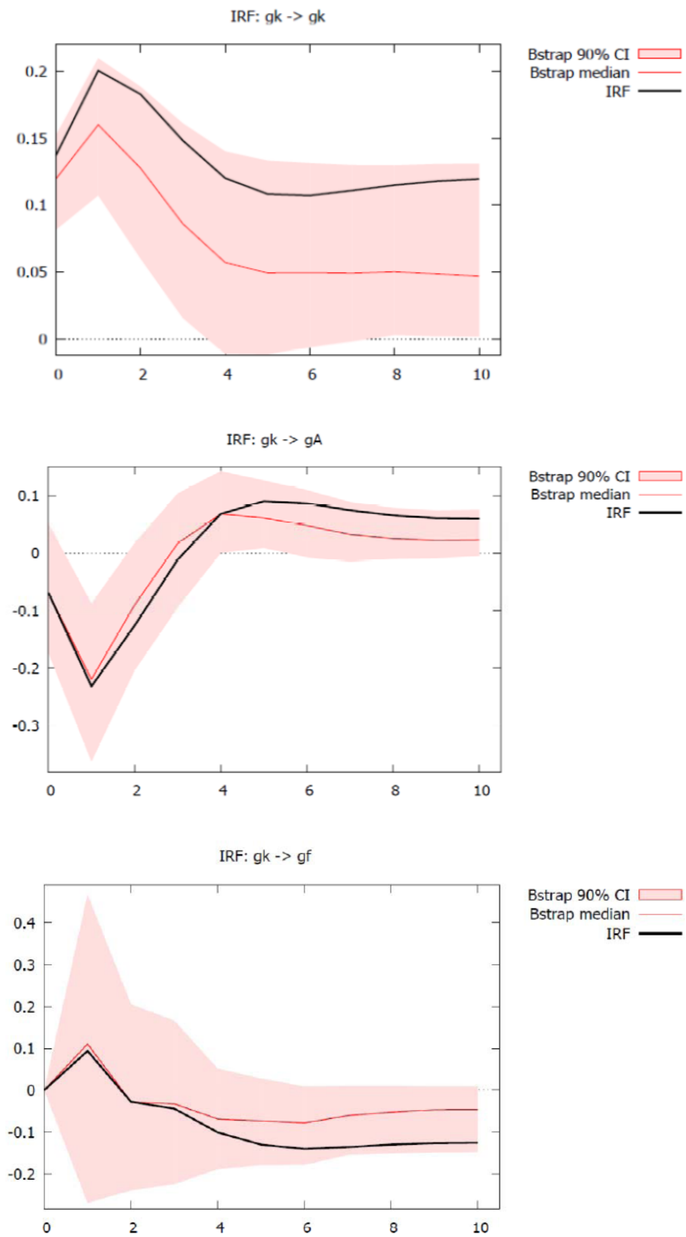

Figure 12: Responses to shocks in investment - Italy.

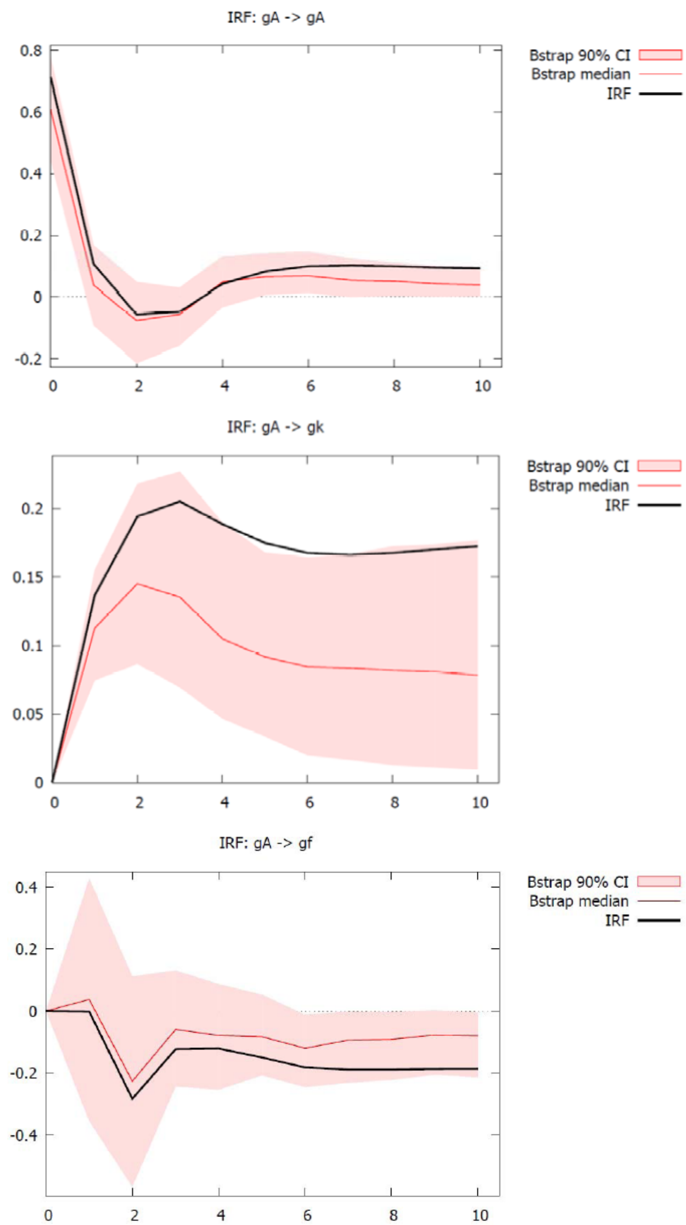

Figure 13: Responses to shock in technology - Italy.

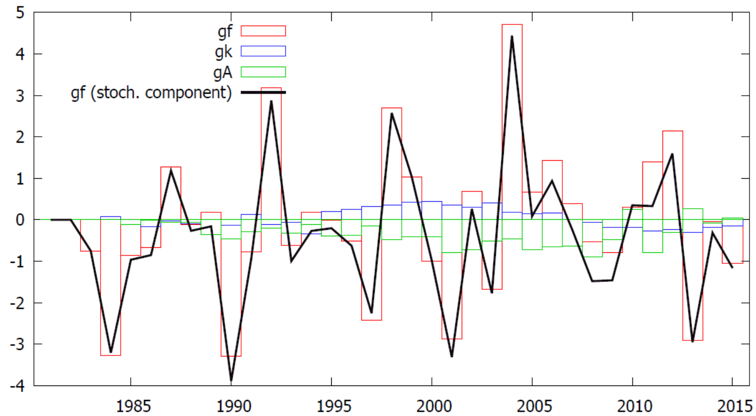

Figure 14: Hystorical decomposition of temporary employment - Italy.

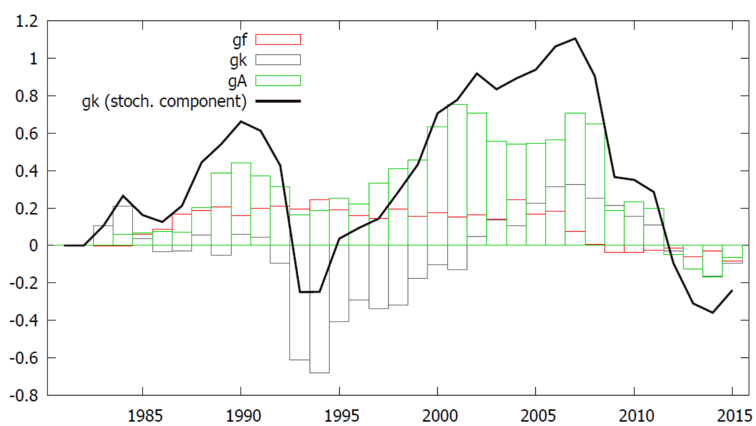

Figure 15: Hystorical decomposition of investment - Italy.

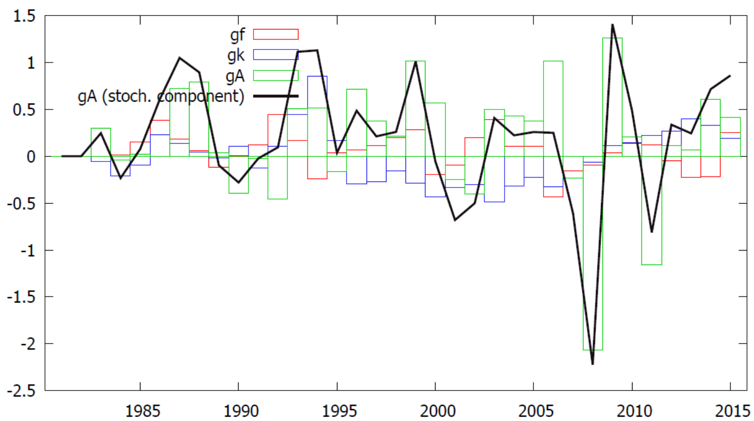

Figure 16: Hystorical decomposition of innovation (TFP) - Italy.

next periods. Data also give a precise answer as to the relative contribution of investment shock to fluctuations in investment. It is initially equal to 99 percent. This contribution falls to around 37 percent in the next periods.

Conversely, estimates of the relative contributions of investment shocks to variation in TFP growth g_A is minor and varies from 2 to 19 percent (Table 2.b). These estimates suggest an important role of technology shocks in explaining both fluctuations in TFP and investment. Contrariwise, a large part of the variance decomposition in investment is explained by investment shocks, with minor but positive contribution of investment to technology fluctuation in the long run (about 19 percent).

In all cases, the fluctuations of the temporary employment g_f appear to be important mainly for employment itself (from 100 to 82 per cent in Table 2.c). The remaining part of temporary employment variance is explained by changes in investment (about 12 percent) and TFP (about 6 percent).

We view these estimates as suggesting an important role of the *neo-*Schumeperian mechanism, as the one describe in this paper, in explaining the dynamic relationship between investment and TFP. Conversely, fluctuations in labor market do not seem to have large impact on the fluctuation of investment and technology progress. Finally, notice that estimates of the relative contributions of the different shocks to fluctuations in the three variables do not appear to vary a great deal across alternative treatments of break and trend. In all cases, investment and technology shocks appears to be quite important for investment and innovation at all horizons, while the reverse for temporary employment is not true.

Table 2.a

Variance decomposition of g_k for Italy

Percentage values

years	Investment		Technology		Temp. Empl.
1	99		0		1
5	72		22		6
10	37		50		13

Table 2.b

Variance decomposition of g_A for Italy

Percentage values

years	Investment		Technology		Temp. Empl.
1	2		98		0
5	15		80		5
10	19		77		4

Table 2.c

Variance decomposition of g_f for Italy

Percentage values

years	Investment		Technology		Temp. Empl.
1	0		0		100
5	3		2		95
10	12		6		82

5.3 Evidence from other economies

This section reports estimates of the impulse response functions for the two remaining countries, Germany and France. For each country we estimate a trivariate reduced VAR model for investment, TFP and temporary employment for young workers. Data for Germany and France are drawn from Eurostat database and the OECD statistics. All data are annual and seasonal adjusted. The sample period goes from 1980 to 2015.

Standard ADF unit root tests and KPPS test were applied to each series used. The tests did reject at the 5 percent significance level the assumption of unit root in the growth rates of all series. That led us to estimate a VAR model in $[g_k, g_A, g_f]$ for the two countries. Identification and estimation of impulse responses proceeds as in the trivariate Italy model.

Figures (17) and (18) report, for each country, the impulse responses of each variable after an initial shock. The estimated patterns provide support to our *neo*-Schumpeterian view of the endogenous relationship linking investment and innovation to labor regulation.

Most interestingly, the estimated responses display an heterogeneous conditional correlation between changes in labor regulation and changes in investment and innovation.

In Germany, a positive shock in labor regulation (a higher temporary employment rate) has initially a negative impact on TFP and investment (first column of both the Figures). But after the initial decrease both variables turn towards the positive values, with a steadly positive impact on investment.

In France, the impact is even positive and stronger in the short run, with a long lasting positive impact on investment. Thus, the estimates point to a positive conditional correlation between shocks in labor regulation and responses in investment. Less clear is the impact on technology progress which tends to return quickly towards the initial equilibrium.

How to interpret these patterns? In our model, since any change in labor regulation modifies the costs and the incentives in doing investment and innovation, the effective pattern of TFP and investment strictly depends on how labor policies and firm's decisions interact over time. Further, notice that the responses to a one-unit shock in investment affects positively the TFP rate of the two countries in the short run (second column of both the Figures). This effect is, however, reversed after few years and the TFP growth becomes slightly negative in the medium run, to converge eventually towards its initial value. Further, notice that the same investment shock has a global negative impact on the temporary employment in Germany, whereas it reduced the share of temporary employment in France. By way of contrast, in Italy a one-unit investment shock has a negative impact of the TFP growth rate.

How shall one interpret those differences? Once again, an answer can be found in the composition of the productive structure of the three economies. In Germany and France the innovative sectors (both in industry and services) prevail on the whole of the economy. In Italy, the reverse is true. Thus, in Germany and France a positive investment shock can result in a technology improvement, at least in the short and medium run.

Finally, from the impulse responses we find that in Germany a one-unit positive technology shock has a negative effect on investment, while the same shock has a large positive effect on investment in France (third column of both the Figures). Compared to Italy, the German response is strongly different. As argued above, in our interpretation the substitution effect between technology and investment (versus a complementarity effect) strictly depends on the prevalence of the traditional sectors on the composition of the whole economy.

Therefore, the above results strongly suggest that changes in labor regulation may have different impact on the economy, depending on the technology and institutional characteristics of the economy in which the same change is applied. However, to the extent that in the long run productivity depends on innovation and investment, more than on labor regulation, one principal goal of the policy maker would be to boost research and development, and to improve human capital, in order to sustain labor productivity rather than to increase labor flexibility. This conclusion may be strengthened by examining the theoretical and empirical arguments presented in this paper.

Therefore, our main conclusion is that how labor regulation affects economic growth strictly depends on the endogenous relationship linking investment and technology to labor regulation, and, ultimately, on the relationship between *all* costs and *all* revenues of economic activity, not only those resulting from the use of labor.

6 Conclusion

The aim of this paper is to study the theoretical effects of labor regulation on innovation and investment. Our theoretical and empirical analysis show that this relationship is ambiguous. Labor regulation, may increase the adjustment costs of labor and investment. But labor regulation may also increase the incentive to make innovation. In this paper we provide a theoretical explanation of this complex relation. In particular, our model suggests that labor regulation may not discourage innovation, so improving productivity and technology in the long-run.

At the methodological level, the paper represents a novelty to the existing literature since our *neo-Schumpeterian* endogenous growth model relies on the assumption that the dynamics of innovation may be positively affected by labor regulation since innovative sector responds to a stricter labor regula-

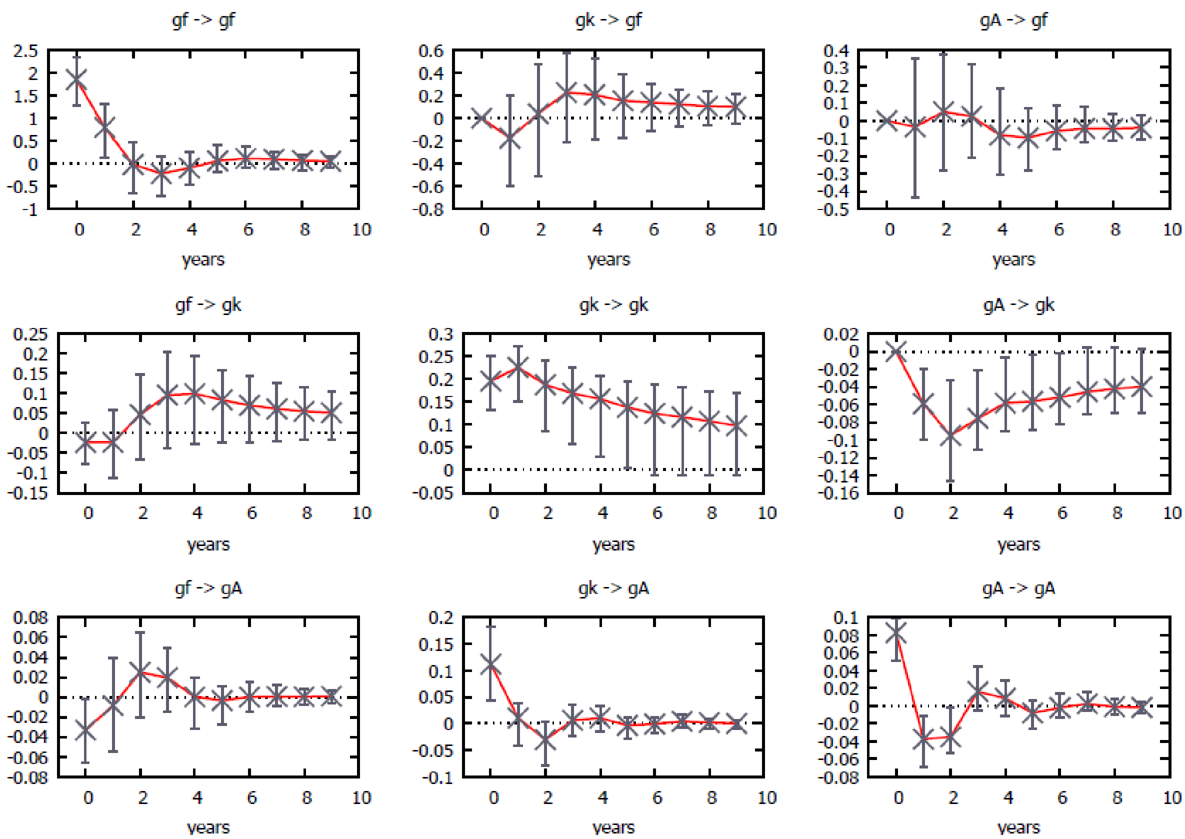

Figure 17: Responses to shocks - Germany.

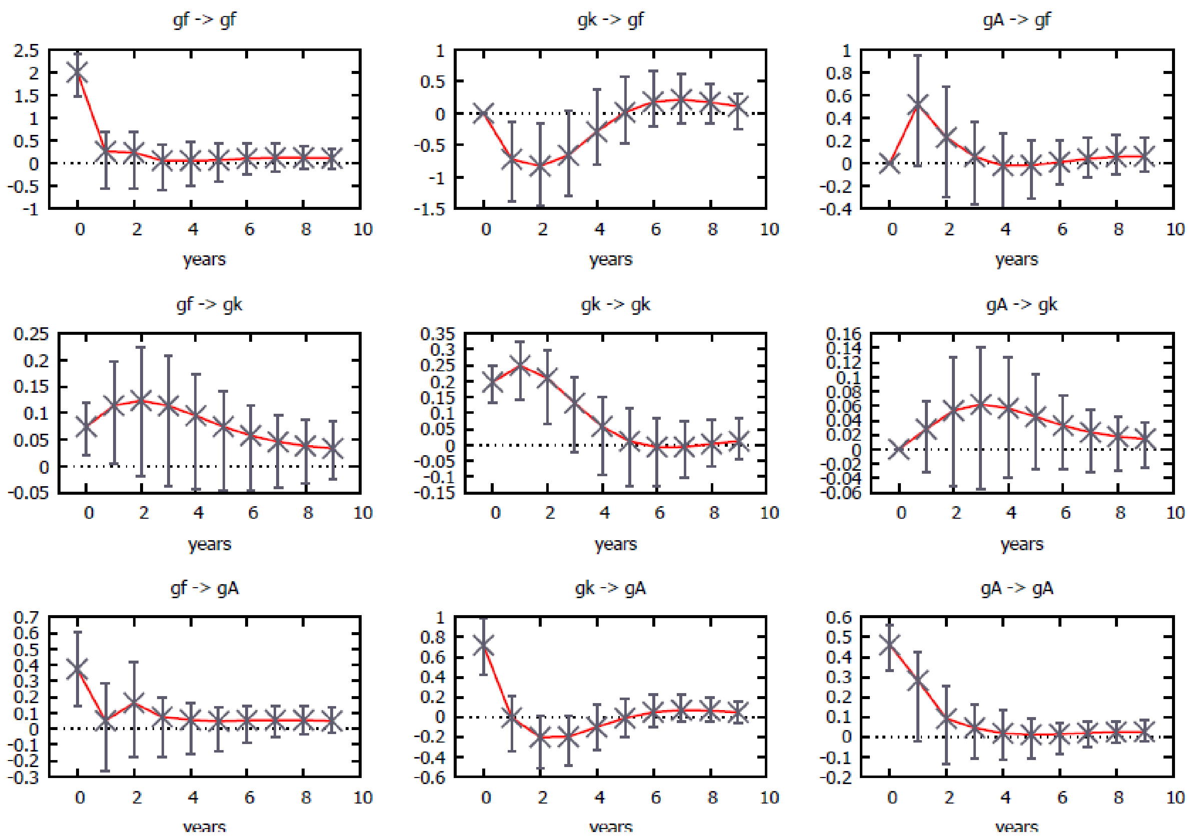

Figure 18: Responses to shocks - France.

tion raising technology progress to recover productivity. This assumption is important since it implies that the adjustment costs of labor and investment, caused by labor regulation (as measured by the EPL), can be curbed by technology progress (proxied by TFP). Within this approach, a key substantive result is the broad importance of the rents that the innovative sector is able to extract from innovation, given labor regulation. This result is formal and strictly depends on the presence of constant, increasing or decreasing returns to scale, and on the comparison between the degree of labor rigidity and the marginal productivity of labor. Moreover, how innovation is affected by labor regulation has also been found to depend on the extent of investments, as well as on the status quo level of the adjustment labor cost.

Then, the theoretical model is investigated by means of a VAR analysis. The impulse responses for Italy, Germany and France are consistent with the implications of the models, where the combination of rigidities in investment, technology and labor determine the dynamic patterns of the economies in response to an exogenous increase in the variables. Substitution and complementary characterize the evolution of the variables. Needless to say, the magnitude and direction of fluctuations, and the role of labor policy associated with such an economy, are very different from those identified with the standard neoclassical paradigm of labor market.

Our model has a basic structure. Its short run implications have been mentioned to stress that when the economy is out the steady state the growth rate of capital and productivity may be negatively correlated with the growth rate of innovation. This is an important implication which provides further elements to discuss about the observed correlation between measured TFP and EPL. Of course, the results presented in this paper are not conclusive. We aim to further investigate the properties of the model and its empirical implications in the future steps of our research.

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