ETLA
**ELINKEINOELÄMÄN TUTKIMUSLAITOS**
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

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Kari E.O. Alho – Nuutti Nikula

## PRODUCTIVITY, EMPLOYMENT AND TAXES – EVIDENCE ON THE POTENTIAL TRADE-OFFS AND IMPACTS IN THE EU*

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**ABSTRACT:** The paper considers time series evidence on the relationships, and possible trade-offs, between productivity and employment, and on the impact of taxes in this connection. First, a theoretical model is built for an open economy leading to the identification of technology, non-technology and tax shocks. Then structural VAR models are estimated for all the EU-15 and some other OECD countries to infer the above links. Our conclusion is that there is in the EU a fairly uniform and significant short-run negative impulse on employment from a positive productivity shock, while this becomes smaller and statistically insignificant over time in most, but not in some member countries. The former situation is interpreted to be an indication of nominal and the latter that of real or structural rigidity in the economy. In the US, there is no such trade-off, either in the short or long run. Tax shocks are found to have mostly a short-run negative effect which is stronger on productivity than on aggregate employment. However, if we separate the effects of labour taxes and corporate taxes, the former have in the EU-15 a strong negative effect on employment while the latter are fairly neutral. Second, we simulate an aggregative econometric labour market model and insert various types of shocks into it: a rise in productivity, achieved, e.g. by enhancing R&D, or by rationalising the use of labour, and a change in the tax/benefit system. We find that although there is no long-run trade-off between productivity and employment, over the medium run acceleration of productivity has a clear positive effect on employment.

**KEY WORDS:** Productivity, employment, taxes, EU

**JEL Codes:** O49, H29, J20

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**TIIVISTELMÄ:** Tutkimusraportti tarkastelee aikasarja-analyysin menetelmin tuottavuuden ja työllisyyden välistä suhdetta ja verojen vaikutuksia tässä yhteydessä. Aluksi rakennetaan teoreettinen avotalouden malli, jonka avulla voidaan tutkittavat hypoteesit identifioida. Rakenteelliset VAR-mallit estimoidaan kaikille EU15 -maille ja joillekin muille OECD-maille. Tulokseksi saadaan, että EU:ssa vallitsee melko yhtenäinen ja tilastollisesti merkitsevä lyhyen aikavälin negatiivinen vaikutus työllisyyteen positiivisesta tuottavuusshokista, joka kuitenkin pienenee ja tulee yli ajan ei-merkitseväksi useimmissa, mutta ei kaikissa EU-maissa. Edellinen tilanne tulkitaan olevan seurausta nimellisestä hintajäykkyydestä ja jälkimmäinen reaalisesta tai rakenteellisesta jäykkyydestä taloudessa. USA:ssa kumpikaan tapaus ei esiinny, joten siellä hinnat ovat joustavia. Kokonaisveroshokeilla on enimmäkseen lyhyen ajan negatiivinen vaikutus, joka on jonkin verran voimakkaampi tuottavuuteen kuin työllisyyteen. Mutta kun teemme jaon työvoima- ja yritysveroihin, edellisillä on EU15-aluetta kokonaisuutena analysoiden voimakas negatiivinen vaikutus työllisyyteen, kun taas jälkimmäiset ovat vaikutuksiltaan melko neutraaleja. Toisena empiirisenä lähestymistapana simuloimme aggregatiivista ekonometristä työmarkkinamallia ja asetamme siihen erilaisia shokkeja koskien tuottavuutta ja veroetuusjärjestelmää. Tuottavuus voi nousta panostamalla T&K:hen tai rationalisoimalla työvoiman käyttöä. Tulokseksi saadaan, että vaikka pitkällä ajalla ei vallitsekaan riippuvuutta työllisyyden ja tuottavuuden välillä, lyhyellä ajalla tuottavuuden nousun kiihtymisellä on selvä positiivinen vaikutus työllisyyteen.

**ASIASANAT:** Tuottavuus, työllisyys, verot, EU

# 1 Introduction

The Lisbon process of the EU, with the goal to enhance the long-term performance of the Union, has two key economic goals: economic growth and employment. Politicians are typically inclined to consider these two as being in a tight positive relation to each other so that more growth means more jobs. The basis for this belief is the seminal Okun law displaying a strong short-run relationship between economic growth and increases in employment. However, a quick look at the cross-section data for the EU countries in relation to the US suggests that the two goals: productivity, being the key determinant of long-term economic growth, and employment would be in sharp conflict with each other, see Kaitila (2006). If more of the EU labour force is wanted to be employed, this can only be met with a lower level of productivity, and vice versa. This is an important policy issue, and therefore information on this link, be there either a trade-off, or a mutual positive relationship, between these two key goals in the short and long run, can deliver essential insight on the internal consistency of the reform process in the EU.

The relationship between productivity and employment is a long-standing issue in macroeconomics. In his seminal paper Galí (1999) criticised the basic result of the real business cycle (RBC) theory that productivity and employment are strongly positively linked in the short run. The structural VAR (SVAR) analysis by Galí was based on the identifying hypothesis, derived fairly uniformly from various theoretical considerations, that the demand (non-technology) shocks do not have a long-run effect on productivity.[1] His empirical results showed that in the short run, up to two years, positive non-technology shocks may boost productivity growth in the US, and that technology shocks contract employment (aggregate hours) in the short, but not in the long run. The case of a negative contemporaneous impulse response on employment from a positive technology shock can be based on the case of nominal price and wage stickiness, while a positive response can emerge in a flexible price economy, see on this Galì (1999) and Giannone and Reichlin (2006). This empirical result of the former type reached by Galí (1999) has, however, raised fierce critique by the RBC school and challenged e.g. by Christiano, Eichenbaum and Vigfusson (2003, 2004), who argue that it is due to a wrong empirical specification of the employment equation in the SVAR analysis. If this is corrected, a positive empirical impulse response emerges, as implied by the RBC model. This controversy boils down to the issue of the relevance of various approaches in

[1] This neutrality situation is also argued by Mortensen (2005).

business cycle analysis, i.e. the RBC vs. New Keynesian paradigm. Aside from the theoretical and empirical controversy of a proper business cycle model, there is an important policy question, mentioned above, connected to this dispute. Accordingly, our main interest here lies in a slightly different way mostly in the question of the long-term effect of productivity gains on employment and thereby we shift the focus to consider the possible long-run structural rigidity in this connection. We also enlarge the model to cover the role of tax policies, which can have an essential impact. This issue of the effects of tax policies has so far received only limited attention in the related SVAR literature, see, however, Uhlig (2004) for an inclusion of capital income taxes in the analysis of productivity and employment.[2]

In the empirical part of the paper, we use two approaches. Both of them are based on a similar theoretical methodology describing the equilibrium in the labour market, but diverge in the method of empirical application. So, to start with, we first build a theoretical open economy model and identify in it a technology, non-technology and a tax shock and their effects. In the empirical part the first approach is to build structural VAR models and empirically find out the impacts of the structural shocks identified in the model in the short and long run for all the EU-15 and some other OECD countries. Secondly, we use an aggregative econometric model built by Alho (2002a) for the Finnish labour market, based on the idea of the equilibrium rate of unemployment, and simulate it under two types of productivity gains, different from their origin. This allows us to provide a complementary view on the nature of the productivity shocks and their effects. In addition, we also consider a change in the tax/benefit system.

The SVAR model analysis shows that in the short, but less so in the long run, there exists a negative trade-off between employment and productivity in most EU countries, but not in all, and unlike in the case of the US. The effects of the tax shocks reveal that, somewhat unexpectedly, taxes have a more marked negative effect on productivity than on employment. However, if we separate the labour taxes and corporate taxes, we find that the former have a marked and statistically significant negative effect on employment, while the effects of the corporate taxes are more neutral. The results of the simulations of the econometric model show that, although not in the short, but in the medium run there may be quite essential employment gains from an acceleration in productivity, although in the long run there is no connection between them.

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[2] Sonedda (2006) considers in a structural VAR framework the role of labour taxes in six European countries.

The rest of the paper is organised as follows. In Section 2 we build a theoretical model for the open economy linking productivity, employment and taxes. In Section 3 we carry out the empirical SVAR analysis and in Section 4 present the evidence produced by the econometric model. Section 5 concludes.

# 2 The theoretical model

As mentioned, the basis for both empirical approaches is an aggregative model of the labour market and the economy. Our model considers an open economy under fixed exchange rates, as most of the EU countries have in effect been for long under this regime and we also consider taxes, and both wage bargaining and choice of hours per worker in the labour market. Let us first consider the long run, the key relationships of which are depicted in Figure 1, and complement this subsequently with short-run considerations. Start from the aggregative production function,

$$Q_t = A_t K_t^{\alpha} (L_t h_t)^{1-\alpha}, \; 0 < \alpha < 1 \; , \tag{1}$$

where Q is production (GDP), A is technology (TFP), K the stock of capital, L the number of employed persons and h is the number of hours worked per person. Assume first that company taxation is neutral in the sense that interest expenses are deductible for the whole financial capital of the firms and true economic depreciation is allowed for. The optimal investment decision is then given by the marginal productivity condition,

$$\alpha A_t \left(\frac{K_t}{L_t h_t}\right)^{\alpha-1} = (1+m)(r_t + d) \; , \tag{2}$$

where r is the real rate of interest, d the rate of depreciation, m the mark-up factor in the goods market, see e.g. Alho 2006. Using Equations (1) and (2) we come to the expression,

$$\frac{Q_t}{L_t h_t} = A_t^{\frac{1}{1-\alpha}} \left[\frac{(1+m)(r_t + d)}{\alpha}\right]^{\frac{\alpha}{\alpha-1}} \; . \tag{3}$$

This shows that labour productivity rises as total factor productivity rises, and the second component is a negative function of the cost of capital. Let us further assume that the return on savings is taxable, so that there is double taxation levied on the dividends of the firms. In equilibrium, the real after-tax interest rate $r_a$ is given by the rate of time preference σ, so that the pre-tax real rate r is

$$r = i - \dot{p} = \frac{\sigma + \tau_K \dot{p}}{1 - \tau_K} \ , \tag{4}$$

where i is the nominal interest rate, $\dot{p}$ the inflation rate, and $\tau_K$ the tax rate on nominal interest income. In equilibrium, the inflation rate is given from abroad to the open economy, see on this below. These considerations imply that the capital intensity and thereby productivity is a negative function of taxation in the long run, too.[3]

Turn then to the household behaviour. The welfare V of the households at time 0 is given by

$$V = \sum_{0}^{\infty} (1+\sigma)^{-t} (\log C_t - h_t^{\beta}) \ , \tag{5}$$

where C is aggregate consumption and $\beta \geq 1$. The budget constraint is

$$P_t C_t + F_t = (1 - \tau_Y) W_t h_t + (1 + (1 - \tau_K) i) F_{t-1} \, , \tag{6}$$

where P is the price level, F is the stock of financial assets (capital stock and net foreign financial assets) and $\tau_Y$ the tax rate on labour income. Maximisation of (5) under (6) gives the outcome:

$$\frac{1}{C_t} - E\left(\frac{1}{C_{t+1}} \frac{1 + r_{at}}{1 + \sigma}\right) = 0 \ \text{ and} \tag{7}$$

$$(1 - t_Y) \frac{W_t}{P_t} = \beta C_t h_t^{\beta - 1} \ , \tag{8}$$

where $r_{at} = (1 - \tau_K) i_t - E\dot{p}_{t+1}$ is the after-tax real rate of interest.

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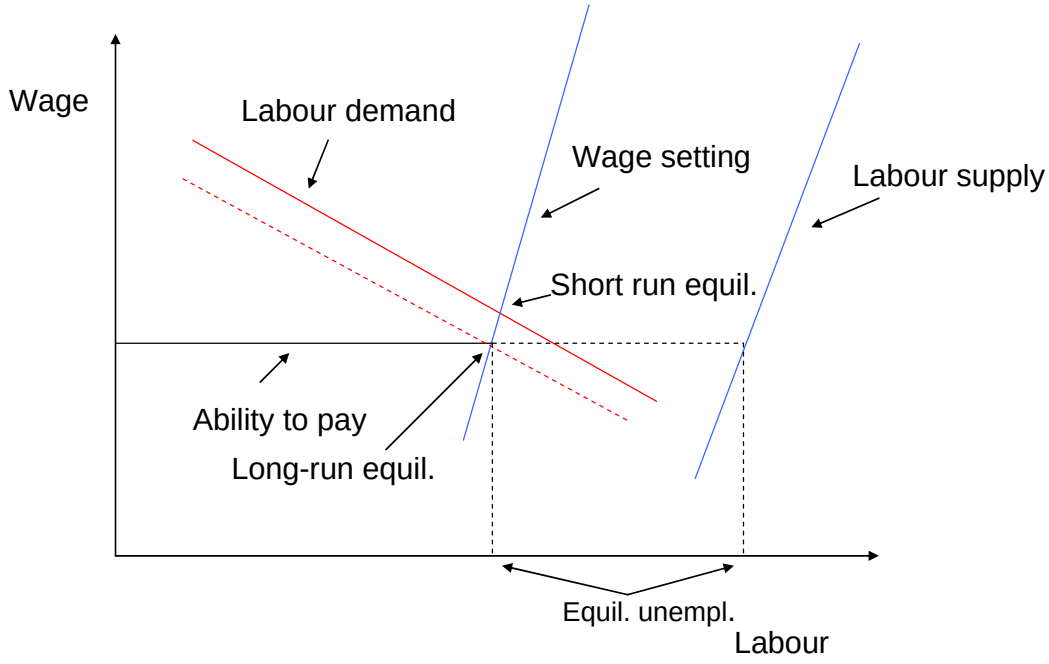
[3] To complement this analysis, we should also pay attention to Mortensen (2005) who showed using an endogenous growth model that the total factor productivity can be affected negatively by taxation, because taxation affects the equilibrium in the labour market, which influences the amount of labour allocated to R&D activities. Here we, however, omit this enlargement of the theoretical model.

In addition to individual behaviour, there is collective bargaining in the labour market between the employer federation and the trade union over the wage rate. The general outcome of this bargaining is

$$\frac{W_t}{P_t} = f(\tau_Y, b_t, U_t, \phi, \eta_t)\frac{Q_t}{L_t h_t}, \tag{9}$$

where b is the outside option (replacement rate related to the unemployment benefit), U the rate of unemployment, $\phi$ the relative bargaining power of the unions in relation to that of the employers, and η the technology shock, elaborated in more details below, and $0 < f < 1$. In (9) we have $f_1 > 0$, $f_2 > 0$, $f_3 < 0$ and $f_4 > 0$. Normally we may also have $f_5 = 0$ throughout, if unions are far-sighted and neutral in their wage claims with respect to productivity shocks, be they positive or negative. But we may have asymmetrically $f_5 < 0$, when $\eta < 0$, if the unions are not willing to act similarly and to moderate their wage claims, when there is a negative productivity shock.[4] This reaction of the equilibrium rate of unemployment to the productivity shock η is taken in the sequel to reflect the real rigidity of the economy in the long run. The labour cost is in equilibrium given by the horizontal ability-to-pay curve by the firms, which preserves the long-run profitability of the firms, see Fig. 1, so that we have,

**Figure 1. The key relationships of a structural model for the labour market**




[4] To be more exact, the value of $f_5 = -1$, maintains the real wage from falling in the case of a negative productivity shock.

$$(1+\tau_{IND})\frac{W_t}{(1-\tau_C)P_t}=\frac{1-\alpha}{1+m}\frac{Q_t}{L_t h_t}\ , \tag{10}$$

where $\tau_{IND}$ is the payroll tax rate on labour and $\tau_C$ is the value added tax. Combining Equations (8) and (10) produces the following outcome

$$\beta h_t^{\beta-1}=\frac{\frac{Q_t}{L_t h_t}}{C_t}\frac{(1-\alpha)(1-\tau_Y)(1-\tau_C)}{(1+m)(1+\tau_{IND})}. \tag{11}$$

We consider three structural shocks, one for technology, one for demand (non-technology) and one for tax policy, and try to identify them below in the empirical analysis. As in Galí (1999), we assume that the technology process A is as follows,

$$A_t = A_{t-1}\exp(\eta_t), \tag{12}$$

where η is an i.i.d. process with a mean which can be positive.

In the open economy flexible price growth models the evolution of the consumption level is separate from production allocation and makes no change to real output. Using the transversality condition and the long-run solvency criterion (balance of payments constraint), the consumption level is a weighted average of future expected levels of income. Using the above assumption about the technology process in (12), the expected future income (human capital) is a function of the current level of productivity $A_t$. This means that hours in Eq. (11) are not a function of the technology shock. With the intertemporal elasticity of substitution being unity in (5), the income and substitution effects of the interest rate cancel each other as to consumption. So, Eq. (11) implies that, all in all, the hours per person are (leaving unessential constants aside) given by

$$h_t=(1-\tau_{Lt})^{\frac{1}{\beta-1}}, \tag{13}$$

where $\tau_L$ is the total tax wedge on labour (including the price wedge). The equilibrium rate of unemployment $U_e$ is given by equating (9) and (10). As the rate of unemployment is given by $U \sim \log(N) - \log(L)$, where N is labour supply which is assumed fixed, we can write for the equilibrium level of employment L,

$$log(L_e)=log(N)-U_e=\log(N)-u(m,\phi,b,\eta,\tau_L). \tag{14}$$

Here on the basis of the discussion above in connection with Eq. (9) $u_1$, $u_2$, $u_3$, $u_5 > 0$ and $u_4 \geq 0$. This last derivative shows that the technology shock may be neutral with respect to employment in the long run, but not necessarily so. Equilibrium unemployment rate depends negatively on labour taxes, but not on the real interest rate, as a higher rate of it only leads to a lower level of productivity and income, and the curves in Figure 1 shift to restore the initial equilibrium in terms of the equilibrium unemployment rate. This and Equation (13) mean that a permanent shift in the capital income tax rate $\tau_K$ does not have an effect on employment in the long run. On the other hand, we come to the conclusion that a permanent change in labour taxes only has a long-run negative impact on employment, but not on productivity, which is determined by the capital-labour ratio in (2). However, these outcome have to be qualified with the assumptions on the nature of the shocks to the tax variables, whether the tax changes, driven by the respective shocks, are sustainable or mean-reverting, as will be discussed below.

Let us next distinguish in the short-run situation the cases of nominal price and wage stickiness and that of the price flexibility.

In the former case monetary policy faces the standard task of using the interest rate to stabilise output as determined by aggregate demand and inflation. Aggregate demand is affected by the demand shocks. The discretionary monetary policy, with fixed expectations and floating exchange rates, gives the standard outcome that it can completely eliminate a demand shock from having an effect on output and inflation, see e.g. Clarida, Galí and Gertler (2002). However, we have to make a qualification here, as it may be that the European countries have in fact had for long a limited sovereignty in monetary policy as to output stabilisation, which also more formally is the case with respect to asymmetric shocks under EMU, and therefore the basic neutrality result may not hold in practice.[5] Under fixed exchange rates, the long run interest rate and the inflation rate in an open economy is given by that abroad.

In the case of nominal wage and price rigidity the wage rate is bargained and the price set before the shocks are realised as in the theoretical model of Galí (1999). In this case the firms supply all the output demanded, if the price is above the marginal cost. Assume that the monetary policy does not react to the technology shock. The total demand for the economy is

[5] Another complication is that the marginal cost of the firms depends here also on the capital cost, which leads to a more complex outcome for monetary policy. Guender (2006) shows that the perfect stabilising property of monetary policy in the case demand shocks breaks down also when the real exchange rate is present in the Phillips curve.

then determined by the predetermined aggregate price and wage level. In the short run, when the capital stock is fixed, the labour demanded can be determined from the production function (1). Now, if there is a positive productivity shock, the demand for labour is reduced, as the firms can meet the output demanded by less production factors, i.e., labour, and there is a negative short-run effect on employment from a positive productivity shock. Positive demand shocks lead to an expansion in employment, but have no long run effect on productivity.

On the other hand, imagine that there is price and wage flexibility in the economy and that output is determined by equilibrium between aggregate supply and demand. In the case of a positive technology shock the short-run labour demand, the long-run ability to pay curve shift in Figure 1 upwards by the amount of the technology shock. Assume, however, that the wage setting curve shifts there with a lag. This means that the real wage rate and labour demand will rise in the short run as a result of a positive technology shock. This issue of diversity of short-term effects of technology shocks can only be settled in an empirical analysis. In the long run there is neutrality from productivity shocks on employment if $du/d\eta = 0$ in Eq. (14).

The budget constraint of the government is,

$$G = T_K + T_L + T_C = T\,, \tag{15}$$

where G is government expenditure, $T_K$ is total taxes on capital income, $T_L$ on labour income and $T_C$ the commodity taxes. The total taxes are assumed to evolve in the following way,

$$(\frac{T}{Q})_t = \lambda(\frac{\overline{T}}{Q}) + (1-\lambda)(\frac{T}{Q})_{t-1} + \nu_t, \tag{16}$$

where ν is an i.i.d. process with mean zero and $0 \le \lambda \le 1$. The long-run impact of the tax shocks ν depends on the size of parameter λ. If it is unity, shocks ν have a permanent effect on the tax rate, and thereby potentially in the long run on the variables of interest, productivity and employment. However, if $\lambda < 1$, the shock is reverted over time and no long-run effects emerge from a tax shock. Our theoretical considerations above also implied a different impact of capital income and labour taxation on the two variables of interest in the long run. However, due to the lack of long time series data, we have not been able to make systematically a separation between the various components of taxes, so that we have had to take recourse to time series on aggregate tax rates. However, over time the relations between the various com-

ponents of taxes have usually been fairly stable and changed only smoothly, so that this assumption may not give too imprecise results. However, for the aggregate EU-15, we make below a separation between labour and corporate taxes.

Let us collect the above results of the theoretical considerations into Table 1.

**Table 1. The effects of the shocks, based on the theoretical analysis**

| Effect of a shock on: | Technology shock | | Non-tech. shock | | Capital inc. tax shock | | Labour income tax shock | |
|---|---|---|---|---|---|---|---|---|
| | SR | LR | SR | LR | SR | LR | SR | LR |
| Productivity | + | + | + | 0 | − | − | + | 0 |
| Employment | −/+ | 0, − /0 | 0,+/+ | + | − | 0 | − | − |

SR = short run, contemporaneous effect
LR = long run asymptotic effect
./. = reaction under: fixed price / flexible price

We do not constrain the employment effect of demand shocks in the long run to be zero, similarly as done also by Galí (1999).

# 3 Structural VAR analysis

Let us now turn to the first case of empirical evidence, the structural VAR analysis. Our basic attention is devoted to the fact, whether the productivity shock drives down employment in the short and long run, or not, and what is the role of taxes as to productivity and employment. So, we are interested to see, whether there are trade-offs between the two key goals of the Lisbon process over the short and long run and how they are affected by tax policies.

The identification of the structural VAR is as follows. Our structural VAR model is,

$$y_t = A(L)\, y_{t-1} + A_0 u_t \ , \tag{17}$$

where $y_1$ is labour productivity, $y_2$ aggregate hours and $y_3$ the tax rate, transformed in a suitable way (see below), and $u_t$ is the vector of the above structural shocks, $u_1$ is technology, $u_2$ non-technology (demand) and $u_3$ the tax shock, and L is the backward difference operator. The corresponding MA representation is

$$y_t = B(L)u_t \ , \tag{18}$$

with $B_0 = A_0$. We use the long-run restrictions imposed on the covariance matrix $B_0 B_0^{'} = \Omega$, derived from the following equation system

$$C(1)B_0 = B(1) \, . \tag{19}$$

Here C(1) represents the cumulated effect of the reduced-form shocks of the VAR model and B(1) represents the cumulated effects of structural innovations, and the constraints are imposed on B(1).[6] We restrict the B(1) matrix to be of the following form, which gives the long-run impulse responses as in Galí (1999) and the literature following it,

$$x_e = \begin{pmatrix} b_{11}(1) & 0 & b_{13}(1) \\ b_{21}(1) & b_{22}(1) & b_{23}(1) \\ 0 & 0 & b_{33}(1) \end{pmatrix} u_t , \tag{20}$$

In order to get the structural VAR system as identified, we have further had to make more identifying assumptions in (20). Here we have assumed that the tax shocks are independent in the long run both from the technology and the non-technology shocks. In addition to the long-run impulse responses, we are also, of course, interested in the short run pattern of them.

We carried out the empirical structural VAR model in three steps: first as based on two variables only: real labour productivity and aggregate hours, and then based on three variables: real labour productivity, hours and the total tax rate, and then making a separation between the labour taxes and corporate taxes in the EU-15. In both cases the two first variables were in logs and first differenced. The tax rates were also just differenced once. This was enough to reach stationarity. In the literature, there have been diverse approaches to the specification of the hours variable. Some researchers, notably Christiano, Eichenbaum and Vigfusson (2003, 2004) have argued that the original specification that uses the differenced total amount of hours by Galí (1999) is not a correct one, and should be replaced by a level specification that uses hours per capita, which, in the case of the US, gives the outcome that a positive productivity shock yields positive, not negative, short-run impulse on employment, the former being the case of a standard RBC model. However, Galí (2004) has responded that especially in Europe the non-differenced level specification of employment is not stationary, and using

[6] For identification of structural VAR model, see e.g. Lack and Lenz (2000).

differenced measure of total hours worked as a variable of employment gives a better basis for his original formulation. Due to this fact, and which is also confirmed here by running the ADF and KPSS tests for the hours variable both in level specification and in difference specification for some countries (see Table 2), we have below basically retained the original specification by Galí (1999), but have in some cases also checked the specification using the level per capita measurement of hours. It is true that the two above-mentioned conflicting outcomes then emerge in the US data, but in Europe in the level specification the positive impact of technology shock on hours is very sluggish and has a very large confidence band. As our interest is mainly here concentrated on the EU, we have not experimented any more with the level specification.

**Table 2. Summary of unit root tests for the employment variable specified as in level and difference**

Augmented Dickey-Fuller unit root test for employment variable:

Null hypothesis: Time series has a unit root

| | USA | EU15 | Finland | France |
|---|---|---|---|---|
| Differenced | -5,53 | -3,92 | -3,31*** | -3,98 |
| Level | -1,38* | -2,20* | -1,74* | -2,11* |

Kwiatkowski-Phillips-Schmidt-Shin stationary test for employment variable:

Null hypothesis: Time series is stationary

| | USA | EU15 | Finland | France |
|---|---|---|---|---|
| Differenced | 0,18* | 0,45** | 0,09* | 0,69*** |
| Level | 0,52*** | 0,51*** | 0,52*** | 0,59*** |

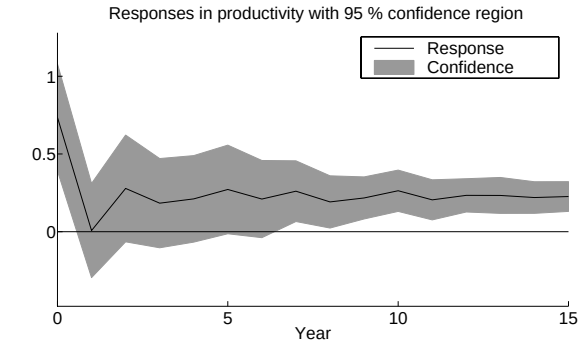
*** = Significant at 1 per cent level, ** = Significant at 5 per cent level, * = Significant at 10 per cent level

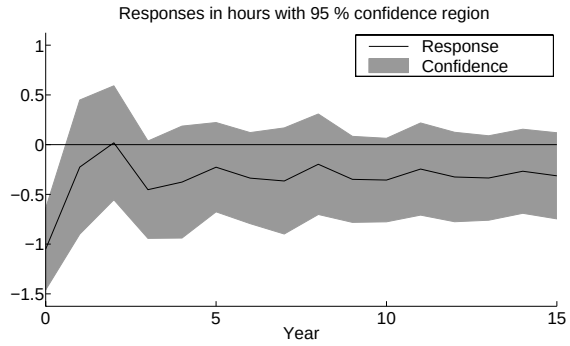
We carried out the analysis for all the 15 EU-15 countries and a few additional OECD countries over the period 1960-2004 using annual data with 5 lags.[7] We illustrate the results as to impulse responses under this identification scheme in (20) only for the aggregate EU-15, and collect the core results concerning the impulse responses of the technology and tax shocks in the short and long run, over all the countries considered, into Table 3 below.

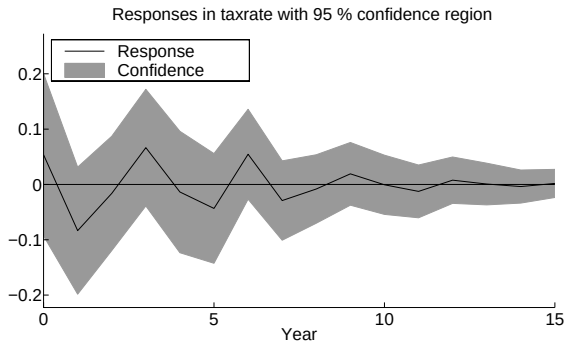
[7] The empirical estimations were carried out with the Structural VAR programme by Anders Warne (http://texlips.hypermart.net/svar/index.html), using the cross-country data collected by Ville Kaitila from ETLA in the TAXBEN project.

**Figure 2. The impulse responses in the aggregate EU-15 with the 95 % confidence bands endogenous variables: first differences of productivity, hours and the total tax rate**

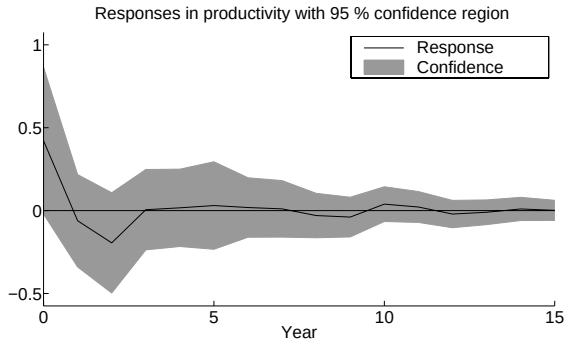
technology shock

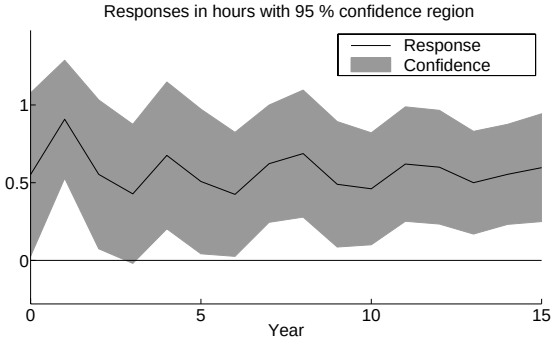


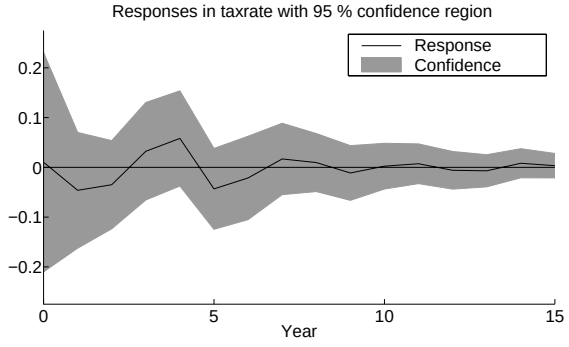



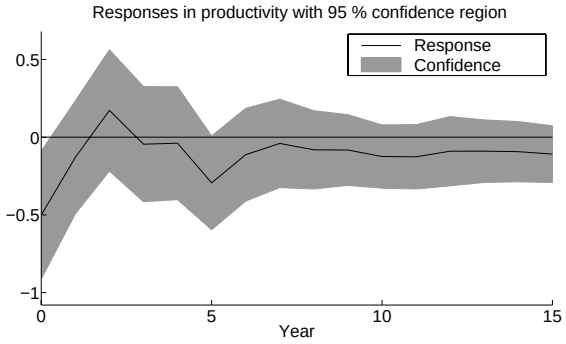

non-technology shock

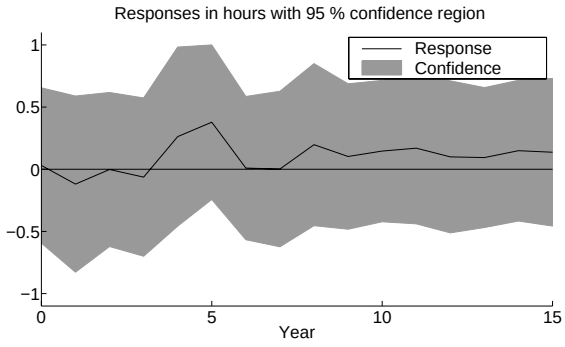


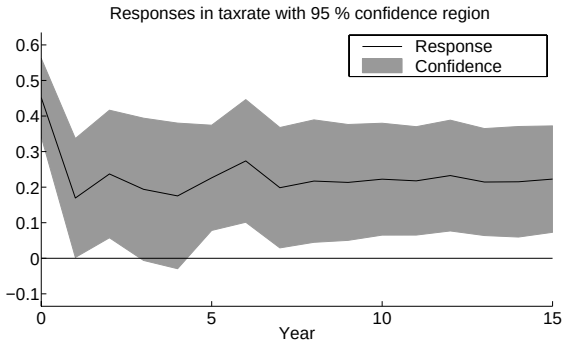



tax shock




From Figure 2 we see that in the short term there is indeed in the EU a trade-off between the two key economic goals of productivity rises and employment. This is less severe in the long run, although does not fully disappear, but turns over time to become statistically insignificant. In the short term, the non-technology shock has a positive effect on productivity. The effect of tax shocks seems to be clearly negative in the short run on productivity, while they are fairly neutral with respect to employment.

**Table 3. Summary of the VAR estimations, key impulse responses in the short and long run** [+]

| Country | Trade-off empl. vs. productivity | | Impact of taxes on productivity | | Impact of taxes on employment | |
|---|---|---|---|---|---|---|
| | Short run | Long run | Short run | Long run | Short run | Long run |
| EU15: | | | | | | |
| Austria | −1.11* | −0.19 | −0.07 | −0.29 | 0.15 | −0.01 |
| Belgium | −0.74* | −0.09 | −0.94 * | −0.33* | −0.28 | −0.07 |
| Denmark | −1.18* | −0.10 | 0.53 | 0.01 | 0.36 | 0.41* |
| Finland | −0.63 | 0.29 | −0.56 | −0.35 | 0.44 | 0.33 |
| France | −0.45* | −0.15 | −0.14 | −0.25 | −0.82* | −0.17 |
| Germany | −2.13* | −0.74* | 0.39 | 0.22 | −0.04 | 0.07 |
| Greece | −0.58 | −0.16 | −1.71 | −0.56 | 0.45 | 0.00 |
| Ireland | 0.34 | 0.32 | −0.55 | −0.08 | −0.51 | −0.18 |
| Italy | −0.89* | −0.45* | 0.15 | −0.10 | 0.39 | 0.05 |
| Luxembourg | 0.04 | 0.40 | −1.86* | −0.54* | 0.24 | 0.01 |
| Netherlands | −1.22* | −0.63* | −0.22 | −0.26 | 0.65 | 0.66 |
| Portugal | 0.51 | 0.56 | 0.23 | −0.15 | −0.08 | 0.14 |
| Spain | −1.44* | −1.23 | −0.61* | −0.36 | 0.72 | 0.36 |
| Sweden | −0.72* | −0.16 | 0.27 | 0.06 | 0.17 | 0.54* |
| United Kingdom | −1.07* | −0.54 | −0.49 | −0.16 | 0.07 | 0.04 |
| EU15 | −1.05* | −0.31 | −0.50* | −0.10 | 0.03 | 0.13 |
| Other OECD: | | | | | | |
| Australia | −1.0* | −0.33 | −0.08 | −0.07 | 0.23 | 0.22 |
| Canada | −0.82 | −0.34 | −0.44 | −0.12 | 0.69 | 0.12 |
| Japan | 0.23 | 0.15 | 0.10 | 0.04 | 0.38 | 0.10 |
| New Zealand | −0.37 | −0.07 | −0.98 | −0.26 | 0.59 | −0.18 |
| Norway | −0.41 | 0.04 | 0.05 | −0.09 | 0.67* | 0.47 |
| Switzerland | −0.31 | 0.10 | −0.20 | 0.05 | −0.75* | −0.72* |
| USA | −0.09 | 0.20 | 0.11 | −0.12 | 0.99* | 0.65* |

[+] A star indicates statistical significance, two times standard deviation. *Trade-off empl. vs. prod.* is the impulse response of a unit of the technology shock on employment, *Impact of taxes on prod (resp. empl.)* is the impulse response of the tax shock on productivity (aggregate hours). Short run means the contemporaneous impulse response in matrix $B_0$ in (19); long run the impulse response as defined in Eq. (20) above.

The country-wise results in Table 3 clearly differ between the countries in some important respects. Quite uniformly there is a short-run trade-off between employment and productivity

so that a positive productivity shock leads to an immediate reduction in employment in the EU countries. In terms of our analysis in Section 2, we can interpret this so that productivity gains have to a large extent been linked in the short run to simultaneous labour shedding, i.e., we have the basic case of price stickiness in the short run, see also Section 4. In the long run, there is in some cases this kind of trade-off, but of a smaller magnitude, and not so significant in statistical terms. Neither is the effect so uniform as in the short run. Typically the negative effect of productivity shocks on employment becomes statistically insignificant already in a year but in some countries the effect lasts over 15 years. So, most of the EU-15 countries do not reveal a long-run trade-off between productivity and employment, with the exception of the Netherlands and Italy. What is interesting is that, in contrast, the US economy does not reveal this kind of characteristics, as there is virtually no trade-off of this type, even in the short run, which confirms the situation of price flexibility there.

The gains of productivity rise on economic growth (unity summed with the figures in columns 1 and 2 in Table 3) are as expected, positive for all the countries, except Spain in the long run. The same also holds in the short run for most of the countries, except Austria, Denmark, Germany, the Netherlands, Spain, the UK and Australia.

In the Introduction we referred to the cross-country evidence on productivity and employment. Also Alho (2002b) referred to the fact that a group of EU countries with high unemployment in the late 1990s, like France, Finland, Italy and Spain, had a high level of productivity, while the group of countries, like Luxemburg, the Netherlands, Austria, Denmark, Portugal and the UK, had in contrast a low level of productivity and low unemployment. In the time series results of Table 3 we can similarly identify that majority of the countries in the latter group do have a trade-off over unity between productivity and unemployment, which reveals that they have utilised this in their employment policies. In contrast, among the group of countries having a high rate of unemployment there does not exist such a trade-off of a similar magnitude.

As to the effects of tax shocks, the pattern of impulse responses is less uniform between the countries than between employment and productivity, and the majority of the effects are not statistically significant. There are also some puzzling positive impulse responses, notably in the US, of taxes on employment. These results are, however, in line with the findings of Sonedda (2006) who found out in her structural VAR analysis that in some countries higher

taxes have led to an increase in employment. The reason for this outcome here might be the modelling of the tax variable; it is possible that the results would change if the analysis would separate different kind of taxes instead of using a single tax variable. Overall, it seems that the negative impact of taxes is stronger on productivity than on hours, which is a somewhat unexpected result.

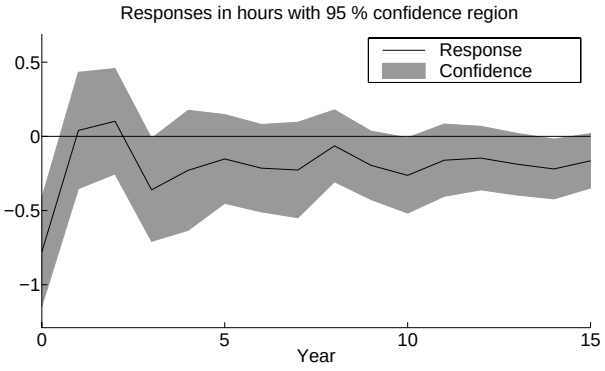
In order to analyze the effects of taxes more accurately we modified the VAR model so that it includes two different kinds of taxes; corporate taxes and employee taxes, in relation to GDP.[8] We have not changed the identification of the previous VAR analysis and the two tax shocks are identified simply so that they are not affected by productivity or hours or each other in the long run. We carried out this analysis only for the aggregate EU-15 countries.

We only display 5 out of the total 16 impulse responses in Figure 3. As can be seen, the use of two different tax shocks causes some differences in the results. Now the employee tax shock have had a statistically significant effect for employment, and not on productivity, which is line with the theoretical model in Section 2. The corporate taxes have been fairly neutral with respect to productivity, which is also in line with reasoning above. However, they also have had a negative effect on employment, although the impulse response is not statistically significant in the long term.

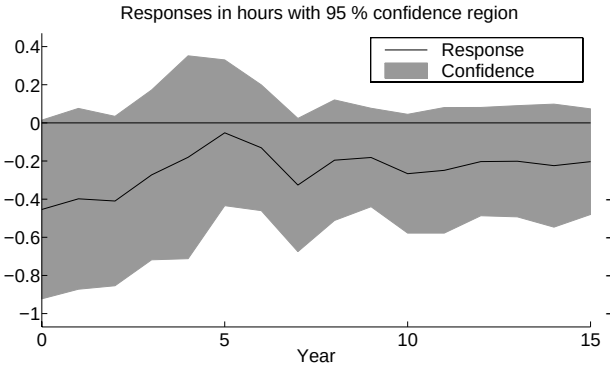
[8] The data for corporate tax rate and employee tax rate are from the OECD, Revenue Statistics of OECD Member Countries Database.

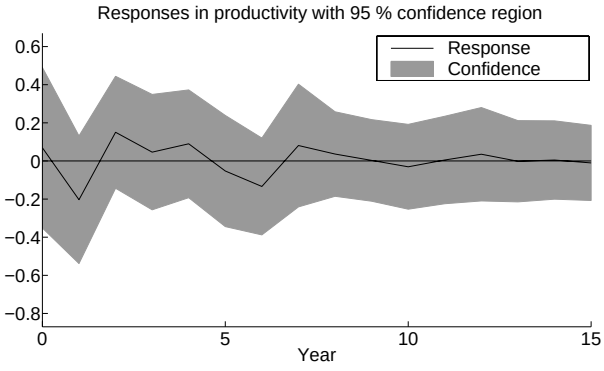
**Figure 3. The impulse responses in the aggregate EU-15 with the 95 % confidence bands endogenous variables: first differences of productivity, hours, the corporate tax rate and employee tax rate**

## technology shock

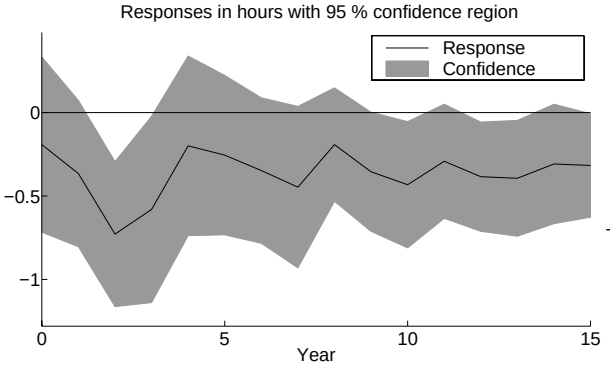


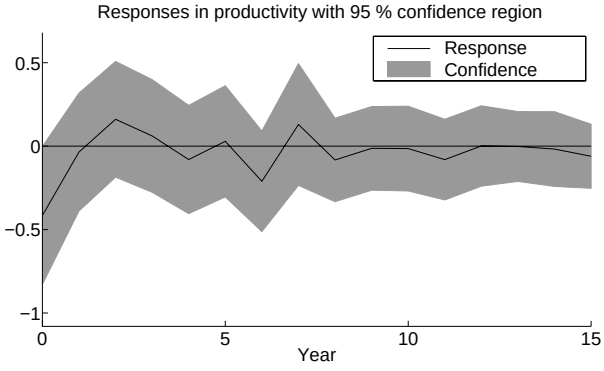

## corporate tax shock




## employee tax shock



# 4 Evidence produced by an econometric model for the labour market

We finally use the econometric model for the labour market, built and estimated for the Finnish economy by Alho (2002a). The reason for this complementary analysis is that we thereby have the possibility to identify the origin of the technology shock in a manner which is more articulated from an empirical point of view than that in connection with the theoretical model above in Section 2, and adopted in the VAR analysis above. We are also able to combine the behaviour of real wages into the analysis of productivity gains, but leave out the role of non-technology shocks. In the model the key relations, depicted above in Figure 1 and derived above, are estimated empirically.[9] The model consists of two behavioural equations: one for labour demand and one for wage setting in real terms, the third equation being the identity for the change in the labour share in GDP. The impact of growth of GDP, determined by fluctuations in aggregate demand, is constrained in the model to be a temporary one so that a rise in the economic activity will boost employment in the short, but vanish in the long run, in effect in four years.

The estimated labour demand equation in Alho (2002a) is written directly in terms of the change in unemployment,[10]

$$\Delta U = u((\frac{WL}{PQ})_{-1}, g)\,,\ u_1 > 0,\ u_2 < 0, \tag{21}$$

and the empirical wage setting curve is determined by

$$\Delta(W / P) = w(U, (\frac{WL}{PQ})_{-1}, b, g)\,,\ w_1 < 0,\ w_2 > 0,\ w_3 > 0. \tag{22}$$

Here U is again the unemployment rate, W the wage rate, Q production (GDP), g its growth rate, P the price level, and b unemployment benefit, and $\Delta$ is the difference operator. Taxes did not play a statistically significant role as an exogenous variable in the estimations, except through their indirect effect on benefits b, which are taxable in Finland.

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[9] See also the model of structural unemployment for the Netherlands by Broer et al. (2000) and for six OECD countries by van der Horst (2003), see also Bean (1993).

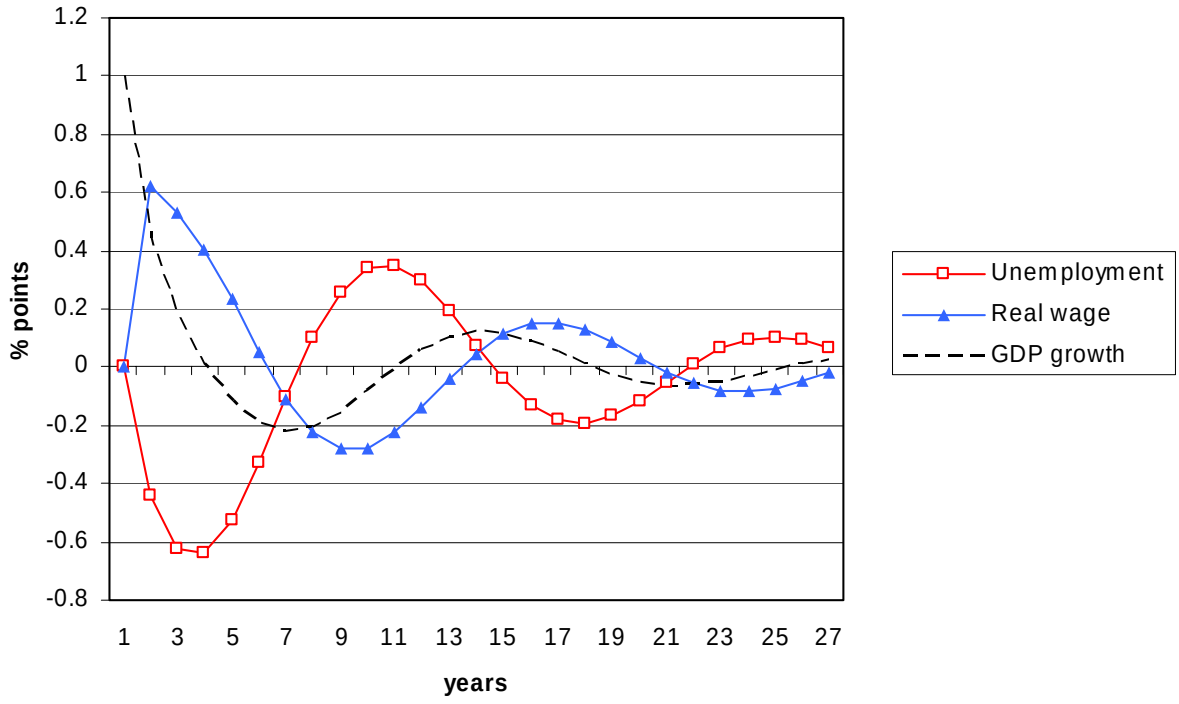
[10] Note that the model does not consider hours, but only aggregate (un)employment.

In the model the rise in labour productivity is an exogenous variable. Empirically, it was not a statistically significant variable in the wage regression, which implies that wage rises are linked to long-run average productivity increases. Let us make two simulations to find out what an impact an acceleration in the growth of labour productivity has on the labour market. For that purpose, we also add a fourth equation to the model for the growth of GDP, which captures the short-run impact on economic activity, linked to productivity growth,

$$g = \hat{a} + \hat{L} \approx \hat{a} - \Delta U \,, \tag{23}$$

where a is labour productivity, L employment, and a caret denotes relative change. In (23) we keep for simplicity the aggregate labour supply as fixed. The model is more in the spirit of what was above called the case of flexible prices (real wages), but we are anyway able to illustrate with the aid of it the two polar cases, referred to above, where employment either declines or increases as a result of a positive technology shock, see below.

**Figure 4. The effects of an autonomous unit impulse in productivity (for details, see the text), %-points deviations from the baseline**



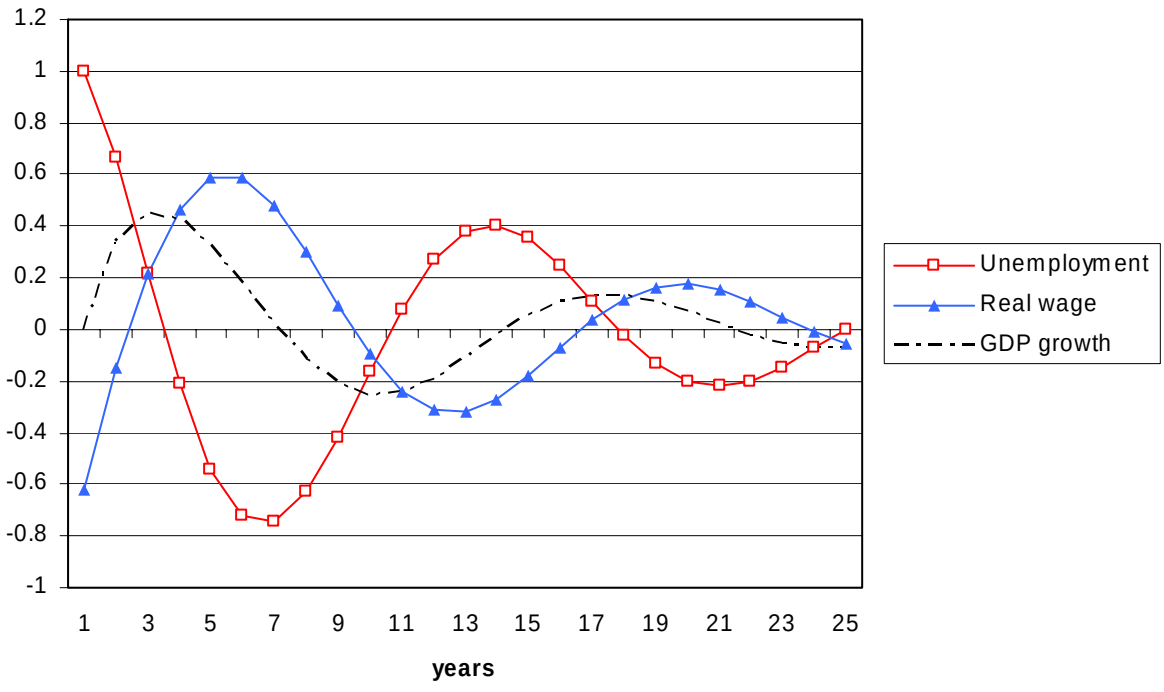

From Figure 2 we see that in the short term there is indeed in the EU a trade-off between the two key economic goals of productivity rises and employment. This is less severe in the long run, although does not fully disappear, but turns over time to become statistically insignificant. In the short term, the non-technology shock has a positive effect on productivity. The

effect of tax shocks seems to be clearly negative in the short run on productivity, while they are fairly neutral with respect to employment.

The dynamic model has imaginary roots with modulus less than unity, which implies oscillating convergence to the equilibrium. We see that there is a lagged reaction in the rise of the real wage in the initial phase, in relation to productivity gains, although the acceleration in the rise in wages lasts much longer than the productivity shock, in order to restore the equilibrium value of the labour share in GDP. This leads to a marked reduction in the unemployment rate over the medium run. In the long run, however, there is no effect on employment from productivity rises.

The second simulated case is one where, as often in practice, the rise in labour productivity is achieved by rationalisation of the use of labour force, through labour shedding in the firms, i.e. corresponding to the case of price rigidity mentioned above in Section 2. Another way to state this is that technical innovations are of labour-saving type. Now we therefore add to the labour demand equation (21) an additional shift term, which is identical sign in size, but of opposite sign than the exogenous acceleration in labour productivity. The results are now as follows, see Figure 5. There is initially a temporary rise in the unemployment rate, but the induced real wage modera-

**Figure 5. The effects of a rise in productivity achieved by shedding of labour (for details, see the text), %-points deviations from the baseline**

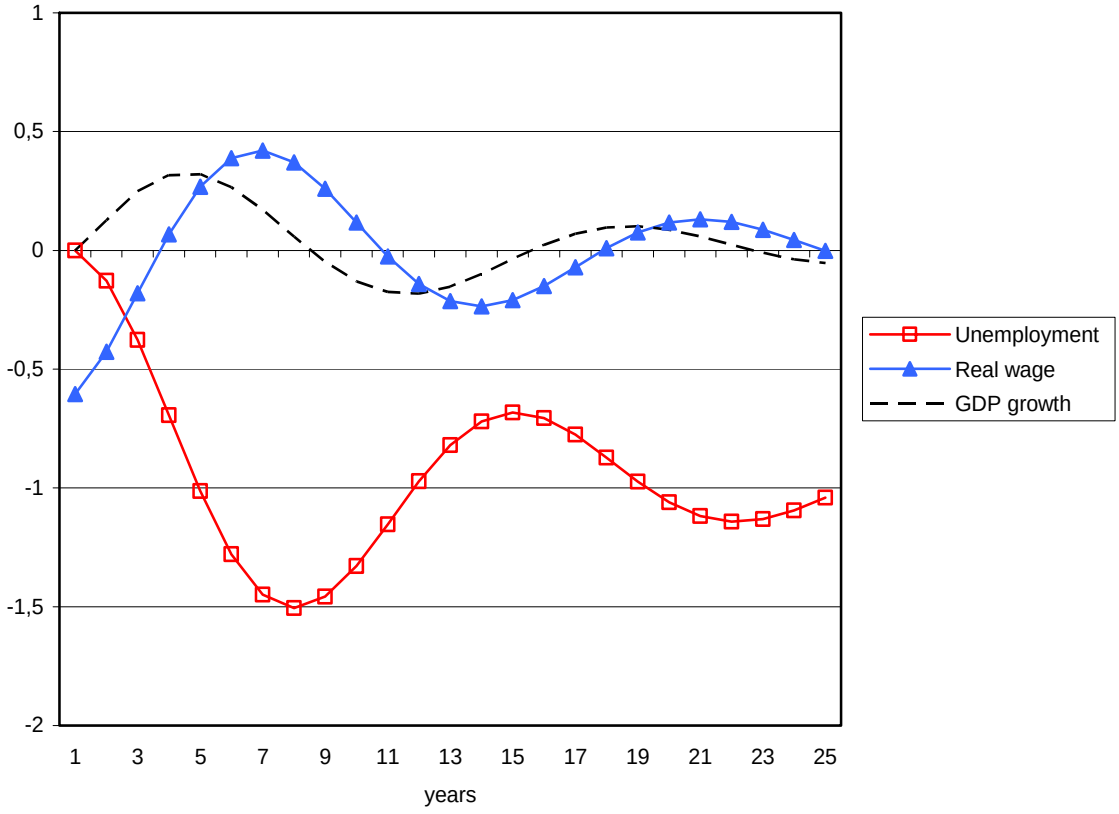


tion starts soon to play its role,[11] so that in the medium run, in fact already after three years, also now the unemployment rate starts to decline, and as vigorously as in the previous case.

The general policy conclusion of these simulations is that, irrespective of the fact that in the long run employment and productivity are not correlated, over the medium run important gains in employment can be achieved through productivity boosting measures if the real wage is capable to adjust and assist in the absorption of the shocks. In this sense, we could take a positive position to the widespread public conception among policy makers about the positive relationship between productivity and employment, as exemplified here at least to apply to the case of a single EU country. In this way we could also conclude that the emphasis on the potential diversity, mentioned in the Introduction, in the contemporaneous effect of a technology shock may not be the most fruitful one from a policy point of view.

As a last simulation, we show effects of a measure in the tax/benefit system and consider lowering of the replacement rate permanently by 5 percentage points. The results are shown in Fig. 6.

**Figure 6. The effects of a permanent lowering of the replacement rate by 5 %-points, %-points deviations from the baseline**




[11] According to the estimated model, it takes some 5 years before most (some 80%) of the adjustment of employment with respect to a change in the real wage takes place.

The shock means a marked moderation in wage claims, leading to a reduction in the real wage and a permanent reduction in the structural rate of unemployment. All the simulations considered in Figures 4-6 also lead to a short run expansion in the economy, measured by GDP growth, which is noteworthy.

# 5 Concluding remarks

We have in this paper derived a model for the aggregate labour market and economy and considered the various shocks in this connection in an open economy context and complementing it with tax considerations. We also characterised the countries in terms of their overall nominal and real rigidity, which gave the outcome that European countries have typically fixed prices and wages in the short term. We also shed light on the long-term possible negative trade-off between employment and productivity, being an essential issue as to the Lisbon process, and could infer that the case for such an adverse situation exists but is not strong in a statistical sense over the long run in the EU.

By using the econometric model of the labour market, we could distinguish empirically within a single EU country in a structured and plausible way the two possible origins of the productivity shock and their effects. This allowed us to sharpen the discussion pursued in the literature on the nature and sign of the short-run impulse response on employment from a productivity shock, and to give a richer inquiry into the problem of the relationship between productivity and employment.

The analysis of the tax shocks produced some important insight on the effects of tax policies in this connection. The analysis should, however, be enlarged to carry out a comprehensive analysis of the separate effects of corporate and labour taxes, which was carried out above for the aggregate of the EU-15 countries only.

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THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
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