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Abstract

In this paper we address the question whether the shift in labour supply curve is the only fundamental change capturing the negative correlation between the growth rates of productivity and employment in European countries in the last fifteen years. If this explanation is correct then the labour demand curve did not shift in recent times, keeping other features of the production function unchanged. This is obviously a problem of identification. Thus, in this study we provide some empirical evidence explaining the shifts in labour demand curve over the same period. Our main conclusion is that the sluggish performance of the European economy in the last fifteen years has a common root in the large changes occurred in the labour market. We refer to these changes as technological and non technological shocks. In our model, adverse technological shocks shift the labour demand curve, while positive non technological shocks shift the labour supply curve. These two shifts contribute simultaneously to rise employment and to decrease the growth rate of productivity. Our evidence shows that labour productivity does respond positively to labour demand (technological) shocks and negatively to labour supply (non technological)

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shocks. Hence, the main result of our study is that both shocks are necessary to provide a complete picture of the employment-productivity trade-off in European countries during the last fifteen years.

Key words: Productivity Slowdown, Labour Market, SVAR

JEL classification codes: E32, J60, E29

1 Introduction

The object of this paper is shown in fig.1, which plots average labour productivity rates over 5-year intervals, from 1970 to 2006, for Europe as a whole (EU15), for the main European countries and for USA.

Explaining this slowdown in Europe, both over time and across countries, has proved to be a serious challenge. For much of the post-war period, European growth was "catching up growth". Firms operated in large and protected markets. Aggregate investment was sustained by an expanding aggregate consumption. Much of the spending in research and development was self-financed. The high elasticity of labour supply assured an increasing level of employment and production with stable real wages and prices.

Nowadays, this model of growth has become dysfunctional. Most of the European markets are open to international competition. Technological progress is sustained by an increasingly amount of external financial resources. Innovations, rather than imitation, are required to rise productivity. Finally, labour markets are characterised by a lower elasticity in labour supply, with a rising trade off between wages and employment.

In the last fifteen years, the most concerning aspect of the labour productivity's evolution has been the further deceleration of its growth rate, especially in the continental economies like Italy, Spain and France. Traditionally, in European countries, productivity has been above Usa level, but it has lost some ground since mid-1990s. In addition, during the same period labour productivity in USA has increased strongly. Unfortunately, as in Europe productivity growth rates have decreased the level of unemployment has generally remained high or even increased. This fact has led to less emphasis on the productivity slowdown, and more on the reasons for the differences between European countries in their capability to create new jobs.

There is a wide consensus that, from the mid-1990s, the recovery of labour utilization in the European economy comes from rising deregulation in labour market and wage moderation. The *labour supply-side approach* explains the recent slowdown of the labour productivity growth as a positive shift in labour supply: the slowdown in the growth rate of productivity is only a short run consequence of the increase in the employment rate, with productivity recovery in the long run.

In this paper we address the question whether the shift in "labour supply" curve is the only fundamental change capturing the negative correlation between the growth rates of productivity and employment in European coun-

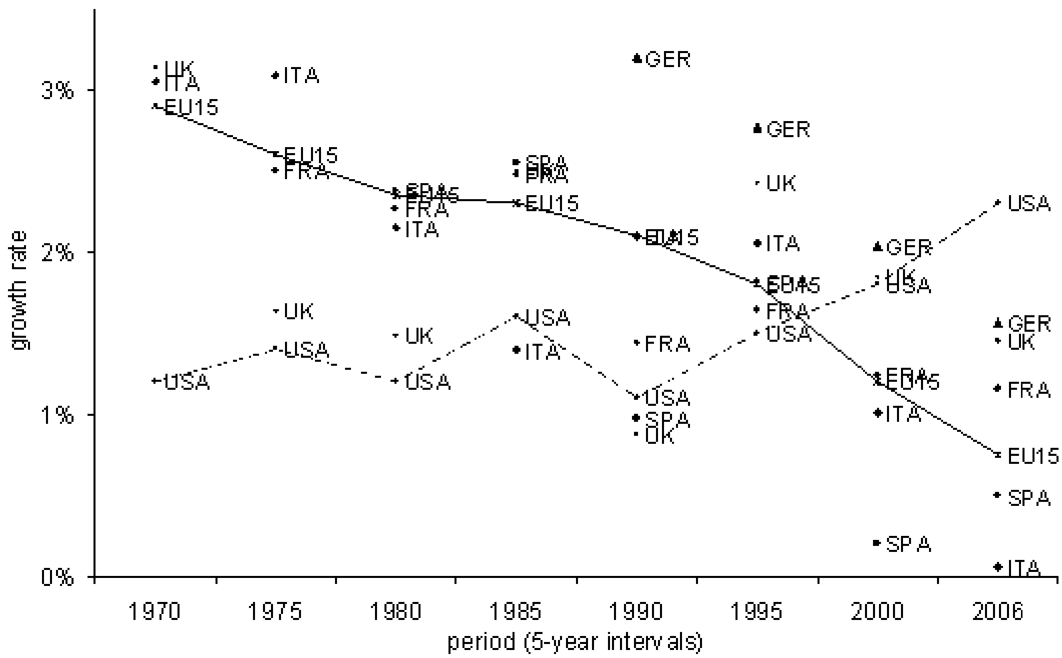

Figure 1: Average labour productivity in EU15 and USA (growth rates by countries).

tries over the last fifteen years. If this explanation is correct then the "labour demand" curve did not shift in recent times, keeping other features of the production function unchanged. This problem of identification may obviously account for the mixed empirical results found by several authors on the relationship between shocks and productivity. For example, Hansen and Wright (1992), Gamber and Joutz (1993), Chirinko (1995) and Christiano *et al.* (2003) find evidence of procyclical productivity and wage, Gali' (1999), Gali' *et al.* (2002) and Francis and Ramey (2003) find evidence of countercyclical productivity, and finally Christiano *et al.* (2001) and Smets and Wouters (2003) find evidence which requires a variety of stochastic disturbances to capture the evolution of productivity.

Thus, we provide some empirical evidence which explains the shifts in labour demand from the beginning of 1990s. If technological shocks were at work, we should have seen a variation in total factor productivity growth rate (TFP) with shifts in production function and changes in capital deepening and productivity. We look at data to investigate if they provide empirical evidence in this direction.

Our main result is that the sluggish performance of the European economy in the last fifteen years has a common root in the large changes occurred in labour market. We refer to these changes as technological and *non* technological shocks. In our model, adverse technological shocks shift the labour demand curve, while positive *non* technological shocks shift the labour supply curve. These two shifts contribute simultaneously to rise employment and to decrease the growth rate of productivity.

We find that labour productivity does respond positively to labour demand shocks and negatively to labour supply shocks. This evidence is consistent with economic theory. Our model predicts that technological shocks generate a positive *conditional* correlation between employment and productivity. In turn, a negative *conditional* correlation between the two variables arises from *non* technological shocks. A Structural Vector Autoregressive (SVAR) model is employed to exploit the different responses of labour productivity and employment growth to each type of shocks. The remarkable result of the econometric analysis is that both shocks are necessary to provide a complete picture of the employment-productivity trade-off in European countries during the last fifteen years.

The paper is organized as follows. After a brief review of the literature, in section 3 the main basic facts characterizing the evolution of the European economy in the last fifteen years will be presented. With an eye to the evolution of employment, productivity, capital deepening and capital share, the dynamic properties of our model will be discussed in section 4, showing that only a combination of shocks can account for the negative correlation between employment and productivity. In the fifth section, we will identify and estimate the component of employment and productivity growth rates associated with alternative shocks. Section 6 concludes.

2 Related literature

There are innumerable papers dealing with the European economic performance. But, almost all the papers study the opposite issue of the European unemployment during the previous two decades (Layard *et al.* 1991; Phelps 1994; Blanchard 1997; Caballero and Hammour 1998; Bertola *et al.* 2002).

We can divide these contributions into two groups.

Firstly, most papers focus on shifts of labour supply, emphasizing the effects of institutional changes on the level of (un)employment. We can label this explanation as labour supply-side approach (Belot and Van Ours 2000, 2001; Nickell and Layard 1999; Nickell 2003). This strand of research is well represented by Nickell *et al.* (2005). Their empirical evidence remarks that in the last forty years the evolution of unemployment in Europe is well explained by changes in labour market institutions.

Secondly, others focus on the interactions between shocks and institutions. The central idea here is that the rigidity in labour market institutions amplifies the initial shock (interest rate, aggregate demand, input price) with a negative and persistent effect on the equilibrium level of unemployment. The influential paper by Blanchard and Wolfers (2000) is perhaps the most notable example. They show that while adverse shocks can explain much of the rise in unemployment, only the interactions between shocks and institutions can capture the heterogeneity of unemployment across European countries from the 1960s to the beginning of the 1990s.

An alternative line of research focuses instead on the recent labour productivity slowdown. A large number of empirical papers study the deterioration of the technological progress and its effect on labour productivity. An adverse technological shock can explain the deceleration of the labour productivity growth rate in European economy in the last fifteen years. (Denis and Roger 2004; Estevao 2004; O'Mahony and van Ark 2003; Timmer and van Ark 2005; Gordon and Drew-Becker 2005). However, these papers do not provide an explicit theoretical foundation of this phenomenon, and they do not relate the dynamics of technological progress to the evolution of employment.

Thus, since the exact nature of the shocks, the relative importance of them, and the mechanisms through which the shocks interact remain largely to be established, we try to combine both types of shocks (*a compromise*). In this perspective, the present study can be seen as an update of the previous papers, and it is very close to Drèze and Bean (1990) who study the effect of capital accumulation in the rise of European unemployment, to Blanchard (1997) who made the first attempt to explain the rising of unemployment in Europe using a labour market model with shifts in both labour demand and supply, and to Caballero and Hammour (1998) who analyse the effects of labour market institutions on capital accumulation and employment.

3 Some basic facts

To begin our analysis, it is worth looking at the next six tables in figure 2. They show the breakdown of the GDP growth rate in its main components over the period 1971-2006, for the main European countries and for Usa. Figures in tables are average growth rates.

For Usa, average growth rates of GDP remained largely stable along the entire period, with an acceleration of labour productivity, and a deceleration of the employment rate in the last fifteen years. This evolution is accompanied by an increase in both average growth rate of TFP and capital deepening.

In turn, in Europe *four* "basic facts" make the point from the beginning of 1990s:

1. European countries have experienced important changes in labour market institutions with an increase in labour utilization, after two decades of rising unemployment.

2. During the same period the recovery in labour utilization was accompanied by a corresponding negative trend in the growth rate of labour productivity.

3. There is a strong decline in TFP growth rate as well. This deceleration has also affected the growth of labour productivity.

average growth rates	1971/80	1981/94	1995/2006
Usa			
Gdp	3.2	2.9	3.4
Labour	1.6	1.5	1.0
Productivity:	1.6	1.4	2.4
TFP	1.2	1.1	1.4
Capital deepening	0.4	0.3	0.7

average growth rates	1971/80	1981/94	1995/2006
Italy			
Gdp	3.7	2.0	1.4
Labour	-0.3	-0.2	0.4
Productivity:	4.0	2.2	1.0
TFP	2.6	1.2	0.3
Capital deepening	1.4	1.0	0.7

average growth rates	1971/80	1981/94	1995/2006
France			
Gdp	3.3	2.1	2.0
Labour	-0.4	-0.6	0.4
Productivity:	3.7	2.7	1.8
TFP	2.1	1.5	1.0
Capital deepening	1.6	1.2	0.8

average growth rates	1971/80	1981/94	1995/2006
Spain			
Gdp	3.5	2.4	3.5
Labour	-1.2	-0.2	2.9
Productivity:	4.7	2.6	0.6
TFP	2.6	1.4	0.2
Capital deepening	2.0	1.2	0.4

average growth rates	1971/80	1991/94*	1995/2006
Germany			
Gdp	3.3**	1.3	1.4
Labour	-	-1.0	-0.3
Productivity:	-	2.3	1.7
TFP	-	1.0	1.0
Capital deepening	-	1.3	0.7

average growth rates	1971/80	1981/94	1995/2006
United Kingdom			
Gdp	1.9	2.2	2.8
Labour	-0.7	0.0	1.3
Productivity:	2.6	2.2	1.5
TFP	1.7	1.7	1.2
Capital deepening	0.9	0.5	0.3

Figure 2: Breakdown of GDP in its components . Total economy. (1971-2006, growth rates. Employment is expressed in total hours worked for total economy. ** Germany before unification. * After riunification. Author's calculation from Ameco database).

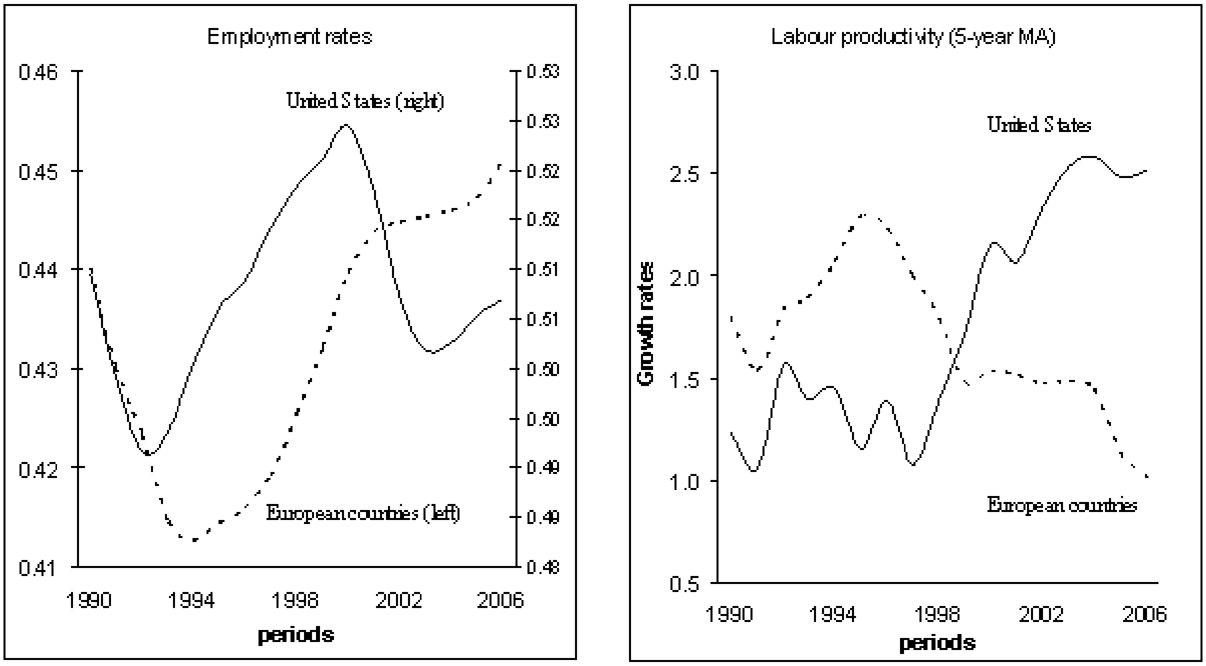

Figure 3: Employment rates and labour productivity trend (5-year moving average).

4. The growth rate of capital deepening has decreased, signaling that firms switched to more labour-intensive forms of production (low quality labour). This change in the ratio of capital to labour may reflect biased technological adoption.

Thus, we should study why European countries have adopted capital-saving technology in the last fifteen years, finding profitable to move towards technology with a lower productivity growth rate. Figures 3 and 4 are the graphical counterparts of these evidence.

At these four basic facts we add a fifth equally important: the rise in capital share over the past fifteen years in European countries, especially in continental countries. The first panel in figure 5 shows that in continental economies shares stand at higher level today than at the end of 1980s. Further, the second panel shows the pattern of capital share in UK and USA. While in UK capital share increased with a partial decrease in the last years,

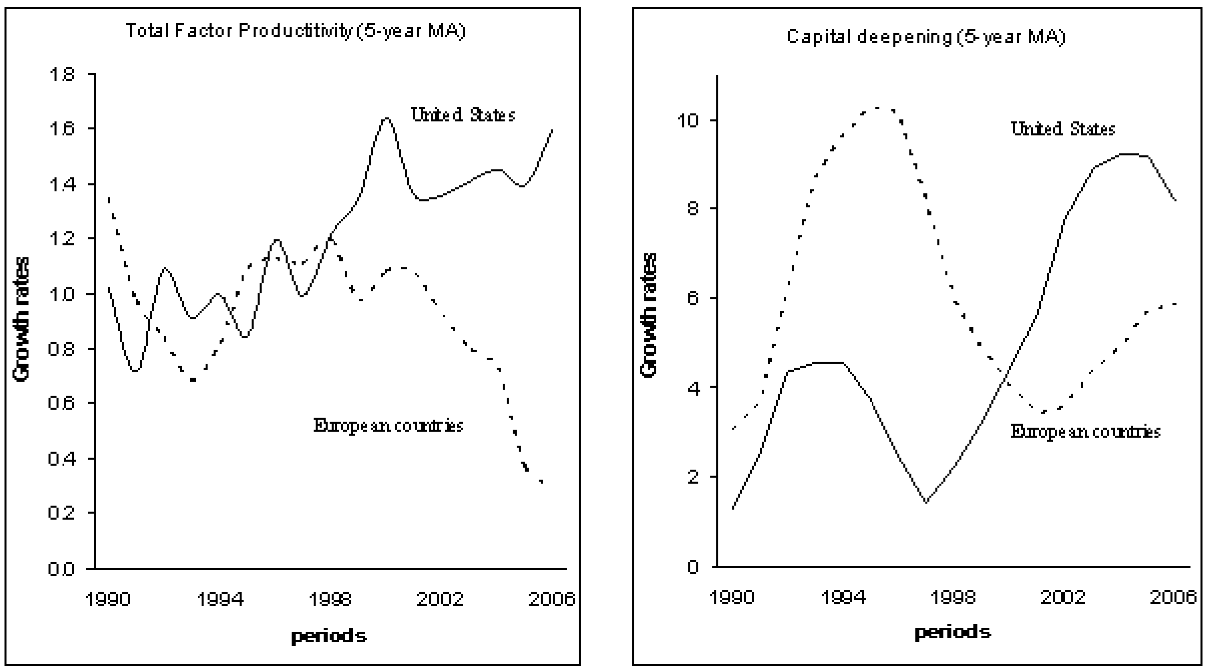

Figure 4: The trend of total factor productivity and capital deepening (5-year moving average).

in USA it remained quite stable around 37 per cent, confirming the old stylized fact of a constant capital share for USA economy.

The comparative dynamics of these historical data provides a first outcome. In European countries and in Usa, the last fifteen years witnessed a reversal of the traditional roles of employment and productivity in contributing to growth. In Europe, the recovery of labour utilization was accompanied by a corresponding negative trend of labour productivity. This recent performance marks a serious downgrading relative to the early 1990s when annual labour productivity growth was about 2.4 per cent, compared with 1.4 per cent for Usa. Since then there has been a reversal in fortunes, with the European countries's labour productivity growth rate declining on average by roughly 1 per cent point, and with the USA's accelerating by a similar amount. From a growth accounting perspective, the 1 percentage point decline in European labour productivity emanates from two sources. About 50 per cent can be attributed to a reduction in the contribution of capital deepening. The remaining part emanates from the deterioration of TFP. Nonetheless, during the same period capital share in European economy has increased.

3.1 Temporary versus permanent slowdown.

Is the slowdown in labour productivity growth rate likely a permanent or a temporary phenomenon linked to labour market reforms? To answer this question, it is helpful to look at the following graphs in figure 6, showing the scatter between the growth rates of labour productivity and employment in European countries from 1990 to 2006.

This comparison shows the existence of a negative (and some times near zero) unconditional correlation between these two variables. The trend line has a negative slope, and for Italy, Spain, UK and USA it is a statistically significative linear relationship.[1] Looking at these data we could be tempted, at first sight, to interpret the negative correlation as a movement along the labour demand curve, or as a shift in labour supply curve. This is what we have called the labour supply-side approach.

This interpretation explains the recent productivity slowdown as a response of the economy to a positive labour supply shock. The shock to

[1] See Hansen and Wright (1992) for a discussion of the employment-productivity puzzle: and Gali' (1999) for the anomalies regarding the labour market predictions of RBC models.

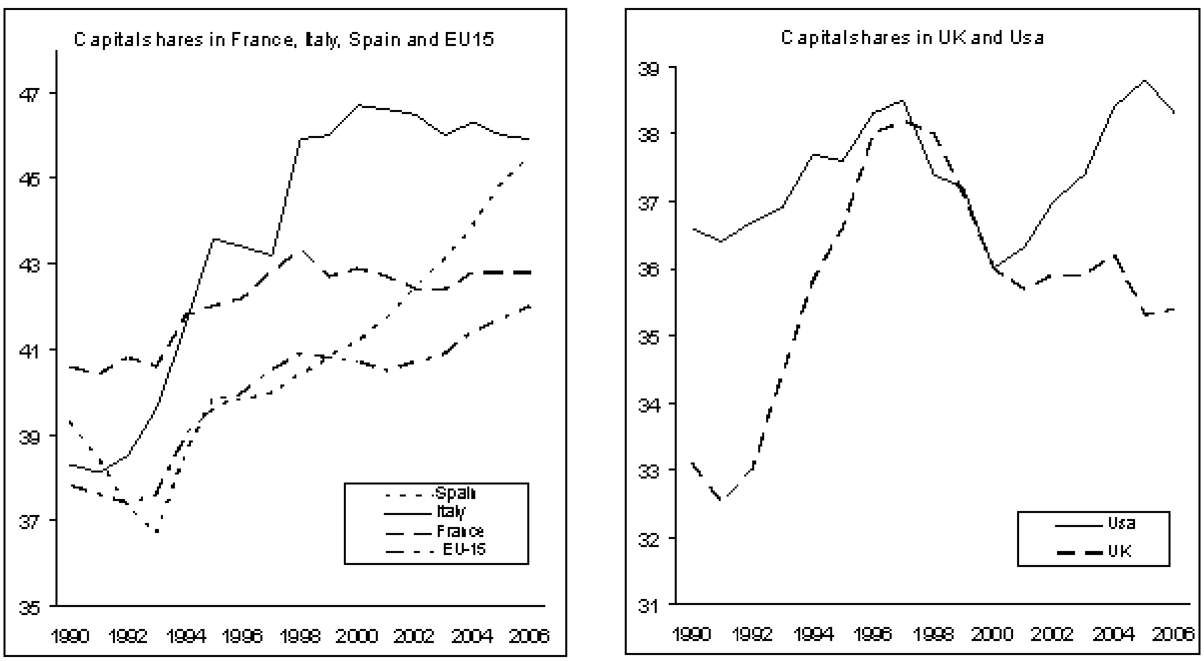

Figure 5: Capital Share (Capital income/GDP. Capital income includes profits, interest rates paid by firms, and profit taxes. Ameco database).

labour supply could be the result of labour market reforms and wage moderation. It could also reflect an increasing immigration of unskilled workers with a lower reservation wage. These changes could have contributed to an increase in labour force participation. Under this interpretation, a slower wage growth could have led to a temporary decline in the capital-labour ratio with a deceleration in labour productivity growth. Once full employment is attained, wage and productivity growth could accelerate again and the economy could go back to a higher productivity level. The recent decline in productivity growth could be regarded as a temporary phenomenon.

But, how much does the decrease in productivity growth reflect an increase in employment? How much might it reflect a decrease of both technological progress and capital deepening? Can we be sure *a priori* that the labour demand curve did not shift in recent times, so that the deceleration in labour productivity is only a short-run phenomenon?

The answer is obviously hard. Nonetheless, we find useful the following exercise. If we are willing to assume that multiple shocks affect the equilibrium in labour market, then we can construct an explanation of the productivity slowdown which depends on both the shifts of supply and demand of labour. Our explanation looks at a possible interaction between technological and *non* technological shocks. We call technological shocks the change in the growth rate of TFP, and *non* technological shocks the institutional changes in labour market, with their effects on regulation and wage moderation.

We offer the following explanation of the "basic facts". Firms reacted to deregulation in labour market (positive *non* technological shocks in supply) reducing capital deepening, switching towards more labour-intensive technology and hiring low quality labour. The initial effect has been to rise capital shares and to reduce the growth rate of productivity. However, since mid 1990s, labour market has been characterized by an adverse shift in labour demand. One explanation of this shift is the deceleration in the growth rate of technological progress, as it is shown by the evolution of TFP (negative technological shock). Moving away from skilled labour, firms led to a decrease in the growth rate of technological progress with a further negative impact on productivity.

We employ a labour market model with shifts in labour supply and demand to explore this interpretation. We make two main assumptions. Firstly, as in the Solow's model, we assume that the rate of technological progress affects labour productivity and capital intensity in the steady state. Secondly,

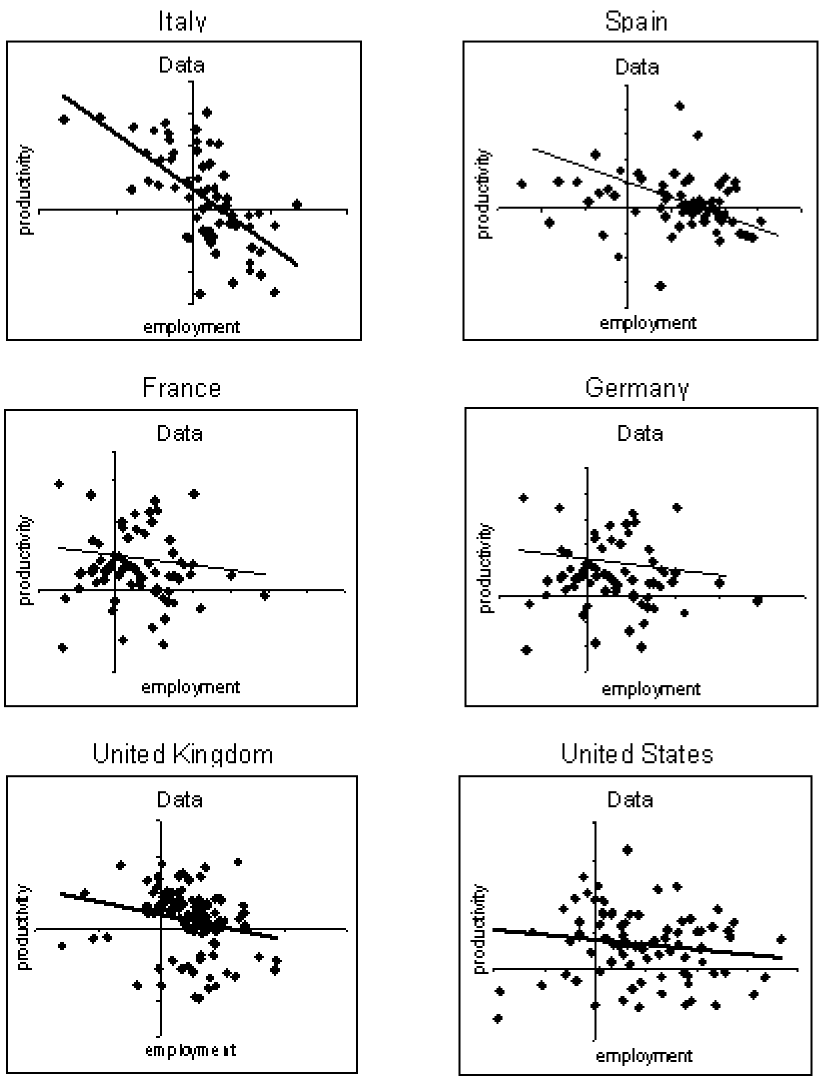

Figure 6: Scatter between labour productivity and employment growth rates. Historical data. (Period 1990-2006. Quarterly data. Eurostat database, OECD database and Federal Reserve of St.Louis database. Germany 1993-2006)

we assume that the equilibrium in labour market is affected by institutions and by changes in institutions.

The result of these assumptions is presented in figure 7. It illustrates the interaction between shocks in labour market. The long run equilibrium shifts from E_0 to E_1, where employment rate is higher and labour productivity growth rate is permanently reduced. Labour supply curve is affected by *non* technological shocks. Thus, the effect of deregulation is to shift labour supply down to the right, along the demand curve. In short run, labour productivity decreases as well as unemployment moving towards point A. However, this point cannot be an equilibrium. Indeed, technological shocks affect the position of the labour demand curve. Let's consider an adverse shock in technological progress.[2] Its effect is to decrease the growth rate of labour productivity, shifting permanently the labour demand curve down to the left. The *uc* line in figure 7 represents ideally the trend line of the previous scatters: two shifts originating from two types of shocks can provide a negative unconditional correlation.

The main implication of this scenario is that technological progress affects permanently the steady state, acting on both labour productivity and employment. Hence, we have a prediction on the sign of the *conditional* correlations. For technological shocks, the conditional correlation between the growth rates of employment and productivity must be positive: given labour supply and institutions, it reflects the shift in labour demand curve caused by technological changes. For *non* technological shock, the conditional correlation must be negative: given labour demand and technological progress, it reflects the shift in labour supply curve caused by institutional changes.

We build up a theoretical labour market model in which employment and

[2]Speaking of adverse technological shocks is just for sake of exposition. Indeed, we can formally represent the changes in labour market in terms of variation of growth rates. Let the production function be $Y = AN^{1-\alpha}$, with A the labour-augmenting technological progress, and $1-\alpha$ the income share of labour. The marginal productivity is $A(1-\alpha)N^{-\alpha}$. In terms of growth rates, this latter expression becomes $\frac{\dot{A}}{A} - \alpha\frac{\dot{N}}{N}$. Hence, the labour demand curve has a negative slope, and it shifts downwards to the left whenever the technological progress decelerates.

Similarly, the labour supply curve can be expressed as $w = \theta N$, where θ is a black box representing the institutional factors in labour market. In terms of rates of growth it can be written as $\frac{\dot{\theta}}{\theta} + \frac{\dot{N}}{N}$. As a consequence, whenever labour flexibility increase – which means a reduction in $\frac{\dot{\theta}}{\theta}$ – the supply curve shifts downwards to the left, increasing employment.

productivity react to each shock. Then, we will identify and estimate the components of the productivity and employment associated with the two alternative shocks using a SVAR model.

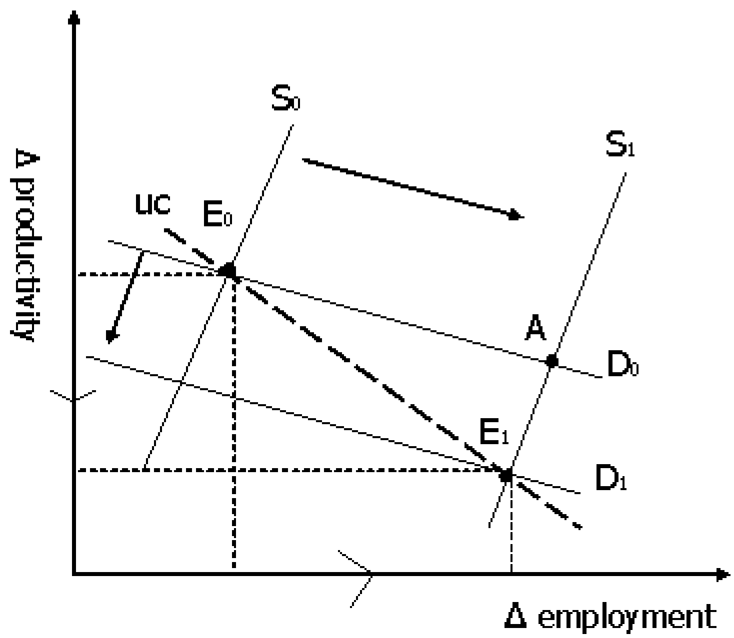

Figure 7: An interaction between technological and *non* technological shocks.

4 The model

This model is a version of Blanchard (1997). The main difference is that in this version the technological shock modifies permanently the steady state of labour market.

Let's assume that every firm uses one unit of capital. When the single firm chooses the amount of labour to hire, it also decides the corresponding labour to capital ratio. For the single firm the optimal labour demand is given by the solution of the following Bellman's equation:

$$\rho v(n) = \max_{\dot{n}} \left[An^{1-\alpha} - wn - \frac{c}{2}(\dot{n})^2 + \frac{d}{dt} v(n) \right] \quad (1)$$

In this equation, $v(n)$ is the value of the firm expressed as a function of the labour-capital ratio, n. As usual, the left-hand side of this equation is the cost of financing the firm, since ρ is the user cost of capital. The right-hand side is the market value of the firm given by the operating profits plus the capital gain. A is the technological progress. To get an analytical solution we assume that the operating profit is the difference between the real value of output $y = An^{1-\alpha}$ minus both the real cost of labour wn, and the quadratic costs $\frac{c}{2}(\dot{n})^2$ that the firm has to bear to adjust (hiring and firing) labour. The first-order and the envelope conditions are:

$$\begin{aligned} c\dot{n} &= v_n \\ \rho v_n &= A(1-\alpha)n^{-\alpha} - w + v_{nn}(n)\dot{n} \end{aligned}$$

and putting $v_n = q$, the previous conditions become:

$$\begin{aligned} c\dot{n} &= q \\ \rho q &= A(1-\alpha)n^{-\alpha} - w + \dot{q} \end{aligned} \tag{2}$$

The first equation says that the firm will increase employment up to the point where its marginal value q is equal to the adjustment cost, $c\dot{n}$. Then, from the second equation we get that along the optimal path the marginal cost of financing the firm ρq must be equal to the marginal value of the firm.

Substituting these two expressions in the Bellman equation (1) we obtain:

$$v(n) = \frac{1}{\rho}\left\{An^{1-\alpha} - wn + \frac{q^2}{2c}\right\} \tag{3}$$

which provides the value of the firm.

The firm must decide whether it is convenient to keep producing or exit the market. It compares its current value $v(n)$ to the cost of one unit of capital. This cost depends on the market demand for capital. Hence, the unit cost of capital p_k can be written as the sum of its direct cost normalized to 1 plus an adjustment cost which depends on the aggregate investment $\dot{K}$:

$$p_k = 1 + h\dot{K} \tag{4}$$

Free entry implies that:

$$v(n) = 1 + h\dot{K} \tag{5}$$

which defines the investment demand:

$$\dot{K} = \frac{1}{h}\left[v\left(n\right) - 1\right] \tag{6}$$

Now, let's focus on the labour *market* equations.

The aggregate labour demand is simply the sum of the individual demands, that is:

$$N = nK$$

For the labour supply we assume that it is a linear increasing function of real wage. At market level, if the labour force is normalized to 1, we can write:

$$w = \theta N \tag{7}$$

As we said above, θ is a black box representing the labour market institutions, with its variations giving account of institutional changes. The labour market equilibrium is then given by:

$$w = \theta nK \tag{8}$$

Finally, by assumption the user cost of capital ρ is an exogenous variable defined by international competition in capital markets. With a Cobb-Douglas production function this assumption implies that the real wage is fixed in the long run to the level w^*.

The following system of differential equations characterises the economy:

$$\begin{cases} \dot{n} = \dfrac{1}{c}q \\ \dot{q} = \rho q - \left[A\left(1-\alpha\right)n^{-\alpha} - w\right] \\ \dot{K} = \frac{1}{h}\left(v - 1\right) \end{cases} \tag{9}$$

In order to study the properties of this system, we begin determining the *steady state* of the economy. Since from the second equation of (9) we have that in equilibrium $\dot{q} = q = 0$, the steady state real wage is:

$$w^* = A\left(1-\alpha\right)n^{*-\alpha} \tag{10}$$

that is w^* is equal to the marginal product of capital. Then, since in steady state the marginal product of capital must be equal to the user cost (which is what the Bellman equation states), we have:

$$\begin{aligned} \rho &= y - wn \\ &= \alpha A n^{1-\alpha} \end{aligned}$$

so that the steady state labour-capital ratio is:

$$n^* = \left(\frac{\rho}{aA}\right)^{\frac{1}{1-\alpha}} \tag{11}$$

It follows that in steady state the real wage is:

$$w^* = A^{\frac{1}{1-\alpha}} (1-\alpha) \left(\frac{\rho}{\alpha}\right)^{\frac{-\alpha}{1-\alpha}} \tag{12}$$

Substituting these latter values in the labour supply equation we get the steady state values of both employment and capital stock at market level:

$$K^* = \frac{1}{\theta} A^{\frac{2}{1-\alpha}} (1-\alpha) \left(\frac{\rho}{\alpha}\right)^{\dfrac{-(1+\alpha)}{1-\alpha}}$$

$$N^* = \frac{1}{\theta} A^{\frac{1}{1-\alpha}} (1-\alpha) \left(\frac{\rho}{\alpha}\right)^{\dfrac{-\alpha}{1-\alpha}}$$

We use these two solutions to linearise the system (9) in the neighborhood of the steady state. It can be shown that the system has two state variables (K and N) and one jump variable (q) (see Appendix A for details). This means that its dynamics is characterised by a stable saddle path.

4.1 Non technological shock

Suppose that the system is initially in steady state. Then, given employment, a *non* technological shock reduces the value of θ. This variation decreases the slope of labour supply and the corresponding wage. At a given level of capital stock, the lower wage increases labour demand rising the labour-capital ratio. These effects are shown in figure 8 where equilibrium shifts from E to A.

In the long run, however, the decrease of wage rises the firm's value making attractive to enter in the market. As a result, both capital and employment increase and the labour demand curve shifts to the right, moving the economy towards the new steady state. In E' the level of employment has increased and the labour productivity has returned to its initial level. Note that in the long run the *non* technological shock does not change the labour-capital ratio, although it does increase the use of both the inputs.

The dynamics of the system is described in figure 9. The parameters values are: $\rho = 0.15$, $\alpha = 0.3$, $h = 10$, $c = 4$, $A = 0.5$. The initial value

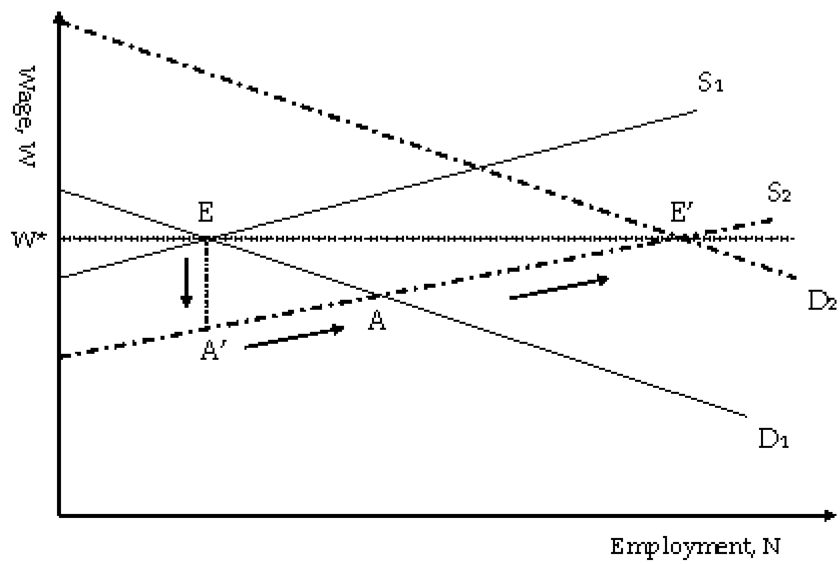

Figure 8: A greater labour flexibility.

of θ is $\theta_0 = 0.385$; for analytical simplicity, the initial value of the labour-capital ratio is $n_0 = 1$, so that $K_0 = \frac{w_0}{\theta_0 n_0} = 0.909$, and employment is $N_0 = n_0 K_0 = 0.909$. We then suppose a *reduction* (which means a positive *non* technological shock) of θ, such that its value is reduced to $\theta_1 = 0.35$.

4.2 Technological shock

Now, let us focus on adverse technological shocks, that is a decrease in the value of A. In our model, only technological shocks have a permanent effect on labour productivity. The impact of this shock is shown in figure 10 where the labour demand curve shifts down to the left, affecting permanently the steady state.

The slowdown of the technological progress has an initial effect on profit rate, wage and labour-capital ratio. Indeed, the reduction in productivity leads the firm to invest less in the long run, modifying the steady state: given the user cost ρ, a lower productivity can only be offset by a lower wage in the long run. Eventually, this change leads to an increase of the labour-capital ratio.

Note, however, that the technological shock reduces permanently employ-

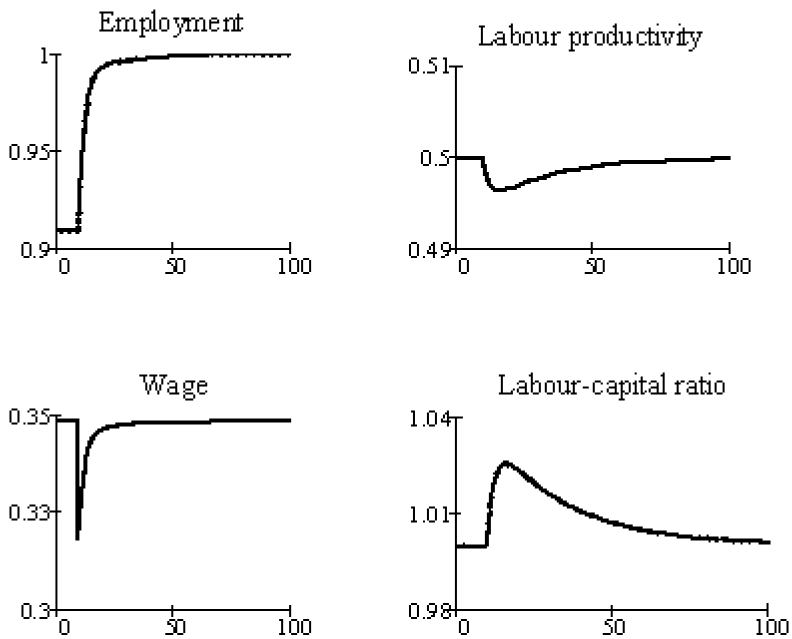

Figure 9: The dynamic effects of a greater labour flexibility.

ment in the long run. This outcome conflicts with one of the stylized facts seen above, i.e. the increase of labour utilization during the 1990s. The slowdown of technological progress is thus a potential, even if incomplete, explanation of the European economic dynamics in the last fifteen years.

The adjustment paths of the system are described in figure 11. The parameters values used are: $\rho = 0.15$, $\alpha = 0.3$, $h = 10$, $c = 4$, $\theta = 0.35$. The initial value of A is $A_0 = 0.5$; we then have an adverse shock to A such that the new level is $A_1 = 0.49$.

4.3 An interaction between shocks

In this simulation we analyse the interaction between shocks. We study the combined effect of a decrease of θ and A. Figure 12 shows that, in this scenario, the steady state shifts from E to E'.

Comparing the two steady state equilibria, we note that two effects arise: employment increases while labour productivity decreases. The rise of em-

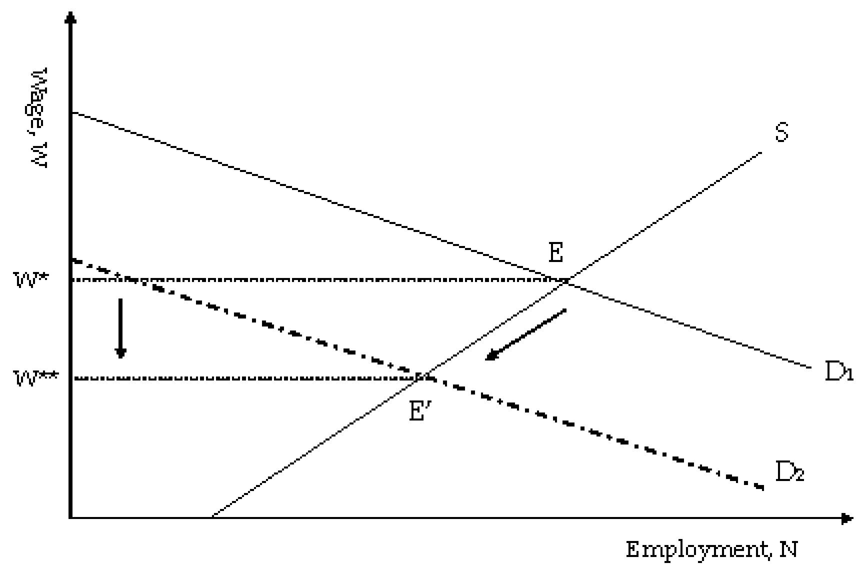

Figure 10: A slowdown in technological progress.

ployment is originated in the deregulation. On the other hand, the reduction of both wage and productivity depends on the slowdown of the technological progress. Since the user cost ρ is exogenously given, the lower productivity of labour must be offset by a decrease in capital accumulation to rise marginal productivity of capital. This implies an increase of the labour-capital ratio in the long run.

As before, the dynamics of the system is described in figure 13. The parameters values are: $\rho = 0.15$, $\alpha = 0.3$, $h = 10$, $c = 4$, $\theta = 0.385$, $A = 0.5$. Then, both A and θ are reduced to $\theta_1 = 0.35$ and $A_1 = 0.48$ to simulate the combined effect of the two shocks.

In summary, two lessons can be drawn from all these simulations. Firstly, technological shocks can potentially explain the slowdown in labour productivity since the early 1990s. Secondly, we need two separate shocks to capture the joint behavior of employment and productivity. Technological shocks, shifting permanently the labour demand curve down to the left, can capture the adverse evolution of productivity; *non* technological shocks, shifting labour supply curve down to the right, can capture the increase in the level of employment.

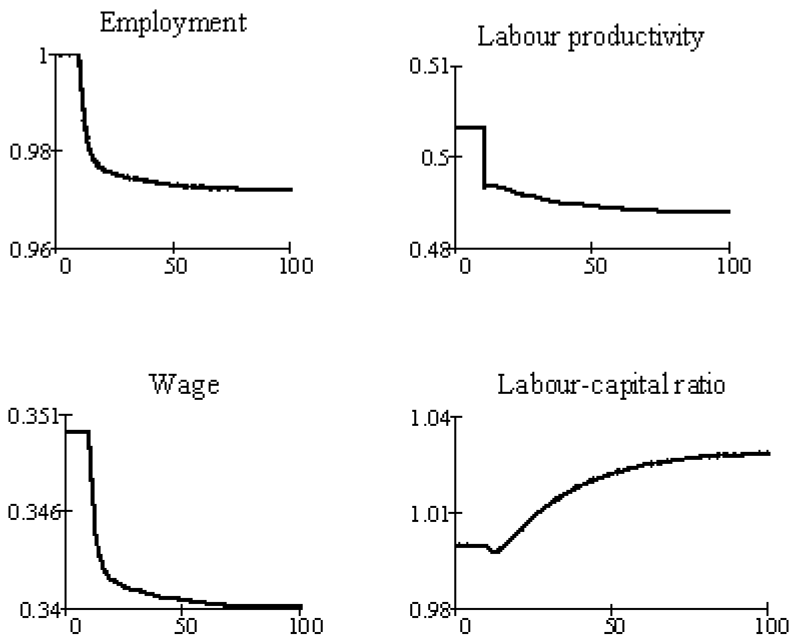

Figure 11: The dynamic effects of the slowdown in technological progress.

5 Empirical results

The previous model provides the identifying restrictions for the structural VAR. Note that these restrictions allow permanent effects of technological shock on both productivity and employment. Following Gali' (1999) we do not restrict technological shocks *not* to have permanent effect on employment. We know that only a combination of technological and *non* technological shocks can capture the "basic facts". However, in the empirical analysis we add a third shock. As it is in Blanchard and Quah (1989), to identify the aggregate demand component of labour productivity and employment we impose that aggregate demand has no long run impact on productivity and employment.[3] These restrictions follow from the assumption that the Nairu holds in the long run.

The data used to estimate the SVAR are total employment in full-time

[3] These same assumptions are used by Gamber and Joutz (1993) to identify the aggregate demand component of real output and productivity.

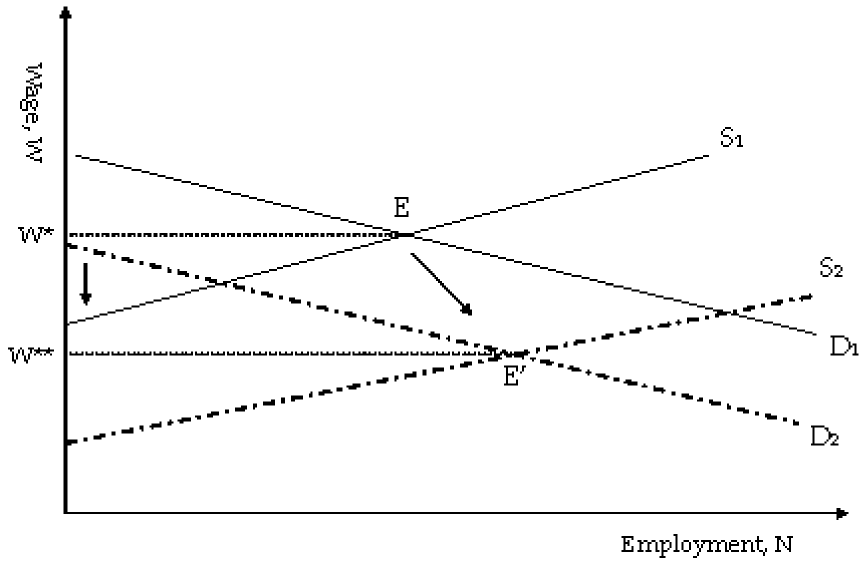

Figure 12: Interaction between shocks.

equivalent for Italy, France and Spain; total employment for UK; and civilian employment for USA. Then, we employ real GNP to calculate labour productivity, and real aggregate demand. Data are quarterly.[4] We interpret the observed variation in (log) productivity (p), (log) employment (l) and (log) demand (d) as originating from three types of shocks, whose impact is propagated over time. Formally:

$$\begin{bmatrix} \Delta p_t \\ \Delta l_t \\ \Delta d_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) & C_{13}(L) \\ C_{21}(L) & C_{22}(L) & C_{23}(L) \\ C_{31}(L) & C_{32}(L) & C_{33}(L) \end{bmatrix} \begin{bmatrix} \epsilon_p \\ \epsilon_l \\ \epsilon_d \end{bmatrix} = C(L)\epsilon_t \tag{13}$$

In the matrix $C(L)$, we find the polynomials $C_{ij}(L)$ with individual coefficients denoted by $c_{ij}(k)$. The innovations ϵ_p, ϵ_l and ϵ_d represent the structural shocks on labor demand and supply. To resume, the long-run restrictions are:

1. technological shocks have a long run impact on the *log* of labour productivity, employment and aggregate demand;

[4]The database employed in the econometric analysis is obtained by Eurostat, OECD and the Federal Reserve of St.Louis.

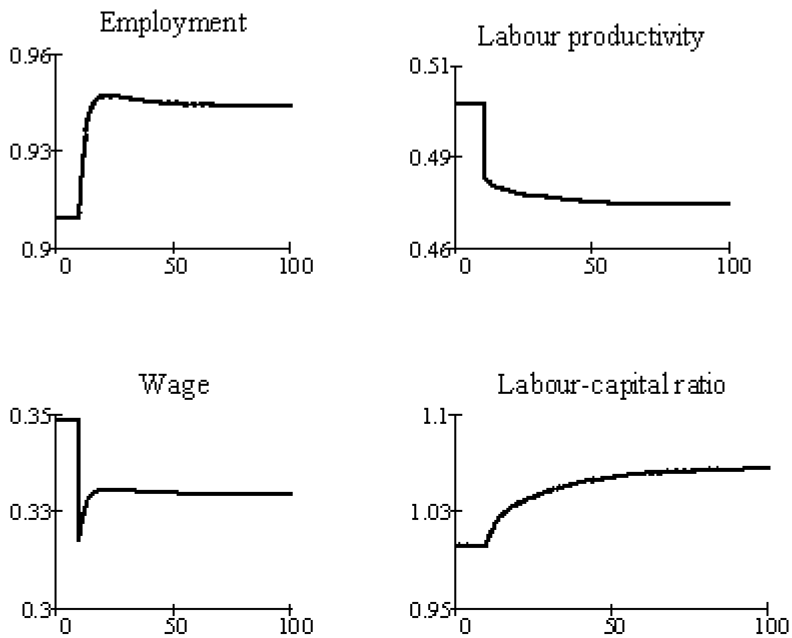

Figure 13: The dynamic effects of two shocks

2. *non* technological shocks have a long run effects on the *log* of employment and aggregate demand, but they do *not* affect labour productivity;[5]

3. aggregate demand shocks have only short run impacts on the growth rate of employment and productivity.

Given these identifying restrictions the matrix of the long run multipliers $C(1)$ is:

$$C(1) = \begin{bmatrix} C_{11}(1) & 0 & 0 \\ C_{21}(1) & C_{22}(1) & 0 \\ C_{31}(1) & C_{32}(1) & C_{33}(1) \end{bmatrix} \tag{14}$$

[5]This restriction is implied by the Solow growth model with a Cobb Douglas production function. In this model, marginal productivity of labour depends on the capital-labour ratio and this latter is constant in steady state. Hence, any change in labour supply (non technological shock) will lead to an equal percentage change in capital stock.

Assuming the shocks are ordered technological, non technological and aggregate demand the above restrictions says that the secular component in labour productivity originates in the technological shocks, and the coefficient $C_{11}(1)$ identifies the long run multiplier of this shock. In turn, the zeros in the matrix (14) imply that both employment and aggregate demand shocks do not affect the *log* of productivity in the long run (however, they may well have short and medium run effects on it), but that the secular component of the *log* of employment depends on both technological and non technological shocks.[6]

The moving-average specification is based on the assumption that the growth rates of variables are stationary. This assumption is motivated by the outcome of the standard Dickey-Fuller tests and Phillips-Perron tests which reject the null of unit root when applied to the first differences of log. Two different specifications of the variables in VAR are run to test the robustness of the result. In the first case (specification A) we remove no means and no trends. In the second case, we remove a mean growth shift for employment and aggregate demand after 1992 and we detrend the employment rate.[7] We present results from specification A.

Figure 14 reports estimates of both unconditional and conditional correlations between the growth rates of employment and productivity, over the period 1975-2006.[8] The unconditional correlation is reported in the first column. As we said above, this correlation is negative in all countries, and, in some case, near zero. However, the SVAR analysis allows to disentangle the intricate effects of the different shocks in generating the correlation. Our benchmark estimates of *conditional* correlations are reported in the second and third columns. They are consistent with our theoretical model

[6] The polynomial $\sum_{k=0}^{\infty} c_{ij}(k) = C_{ij}(1) = 0$ implies that a specific structural shock has no effect on the level of variables in the long-run .

[7] The VAR contains from four to eight lags depending on the specification of the dynamic model. The impulse response functions are similar across alternative treatments of lags, breaks and time trends.

[8] The estimates of conditional correlations are obtained applying the formulas provided by Gali' (1999, p.257). It is interesting to compare our decomposition to the one provided by Hansen and Wright (1992), Gali' (1999) and Christiano et al. (2003). The significance of the correlation index is obtained applying the formula $t = \frac{r}{\sqrt{(1-r^2)/(n-2)}}$, where t is the Student's t, r is the correlation and n the size of the sample. The t value is distributed approximately with $n-2$ degrees of freedom. Application of this formula to any particular observed sample value of r will test the null hypothesis that the observed value comes from a population in which $r = 0$.

	Unconditional	Conditional	
		Technology	*Nontechnology*
Italy	-0.40**	0.25**	-0.70**
	(4.84)	(2.74)	(10.4)
Spain	-0.27**	0.11*	-0.25**
	(3.11)	(1.18)	(2.74)
France	-0.08	0.56**	-0.41**
	(0.89)	(7.12)	(4.77)
United Kingdom	-0.21**	0.22**	-0.42**
	(2.41)	(2.28)	(4.92)
United States	-0.18**	0.57**	-0.68**
	(2.03)	(7.37)	(9.85)
Germany	-0.10	-	-
	(1.12)		

Figure 14: Correlation Estimates for the European countries and Usa. Total economy. (Growth rates. Quarterly data for the period 1975:1-2006:3. t values are in parentheses (125 degrees of freedom). Significance is indicated by one asterisk (10-percent level) or two asterisks (5-percent level)).

of labour market. We get a *positive* correlation between the growth rates of productivity and employment conditional on technological shocks; and a *negative* conditional correlation to *non* technological shocks. Thus, the historical correlation provided by the data can be reconciled with shifts in both the demand and the supply curve in labour market: productivity responds positively to technological shocks and negatively to *non* technological shocks. Figures 15 and 16 provide the graphical counterpart of the previous evidence.

To clarify the reason of the historical decomposition, it is helpful to look at the impulse response functions estimated from the SVAR. Because of the similarity in the features, in figure 17 we report only the basic case for Italy and France.[9]

Both productivity and employment response positively to a one-unit technological shock. We interpret the impact of this shock as a shift of the labour demand curve along the supply curve. This comovement does not explain entirely the evolution of employment: the order of magnitude of the em-

[9] The impulse response functions for the other three countries are close to these. The main difference lies in the magnitudes of the responses.

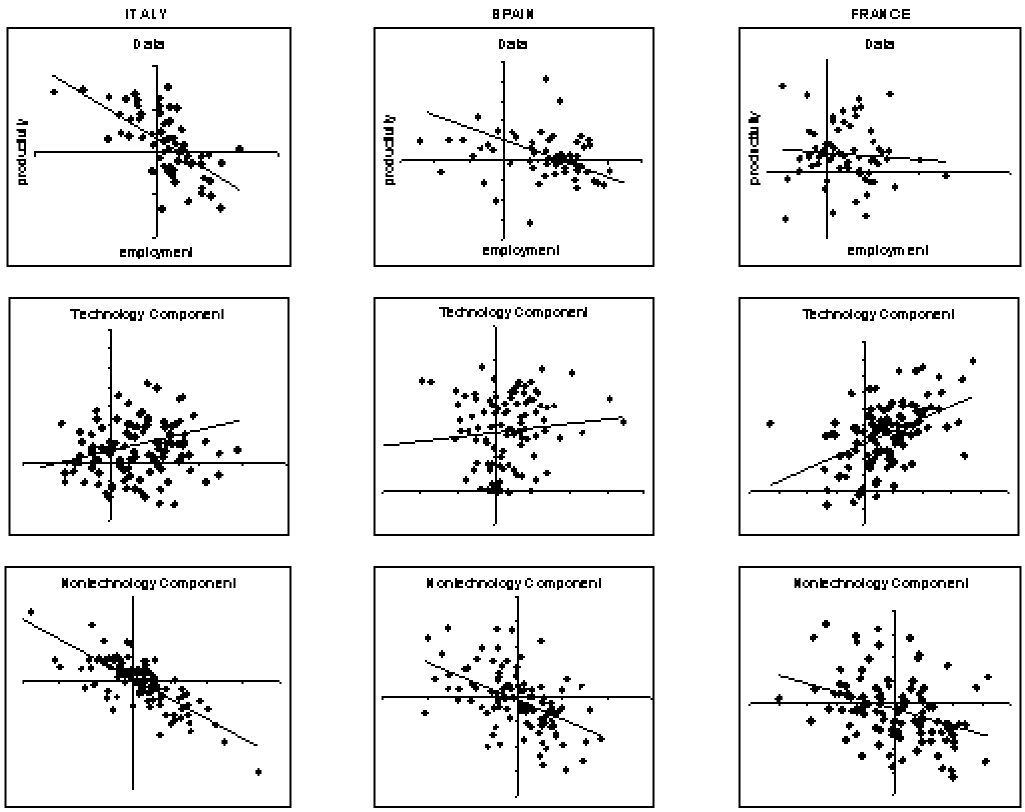

Figure 15: Productivity vs. employment. Historical data, technological component, and non technological component (Italy, Spain, France).

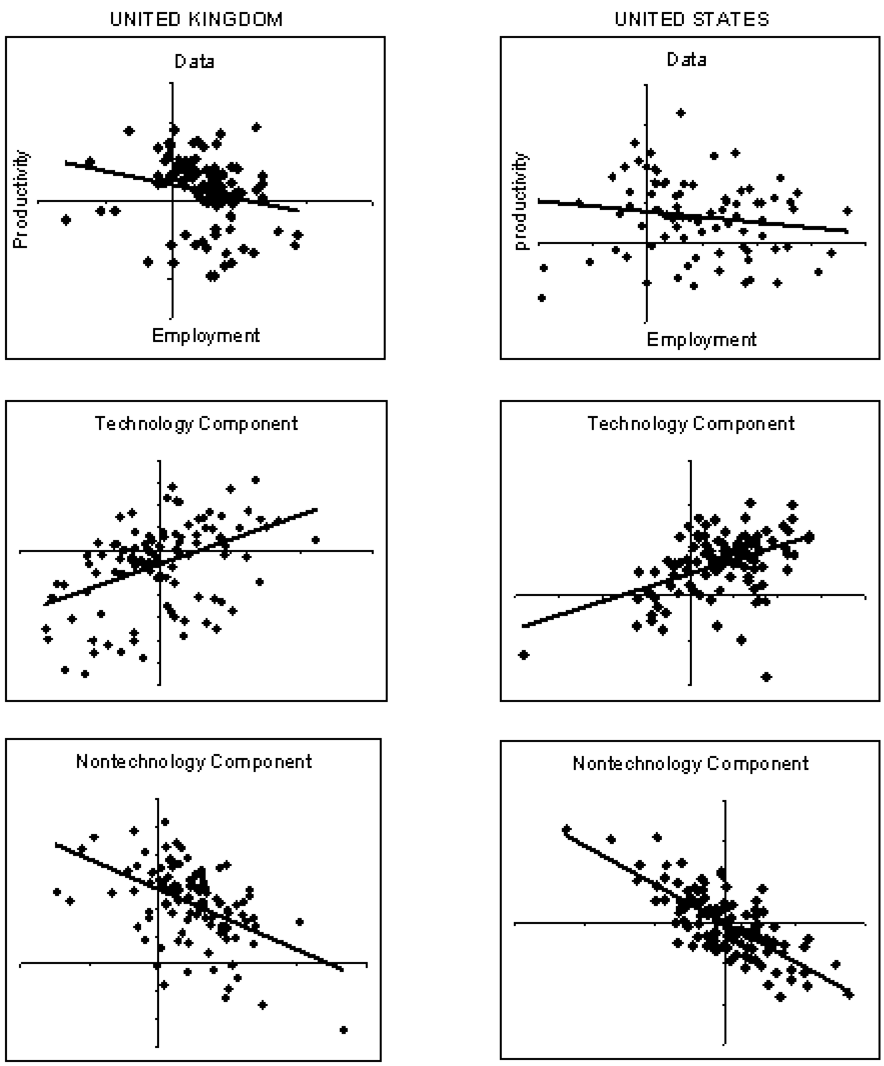

Figure 16: Productivity vs. employment. Historical data, technological component, and non technological component (UK and USA).

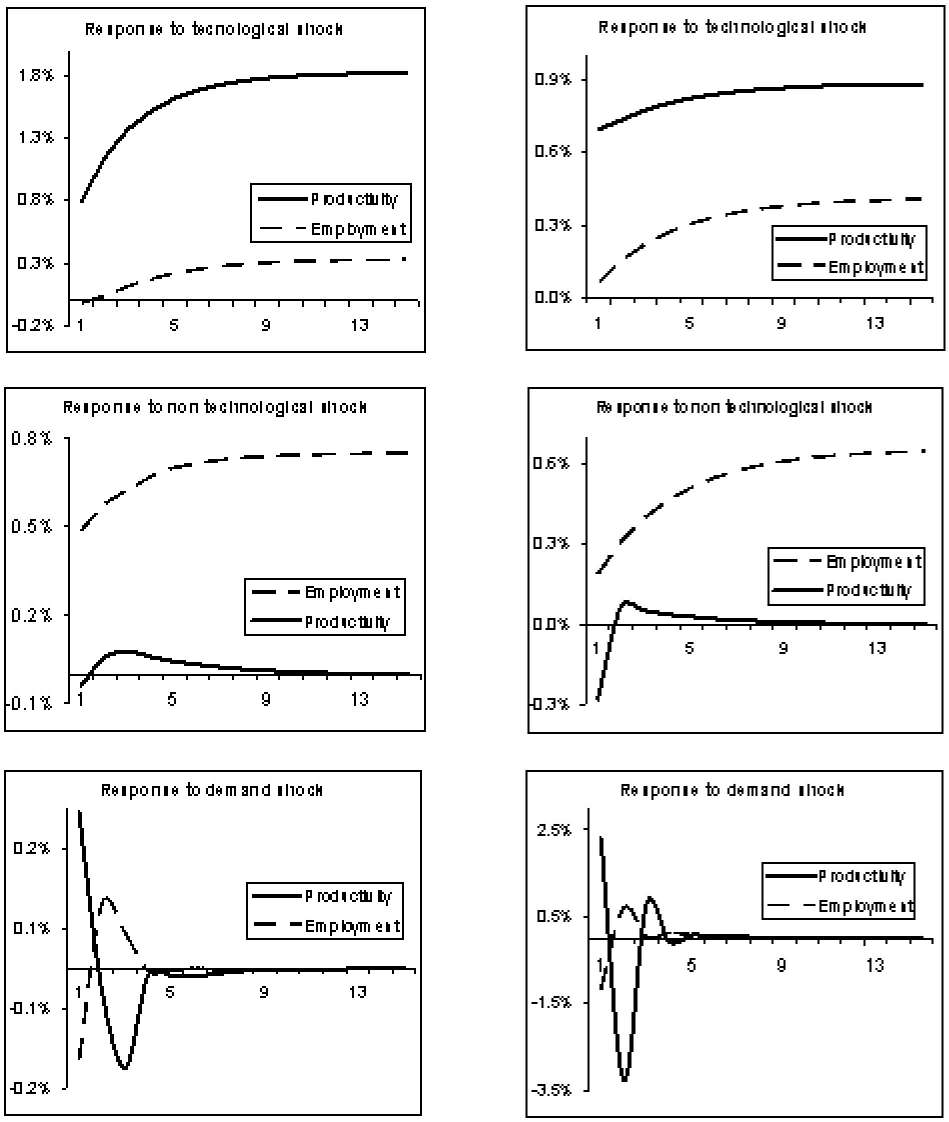

Figure 17: Estimated impulse response function of employment and productivity.

ployment response is smaller than the productivity variation over the same period. Thus, technological shocks appear as the main source of the productivity slowdown, while it does not capture the actual changes in employment.

The second two panels in figure 17 show that employment increases permanently to a *non* technological shock, while labour productivity decreases temporarily in response to the same shock. We interpret this response as the shift of the supply curve along the demand curve. This dynamics is coherent with the adjustment path described by the labour market model. The impact on productivity of the *non* technological shock is negative in the short run, with labour productivity recovery in the long run. In the new steady state, the rise in (log) employment is associated to an unchanged level for (log) labour productivity.

Finally, the bottom two panels in figure 17 show that aggregate demand has only a short run effect on the growth rates of employment and productivity. This shock is initially associated with a positive productivity effect. This is plausible since in short run an expansion of aggregate demand rises the level of GDP and of capital utilization. But, as this initial impact fades away, productivity and employment return to their original levels, so that the initial impact vanishes over time.

Thus, our evidence suggests that only the contemporaneous shift of both labour demand and supply can appropriately explain the trade-off between the employment and productivity growth rates occurred in European countries during the last fifteen years. The contribution of the technological shock can explain the main part of the slowdown in labour productivity growth, while it is unable to explain the evolution of employment. A similar interpretation holds for the change of employment which, generally, at longer horizon reflects responses to *non* technological shocks.

6 Conclusions

In this paper we have provided an explanation of the productivity slowdown puzzle in European countries during the last fifteen years. We have found that both shifts in labour supply and demand are necessary to give a correct explanation of this adverse evolution. These two shifts have contributed simultaneously to rise employment and to decrease the growth rate of productivity. These findings have three main implications for the current debate on the European productivity slowdown.

Firstly, the responses to shocks of productivity and employment are difficult to reconcile with theories focusing only on one side of labour market. A more helpful approach is to interpret the productivity slowdown as the interaction between technological and *non* technological shocks. These shocks act on the equilibrium in labour market, affecting both labour supply and demand.

Secondly, as said above, one interpretation of the "basic facts" we presented at the very beginning of our study is that firms reacted to labour market reforms in 1990s reducing capital deepening and hiring low quality labour. The initial effect of this choice has been to rise capital shares. But, moving away from skilled labour had the main consequence to decrease the growth rate of technological progress with an adverse impact on both the growth rate of labour productivity and GDP. Hence, labour market reforms resulted in unintended and undesirable consequences for capital accumulation and productivity.

Thirdly, the predictions of our model provide a non optimistic message about the future of the European economy. Actually, the rise in labour utilization might lead to slower capital accumulation and technological progress in the long run, with obvious consequence on both productivity and growth. Thus, the further outcome of our analysis is the policy implication that with two goals (employment and productivity) more than an instrument (labour market reforms) is needed to increase employment without depressing productivity. The policy to remedy to this situation appears much more complex than the ones drawn from the traditional labour supply explanation.

To conclude, we believe that the hypotheses employed in this paper are a plausible set of assumptions. A more comprehensive approach is needed. In this perspective, the European productivity slowdown puzzle can well be explained by the intricate interplay of technological and *non* technological in labour market over the last fifteen years.

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A Appendix. Stability analysis

In this appendix we study the stability of the system (9). We show that the steady state is a saddle point with a unique stable path. For convenience, we rewrite here the differential equations characterizing the economy:

$$\begin{cases} \dot{n} = \dfrac{1}{c} q \\ \dot{q} = \rho q - \left[A\left(1-\alpha\right) n^{-\alpha} - w\right] \\ \dot{K} = \frac{1}{h}\left(v-1\right) \end{cases} \tag{15}$$

and the steady state values of the variables:

$$\begin{aligned} q^{*} &= 0 \\ K^{*} &= \frac{1}{\theta} A^{\frac{2}{1-\alpha}} \left(1-\alpha\right) \left(\frac{\rho}{\alpha}\right)^{\dfrac{-\left(1+\alpha\right)}{1-\alpha}} \\ N^{*} &= \frac{1}{\theta} A^{\frac{1}{1-\alpha}} \left(1-\alpha\right) \left(\frac{\rho}{\alpha}\right)^{\dfrac{-\alpha}{1-\alpha}} \end{aligned} \tag{16}$$

Using these steady state values to linearise the system (15) we get:

$$\begin{cases} \dot{n} = \dfrac{1}{c} \bar{q} \\ \dot{q} = \rho \bar{q} - \left[d - g\bar{n} - \theta\left(n^{*}K^{*} + n^{*}\bar{K} + K^{*}\bar{n}\right)\right] \\ \dot{K} = \frac{1}{h}\left\{\frac{1}{\rho}\left[p + d\bar{n} - \theta\left(n^{*2}\bar{K} + 2K^{*}n^{*}\bar{n} + \left(n^{*}K^{*}\right)^{2}\right)\right] - 1\right\} \end{cases}$$

The variables with bar indicate deviations from the *steady state* – for instance, $\bar{n} = n - n^{*}$. d is the labour marginal product in *steady state*, $d = A\left(1-\alpha\right) n^{*-\alpha}$, g is its derivative in absolute value, $g = Aa\left(1-\alpha\right) n^{*-\alpha-1}$, p is the output in steady state, $p = An^{*1-\alpha}$.

We now look at the homogenous part of the system to analyze its stability:

$$\begin{aligned} \begin{pmatrix} \dot{n} \\ \dot{q} \\ \dot{K} \end{pmatrix} &= \begin{pmatrix} 0 & \dfrac{1}{c} & 0 \\ g + \theta K^{*} & \rho & \theta n^{*} \\ -\dfrac{\theta n^{*} K^{*}}{h\rho} & 0 & -\dfrac{\theta n^{*2}}{h\rho} \end{pmatrix} \begin{pmatrix} \bar{n} \\ \bar{q} \\ \bar{K} \end{pmatrix} \\ &= M \begin{pmatrix} \bar{n} \\ \bar{q} \\ \bar{K} \end{pmatrix} \end{aligned}$$

where in the previous expression we have taken into account that in equilibrium the demand wage is equal to the supply wage, so that $d\bar{n} = \theta K^* n^* \bar{n}$. From the previous system we get the characteristic equation:

$$M - \lambda I = 0 \Longrightarrow$$
$$-\lambda^3 + \lambda^2 \left(\rho - \frac{\theta (n^*)^2}{h\rho} \right) + \lambda \left(\frac{g}{c} + \frac{\theta K^*}{c} + \frac{\theta n^{*2}}{h} \right) + \frac{g\theta n^{*2}}{ch\rho} = 0$$

Since the sequence of the signs is $-$? $+$, it is straightforward to conclude that there are two negative roots and a positive one. Thus, the equilibrium is a saddle: that is, there is only one path to the steady state.[10] Intuitively, this result derives from the presence of two state variables (n and K), whose number must equal the number of negative roots, and one *jump* variable, which is q the marginal value of the firm (Gandolfo 1997, pp.401-3).

We can eliminate the positive root to converge on the saddle path. Denoting the two negative roots with λ_1 and λ_2, and the eigenvectors with con v and w, we write the solution of the system (15) as:

$$\begin{aligned} n_t &= \gamma v_1 \exp(\lambda_1 t) + \beta w_1 \exp(\lambda_2 t) + n^* \\ K_t &= \gamma v_2 \exp(\lambda_1 t) + \beta w_2 \exp(\lambda_2 t) + K^* \\ q_t &= \gamma v_3 \exp(\lambda_1 t) + \beta w_3 \exp(\lambda_2 t) + q^* \end{aligned}$$

where γ and β are determined by the initial conditions of the state variables:

$$\begin{aligned} n_0 &= \gamma v_1 + \beta w_1 + n^* \\ K_0 &= \gamma v_2 + \beta w_2 + K^* \end{aligned}$$

We use these solutions to simulate the model.

[10] It can be shown that this is true even when there are complex roots, so that we cannot apply Cartesio rule.