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PRODUCTIVITY, EMPLOYMENT AND TAXES – A SVAR ANALYSIS OF THE TRADE-OFFS AND IMPACTS *

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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 labour and capital tax wedge shocks, as based on their long-run effects. Then structural VAR models are estimated for the EU-15 and some other OECD countries to infer the above relationships. 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. The impulse response of the shocks in the tax wedge on labour in the aggregate EU-15 is a fairly sizeable negative impact on employment both in the short and long run, and the effects of capital income tax shocks are negative on productivity. In the majority of the individual EU-15 countries these results are not, however, statistically significant.

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 identifioida teknologia-, kysyntä- sekä työn ja pääoman verokiilan shokit niiden pitkän ajan vaikutuksia koskevien rajoitteiden pohjalta. Rakenteelliset VAR-mallit estimoidaan 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. Työlle asetetun verokiilan muutoksilla on huomattava negatiivinen vaikutus työllisyyteen lyhyellä ja pitkällä ajalla EU-15 -alueella, myös pääomaveroshokkien vaikutukset tuottavuuteen ovat negatiivisia. Valtaosalla yksittäisistä EU15-maista nämä vaikutukset eivät kuitenkaan ole tilastollisesti merkitseviä.

ASIASANAT: Tuottavuus, työllisyys, verot, EU

1 Introduction

The Lisbon process of the EU, with the pursuit of enhanced 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.[1] 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. 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

[1] See on this also Alho (2002a).

model. This controversy boils down to the issue of the relevance of various approaches in 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 trade-off, which has not received attention in the literature so far. While the short-run impact of a technology shock basically displays the nominal price flexibility or rigidity, the long-run trade-off reflects the structural rigidity in the labour market in the economy. So far, this literature has not either paid systematic attention to the role of taxes, although they potentially have an essential role on productivity and employment in the short and long term.[2] So, we enlarge the basic model to cover the role of tax policies.

The empirical SVAR analysis of the paper is based on a theoretical model of the open economy in which we identify a technology, non-technology and two tax shocks for labour tax wedge and capital tax wedge and their long-run effects. The reason for identifying two tax shocks is that they have a different long-run effect in our theoretical model on productivity and employment so that the labour tax wedge only affects employment in the long run but not productivity, while the reverse holds for the capital income tax. In the empirical part we build structural VAR models using this identification scheme and empirically find out the impulse response of the structural shocks identified in the model for all the EU-15 and some other OECD countries.

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 labour tax shocks have a marked and statistically significant negative effect on employment in the EU-15, and the corporate taxes have effects on productivity which are also negative but not significant. However, it should be added that many of the country-wise impulse responses of tax shocks, especially those of the capital income taxes, are not statistically significant.

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[2] See, however, Galí (2004) and Uhlig (2004) for a discussion on capital income taxes in the analysis of productivity and employment. 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. Section 4 concludes.

2 The theoretical model

As mentioned, the basis for the empirical analysis 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 in corporate taxation interest expenses are deductible for the debt capital of the firms and true economic depreciation is allowed for. The optimal investment decision by the firms is then given by the marginal productivity condition,

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

where r is the real rate of interest, e is the share of equity capital in the total capital of the firms, τ_F is the corporate tax rate, 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,

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

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, measured in consumer prices, and τ_K the tax rate on nominal capital 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 capital income 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

$$V = E_0 \sum_{t=0}^{\infty} (1+\sigma)^{-t} (\log C_t - h_t^{\beta}) \ , \tag{5}$$

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

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

where P is the producer price level, τ_C the consumption tax, F is the stock of financial assets (capital stock and net foreign financial assets) and τ_Y the tax rate on labour income. Maximisation of (5) under (6) with respect F_t and h_t gives the outcome:

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

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

[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.

where $r_{at} = (1-\tau_K)i_t - E\dot{p}_{t+1}$ is the after-tax real rate of interest. The stock of foreign financial assets is determined as a residual from the total desired stock of assets F and the investment decision by the firms given by (2), determining the capital stock K.

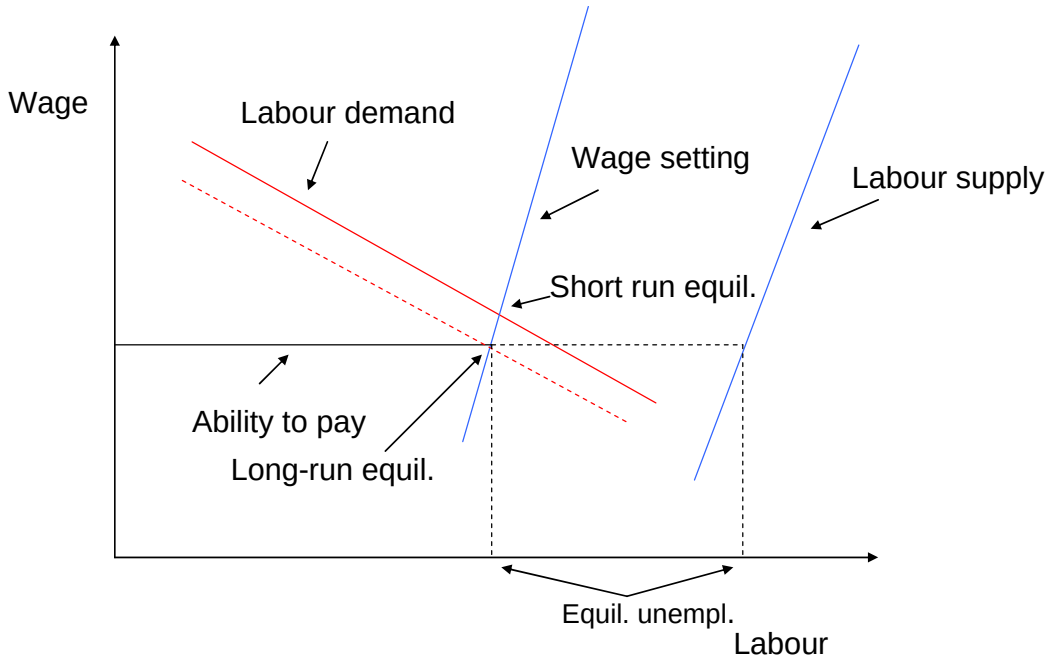
In addition to individual behaviour, there is collective bargaining in the labour market between the employer federation and the trade union over the wage rate. The general outcome of this bargaining is

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

where b is the outside option (replacement rate related to the unemployment benefit), U the rate of unemployment, ϕ 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 $f_5 > 0$, if the unions are aggressive and in the case of a positive productivity shock they strive to get a bigger share of the national income than earlier. 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,[4] so that we have,

[4] See for more details on this analysis e.g. Bean (1993), Broer at al. (2000) and Alho (2002b).

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



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

where τ_{IND} is the payroll tax rate on labour. Combining Equations (8) and (10) produces the following outcome

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

We consider four structural shocks, one for technology, one for demand (non-technology) and two 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. We assume in a standard way that in the long run productivity is not influenced by demand shocks.

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 transver-

sality 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 technology 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 τ_L is the total tax wedge on labour (including the price wedge), reached by collecting the tax terms in Equation (11). The equilibrium rate of unemployment U_e is given by equating (9) and (10). As the rate of unemployment is given by U ~ log(N) − log (L), where N is labour supply which is assumed fixed, we can write for the equilibrium level of employment L,

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

Here on the basis of the discussion above in connection with Equation (9) u_1, u_2, u_3, u4 > 0 and $u_5 \geq 0$. 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 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).

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 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, which is the cornerstone of this strand of literature in identifying the SVAR model.

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 curve, and 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).

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[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.

The budget constraint of the government is,

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

where G is government expenditure, T_K is total taxes on capital income, T_L on labour income, including the commodity taxes. 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. 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		Labour tax wedge shock		Capital tax wedge shock	
	SR	LR	SR	LR	SR	LR	SR	LR
Productivity	+	+	+	0	?	0	−	−
Employment	−/+	0, − /0	+	+	−	−	−	0

SR = short run, contemporaneous effect
LR = long run asymptotic effect
. / . = reaction under: price rigidity, long-run real rigidity / price flexibility, long-run flexibility

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 empirical evidence, the structural VAR analysis. Our basic attention is devoted to the fact, whether a positive productivity shock drives down employment in the short and long run, or not, and what is the role of tax shocks 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,

$$y_t = A(L)\, y_{t-1} + A_0 u_t\,, \tag{16}$$

where y_1 is labour productivity, y_2 aggregate hours, y_3 the tax wedge on labour and y_4 the capital income tax rate, transformed in a suitable way (see below), and u is the vector of the above structural shocks, u_1 is technology, u_2 non-technology (demand), u_3 the labour tax shock, u_4 capital income tax shock, and L is the backward difference operator. The corresponding MA representation is

$$y_t = B(L)u_t \ , \tag{17}$$

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

$$C(1)B_0 = B(1) \, . \tag{18}$$

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 also includes the constraints imposed on the long-run impulse responses as in Galí (1999) and the literature following it,

$$x_e = \begin{bmatrix} b_{11}(1) & 0 & 0 & b_{14}(1) \\ b_{21}(1) & b_{22}(1) & b_{23}(1) & 0 \\ 0 & 0 & b_{33}(1) & b_{34}(1) \\ 0 & 0 & b_{43}(1) & b_{44}(1) \end{bmatrix} u_t \, . \tag{19}$$

In order to get the structural VAR system as identified, we have further had to make more identifying assumptions in (19). Here we have assumed that the tax rates (taxes/GDP) are independent in the long run both from the technology and the non-technology shocks. Altogether, we have in (19) one over-identifying condition for the SVAR model. 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 (SVAR) based on four variables: real labour productivity, aggregate hours, labour taxes and capital taxes. The two first variables were in logs and first differenced. The tax rates that were in ratios to GDP were also just differenced once. This was enough to reach stationarity in almost all the countries under study,

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

which shows that there have been permanent shifts also with respect to taxes. 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 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 test 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. Augmented Dickey-Fuller unit root test for employment variable in differenced and level modification

	One-sided p-values.	
	Hours, differenced	Hours, per capita
Austria	0.00	0.50
Belgium	0.01	0.08
Denmark	0.00	0.15
Finland	0.03	0.40
France	0.02	0.24
Germany	0.00	0.14
Greece	0.00	0.46
Ireland	0.02	0.20
Italy	0.01	0.30
Luxembourg	0.22	0.34
Netherlands	0.01	0.06
Spain	0.37	0.29
Sweden	0.01	0.14
United Kingdom	0.00	0.24
EU15 − Portugal	0.00	0.20
Other OECD:		
Australia	0.00	0.19
Canada	0.01	0.14
Japan	0.01	0.85
New Zealand	0.04	0.38
Norway	0.00	0.54
Switzerland	0.02	0.40
USA	0.00	0.58

Null hypothesis: Time series has a unit root

Data for constructing labour and capital tax variables is gathered from the OECD Revenue Statistics. It has information about tax structures in different OECD countries and the tax data are expressed in a standardised framework based upon the OECD classification of taxes. We have divided each country's total tax revenues into two different groups, taxes on labour and taxes on capital. As a measurement of capital taxes we have combined tax revenue from property income and revenue from corporations. The tax wedge on labour is for simplicity considered to consist of all other tax revenue. This separation is somewhat harsh but because some countries have less data about their tax revenues than others, this is the best way to get data for labour and capital taxes in order to achieve maximum coverage. Even with this formula-

tion we can not include Portugal in our SVAR model analysis because of the lack of data. Labour and capital tax revenues are transformed into ratios to GDP.

We carried out the analysis for the 14 EU-15 countries and a few additional OECD countries over the period 1965-2004 using annual data with 5 lags.[7] We illustrate the results as to impulse responses under this identification scheme in (19) only for the aggregate EU-15 (not including Portugal), 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. For Germany and EU-15 we added a dummy in 1991, with a proper amount of lags, to reflect the effect of German unification.[8]

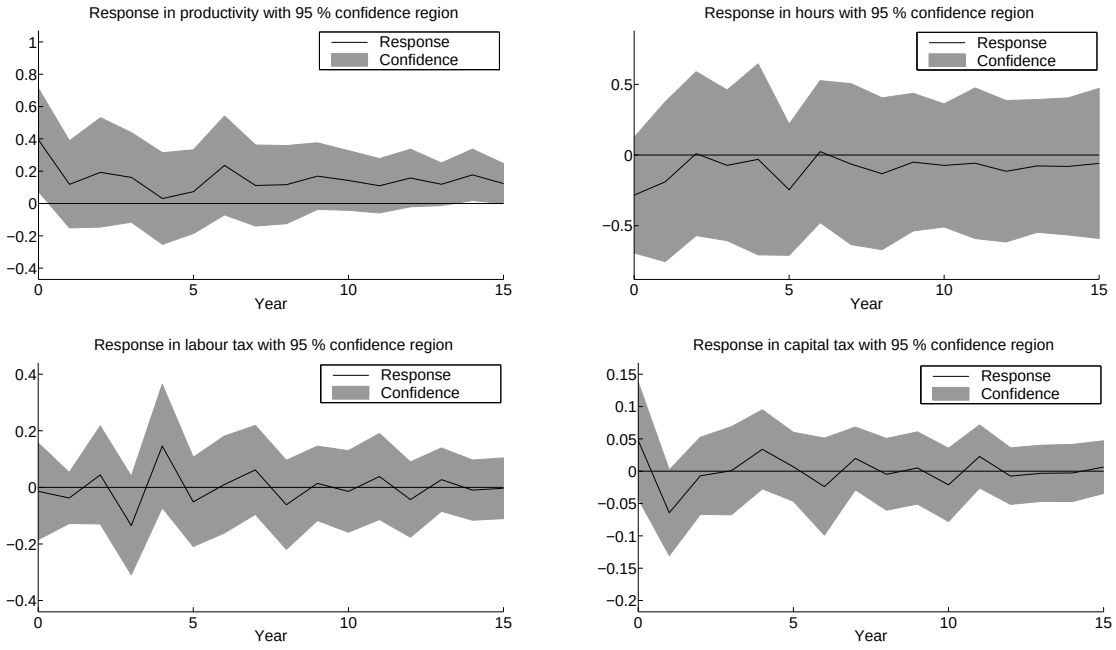
In the following we only report figures of impulse responses for the EU-15 area as a whole. Other similar figures are available upon request from the authors. In Table 3 we report the basic outcome of the SVAR analysis by countries.

From Table 3 we see that in the short term there is indeed quite uniformly in the EU-15 countries 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 Figure 2 the effect of a labour tax wedge shock is clearly negative in the short and long run on employment and in the short run on productivity. The capital tax wedge shock has a negative, but statistically not significant effect on productivity in the short and long run, and in Table 3 a negative effect on employment in the short run in most EU countries.

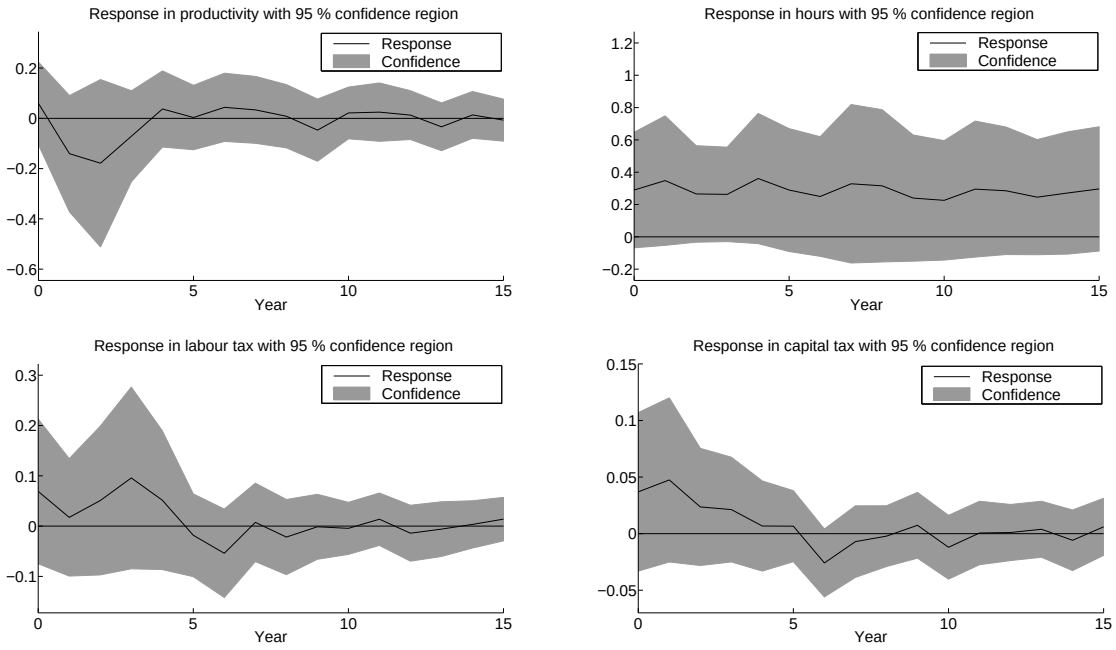
[7] The empirical estimations were carried out with the Structural VAR programme by Anders Warne (http://texlips.hypermart.net/svar/index.html).
[8] We also report below the SVAR analysis for EU-15 less Germany as it and Germany alone both better satisfy the constraints imposed in Equation (19).

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

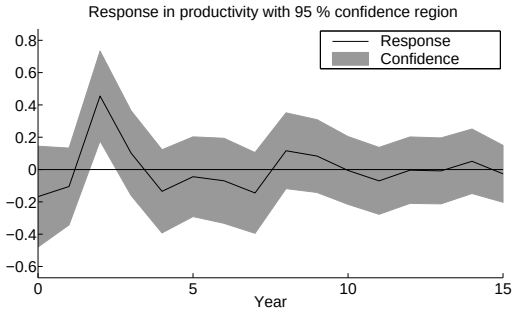
technology shock

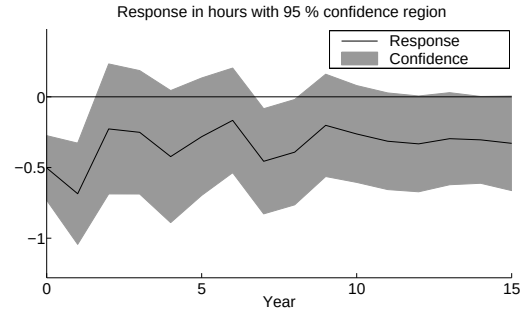


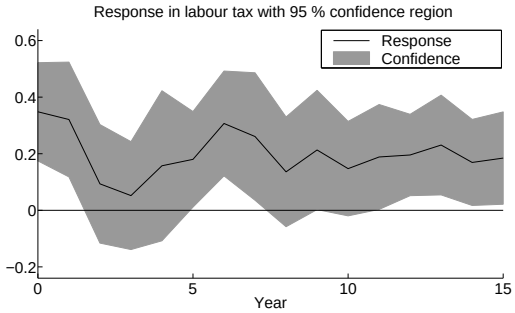
non-technology shock

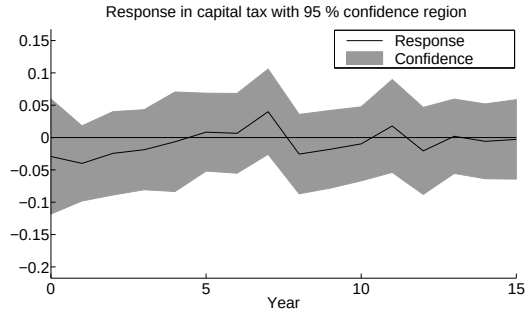


labour tax shock

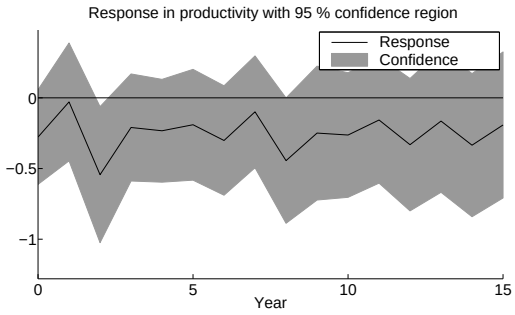


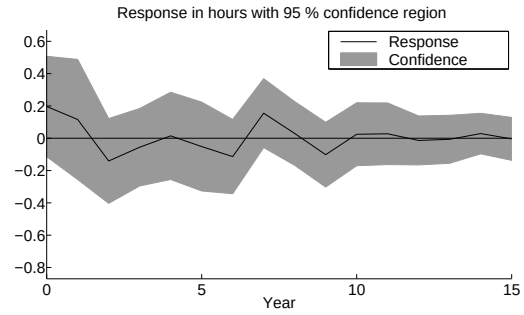


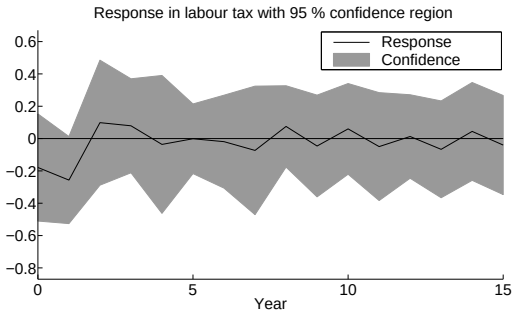




capital tax shock







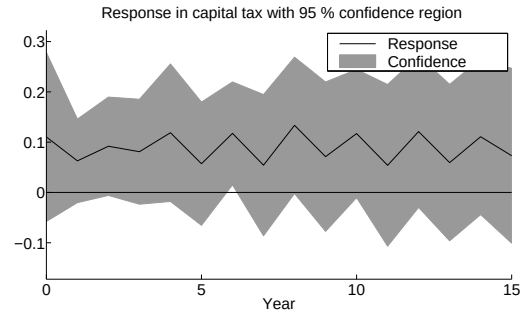


Table 3. Summary of the VAR estimations, key impulse responses in the short and long run [+]

Country	Trade−off empl. vs. prod.		Impact of labour taxes on prod.	Impact of labour taxes on empl.		Impact of capital taxes on prod.		Impact of capital taxes on empl.	LR test for over identification,
	Short run	Long run	Short run	Short run	Long run	Short run	Long run	Short run	p−value
Austria	−0.46	−0.08	0.34	−0.50*	−0.20	0.64	0.41	−0.73*	0.34
Belgium	−0.50*	−0.14	−0.12	−0.21	0.20	0.76*	0.33*	0.02	0.50
Denmark	−1.05*	−0.09	0.56	0.44*	0.45*	0.52	0.03	−0.48*	0.22
Finland	−0.82*	0.02	−0.74	−0.81*	−0.99*	−0.80*	−0.44*	0.20	0.94
France	−0.23	−0.15	0.18	−0.83*	−0.15	0.43*	0.39*	−0.20	0.78
Germany	−0.34	−0.02	−0.07	–0.46*	–0.12	–0.24*	–0.23*	−0.03	0.47
Greece	−0.45	−0.11	0.10	−0.22	−0.01	−2.07*	−0.67	0.36	0.56
Ireland	0.26	0.28	−0.30	−0.56*	−0.26*	0.81	0.12	−0.05	0.69
Italy	−0.79*	−0.38	−0.22	0.16	−0.01	−0.23	0.11	−0.22	0.00
Luxembourg	0.11	0.29	−0.42	0.56*	0.58*	0.41	0.30	−0.38*	0.23
Netherlands	−1.23*	−0.76*	−0.22	−0.09	0.16	−0.39	0.18	−0.05	0.06
Spain	−0.97*	−0.46	−0.29	−0.51	−1.00	−0.34	−0.00	−0.44	0.00
Sweden	−0.29	−0.06	0.15	−0.09	0.43*	0.44	0.15	−0.69*	0.74
United Kingdom	−0.86*	−0.76*	−0.11	0.39	−0.03	−0.90*	−0.20*	0.12	0.19
EU15 − Portugal	−0.28	−0.08	−0.17	−0.50*	−0.31	−0.28	−0.25*	0.17	0.00
EU15 − Portugal and Germany	–0.45*	–0.16	–0.20	–0.39*	–0.26	–0.27	–0.12	–0.19	0.45
Other OECD:									
Australia	−0.68*	−0.18	−0.80*	−0.55*	−0.45	0.41	0.06	−0.19	0.08
Canada	−0.79*	−0.34	0.15	−0.40	−0.27	−0.54	−0.05	0.58*	0.00
Japan	0.43*	0.17	0.22	0.15	0.02	0.34	−0.44	0.27	0.63
New Zealand	−0.34	0.11	−0.55	−0.22	−0.43	−0.26	0.05	0.67*	0.49
Norway	−0.38	0.05	0.24	0.56*	0.46	−0.15	−0.09	−0.09	0.98
Switzerland	−0.42	−0.02	−0.14	−0.68*	−0.80*	0.50	0.56	−0.24	0.73
USA	0.01	0.12	−0.01	0.18	−0.29	−0.03	−0.14	0.72*	0.28

[+] 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. (19) above.

The results in Table 3 clearly differ between the countries in some important respects. As said, quite uniformly in the short-run 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. 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 Netherlands and the United Kingdom. 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.

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 Luxemburg and Denmark, of labour 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. Overall, it seems that the negative impacts of labour tax wedge shocks on employment are stronger than the effect of capital tax wedge shocks on productivity. Capital tax shocks have a problematic positive impulse response on productivity in Belgium and France. The LR tests of the overidentifying restrictions in (19) in broad terms produce the result that these constraints are satisfied by data in most cases.

4 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 produced a long-run identification of the tax shocks, leading to a duality so that the labour and capital tax wedge shocks have diverse long-run impacts on productivity and employment.

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. The analysis of the tax shocks produced some important insight on the diverse effects of tax policies in this connection.

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