Do labour taxes (and their composition) affect wages in the short and the long run?

PRELIMINARY DRAFT – NOT FOR QUOTATION

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ABSTRACT

Measures aimed at reducing the tax burden on labour have been advocated to alleviate the EU unemployment problem. Most of the analyses document a relationship between the unemployment rate and the tax burden on labour. Hence, it is not possible to discern whether the effect on unemployment derives from labour demand, labour supply or trough the wage formation mechanism. Moreover, the empirical analyses are usually static, and may be indicative of the steady-state determinants of the unemployment rate and do not reveal the features of the adjustment process. This paper studies the relationship between labour taxes and labour costs by modelling the wage formation mechanism in a dynamic context. We test if the composition of labour taxes affects labour costs in the short- and in the long-run and whether highly centralised bargaining systems have better employment performance than decentralised ones. We apply static and dynamic panel data techniques to a panel of EU countries.

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I. Introduction

The increase in the tax burden on labour in the 1980s and 1990s has often been advocated as one of the main causes of the rising and persistent EU unemployment rate. To alleviate the European unemployment problem, some EU countries have started implementing measures aimed at reducing the tax burden on labour.

Despite the broad concerns on the effect of taxes on labour market performance, the empirical findings are somewhat ambiguous[2]. Most of the analyses document a relationship between the unemployment rate and the (average) tax burden on labour. Hence, it is not possible to discern whether and to what extent taxes affect the unemployment rate because of a labour demand effect, i.e. through the impact of taxes on the labour cost at an unchanged wage rate, or because of a labour supply effect, i.e. operating through the incentives and disincentives to take-up a job (as generated by the interaction between tax and benefit systems) or through the wage formation mechanism. Furthermore, apart from few recent exceptions, the empirical analyses are static, and thus indicative of at most steady-state determinants of the unemployment rate. Static methods do not reveal the features of the adjustment process, and, consequently, the time needed to achieve a desired change in the variable of interest.

This paper explores the empirical relationship between taxes on labour and labour costs by modelling the wage formation mechanism in a dynamic context. In competitive markets the quantity traded in the market is independent of the side of the market which is taxed. In contrast, in imperfect competitive markets, the composition of the tax burden on labour may not be irrelevant. A shift of social security contributions from employers to employees that leaves unaffected the average tax wedge may still affect the after-tax wage. A similar argument holds for a shift from social security contributions to income taxes. We verify if the distribution of the tax burden between workers and employers affects the wage formation mechanism, both in the short and in the long-run. Finally, we test the hypothesis that the effects on real labour costs of changes in the tax burden and/or in its distribution between workers and employers are mediated by the extent of centralisation and coordination of wage bargaining. We test whether centralisation and coordination are associated with wage moderation.

The contribution of this paper to the existing empirical literature is threefold. First, we base the analysis on a measure of the tax wedge and of its components calculated by the OECD on the basis of micro-simulation of national tax legislation. Combining information on tax schedules and tax

[2] See OECD(1994) and Nickell and Layard (1999).

codes with data on income distribution overcomes the limits of the alternative approach mainly used in the literature to calculate tax indicators (the so-called Mendoza-Razin–Tesar approach[3]). By relating the effective tax revenues directly to the relevant macroeconomic variables in national accounts the Mendoza approach has the limit that the implicit tax rates are endogenous. Second, we explore the effect on the labour costs of the different components of the tax wedge, while most of the analyses focus on the overall tax wedge (i.e. assume the invariance of the composition). Third, we check the robustness of our findings against alternative estimation methods.

The remainder of the paper is structured as follows. Section 2 briefly reviews the main issues related to the impact of labour taxation on real labour costs and employment. Section 3 presents some empirical findings along with descriptive statistics on the structure and the dynamics of tax wedge across countries. Section 4 presents the econometric results. First, we explore the relationship between the tax burden on labour and the before-tax wage. Second, we evaluate if the effect of taxes on labour costs differs according to the degree of centralisation/coordination of wage bargaining. Third, we test whether the composition of taxes on labour matters. Section 5 concludes.

II. Taxation, labour cost and unemployment

There is an extensive theoretical and empirical literature on the impact of labour taxation on both wage and employment. While the statutory incidence of a tax may be relevant for political reasons[4], it is well known from the tax theory that the nominal statutory incidence is irrelevant in determining the economic incidence of a tax. To the extent that the price of the item taxed changes when a tax is levied, the tax is shifted and the final incidence can be on a base that is completely different from that implied by the statutory nominal incidence. Hence, the actual burden of the tax depends on a set of complicated behavioural responses and generally falls on the side of the market (demand or supply or real wage bargaining curve, in imperfect competitive markets) that is most inelastic. The final incidence of the tax is determined not only by the elasticities of labour demand and labour supply to, respectively, labour costs and the after tax wage but also by the nature of wage negotiations and by the interactions of tax with other institutions (e.g. the fiscal treatment of unemployment benefits and the extent of coordination of bargaining).

From the demand side, when increases of taxes on labour income (personal income tax and social security contributions-hereafter SSCs) raises labour costs, the labour demand shifts downward. In the case of the right to manage bargaining model, the wage-setting curve is negatively sloped and an increase

[3] See Mendoza et al. (1994).
[4] Although this can be the result of "fiscal illusion", voters do not seem indifferent between a statutory tax rate of 10% or 30% even if the final incidence would be the same.

in SSCs always raises unemployment, the more so when the unemployment benefits are not indexed or not taxed at the same rate as wage income.

From a theoretical point of view, the size of the impact of tax cuts on wages and unemployment is crucially related to the fiscal treatment of unemployment benefit (see Pissarides (1998), Van Der Ploeg (2003)). What is relevant is whether UBs are taxed or not[5] or, more generally, whether it is the net replacement rate (the ratio of unemployment benefit to net wages) rather than the level of unemployment benefits that is fixed. The effects of tax cuts on wage and unemployment under these two different UB schemes and for four labour market models (competitive, union bargaining, search and efficiency models) were modelled and simulated by Pissarides (1998). The four models have the same implication in terms of the interaction of tax cuts and unemployment benefits: a scheme in which UBs are taxed (or, equivalently the net replacement rate is fixed) makes the supply/wage-setting curve less elastic (steeper) than the case of non-taxed UB.

This can be seen in Figure 1 that provides a simple diagrammatic illustration of the labour market outcomes following a tax cut, under the two conditions of unemployment benefits taxed and not taxed. We have represented the impact on real wage and on employment when the downward-sloping price setting relationship (or labour demand curve- L_d)[6] shifts upwards, following a cut in the tax rate. The vertical axis measures the after-tax wage level while the horizontal axis measures the level of employment. There are two upward-sloping wage-setting curves (or labour supply curve *WS*)[7] with two different slopes, related to the two UB schemes (taxed-non taxed). Because of the lower elasticity of the wage-setting curve under the condition of taxed UB (or fixed NRR), tax cuts will more likely be absorbed by increased real wage. Then, any tax cut is reflected more on real net take-home pay than on employment[8].

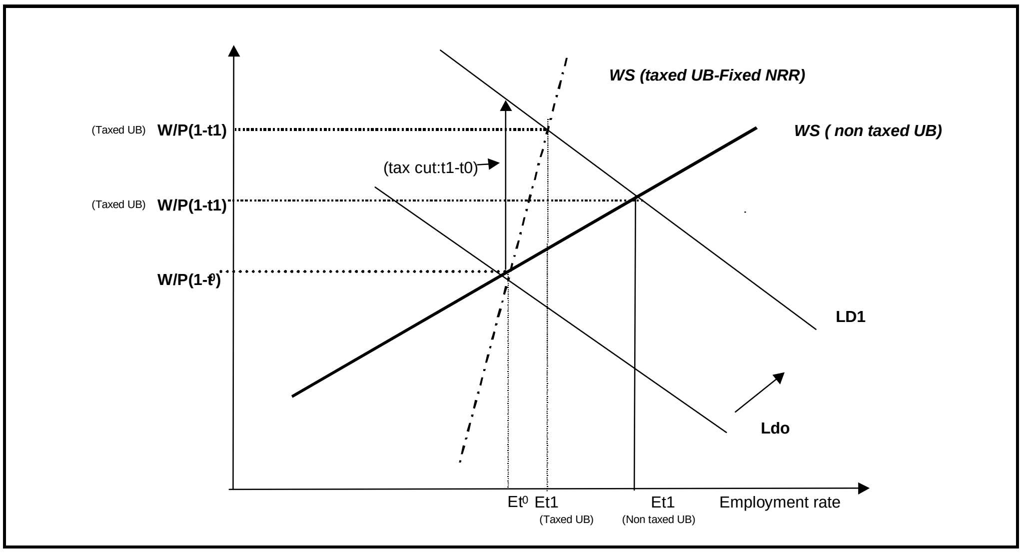
[5] At least, taxed less than income from work.

[6] The downward sloping labour demand curve represents, in an imperfectly competitive framework, the profit-maximizing combination of real-wage and employment for firms making employment and pricing decisions, given a predetermined nominal wage.

[7] The upward-sloping wage-setting curve represents either the no quitting/no shirking condition in efficiency wage models (that is the minimum wage, at any given level of employment that firms have to offer to discourage quitting or to keep workers motivated) or the result of wage negotiations in wage bargaining models.

[8] In the case of inelastic labour supply, an increase in taxation will also be passed on net real wages (take-home pay) with few if any impact on labour cost and employment.

Figure 1 **Impact of tax cuts on wage and unemployment under two different UI schemes**



The result is also rather intuitive if we think about the role of unemployment as a discipline device (and the welfare reduction from a job loss) in most of the aforementioned partial equilibrium models, refraining wage demands[9]. Thus, if after a tax cut the unemployment benefits does not increase with the after-tax wage increases – (the case of non-taxed UB /fixed real level of benefits, not indexed to wages), the wedge between income if employed and income if unemployed, i.e. the cost of being unemployed, will increase.

Changes in the tax burden, to the extent they are reflected in a change in real labour costs, can also have an indirect impact on labour demand by changing domestic production costs relative to those of foreign competitors (see Alesina-Perotti (1994). In this context, for example, a reduction of employers' social security contributions can enhance the international competitiveness of a country, thereby acting like a real exchange rate depreciation[10].

Finally, in dynamic models, tax policies that reduce the prices of non-labour productive factors relative to labour tend to modify the relative factor intensities to the detriment of labour (in particular low-skilled labour).

To see how the tax incidence is relevant, it is sufficient to look at the tax wedge between the real product wage (or real labour cost) paid by firms, *RLC,* and the real consumption wage of the worker *RWC:*

[9] In the class of efficiency–wage (or incentive-wage) models, the role of unemployment is to increase the cost of dismissal and therefore to discipline workers behaviour on the job (not shirking or not quitting).

[10] This effect has been called the "internal exchange-rate depreciation" in the Scandinavian policy debate and it is one of the reasons behind the set-up of the "buffer stock" in Finland (Calmfors, 1998)). This is also why changes in social security contributions and payroll taxes paid by employers are being suggested as counter-cyclical policy tools in EMU to support macro-stabilisation objectives.

$$RLC = W(1+\tau_F)/P$$
$$RWC = W(1-\tau_E)(1-t_A)/P(1+t_c)$$

where W is the nominal gross wage, P is the deflator of GDP at factor costs, τ_F is the rate of social security contributions paid by employers, τ_E employees' social security contributions, t_A the tax rate on personal income and t_c is the tax rate on consumption goods. Thereby the wedge is given by:

Tax wedge = $\delta = (1+\tau_F)(1+t_c)/(1-\tau_E)(1-t_A)$ and $RLC = \delta * RWC$

An increase in a component of the tax wedge δ (personal income taxes, consumption taxes or SSCs) can increase the labour cost (the real product wage) for a given real consumption wage, or decrease real consumption wage, for a given labour cost. The relevant empirical issue here is whether and to what extent the total tax wedge is passed on into higher gross labour costs. The shift of a change in the tax wedge on the labour costs is likely to be higher, the greater the real consumption wage rigidity or the higher the wage elasticity of labour supply. In the extreme case of an infinite elasticity of labour supply (i.e. constant real wage), any change in taxation will be completely passed on labour costs to employers, with the higher impact on employment and no change in real after-tax wage. In the literature, this complete shift of taxes on labour cost is termed "real wage resistance". It is referred to a situation where, a change of one of the components of the fiscal wedge (personal income tax, SSCs, consumption taxes), gives rise to a change in the real labour cost (taxes fall fully on the firm) because workers try to protect their living standards[11].

For example, a higher tax wedge through an increase in employers' social security contributions could, all other things equal (for example in the presence of a wage floor due to minimum wages, non co-ordinated unions or benefit levels or a complete real wage resistance), raise the cost of labour, lower the price-competitiveness and ultimately increase unemployment. This will happen if the increase in the payroll tax cannot be passed on to workers in the form of lower wages (see Blau-Kahn (1999)).

<u>The invariance of incidence proposition (IIP)</u>

In this paper we also test the so called "irrelevance theorem" or "invariance of incidence proposition" (IIP). The IIP implies that any change in the composition of the tax wedge, (for example, from SSCs paid by employees towards those paid by employers), does not affect labour costs and thus labour market outcome because the switch is supposed to leave the wedge between the producer costs and net take-home wage unchanged. Theoretical

[11] In more general terms real wage resistance occurs when workers seek recompense from any erosion of their real wage through whatever the source of such erosion (being decline in TFP productivity growth, increase in price levels or in tax rates)

models of wage setting assume that personal income tax, employers' and employees' tax rates and consumption tax rates have all the same impact on wages. Usually, the IIP is not even tested in empirical models but simply assumed, by estimating models that include only the overall tax wedge as explanatory variable (Goerke (1999)).

Yet, there is a wide strand of literature that shows that even revenue neutral shift of taxes on labour can alter labour market outcomes (e.g. Rasmussen (1997a), (1997b)). For example, testing a wage equation for ten OECD countries, Knoester and Van der Windt (1987) find that the employers' and employees' tax rate have a larger impact on wage costs than indirect tax rates in the case of Australia, Canada, Germany, Italy, Japan, The Netherlands, Sweden and the United Kingdom. For the United Kingdom, Layard and Nickell (1986) find that only the employers' tax rate affects wages.

The degree of shifting of social security contributions on wages is not only function of the real downward or upward wage rigidity and of the bargaining power of wage earners. It also depends on how workers value the benefits linked to the payment of SSCs. This tax/benefit linkage is well-known in the public finance theory (See Musgrave (1959), Summers (1989) and Gruber (1995)). In theory, when benefits of social insurance are tied to the contributions, there exists a social insurance system where present discounted value of individual's contributions equals present discounted value of individual's benefits. Consequently, payroll taxes that are used to finance the provision of earnings related social security in such an optimal system should have little or no detrimental effect on labour supply and unemployment[12]. If this linkage is considered in the model, a change in the payroll rate implies a change in the future benefits and, thus, in the (deferred) net wage. This should be represented by a shift of the supply curve as well. As a consequence, if workers value the benefits that they are buying with their payroll taxes, the impact of this change on the employment will be more limited, if any. Along the same lines, Disney (2004) argues that to the extent that pension contributions are perceived as giving individuals rights to future pensions the potential adverse risks on employment are alleviated.

Hence, the analysis of incidence relying only on the relative elasticity of labour demand and labour supply (or wage curve) is incomplete. Indeed, it is important to account for the link between tax and benefit (the stricter the relationship the higher the incidence on after-tax wage). An important qualification here is due to the presence of minimum wage, because in this case firms cannot entirely shift on workers the increase of SSCs. Furthermore,

[12] As stressed by Stiglitz (1999) "the major impact of social insurance depends on the difference between the (marginal) expected present discount values of benefits and contributions. In particular, the impact of social insurance financed by payroll taxes on the supply of labour depends on the precise specification of the system. By enabling individuals to see more clearly the link between the contributions and benefits, one reduces any adverse incentive effects arising from a failure to see the link".

if gross wages are rigid downwards, they may react more flexibly to tax cuts than to tax increases. It follows that, a rise in the payroll taxes levied on firms might lead to higher labour costs if the payroll tax increases do not lead to a corresponding fall in the before-tax wage rate. This 'less-than-full-shifting' of SSCs on wages is more likely when there are weak linkages between benefits and taxes or in the presence of downward wage rigidities induced by a binding minimum wage. When there is a full shifting, that is the incidence of changes on mandated employers' SSCs is fully on after tax wages, there should also be only little if any impact on labour supply and thus employment because workers may consider the immediate reduction in net wages to be compensated by the insurance value or any future benefit bought by SSCs[13].

Empirical evidence on the impact of payroll taxation for different countries is mixed (see Kugler & Kugler, 2003). Results range from full-shifting to little shifting and large disemployment effects. Gruber (1994, 1997) and Gruber and Krueger (1991), using cross-section and time-series variation in Chile for social security contributions and in the U.S. for disability insurance and maternity benefits, find full shifting of employer contributions on wages and no disemployment effects. As already mentioned, an important influence on the degree of tax shift is the presence of downward wage rigidities, which may make it more difficult to shift a large increase in payroll taxes on to workers. Furthermore, when wages are flexible upwards but not down, there could be full shifting in response to a large reduction in payroll taxes but not in response to a large increase. Institutional aspects of wage bargaining are also important. Usually, collective bargaining fixed contracts for the gross wage (e.g. wage costs excluding SSCs paid by employers). Once the gross wage has been fixed, an unanticipated increase in the employers' tax rate will, in the short run, cause a similar change in labour costs. On the contrary, an unexpected increase in the employees' tax rate, is absorbed by workers in terms of a lower net wage. Thus, at least in the short-run, unexpected changes in the employers' and employees' tax rate may have different impact on labour costs. However, these effects due to nominal contracting are not likely to persist in the long run (see Graafland-Huizinga, (1995)).

[13] This is the main result by Gruber (1995) with reference to the big reduction of the employers' SSCs in Chile in 1981. It is well known from public finance literature that economic theory cannot give a precise prediction for the size and direction of the supply responses to tax changes due to the offsetting impacts of the income and substitution effects. From an empirical viewpoint, there is a general consensus that labour supply responses to tax/benefit need to be distinguished by type of individual and labour market "segment" and by whether these responses are related to a change in the hours worked or effort of work of those already in employment or a move from unemployment or inactivity to employment. The evidence on the importance of tax changes for labour supply is mixed. However, there is considerable evidence that high marginal tax rates can be relevant for age and gender specific groups (partners in couples where one spouse is not working, usually married women, and lone-parent families. On the contrary, tax (and benefit) changes seem far less likely to induce a relevant labour supply response for prime-age males.

Centralisation of wage bargaining and effects of labour taxes

In this paper we also test the relevance of the degree of centralisation of wage bargaining. The argument of the well-known analysis by Calmfors and Driffill (1988) is that both highly centralised (at national or multi-industry level) and decentralised (at the level of firms) bargaining systems perform better than intermediate ones (at the level of sectors/industries), as the co-operative behaviour of the former creates incentives to moderate wage claims while market forces restraint wages when bargaining occurs at the plant level. Hence, the relationship between wage levels and centralization is hump-shaped. Wages are higher when bargaining occurs at the industry level than when it occurs at very centralised or very decentralised levels. Of course, in open economies wage restraint occurs also in intermediate systems. The hump-shaped curve becomes flatter the more open is the economy and/or the more competitive is the product market[14].

The hump-shaped curve predicted by Calmfors and Driffill becomes linear when one takes into account the influence of unions in the political process which leads to the determination of labour taxation and of its structure. Unions can be assimilated to large encompassing coalitions recognising the link between taxes paid by workers and the benefits they receive. The argument by Summers, Gruber and Vergara (1993) is based on the idea that centralised unions *look through the budget,* and internalise the effect of their wage claims on the tax base and on the provision of public goods that enter into the union utility function. Hence, labour taxation is higher but less distorting. If unions are large enough, they recognise the linkage between taxes and benefits received, internalizing the aggregate consequences of their actions (Kiander, Kilponen and Vilmunen (2000)). Centralised unions recognise that higher wages lead to a drop in employment, in the tax base and, finally, in the provision of public goods. The wage moderation effect of public good is higher the higher is the marginal utility from public good (Kilponen and Sinko (2003)). In the model of Summers et al., countries with centralised unions perform better than both intermediate and decentralised systems[15]. Hence, when compared to countries with decentralised wage setting, countries with centralised bargaining should have higher income taxes, as means of income redistribution, and higher employment[16]. An

[14] When there are strong externalities across industries, the relationship between wages and the extent of centralisation becomes downward sloped (i.e. the level of wages decline with the level of centralisation of bargaining. Given the negative relation between employment and wages, the level of employment rises with the level of centralisation/co-ordination). See Calmfors (1993).

[15] In Calmfors and Driffill (1988) the mechanisms driving the externality works through the link between wages and prices, while in Summers *et al* the connection between wages and government budget is decisive. In the former there are two levels of internalisation of price externalities: a micro level working at the firm level and a macro level working at the aggregate demand level. In the latter, internalisation only occurs at the macro level. This implies the superiority of centralised systems on any other bargaining system in the model by Gruber et al.

[16] Wage moderation of centralised wage bargaining systems occurs also with endogenous supply of hours worked. However, in the context of a median voter model, the only possible cost implied by

increase in the average tax rate reduces the after-tax pay because the unions internalises the effect on the provision of public goods and do not fully compensate for the increase in the tax as they do in the decentralised case.

When individuals and unions derive utility from the provision of a public good financed through general taxation, the effects of a change in the average tax rate depends on the degree of unions' "encompassment", i.e. the degree in which a centralised union compensates the effect of its wage policy on the provision and financing of the public good (Kilponen and Sinko (2001)). With centralised union, higher (lower) taxes lead to a lower (higher) after-tax wage. In contrast, with decentralised unions changes in the average tax rate are fully compensated by changes in the before tax wage (i.e. the after tax income remain unchanged). Hence higher taxes on wages are less harmful for employment in centralised systems. Similarly, a reduction in the average tax has lower effects on employment with centralised bargaining.

The empirical evidence (Daveri and Tabellini (2000)) seems to support the view that in more corporatist countries labour taxes are less distortionary (i.e. the effect on unemployment is lower) than in countries where wage bargaining is less centralised but not fully decentralized. In particular, distortionary effects of labour taxes are found to be largest in countries with intermediate (industrial) level wage-bargaining systems.

III. Empirical findings to date

Despite the notably amount of research devoted to the issue, empirical findings on the degree of real wage resistance and therefore on the final incidence of taxes on labour is mixed and remains highly controversial. As stressed by Gruber (1995), problems of biased estimates due to omitted variables, cross-country differences in wage-setting correlated with tax rates differences, or contemporaneous time series changes in other variables which determine wages, not controlled for in the estimation are among the major pitfalls of existing empirical works.

Although wage resistance and tax-push phenomena seem different in different countries, in different times and for different fiscal policies (Padoa Schioppa Kostoris (1992) and Tyrväinen (1995)), there is some evidence of wage resistance and therefore of a significant and long-lasting impact of taxes on labour costs and unemployment in many European countries, especially of continental Europe (Daveri and Tabellini, (2000), Marino and Rinaldi (2000)). There is also empirical evidence that a tax cut is more likely to have a greater positive impact on employment in countries where there is either a highly decentralised bargaining system or a high degree of centralisation or co-

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higher taxation is the reduction in the take home pay. In this case, the relationship between degree of centralisation and optimal tax rate is ambiguous ((Kilponen and Sinko (2001)).

ordination of unions and therefore a higher internalisation of the beneficial effects of wage moderation on employment and macroeconomic performance (a confirmation of the well-known Calmfors-Driffill hypothesis)[17].

According to some (Nickell-Layard (1997), (1999)), the balance of empirical evidence suggests that, in the long-run, a kind of "*tax neutrality*" holds. In theoretical terms this is equivalent to say that in the long run, in a perfectly competitive model, the labour supply is considered vertical. In a wage-bargaining model this is equivalent to assume that the (upward or downward) shift of the price-setting and the wage-setting curves is of equal amount. There is probably some wage resistance in the short-term but not in the long-term, although the transition to the long–term can be very long and therefore the short-term impact and the dynamics of adjustment can be long-lasting. As a result, there should be only a rather limited adverse effect of tax on unemployment and labour input, and the precise size of this effect remains unclear (see Nickell-Layard (1999)). Furthermore, in a small open economy with international capital mobility, the expected rate of returns on domestic and foreign investment must be the same. Thus, in the medium-long term real labour costs are tied down by this equivalence condition. Hence, in the medium-long term any increase in tax wedge (labour taxes) will be entirely borne by labour (Nickell(1997)).

To sum up, the final labour market outcome of a change in taxation depends on all the institutional factors (unions, wage setting mechanisms, minimum wage, unemployment benefits, EPL) that, by impinging on both product market and labour market functioning[18], affect the degree of tax shifting and the final incidence of taxation on the production wage (labour cost) and/or the consumption wage (take-home wage). Moreover, these institutional factors are also apt to change over time as a result of structural reforms. Therefore, it is also difficult to predict the actual impact on labour market of a change in tax policy on the base of past experiences.

Some descriptive statistics

Table 1 reports the overall tax wedge for two different socio-economic groups. The tax wedge is a measure of the non-wage component of the labour costs and is defined as the difference between the after-tax and the before-tax labour costs as a percentage of total before-tax labour costs. The average tax wedge used in this paper is the one calculated by the OECD and covers annual data for the period 1980-2000[19]. We use the tax wedge for a single person

[17] See Alesina and Perotti (1994), Scarpetta (1996), Marino and Rinaldi(2000).

[18] The degree of product market competition is also relevant in determining the degree of wage-resistance. To the extent that employers share the "monopoly rents" of firms in a market with low competition, increases in taxation on labour is more likely to be shifted forward into product prices, because of low firm resistance against compensatory wage claims.

[19] See OECD-*Taxing Wages* publication. The OECD tax indicators are the result of microeconomic simulations for a set of stylised taxpayers whose income from labour range below and above the

(without children) working in the manufacturing sector at the average wage level as a proxy for the average tax wedge referred to the entire working population.[20].

There are large cross-countries differences which also persist over time, mainly within rather than between each of the two decades considered. Moreover, when countries are ranked according to the level of the tax wedge, those countries with a relatively low wedge in the first half of the 1980s (Austria, Spain, Germany and Greece) worsened their relative position in the second half of the 1990s.

In countries such as the UK, the Netherlands and Luxembourg, taxes on labour declined during all the 1980s and the 1990s while in Denmark, Italy, Portugal, Sweden and Ireland this downward trend started only in the 1990s. For the remaining countries the wedge increased, with increases after 1995 coming to a halt or being more moderate in the case of France and Greece and going further up in the case of Germany. In the case of a married couple with children, there is less variation of the tax wedge over time but the time pattern is similar to that observed for the "single worker with no children".

Table 2 shows the wide difference in the composition of the tax wedge across Member States and its evolution over the period 1980-2000. The composition of the wedge highlights clear differences across countries in the pattern of reduction of the overall tax burden on labour or in its distribution among employers or employee.

"average production worker" (hereafter APW) wage level, which is taken up as a benchmark in cross-country comparisons. They differ from "effective" (or implicit) tax rates based on macroeconomic data, which convey different ex-post and aggregate (nation-wide) information on the fiscal pressure. The figures show how much personal income taxes and social security contributions are paid by employers and employees. Calculations are available for different family types (single, one-earner and two earner households) and various wage levels.

[20] This is a reasonable assumption. Indeed, the OECD produces measures referred to 6 different family types, but the correlation across countries of the tax wedge for different family types is rather high and stable over time (see for example results in Table 1 for the two categories "single worker with no children" and "married couple with two children"). Hence countries with a high level of the tax wedge for the former category also tend to have over time a high level of the wedge for the latter. This correlation is of at least 0.8 and authorises to consider one of the family type as statistically representative of the others.

Table 1

Tax Wedge								
	Single without children 100% of APW				Married couple with two children one-earner 100 % of APW			
	1980-1984	1985-1989	1990-1995	1996-2002	1980-1984	1985-1989	1990-1995	1996-2002
Austria	38.2	39.8	39.6	44.8	27.6	28.7	28.0	33.4
Belgium	50.0	52.6	54.2	56.6	39.7	41.9	41.1	44.1
Denmark	44.5	47.4	46.3	44.5	36.6	37.0	34.0	33.1
Spain	36.4	36.8	37.5	38.4	32.5	32.8	32.8	32.5
Finland	43.8	45.8	48.1	48.5	36.1	37.6	40.1	44.5
France	38.7	41.2	43.4	44.1	:	:	41.4	41.2
Germany	43.0	45.0	47.2	51.8	34.0	34.7	36.1	35.5
Greece	28.5	32.5	33.9	35.8	15.1	30.1	33.3	35.7
Ireland	37.9	41.8	38.9	32.9	26.4	31.1	29.8	23.3
Italy	48.1	50.3	49.3	48.7	43.6	45.7	44.4	42.8
Luxembourg	38.3	36.6	34.7	34.7	20.2	17.5	15.0	13.6
Netherlands	49.7	49.1	46.0	44.0	44.3	43.3	39.5	36.2
Portugal	30.9	34.4	33.6	33.7	27.6	30.7	27.2	27.6
Sweden	50.7	51.8	47.3	50.3	45.9	47.0	42.8	46.8
United Kingdom	38.4	35.9	33.1	31.5	29.9	27.5	26.2	26.1

Source: own calculation on OECD data, *Taxing Wages* various issues. The tax wedge is computed as the sum of income tax, employers' and employees' social security contributions as a percentage of gross earnings and employers' social security contributions.

Table 2

The tax wedge structure in 1980-2000 -Single at APW wage level , no children

	Income Tax		*Social security contributions*						*Total tax wedge*		*Ranking Position*
			Employee		Employer		Total SSCs				
	2000	Change 2000-1980	2000	Change 2000-1980	2000	Change 2000-1980	2000	Change 2000-1980	2000	Change 2000-1980	2000
BELGIUM	21.0	8.5	10.5	3.0	24.7	-4.7	35.2	-1.7	56.2	6.8	1
DENMARK	32.3	-5.6	11.6	7.4	0.5	0.0	12.1	7.4	44.4	1.8	10
GERMANY	17.2	1.9	17.0	3.4	17.0	3.4	34.0	6.9	51.3	8.8	3
GREECE	1.4	na	12.4	na	21.9	na	34.3	na	35.7	na	14
SPAIN	9.3	1.0	4.9	0.5	23.4	2.3	28.3	2.8	37.6	3.8	13
FRANCE	10.3	na	9.6	na	28.2	0.0	37.8	na	48.1	na	5
IRELAND	13.5	-8.6	4.6	0.5	10.7	2.0	15.3	2.5	28.8	-6.1	18
ITALY	14.2	5.8	6.9	1.4	25.4	-4.8	32.3	-3.4	46.4	2.3	7
LUXEMBOURG	11.2	na	12.0	na	11.9	na	24.0	na	35.2	na	15
NETHERLANDS	7.4	-5.6	25.0	8.3	13.7	-5.3	38.7	3.1	46.1	-2.5	8
AUSTRIA	6.3	-1.4	14.0	2.6	24.7	7.0	38.7	9.7	45.0	8.3	9
PORTUGAL	5.4	1.3	8.9	2.2	19.2	2.2	28.1	4.4	33.5	5.8	16
FINLAND	21.0	-3.7	5.6	3.1	20.6	2.6	26.2	5.7	47.2	2.0	6
SWEDEN	19.5	-8.3	5.3	5.3	24.8	2.6	30.0	7.8	49.5	-0.4	4
UNITED KINGDOM	14.5	-6.0	7.2	1.3	8.6	-3.5	15.8	-2.2	30.3	-8.2	17
HUNGARY	13.1	na	8.8	na	29.5	na	38.3	na	51.4	na	2
POLAND	5.4	na	20.6	na	17.0	na	37.6	na	43.0	na	12
CZECH Rep.	7.8	na	9.3	na	25.9	na	35.2	na	43.0	na	11

Source: OECD, Taxing Wage, various issues.

In general, countries with the highest tax wedge are also those with the highest social security contributions (SSCs), in particular those paid directly by employers. In 2000 total SSCs ranged from 30% to slightly less than 40% of labour cost in most European countries, notably exceptions being Denmark, the United Kingdom, Ireland, Luxembourg and Finland. In particular, employers' SSCs ranged from 20% to about 30% of labour cost in half member states (Finland, France, Greece, Spain, Austria, Sweden, Italy and Belgium). In Denmark the low overall SSCs (about 11%) is compensated by relatively high personal income tax in percentage of labour cost.

Table 3 presents the evolution of both unemployment and employment rates over the period 1980-2002, while Charts 1-3 show the correlation of the unemployment and the employment rate with the tax wedge. This relation is complex and dominated by country-specific patterns, with significant differences in both the cross-country and the cross-time comparisons. Across countries and in different periods, the correlation between the tax wedge and the unemployment and employment rate is almost zero.

On the other hand, even though not easy to interpret in terms of causality, within each country there is a significant time correlation between labour taxes and employment performance. In Member States such as Germany, Greece, Spain, France, Ireland, and to a lesser extent, Austria, high (low) unemployment rate is associated with high (low) tax wedge and *vice versa*[21]. For the Scandinavian countries, Belgium and Finland the correlation, that was negative in the 1980s, became significantly positive in the 1990s. Compared to the 1980s, it markedly decreased in the 1990s in Italy, Luxembourg and the Netherlands. Besides, with only few exceptions, the correlation between the unemployment rate and the tax wedge is higher in the first half than in the second half of the 1990s, and in both sub-periods higher than in all the decade. This suggests that there is an important role for the time dimension of the relationship linking taxes with unemployment which cannot be understood if the focus is on a cross-country comparison at a certain point in time.

These findings do not change significantly when the correlation is calculated with respect to the employment rate or the structural unemployment rate (charts 2-3). The time correlation between labour taxes and structural unemployment is usually highly significant and even higher than that between taxes and actual unemployment rates. As expected, a negative correlation between taxes on labour and employment rates is found for almost all Member States (chart 3).

This first look at the data shows that, although the cross-country correlation between unemployment and the tax burden on labour is not very significant - i.e. countries with high taxes on labour and high employment coexist with countries with high taxes on labour and low employment - the within country time correlation is important. Unemployment is not necessary

[21] Since a correlation does not imply in any sense causality, it is equally correct to say that countries with high (low) tax wedge had also high (low) unemployment rate.

high (low) in countries with high (low) tax wedge, but, in most countries, it tends to be higher after increases in the wedge. This implies that changes in the tax wedge are likely to account more for the country-specific response of the (un)employment rate than for the cross-countries differences at a certain point in time. Although bivariate correlations are not indicative of the direction of causality between two variables[22], the existence of significant correlation is suggestive of labour taxes being a factor affecting labour market performance. This first evidence suggests that the mechanism relating taxes to labour market performance is not simple. Since employment and unemployment react often with lags, such dynamics should be properly taken into account in order not to underestimate the long-run impact on employment.

Chart 1

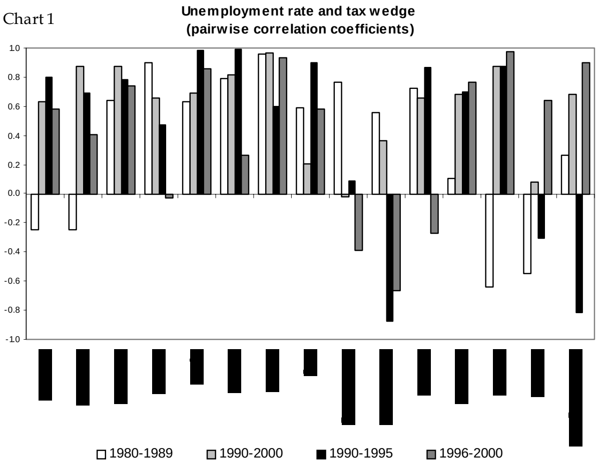


Chart 2

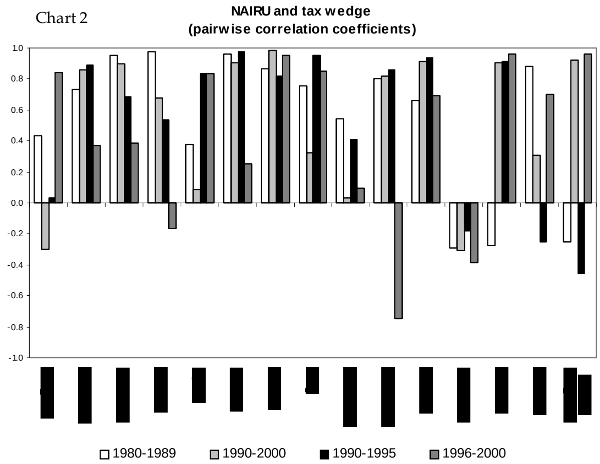
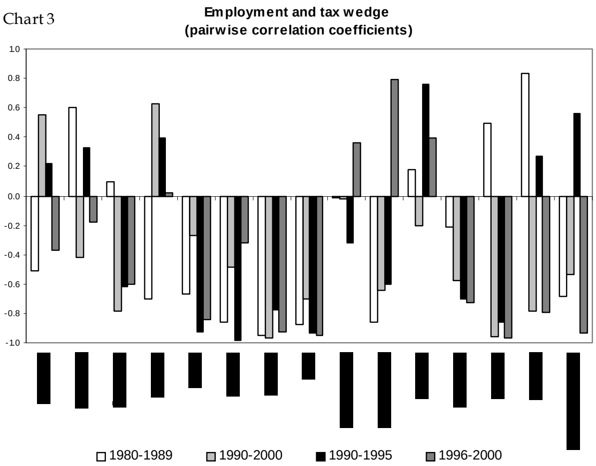


Chart 3



[22] A significant correlation between the two variables is equally consistent with a causality from taxes to unemployment and *vice versa*. Apart the expected causality from labour taxes to (un)employment, a shock leading to unemployment may require an increase in the level of taxes necessary to provide direct or indirect transfers to the unemployed. Besides, the correlation of (un)employment with taxes, can be highly significant but the effect of taxes quantitatively extremely small.

IV. Econometric methodology and results

Methodology

Since we want to study the interactions between the bargaining system and the tax wedge, a natural candidate to depict the wage formation mechanism is the right-to-manage model. In this model unions and firms bargain over the wage level given the labour demand. Firms then choose the number of employees they wish once wages have been set. When the production function is of a Cobb-Douglas, the real labour costs are the log(sum) of the firm specific factors (price and productivity), "outside" factors (unemployment rate, the tax wedge, the reservation wage) and the tax wedge. In the annex we review the role of taxation in search, efficiency wage and union bargaining models taking the Walrasian labour market as a benchmark against which we compare models of imperfect labour markets.

In broad terms we have the following general form for the wage equation

$$W(1+\tau_F) = f\left(P_c, t_A, \tau_F, \tau_E, t_C, \Pi, u, \rho\right)$$

where $W(1+\tau_F)$ is the labour cost, P^c is the consumer price index, Π is labour productivity, u the unemployment rate, ρ the gross replacement rate, t^A , t^c, τ^F, and τ^E respectively the average income tax, the consumption tax rate, the employers' and employees social security contributions.

The models considered so far assume that wages are continuously on the labour supply or, in imperfectly competitive models, on the wage curve. Nevertheless, wages can deviate from the long run equilibrium either because of overlapping wage contracts or delayed adjustment. Neglecting such dynamics may lead to biased estimates of the impact of labour taxes on the wages. A general dynamic linear specification of the wage equation for a panel of *i* countries and *t* periods which also allows for country specific effects is as follows:

$$rlc_{i,t} = \alpha_i + A_1(L)rlc_{i,t-1} + A_2(L)p^C_{i,t} + A_3(L)\pi_{i,t} + A_4(L)u_{i,t} + A_5(L)\log t^C_{i,t} + A_6(L)\log(1+\rho_{i,t})$$
$$+\alpha(L)\log(1+t^A_{i,t}) + \beta(L)\log(1+\tau^F_{i,t}) + \gamma(L)\log(1+\tau^E_{i,t}) + \varepsilon_{it}$$

where *rlc* is the (log) real labour costs, p^c the (log)consumer price index, π the log(labour productivity), u the unemployment rate. As a proxy for indirect taxation (t^c) we used the price wedge (ratio between the consumption and the GDP deflators), which contains information on indirect taxation, but also on import prices and terms-of-trade shocks. ρ is the gross replacement rate, while the last three terms in the equation are the components of the tax wedge[23].

In order to check the robustness of results against alternative methods, the above equation has been estimated applying three different techniques (OLS fixed effects, Within Group (WG) and Generalised Method of Moments (GMM)) to a balanced panel of 15 EU Member States over the period 1979-2000. It is well known that in dynamic panels the presence of fixed effects makes the OLS estimator biased and inconsistent. The WG estimator wipes out the fixed effects but do not solve the problem. It still suffers from bias in dynamic models due to the correlation between lagged dependent variable (real labour costs) and the average across time of the disturbances[24]. Another problem concerns the treatment of endogenous variables (i.e. the lagged dependent variable and other possible endogenous explanatory variables). To address these problems the dynamic wage equation is estimated using the first difference GMM (GMM-dif) estimator (Arellano and Bond (1991)), with the instrument matrix defined on the basis of the assumptions made on whether the explanatory variables are exogenous, endogenous or predetermined. The procedure uses lags of the dependent variable and, eventually, of other explanatory variables as instruments. However, when the number of time periods is small, the time series highly persistent and there are relatively important country idiosyncratic individual effects, the GMM-dif estimator looses its efficiency. In this case the system GMM (GMM-sys) estimator is more appropriate (Arellano and Bover (1995) and Blundell and Bond (1998))[25]. GMM estimates can be based on a one step or on the asymptotically more efficient (with heteroskedastic errors) two step estimators. Monte Carlo simulations (Arellano and Bond (1991) and Blundell and Bond (1998)) showed that the standard errors of the two steps estimator are biased downwards in small samples (i.e. the t statistics are unduly high). Under these circumstances, the one-step estimator with standard errors corrected for the heterosckedasticity should be preferred.

Although the OLS and the WG estimates of the coefficient of the lagged dependent variable are biased, respectively upwards (Hsiao 2002) and downwards (Nickell 1981), we are using them because they provide bounds within which the consistent GMM estimate of the coefficient of the lagged dependent variable lies (Blundell et al. (2000)). As required, in order to get consistent GMM estimation we use lags of the dependent variable in levels as

[23] The econometric technicalities and the data source are described in the annex.

[24] The bias disappears as T gets large but the within transformation does not necessarily eliminate the endeogeneity between the error term and possible predetermined variables.

[25] The GMM-sys estimator gives a more precise estimate of the autoregressive parameter than the GMM-dif when series are highly persistent, i.e. the parameter is close to unity. For a panel of 100 individuals and 7 time periods, Monte Carlo simulations by Bårsden et al. (2004) of a dynamic equation with an exogenous variable generated by a persistent AR(1) process show that the bias of the GMM-dif estimator is enormous for small values of the coefficient of the explanatory variable while the GMM-sys overestimates but its bias is not affected by the coefficient of the explanatory variable. However, the bias in the coefficient of the explanatory variable is never so dramatic.

instruments for the lagged dependent variable in first differences. The validity of these instruments is checked with the Sargan test of over-identifying restrictions (which verifies the lack of correlation between errors and instruments) and with a test of absence of serial correlation of residuals, since the moment conditions are valid if the error term is not serially correlated. In equations in first differences, first order autocorrelation is expected even when the original errors are serially uncorrelated, unless they follow a random walk. Moreover a GMM-dif estimate not far from the WG estimate is an indication of weak instruments requiring a GMM-SYS estimator.

We present the results checking their robustness with respect to different econometric techniques and alternative definitions of the tax variables. All variables are expressed as deviation from period means so that we do not have to include time-specific dummies to account for a common component in the determination of real wages[26]. Usually, nominal wages respond positively to increases in producers' and consumers' prices. Since we were not able to reject the homogeneity assumption suggested, to get a more parsimonious equation we expressed labour costs in real terms (nominal labour costs deflated with the consumer price index).

Results

The dynamic wage equations using different methods are reported in Table 4[27]. The findings seem to be robust to alternative econometric techniques and provide indication of a rich dynamics. The validity of the specification comes from the value of the GMM Sargan test of over-identifying restrictions and the absence of autocorrelation (insignificant first and significant second order negative serial correlation)[28].

Turning to the estimates, the value of the coefficient of the lagged dependent variable suggest that real labour costs are highly persistent leading us to choose the GMM-SYS as preferred estimates. As expected, in GMM-SYS the coefficient of the lagged dependent variable lies between the OLS and the WG estimate. Productivity has a positive contemporaneous effect, while the coefficient of lagged productivity is negatively signed. An increase by 1% in the level of productivity raises the real labour costs by about 0.5% in the short-run. This increase partly wanes one year later but tends to be transferred on higher real wages when the dynamics has worked its effects out (see the static solution of the dynamic equation in Table 4a). The

[26] In symbols, for any variable x_{it} the period t mean is calculated averaging over countries i. Hence, the generic variable used in the econometric analysis has the form $x_{it} - \bar{x}_t$.

[27] The results are obtained with the software PCGIVE10.

[28] The equation is estimated in first differences. If the error term is uncorrelated in the equation in levels differentiation introduces an MA(1) process and should thus fail a test of first order negative autocorrelation but not a test of second order autocorrelation.

corresponding long run elasticity of 0.91 suggests that real wages rise in line with productivity growth, which implies a constant wage share. However, a formal test of homogeneity with respect to productivity gives a p-value at about 1% and thus leads to reject the null at 5% of significance[29]. This finding suggests that in the period covered by our dataset real wages grew less than productivity and that the wage share declined - a well-known stylised fact of the 80s and 90s.

Indirect taxes (captured by the ratio of consumption deflator and GDP deflator) have a negative and significant contemporaneous impact on real labour costs. A 1% increase in the consumption deflator relative to the GDP deflator leads to a decline in real labour costs by about 0.8%. This decline is only temporary and compensated by labour costs' increases during the following two years. The fact that the price wedge does not have a statistically significant impact in the real labour costs in the long run implies that the nominal gross wage change as much as the consumer price. Hence, any change in the consumer price level in response to a change in the price wedge is transferred completely on the nominal labour costs.

The tax wedge has a positive impact on the real labour cost, but only in the short-run. In the case of GMM-SYS estimate, a one percentage point increase in the tax wedge raises contemporaneously real labour costs by 0.10% (implied elasticity 0.04)[30]. This figure implies that a 10% increase in the tax wedge (say from 40% to 44%) leads to an increase in the real labour costs by 0.4% (i.e. 0.04*10)[31].

Hence, an increase in labour taxation is largely offset in the short-run by a reduction of the real after-tax wage. In the long-run, the coefficient of the tax wedge is statistically insignificant, implying that any change in the tax wedge

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[29] The linear restriction H_0: $A_3(1)=1-A_1(1)$ gives a $\chi(1)^2=6.17$ with a p-value of 0.013. When the same test is run on DIF-GMM, we get $\chi(1)^2=0.03$ with a p-value of 0.87; on WG $\chi(1)^2=0.09$ with a p-value of 0.75; on OLS estimates $\chi(1)^2=0.25$ with a p-value of 0.61. Hence, in 3 out of 4 cases the homogeneity hypothesis cannot be rejected by the data. Nevertheless, the findings of the GMM-SYS should be preferred for the reasons already mentioned in the text.

[30] The implied elasticity is calculated as follows $\frac{\partial \log rlc}{\partial \log \tau} = \frac{\partial \log rlc}{\partial \log(1+\tau)} \frac{\partial \log(1+\tau)}{\partial \log \tau} = \frac{\partial \log rlc}{\partial \log(1+\tau)} \frac{\tau}{1+\tau}$ where τ is the grouped average over the sample period. The percentage increase in the real labour costs due to a percentage point increase in the tax wedge is

$$\frac{\frac{\partial rlc}{rlc}}{\partial \tau} = \frac{\partial \log rlc}{\partial rlc} \frac{\partial rlc}{\partial \tau} = \frac{\partial \log rlc}{\partial \log(1+\tau)} \frac{\partial \log(1+\tau)}{\partial \tau} = \frac{\partial \log rlc}{\partial \log(1+\tau)} \frac{1}{(1+\tau)}$$

, where in the expression before the last we have made use of the definition of elasticity. The coefficient in the table corresponds to $\frac{\partial \log rlc}{\partial \log(1+\tau)}$ while the average values of $\frac{1}{1+\tau}$ and $\frac{\tau}{1+\tau}$ used to get the percentage point increase are 0.71 and 0.29.

[31] In the case of the Dif-GMM estimate, a one percentage point increase in the tax wedge raises contemporaneously real labour costs respectively by 0.14% with an elasticity of 0.06.

is entirely shifted on consumers as lower (or higher in the case of decreases) after–tax real wage. This result appears in line with those in Nickell et al. (1999) and is consistent with either an iso-elastic union utility function or with unemployment benefits indexed to the after tax wages (i.e.: constant net replacement rate). Yet, this result needs a qualification. Indeed, given the high degree of persistency in real labour costs, an increase in the tax wedge although temporary tends to have long-lasting effects on the real labour costs.

Finally, the short-run effect of the unemployment rate is significant and with the expected negative sign. High unemployment rates lead to low real labour costs, with a corresponding long-run elasticity broadly in line with that found by many microeconomic studies (0.1%)[32]. Therefore, there is only a weak feedback from unemployment to real wages which does not exclude insider hysteresis effects.

1. *Alternative specifications: inclusion of unemployment benefits, non-linearity effects and different tax indicators*

The specification has also been estimated controlling for the gross replacement rate. The coefficient is resulted to be not statistically significant in all cases[33]. The model has been re-estimated by using the more traditional indicator for the average tax wedge based on national accounts data on tax revenues[34]. Results are reproduced in Table A2 in the annex. The estimates are robust across different methods of estimation and alternative definitions of the wedge and confirm the findings of table 4. We have also tested the possibility of non-linearity in the response of real labour costs to a change in the tax wedge, as an increase in the tax wedge may have different effects than a decline. However, this form of non-linearity is not supported by the data. When we separate the effect of taxation on labour cost when the wedge is increasing from the effect when it is declining, a test of symmetry can never be rejected (see table A1 in the appendix).

[32] The long-run unemployment elasticity of real wages is -0.14 and is obtained, to get rid of the semi-log form, by multiplying the coefficient of unemployment in table 4a (-0.02) times 7.72% (the average unemployment rate in our sample over the period 1979-2000). Our estimate of the elasticity is not far from the so-called "universal value" (-0.1%) found by Blanchflower and Oswald (1994). Hence, a doubling of the unemployment reduces wages by about 10%.

[33] Although this finding is in line with that of Daveri and Tabellini (2000), it should be recalled from the theoretical analysis that it is the net replacement rate that should affect the real labour costs. However, a time series for the net replacement rate is not available. Results are not reproduced here but are available upon request.

[34] We use implicit tax rates calculated by Martinez-Mongay (2000).

LIST OF VARIABLES
RLCOMPCM: real labour costs **LPRODM: labour productivity** **LREALCM: price wedge** **LWEDGEM: tax wedge** **LWEDGEMN: tax wedge when wedge is decreasing** **LWEDGEMP: tax wedge when wedge is increasing** **LINTAXM: income tax as % of gross wage** **LSSCLM: employees' social security contributions as % of gross wage** **LSSCFM: employers' social security contributions as % of gross wage** **SSCM: social security contributions as % of gross wage** **LPERSTAXM: (income tax + employees' social security contributions) as % of gross wage** **U: unemployment rate**

Table 4	**Short-run wage equation: endogenous explanatory variables (Balanced panel 1979-2000**			
	OLS	**Within**	**Dif-GMM**	**Sys-GMM**
RLCOMPCM(-1)	0.98***	0.93***	0.93***	0.94***
LPRODMe	0.50***	0.49***	0.48***	0.48***
LPRODMe(-1)	-0.48***	-0.41***	-0.40***	-0.42***
LREALCM	-0.84***	-0.81***	-0.81***	-0.85***
LREALCM(-1)	0.59***	0.56***	0.57***	0.59***
LREALCM(-2)	0.32***	0.32***	0.32***	0.33***
LWEDGEM	0.008	0.17**	0.20**	0.15**
U(-1)	-0.0005*	-0.002***	-0.002***	-0.0012***
Sargan Test	:	:	χ2(660)=348.7***	χ2(720)=583.5***
	:	:	:	
Ar(1): m1-test	0.06	0.10	0.013	0.007
Ar(2):m2-test	0.83	0.50	0.18	0.18
Obs.	300	300	300	300

Table 4a	**Implied long-run wage equation**			
	OLS	**Within**	**Dif-GMM**	**Sys-GMM**
LPRODMe	0.96 (10.7)	1.2 (1.62)	1.1 (1.52)	0.91 (19.6)
LREALCM	3.75 (1.72)	1.2 (0.71)	1.01 (0.71)	1.01 (0.6)
LWEDGEM	0.47 (0.35)	2.6 (1.08)	2.7 (1.15)	2.23 (1.53)
U	-0.03 (-1.9)	-0.03 (-1.37)	-0.03 (-1.4)	-0.02 (-1.86)

Student t in parentheses m1 and m2 are tests of first- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals. * Significant at 10% level; * * significant at 5% level; * * * significant at 1% level. In dif-GMM instruments are $RLCOMPCM_{t-2}$, $LWEDGEM_{t-1}$, $LREALC_{t-1}$ and all further lags. In Sys-GMM additional instruments for level equations are $RLCOMPCM_{t-1}$ $LWEDGEM_{t-1}$, $LREALC_{t-1}$

2. *Testing the role of centralisation*

The next question we have investigated is whether centralisation of wage bargaining influences the degree of shifting of taxes on real labour cost. As already discussed in section 2, the relation between wages and employment may depend on the extent of centralisation and co-ordination of wage bargaining. In order to identify the role of centralisation we have used different data sets. The first is based on the data set assembled by Golden, Lange and Wallerstein (henceforth GLW)[35], the second dataset is based on the taxonomy of Elmeskov, Martin and Scarpetta (henceforth EMS) [36], the third on the labour market institutions data base by Nickell and Nunziata (henceforth NN). The role of centralisation and co-ordination of bargaining is analysed in Table 5 which reproduces the estimates of the wage curve but with the effects of the tax wedge conditional to the specificities of centralisation/coordination of wage bargaining.

Table 5 reports the estimates of the wage equation with the OLS and WG (columns 1-2). It also shows GMM-Dif estimates (columns 3-5) under different assumptions on the endogeneity of the tax wedge and the price wedge[37]. Finally columns 6-8 display the GMM-SYS estimates under different assumptions on the extent to which the instruments used in dif-GMM3 are informative[38]. With OLS the tax wedge is significant, although with an unexpected negative sign, in both systems with low and intermediate levels of coordination/centralisation. The signs turn positive with the WG estimator but the coefficients are different from zero (at the 10% level of significance) only when the level of low coordination is low. When we control for the endogeneity of the tax wedge, this effect is always statistically significant in countries with both low and high level of coordination/centralisation of bargaining; by contrast real labour costs are not sensitive to variations in the tax wedge when the extent of coordination is at the intermediate level. However, the OLS estimate of real labour costs on itself lagged once is close to 1 and supports the choice of the more efficient GMM-SYS estimator[39]. In this

[35] Golden, Lange and Wallerstein (2002) Dataset available at http://www.shelley.polisci.ucla.edu/data. Version dated September 19, 2002. See also Annex.

[36] We use the summary measure of centralisation/co-ordination reported by Elmeskov, Scarpetta and Martin (1998). The data refer to the period 1983-1995. From 1995 on the index takes the values of 1995.

[37] In Dif-GMM1 only the lagged dependent variable is considered endogenous. In Dif-GMM2, in addition to the lagged dependent variable, the tax wedge is a further endogenous variable. Finally, in Dif-GMM3 the lagged dependent variable, the tax wedge and current and lagged values of the price wedge are endogenous.

[38] In GMM-SYS the instruments used in Dif-GMM3 (i.e. model with all explanatory variables endogenous) are considered weak because of the persistency of the lagged dependent variable (GMM-SYS1) , the tax wedge (GMM-SYS2) and the price wedge (GMM-SYS3).

[39] GMM-SYS2 is our preferred estimate for the following reasons: 1) GMM-SYS1 control only for the effects of the persistency on instruments for the lagged dependent variable; 2) however, the autocorrelation coefficient in a AR(1) regression of the tax wedge gives a coefficient of 0.99 which supports the use lagged first differences of the tax wedge as additional instruments in the equation in levels; 3) the AR(1) regression of the price wedge gives a coefficient far from 1 (0.88) and, thus, there

case, if one is ready to accept very imprecise estimates, there is an indication that the tax wedge has an impact on the real labour costs only when centralisation and co-operation is high (SYS-GMM2)[40].

For both the productivity and the price wedge variables, the previous findings are confirmed when the same equation is estimated using the classification of bargaining level in the GLW dataset (table 6)[41]. The tax wedge has a significant impact on the real labour costs in systems with industry and sectoral level wage settings (Barglev23 and Barglev45) only when we control for the endogeneity of lagged real labour costs and of the price wedge. In this case, with sectoral wage setting the impact of the tax wedge is twice as much as that obtained for industry wage setting. However, when we control for the endogeneity of the tax wedge, its effect on real labour costs turns significant but with a negative sign only when the wage setting is at the plant level (i.e. in the UK). In our preferred estimate (SYS-GMM2, see footnote 36), the tax wedge is correctly signed but statistically insignificant. These results are broadly in line when the measure of the level of coordination is the NN CO1 index. Although the tax wedge has a positive impact on the real labour costs, there is no evidence that this impact is stronger when the extent of coordination is high rather than low.

is no reason to use the lagged first difference of the price wedge in the equation in levels as additional instruments. This is confirmed by the coefficients of GMM-SYS3 not different from those in GMM-SYS2.

[40] The evidence is only mildly supportive because the coefficient of the tax wedge in high bargaining systems is not precisely estimated – the t-value is 1.60 corresponding to a probability of 0.12. We also run regressions of the real labour costs equation without the price wedge, under different assumptions on the informativeness of the instruments and on the endogeneity of the tax wedge. The results, not reported for brevity, indicate real wage resistance only in the case of low bargaining systems.

[41] However, the GLW and the EMS data base are not strictly comparable as in the former data on 4 Member States are missing while in the latter this is the case only for two of them.

Table 5	Short-run wage equation: interaction of LM institutions (Elmeskov et al.) and tax wedge (Balanced panel 1979-2000)							
	OLS	**WITHIN**	**Dif-GMM1**	**Dif-GMM2**	**Dif-GMM3**	**GMM-SYS1**	**GMM-SYS2**	**GMM-SYS3**
RLCOMPCM(-1)	0.98***	0.98***	0.95***	0.96***	0.97***	0.95***	0.95***	0.94***
LPRODMe	0.52***	0.52***	0.54***	0.50***	0.52***	0.50***	0.50***	0.50***
LPRODMe(-1)	-0.50***	-0.46***	-0.46***	-0.44***	-0.45***	-0.45***	-0.45***	-0.45***
LREALCM	-0.76***	-0.72***	-0.67***	-0.71***	-0.72***	-0.76***	-0.76***	-0.78***
LREALCM(-1)	0.44***	0.47***	0.30***	0.46***	0.46***	0.41***	0.42***	0.46***
LREALCM(-2)	0.39***	0.37***	0.44***	0.38***	0.37***	0.41***	0.40***	0.37***
LWEDGEM LOW	-0.04**	0.16*	0.28*	0.18**	0.15**	0.14*	0.12	0.11
LWEDGEM INT	-0.04***	0.05	0.16	0.10	0.07	0.06	0.03	0.04
LWEDGEM HIGH	0.03	0.16	0.27**	0.20*	0.17*	0.11	0.12	0.11
U(-1)	-0.001***	-0.001***	-0.002***	-0.0019***	-0.0018***	-0.0011***	-0.0011***	-0.0011***
Sargan Test			χ2(202)= =222.1***	χ2(430)= =259.8***	χ2(658)= =276.1***	χ2(678)= =422***	χ2(698)= =484.4***	χ2(718)= =525.6***
Ar(1): m1-test	0.11	0.08	0.034	0.032	0.030	0.022	0.022	0.020
Ar(2):m2-test	0.96	0.63	0.49	0.43	0.43	0.44	0.45	0.43
Obs.	260	260	247	247	247	260	260	260

m1 and m2 are tests of first- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals.

* Significant at 10% level; * * significant at 5% level; * * * significant at 1% level.

In Dif-GMM1 instruments are UM(-1), LPRODMe, LPRODMe(-1), $RLCOMPCM_{t-2}$, and all further lags.

In Dif-GMM2 in addition to instruments in Dif-GMM1 further instruments are $LREALCM_{t-1}$, and all further lags.

In Dif-GMM3 in addition to instruments in Dif-GMM2 further instruments are $LWEDGEM_{t-1}$, and all further lags.

In GMM-SYS1 in addition to instruments in Dif-GMM3 further instruments are levels of $RLCOMPCM_{t-1}$

In GMM-SYS2 in addition to instruments in Dif-GMM3 further instruments are levels of $LWEDGEM_{t-1}$

In GMM-SYS3 in addition to instruments in Dif-GMM3 further instruments are levels of $LREALCM_{t-1}$

Table 6	Short-run wage equation: interaction of LM institutions (Golden et al.) and tax wedge (Balanced panel 1979-2000)							
	OLS	**WITHIN**	**Dif-GMM1**	**Dif-GMM2**	**Dif-GMM3**	**GMM-SYS1**	**GMM-SYS2**	**GMM-SYS3**
RLCOMPCM(-1)	0.98***	0.84***	0.76***	0.84***	0.84***	0.94***	0.96***	0.96***
LPRODMe	0.49***	0.51***	0.55***	0.49***	0.51***	0.49***	0.48***	0.48***
LPRODMe(-1)	-0.48***	-0.33***	-0.33***	-0.32***	-0.33***	-0.44***	-0.44***	-0.44***
LREALCM	-0.80***	-0.78***	-0.80***	-0.75***	-0.78***	-0.80***	-0.77***	-0.80***
LREALCM(-1)	0.47***	0.40***	0.30	0.36**	0.40***	0.45***	0.45**	0.49***
LREALCM(-2)	0.39***	0.36***	0.39***	0.40***	0.36***	0.44***	0.43***	0.40***
LWEDGEM *Barglev1	-0.086***	0.16*	-0.12	0.04	-0.11***	0.04	0.076	0.02
LWEDGEM*Barglev23	-0.02	0.05	0.07**	0.07*	-0.009	0.06	0.049	0.03
LWEDGEM*Barglev45	-0.03*	0.16	0.11*	0.14***	0.08	0.10*	0.049	0.04
U(-1)	-0.009***	-0.002***	-0.002***	-0.0025***	-0.002***	0.11*	-0.0011***	-0.0011***
Sargan Test			$\chi2(202)$= =180.9***	$\chi2(430)$= =208.6***	$\chi2(658)$= =223.7***	$\chi2(678)$= =331***	$\chi2(698)$= =418.9***	$\chi2(718)$= =470.4***
Ar(1): m1-test	0.64	0.47	0.06	0.044	0.04	0.04	0.04	0.04
Ar(2):m2-test	0.67	0.80	0.72	0.66	0.62	0.70	0.70	0.67
Obs.	220	220	209	209	209	220	220	260

m1 and m2 are tests of first- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals. * Significant at 10% level; * * significant at 5% level; * * * significant at 1% level.
In Dif-GMM1 instruments are current levels of UM(-1),LPRODMe,LPRODMe(-1),and current levels of RLCOMPCM $_{t-2}$, and all further lags.
In Dif-GMM2 in addition to instruments in Dif-GMM1 further instruments are current levels LREALCM $_{t-1}$, and all further lags.
In Dif-GMM3 in addition to instruments in Dif-GMM2 further instruments are current levels LWEDGEM$_{t-1}$, and all further lags.
In SYS-GMM1 in addition to instruments in Dif-GMM3 further instruments are levels of RLCOMPCM $_{t-1}$
In SYS-GMM2 in addition to instruments in Dif-GMM3 further instruments are levels of LWEDGEM $_{t-1}$
In SYS-GMM3 in addition to instruments in Dif-GMM3 further instruments are levels of LREALCM$_{t-1}$

Table 7	Short-run wage equation: interaction of LM institutions (Nickell et al.) and tax wedge (Balanced panel 1979-2000)							
	OLS	**WITHIN**	**Dif-GMM1**	**Dif-GMM2**	**Dif-GMM3**	**Dif-GMM4**	**GMM-SYS1**	**GMM-SYS2**
RLCOMPCM(-1)	0.98***	0.96***	0.95***	0.95***	0.96***	0.96***	0.95***	0.95***
LPRODMe	0.51***	0.51***	0.53***	0.50***	0.51***	0.51***	0.50***	0.50***
LPRODMe(-1)	-0.49***	-0.44***	-0.45***	-0.43***	-0.45***	-0.44***	-0.45***	-0.46***
LREALCM	-0.77***	-0.73***	-0.67***	-0.71***	-0.72***	-0.73***	-0.77***	-0.76***
LREALCM(-1)	0.43***	0.45***	0.29***	0.38***	0.45***	0.45***	0.41***	0.41***
LREALCM(-2)	0.38***	0.37***	0.46***	0.40***	0.38***	0.37***	0.41***	0.41***
LWEDGEM	-0.01	0.14*	0.24***	0.24***	0.17**	0.14*	0.08	0.08
WEDGEM*CO1M	0.048	0.01	0.03	-0.03	0.01	0.01	0.008	0.008
U(-1)	-0.001***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.001***	-0.001***
Sargan Test	:		$\chi 2(203)=$ =221*	$\chi 2(431)=$ =258.7***	$\chi 2(659)=$ =274.1***	$\chi 2(887)=$ =280.2***	$\chi 2(907)=$ =544.1***	$\chi 2(927)=$ =544.1***
Ar(1): m1-test	0.14	0.12	0.034	0.03	0.03	0.03	0.02	0.02
Ar(2):m2-test	0.88	0.65	0.507	0.461	0.45	0.43	0.44	0.45
Obs.	260	260	247	247	247	247	260	260

m1 and m2 are tests of first- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals. * Significant at 10% level; * * significant at 5% level; * * * significant at 1% level.
The interacting variable is expressed as deviation from pooled means. Hence, it takes value zero at the average level. The coefficient of WEDGE is interpreted as the effect for the "representative" country.
In Dif-GMM1 instruments are current levels of UM(-1),LPRODMe,LPRODMe(-1), current levels of $RLCOMPCM_{t-2}$ and all further lags.
In Dif-GMM2 in addition to instruments in Dif-GMM1 further instruments are current levels of $LWEDGEM_{t-1}$ and all further lags.
In Dif-GMM3 in addition to instruments in Dif-GMM2 further instruments are current levels of $WEDGEM_{t-1}$*$CO1M_{t-1}$ and all further lags.
In Dif-GMM4 in addition to instruments in Dif-GMM3 further instruments are current levels of $LREALCM_{t-1}$ and all further lags.
In SYS-GMM1 in addition to instruments in Dif-GMM4 further instruments are levels of $RLCOMPCM_{t-1}$
In SYS-GMM2 in addition to instruments in SYS-GMM1 further instruments are levels of $WEDGE_{t-1}$

3. Testing the invariance of incidence proposition

Turning to the role of the composition of the tax wedge, evidence of GMM estimation of wage equations (see Table 8) suggests that the composition matters only in the short-run, while in the long-run the so-called "invariance of incidence proposition" holds[42]. In the short-run, employers' social security contributions have a positive and statistically significant impact on real labour costs, which is of about the same order as the effect of the income tax rate. Real labour costs are estimated to rise by about 0.10% when the income tax rate rises by 1 percentage point (implied elasticity 0.02), while they rise by 0.07% for a 1 percentage point increase in the employers' social security contributions (implied elasticity 0.02). On the contrary, the impact of employees' social security contributions is not statistically significant, meaning that any change in this component is completely shifted on gross wages.

One problem with table 8 is that the income tax rate and the employees' social security contributions tend to be negatively correlated (chart 4 and table 9). In this case the estimates of the coefficient tend to have large standard errors. We have addressed this problem re-estimating the regressions with direct taxation aggregated with employees' social security contributions in the variable personal taxation (table 10). Personal taxation has a positive and statistically significant impact on real labour costs when we control for the endogeneity of lagged real labour costs only or also for the tax variables (personal taxation in GMM2 or personal taxation and employers' social security contributions in GMM3). However, when we apply the more efficient GMM-SYS estimator, the coefficient of personal taxation turns out statistically insignificant. In contrast the impact of employers' social security contributions appears robust to different assumptions on persistency and endogeneity of variables.

This result can be explained by institutional aspects of wage bargaining. Once the gross wage has been fixed, in the short run an unanticipated increase in the employers' tax rate will be mainly shifted on labour costs. On the contrary, an unexpected increase in the employees' personal income tax, is absorbed by workers in terms of a lower net wage.

A further check of the invariance of incidence proposition is provided by table 11, where employers' and employees' social security contributions have been aggregated in the social security contributions variable. With the exception of the biased and inconsistent OLS estimate, the income tax rate and the social security contributions are statistically significant.

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[42] Because of the lack of a statistically significant long-run impact of any component of the tax wedge, the invariance incidence proposal is a sort of "super-neutrality".

Table 8	Short-run wage equation: effects of tax wedge components (Balanced panel 1979-2000)					
	OLS	**Within**	**Dif-GMM**	**Sys-GMM**	**AH-IV1**	**AH-IV2**
RLCOMPCM(-1)	0.98***	0.93***	0.93***	0.92***	-0.08	0.37
LPRODMe	0.48***	0.48***	0.50***	0.48***	0.53***	0.55***
LPRODMe(-1)	-0.47***	-0.41***	-0.40***	-0.41***	0.07	-0.17
LREALCM	-0.84***	-0.82***	-0.79***	-0.81***	-0.87***	-0.84***
LREALCM (-1)	0.59***	0.56***	0.54***	0.54***	-0.40	0.002
LREALCM (-2)	0.30***	0.32***	0.35***	0.35***	0.15***	0.30
LSSCLM	-0.0152	0.14	0.21	0.09	0.07	-0.013
LINTAXM	-0.011	0.09	0.16**	0.12**	0.19*	0.12
LSSCFM	0.005	0.07**	0.10***	0.09***	0.05	0.06
U(-1)	-0.0006**	-0.002***	-0.002**	-0.002**	-0.002*	-0.002***
Sargan Test	:	:	$\chi2(415)$= 326.5	$\chi2(435)$= 401.7		
Ar(1): m1-test	0.06	0.10	0.014	0.01	0.49	0.90
Ar(2):m2-test	0.751	0.47	0.20	0.20	0.78	0.82
Wald test: tax wedge components with same coeff.	$\chi2(2)$=3.1 [0.22]	$\chi2(2)$=0.56 [0.75]	$\chi2(2)$=1.25 [0.54]	$\chi2(2)$=0.94 [0.62]	$\chi2(2)$=3.93 [0.14]	$\chi2(2)$=2.23 [0.33]
Obs.	300	300	285	285	285	285

m1 and m2 are tests of first- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals.

In Dif-GMM1 instruments are current levels of UM $_{t-1}$, LPRODM $_t$, LPRODM $_{t-1}$, LREALCM $_t$, LREALCM $_{t-1}$, LREALCM $_{t-2}$, LINTAXRATEM $_t$, and current levels of LSSCLRATEM $_t$ and RLCOMPCM $_{t-2}$ and all further lags.
In SYS-GMM1 in addition to instruments in Dif-GMM4 further instruments are levels of RLCOMPCM $_{t-1}$
In AH-IV1 instruments are first differences of dependent variable lagged twice ($RLCOMPCM_{t-2}$-$RLCOMPCM_{t-3}$)
In AH-IV2 instruments are levels of the dependent variable lagged twice ($RLCOMPCM_{t-2}$)
* Significant at 10% level; * * significant at 5% level; * * * significant at 1% level

Table 8A	Implied long-run wage equation: effects of tax wedge components					
	OLS	**Within**	**Dif-GMM**	**Sys-GMM**	**AH-IV1**	**AH-IV2**
LPRODMe	0.90 (6.7)	1.09 (1.53)	1.29 (1.44)	0.91 (0.83)	0.56 (8.28)	0.61 (2.45)
LREALC	4.05 (1.5)	0.90 (0.69)	1.35 (0.80)	0.94 (0.62)	-1.03 (6.8)	-0.86 (1.077)
LSSCLM	-0.92 (-0.59)	1.94 (0.88)	2.95 (0.96)	1.09 (1.02)	0.06 (0.60)	-0.02 (0.59)
LINTAXM	0.66 (0.60)	1.33 (0.89)	2.21 (0.98)	1.47 (1.50)	0.18 (2.53)	0.18 (0.05)
LSSCF	0.30 (0.47)	0.97 (1.51)	1.44 (1.44)	1.07 (1.57)	0.05 (0.78)	0.10 (1.99)
U	-0.04 (-1.90)	-0.03 (-1.42)	-0.03 (-1.24)	-0.02 (-1.54)	-0.02 (-1.45)	-0.003 (0.42)
t in parentheses						

Chart 4 Income tax and employees social security contributions

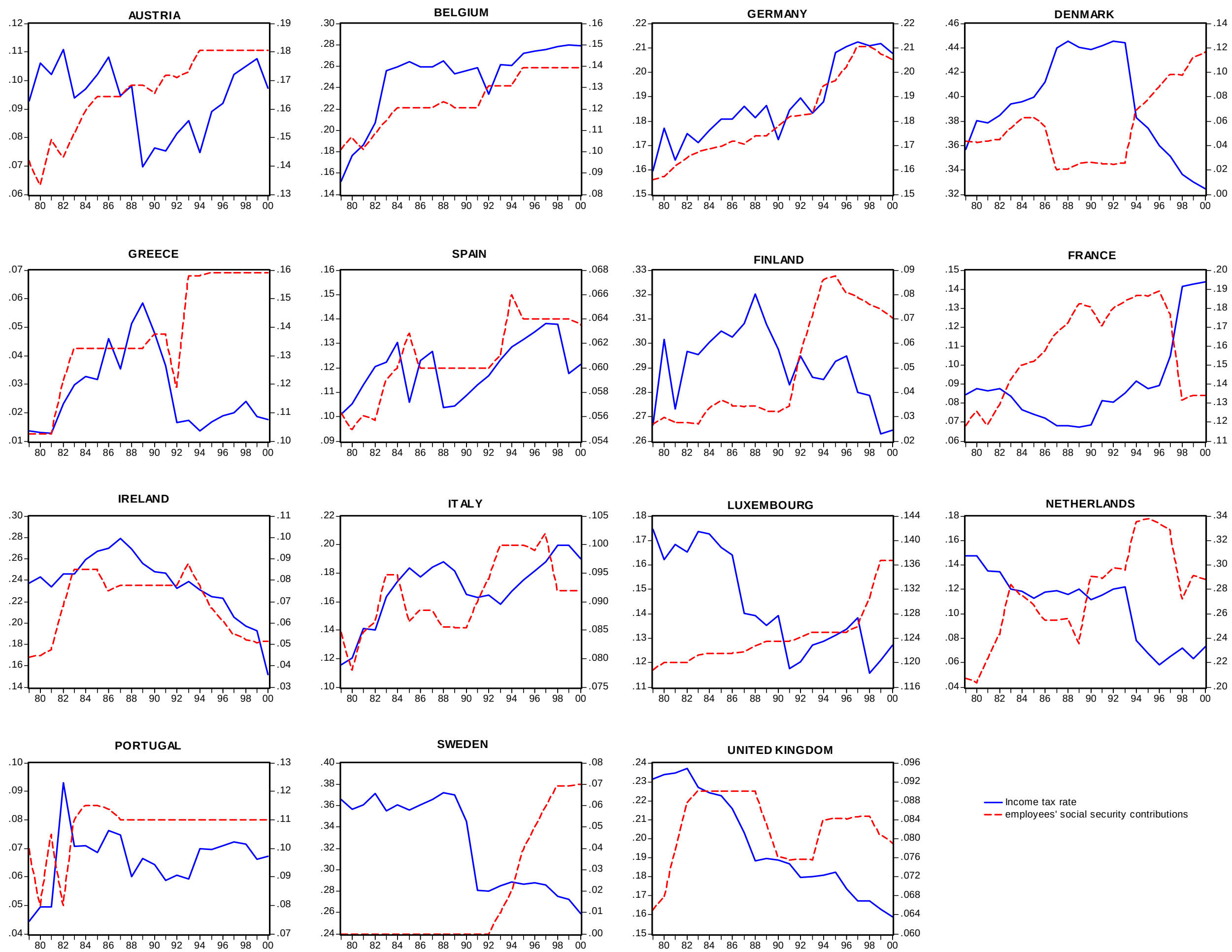

Chart 5 employers' employees' social security contributions

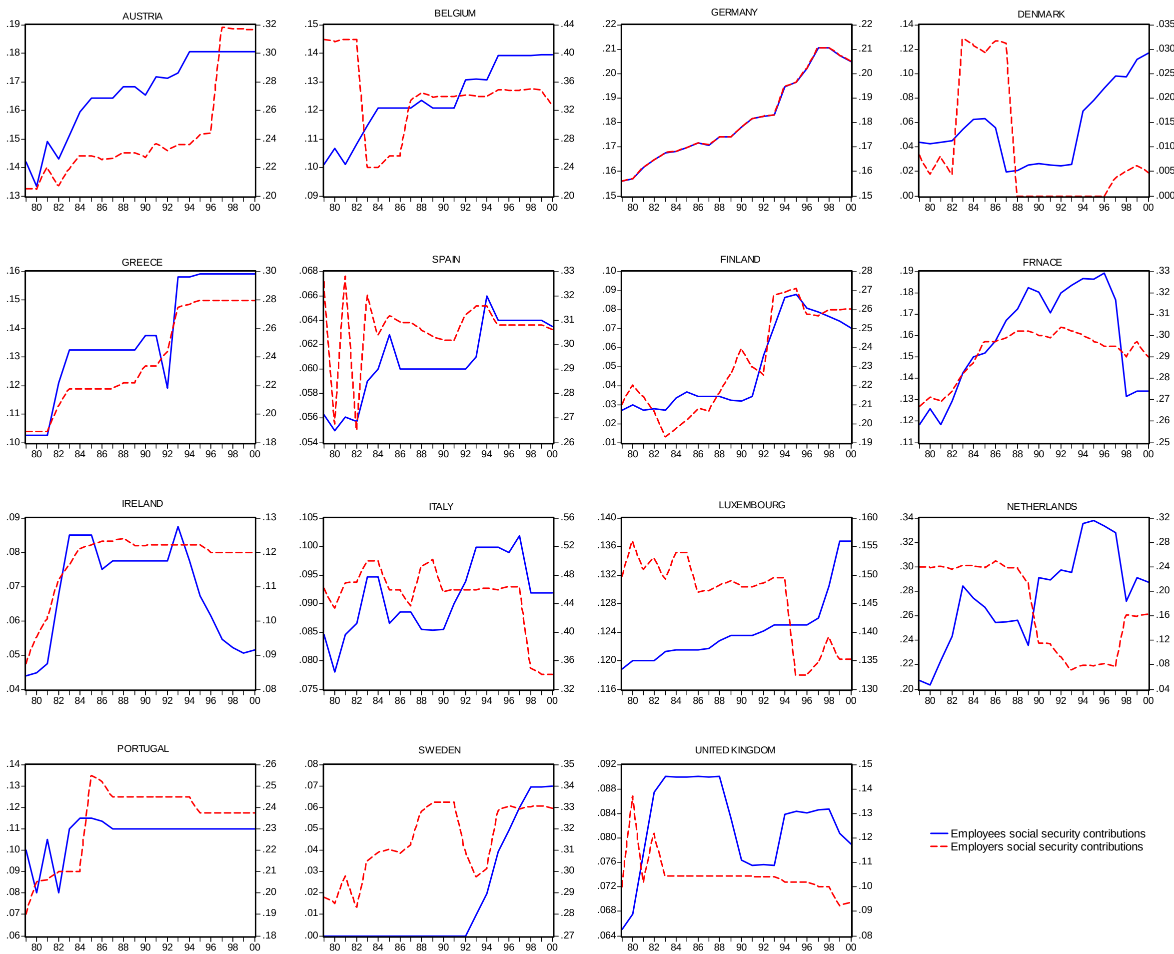

Table 9 Correlation of income tax rate with the

	AT	BE	DE	DK	EL	ES	FI	FR	IE	IT	LU	NL	PT	SE	UK
Employees social security contributions	-0.3	0.8	0.9	-0.9	0.0	0.6	-0.4	-0.4	0.6	0.4	-0.7	-0.8	0.0	-0.8	0.0
Employers social security contributions	0.2	-0.6	0.9	0.1	-0.3	0.1	-0.5	-0.1	0.0	-0.4	0.6	0.6	0.3	-0.5	0.6

Table 10	Short-run wage equation: effects of tax wedge components (Balanced panel 1979-2000)							
	OLS	**Within**	**Dif-GMM1**	**Dif-GMM2**	**Dif-GMM3**	**SYS-GMM1**	**SYS-GMM2**	**SYS-GMM3**
RLCOMPCM(-1)	0.98***	0.93***	0.91***	0.92***	0.93***	0.93***	0.94***	0.95***
LPRODMe	0.50***	0.49***	0.49***	0.49***	0.47***	0.48***	0.49***	0.49***
LPRODMe(-1)	-0.48***	-0.41***	-0.39***	-0.41***	-0.40***	-0.41***	-0.43***	-0.44***
LREALCM	-0.84***	-0.81***	-0.83***	-0.77***	-0.81***	-0.86***	-0.87***	-0.85***
LREALCM (-1)	0.58***	0.56***	0.46***	0.52***	0.56***	0.52***	0.56***	0.55***
LREALCM (-2)	0.32***	0.33***	0.43***	0.35***	0.34***	0.41***	0.40***	0.38***
LPERSTAXM	0.0005	0.10	0.23***	0.14**	0.12*	0.09	0.08	0.06
LSSCFM	0.003	0.07**	0.08*	0.07*	0.07**	0.06**	0.09**	0.07**
U(-1)	-0.0005**	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.001**	-0.001**
Sargan Test	:	:	$\chi2(203)=$ 279.7	$\chi2(431)=$ 335.1	$\chi2(431)=$ 335.1	$\chi2(431)=$ 473.3	$\chi2(699)=$ 500.2	$\chi2(719)=$ 576.1
Ar(1): m1-test	0.06	0.10	0.014	0.014	0.014	0.009	0.008	0.008
Ar(2):m2-test	0.83	0.51	0.21	0.20	0.18	0.19	0.19	0.19
Obs.	300	300	285	285	285	300	300	300

m1 and m2 are tests of first- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals.

In Dif-GMM1 instruments are UM(-1), LPRODMe, LPRODMe(-1), $RLCOMPCM_{t-2}$ and all further lags.

In Dif-GMM2 in addition to instruments in Dif-GMM1 further instruments are $LPERSTAX_{t-1}$ and all further lags.

In Dif-GMM3 in addition to instruments in Dif-GMM2 further instruments are $LSSCFM_{t-1}$ and all further lags.

In SYS-GMM1 in addition to instruments in Dif-GMM3 further instruments are levels of $RLCOMPCM_{t-1}$

In SYS-GMM2 in addition to instruments in SYS-GMM1 further instruments are levels of $LPERSTAXM_{t-1}$

In SYS-GMM3 in addition to instruments in SYS-GMM2 further instruments are levels of $LSSCFM_{t-1}$

* Significant at 10% level; * * significant at 5% level; * * * significant at 1% level

Table 11	Short-run wage equation: effects of tax wedge components (Balanced panel 1979-2000)							
	OLS	**Within**	**Dif-GMM1**	**Dif-GMM2**	**Dif-GMM3**	**SYS-GMM1**	**SYS-GMM2**	**SYS-GMM3**
RLCOMPCM(-1)	0.98***	0.93***	0.92***	0.93***	0.93***	0.93***	0.95***	0.95***
LPRODMe	0.49***	0.49***	0.48***	0.48***	0.48***	0.47***	0.48***	0.48***
LPRODMe(-1)	-0.47***	-0.41***	-0.39***	-0.40***	-0.41***	-0.41***	-0.44***	-0.43***
LREALCM	-0.84***	-0.81***	-0.83***	-0.81***	-0.82***	-0.87***	-0.82***	-0.82***
LREALCM (-1)	0.59***	0.55***	0.46***	0.52***	0.55***	0.56***	0.52***	0.58***
LREALCM (-2)	0.31***	0.33***	0.45***	0.35***	0.33***	0.39***	0.40***	0.33***
LINTAXRATEM	0.02	0.08*	0.16**	0.10**	0.07*	0.12**	0.10***	0.10***
LSSCM	0.003	0.09**	0.11***	0.11***	0.08**	0.06*	0.05*	0.05*
U(-1)	-0.0006**	-0.002***	-0.002***	-0.002***	-0.002***	-0.001***	-0.001***	-0.001**
Sargan Test	:	:	$\chi2(203)$= 283.1**	$\chi2(431)$= 343.6	$\chi2(659)$= 355.7	$\chi2(679)$= 480.3	$\chi2(699)$= 594.8	$\chi2(719)$= 651.9
Ar(1): m1-test	0.05	0.10	0.015*	0.014	0.013	0.008	0.008	0.007
Ar(2):m2-test	0.79	0.49	0.20	0.19	0.18	0.19	0.20	0.19
Obs.	300	300	285	285	285	300	300	300

m1 and m2 are tests of first- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals.

In Dif-GMM1 instruments are UM(-1),LPRODMe,LPRODMe(-1), $RLCOMPCM_{t-2}$ and all further lags.

In Dif-GMM2 in addition to instruments in Dif-GMM1 further instruments are $LSSCRATEM_{t-1}$ and all further lags.

In Dif-GMM3 in addition to instruments in Dif-GMM2 further instruments are $LINTAXRATEM_{t-1}$ and all further lags.

In SYS-GMM1 in addition to instruments in Dif-GMM3 further instruments are levels of $RLCOMPCM_{t-1}$

In SYS-GMM2 in addition to instruments in SYS-GMM1 further instruments are levels of $LSSCRATEM_{t-1}$

In SYS-GMM3 in addition to instruments in SYS-GMM2 further instruments are levels of $LINTAXRATEM_{t-1}$

* Significant at 10% level; * * significant at 5% level; * * * significant at 1% level

Table 12 shows the implied real labour costs elasticity and the percentage change in the real labour costs due to a percentage point increase of the different components of the wedge. These figures have been calculated applying the formula in footnote 31. We distinguish the relevant parameters in the case of different definitions of the labour taxation. Panel (a) reports the results when employees' social security contributions are lump together with the income tax rate in a personal income tax rate. Panel (b) displays the case of employers' and employees social security contributions aggregated in the social security contributions rate. For convenience the table also reports the same coefficients of table 10 and 11.

The following facts stand out. Firstly, the impact of employers' social security contributions is robust across different estimation methods. According to our estimates a 10 percentage point decline (that is from 30% to 20% if the gross wage) in the employers' social security contributions may reduce real labour costs by about 0.5%-0.7%. Secondly, the impact of personal taxation (the sum of employees' social security contributions and income tax rate) is uncertain and sensitive to the estimation methods[43]. A similar result applies in the case of social security contributions and the income tax rate. In addition, the empirical evidence supports the view that the statutory incidence is irrelevant while the economic is not. Indeed, a shift in the tax burden from employers to employees (in the form of either higher social security contributions or higher income taxation) that leaves unchanged the total wedge is not associated with any significant reduction in the real labour costs (i.e. labour costs remains unchanged or even increase). Finally, an increase in the social security contributions (either of employers or of employees) to compensate a reduction of the income tax rate will be associated to a slight reduction in the real labour costs. This last result implicitly suggests that wage setters perceive the existence of a link between benefits and social security contributions, while this link is weaker in the case of the general taxation. It is consistent with the conclusions of Disney (2004) on the impact of social security contributions on activity rates, supporting pension reforms that increase the linkage between contributions and benefits (i.e. the actuarial fairness of pensions' programmes)[44].

[43] The impact is the largest when we treat the tax rate variables as exogenous (Gmm1) and tend to decrease (and to be more uncertain) the larger is the set of endogenous tax variables (Gmm2 and Gmm3 that take as endogenous respectively the personal tax rate and employers' social security contribution in addition to the personal tax rate). However, when we use the GMM-Sys estimator to account for the problem of weak instruments due to the high persistency of the variables, the coefficients are less sensitive to the endogeneity hypothesis made for labour taxation.

[44] Disentangling the tax component of pensions' payroll contributions from the non-tax component (i.e. forced savings), Disney finds that only the tax component of contributions reduce activity rates, especially among women.

SHORT TERM IMPACT ON REAL LABOUR COSTS

Table 12 a

	Gmm1	Gmm2	Gmm3	Sys1	Sys2	Sys3
			Personal income tax rate			
Coefficients	0.23***	0.14**	0.12*	0.09	0.08	0.06
Elasticity	0.05	0.03	0.03	0.02	0.02	0.01
% increase in RLC due to pp increase	0.18	0.11	0.09	0.07	0.06	0.05
			Employers' social security contributions rate			
Coefficients	0.08*	0.07*	0.07**	0.06**	0.09**	0.07**
Elasticity	0.01	0.01	0.01	0.01	0.02	0.01
% increase in RLC due to pp increase	0.07	0.06	0.06	0.05	0.07	0.06

SHORT TERM IMPACT ON REAL LABOUR COSTS

Table 12 b

	Gmm1	Gmm2	Gmm3	Sys1	Sys2	Sys3
			Social security contributions rate			
Coefficients	0.11***	0.11***	0.08**	0.06*	0.05*	0.05*
Elasticity	0.03	0.03	0.02	0.015	0.012	0.012
% increase in RLC due to pp increase	0.08	0.08	0.06	0.04	0.04	0.04
			Income tax rate			
Coefficients	0.16**	0.10**	0.07*	0.12**	0.10***	0.10***
Elasticity	0.02	0.01	0.01	0.02	0.01	0.01
% increase in RLC due to pp increase	0.14	0.09	0.06	0.10	0.09	0.09

V. Conclusions

In many empirical analyses the issue of the tax incidence has been addressed assuming the invariance of the composition of the wedge. In a standard framework, we have investigated how real labour costs respond to changes in the tax wedge and in each of its components, controlling for the labour productivity, the unemployment rate and the price wedge. Besides, most of the studies of the tax incidence are static, which implies that wage setters are always on their wage curve or the labour supply. This assumption does not consider the existence of dynamic adjustment with the consequence that the impact of a change in the tax wedge is likely to be biased, especially when real labour costs are highly persistent. A dynamic specification of a wage equation for the EU countries allows distinguishing the short from the long run effects. Nevertheless, with a dynamic specification the traditional estimators used for the static methods are not without problems while estimators of GMM family have been developed for panel with a large number of individuals and small time periods. Rather than choosing one technique this paper presents results obtained with the main techniques used in the literature. The credibility of these results should be higher if they are similar regardless of the technique used.

Our findings suggest that there is probably some wage resistance in the short-term but not in the long-term, although the transition to the long-term can be very long and therefore the short-term impact and the dynamics of adjustment can be long-lasting. In the short run, although limited an increase in the tax wedge has an impact on the labour cost, and thus on employment. Our estimates suggest that a 1 percentage point increase in the tax wedge leads to a contemporaneous increase in the real labour costs by 0.1%, slightly below the un-weighted average of the coefficients found for the EU Member States by Alesina and Perotti (1994) and Padoa Schioppa Kostoris (1992) respectively of 0.2% and 0.14%[45]. The empirical results in this paper are in line with those found in many occasion by Nickell and Layard, (1991, 1994, 1999), who argue that in the long-run the tax wedge leaves equilibrium unemployment unaffected. On the other hand they partly contrast with the results of Daveri-Tabellini (2000), who find that higher taxes lead to higher gross wages in continental Europe (but not elsewhere in particular certainly not in the USA and the UK).

Turning to the role of the different components of the tax wedge - employers' and employees' social security contributions, income tax rate – their short-run effects on real labour costs differ but not substantially: the null hypothesis of equal coefficient cannot be rejected. In addition, the temporary but persistent effects of the different components of the wedge tend to disappear in the long run, implying a sort of "super neutrality" of labour taxes.

The findings yield important policy implications. First, the lack of a significant long-term influence of the tax wedge on wage costs implies that tax policy have only a limited (if any) impact on the overall equilibrium unemployment. Yet, the long-run total shift of changes in taxation on net wages may have relevant impact on the labour supply of those groups of people that are more responsive to changes in after-tax wages. The effect of labour taxation on relative employment performance of different groups is an important topic for further research.

Although limited to the short run, an increase in the employers' social security rate or in the income tax rate is likely to be partially translated on labour costs. Overall, in our sample of the EU 15 member states we have found only a limited short-run "real wage resistance". This also implies that any reduction of the tax wedge cannot be expected to have a major impact on labour cost and thus on unemployment and employment (unless one assumes a high elasticity of labour supply) because it will mostly accrue to workers in terms of higher real take-home wage.

The composition of the tax wedge is relevant but only in the short-run. A shift from employers' to employees' social security contributions may lead to a reduction in labour costs in the short-term. According to our estimates, a reduction in the average

[45] Alesina and Perotti (1994) and Padoa Schioppa Kostoris (1992) have a definition of the tax wedge that omits as our does the consumption tax rate. See Nickel and Layard (1999, pp 3060 table 18).

income tax rate accompanied by an increase in the employees' social security contributions can be an option to reduce both real labour costs and enhance the link between contributions and benefits. Moreover, given that social security contributions have a lower impact on real labour costs than income taxation (probably reflecting, although weak, workers' perception of a linkage between benefit and social security contributions), a shift from the former to the latter that leaves unchanged the tax wedge will risk increasing the real labour costs also in the short-run.

Annex

Taxation and labour market: an overview of some theoretical aspects

1) The perfect competition model

It is well-known that in a perfect competitive labour market the labour demand is a decreasing function of the real wage. An increase in the payroll tax reduces labour demand at any wage rate. When each consumer derives utility from consumption and leisure, the utility function is concave in both arguments, and preferences are homothetic, labour supply is increasing in the income level and in the after-tax real consumption wage.

Profit maximisation and log-linearisation of the first order condition ($f^{'}(L)=W(1+\tau)$) yields the demand for labour: $\log(L)=-\alpha(\log(W)+\tau)$ with $\alpha=-(1+\tau)w/f''L<0$ the elasticity of labour demand and τ the payroll tax. Each household maximises a concave utility function $U(C,L_0-L)$ defined on consumption and leisure. The budget constraint is $P(1+t_c)C=Y+WL-T$ where $T=T(WL)$ is a general tax function with marginal rate t_m. In equilibrium the marginal rate of substitution between consumption and leisure equals the after-tax real consumption wage: $\frac{U_{L_0-L}}{U_C}=\frac{W}{P}\frac{1-t_m}{1+t_c}$. The after tax real consumption wage includes both the marginal income tax rate t_m and the consumption tax rate t_c. Log-linearising the consumer's first order condition and assuming homothetic preferences yields the following labour supply

$$\log(L)=\varepsilon_w^M\log(W)-\varepsilon_w^H t_m-(\varepsilon_w^M-1)t_c-\varepsilon_w^M t_A+\varepsilon_w^H-\frac{\omega_Y\,\omega_L\log(Y)}{1+\omega_L(1-\omega_Y)}$$

where $\varepsilon_W^M=(\sigma-1)\frac{\omega_L}{1+\omega_L}$ is the uncompensated (Marshallian) wage elasticity and $\varepsilon_W^H=\sigma\frac{\omega_L}{1+\omega_L}$ is the compensated (Hicksian) wage elasticity; $\omega_L=\frac{L_0-L}{L}$; $\omega_Y=\frac{Y/P}{Y/P+(1-t_A)WL}$ is the initial share of non-labour income in total income and σ the elasticity of substitution between consumption and leisure which, in the case of homothetic preferences, is equal to $\frac{d\log(c/L_0-L)}{d\log(U_{L_0-L}/U_c)}\geq 0$. t_A, t_m, t_c are respectively the average, the marginal and the consumption tax rates. When the substitution effect prevails over the income effect (σ>1), the labour supply is increasing in the real wage.

The market-clearing wage and employment levels are set to equate labour demand and labour supply. Assuming for simplicity that the share of non-labour income is zero (ω_Y=0), the consumer and producer real wages are respectively:

$$\log(W) - t_A = \frac{-\alpha(t_A + \tau) - \varepsilon_w^H (t_A - t_m) + \varepsilon_w^M t_c}{\alpha + \varepsilon_w^M}$$

$$\log(W(1+\tau)) = \frac{\varepsilon_w^M (\tau + t_A + t_c) - \varepsilon_w^H (t_A - t_m)}{\alpha + \varepsilon_w^M}$$

In atomistic labour markets, the side that is legally taxed does not bear the entire tax burden. The legal incidence of the tax differs form the economic incidence and the impact of payroll taxes is distributed on both producers' and consumers' wage according to the elasticity of labour demand and labour supply. When labour supply is not completely inelastic, labour taxes are partially shifted on employers via higher labour costs. With inelastic labour supply ($\varepsilon_W^M = 0$), the tax is entirely shifted on labour through the gap between real consumption and real production wage: the production wage does not change while the consumption wage falls by as much as the increase in the payroll tax. Payroll taxes are fully shifted as lower real consumption wages and there are no dis-employment effects. Finally, if the tax system becomes more progressive (i.e. t_m -t_a increases) wages rises and employment falls. Similar result holds in the case of the consumption tax rate.

Downward wage rigidity may, however, limit the ability of firms to pass payroll taxes in the form of lower wages. This is likely to occur in the more realistic case of non-Walrasian labour markets. We will review the role of taxation in search, efficiency wage and union bargaining models.

2) Search and matching models

Search and matching models emphasise the presence of heterogeneity, information imperfections about potential trading partners, low mobility that generate labour market frictions (see e.g. Pissarides 2000). The presences of frictions introduce monopoly rents which affect job creation and job destruction. The outcome of the exchange process between those seeking a new job and those posting new vacancies is described by the matching function (see Petrongolo and Pissarides (2000)). Inputs are the existing stocks of unemployed and vacancies and output the flow of new hires. The Beveridge curve is the locus in the unemployment and vacancy space that equates inflows and outflows from unemployment:

$$u = \frac{s}{s + \theta q(\theta)}$$

where s is the (exogenous) rate at which workers quit jobs, θ=v/u a measure of labour market tightness, q(θ)=m(u,v)/v the probability of filling a job and θq(θ)=m(u,v)/u the probability of finding a job, m(u,v) a constant returns to scale matching function. The expected cost of filling a vacancy equals the sum of the producer wage and the capitalised recruitment cost: $w(1+\tau) + \frac{r+s}{q(\theta)}c$. Labour demand is obtained from the usual first order condition for profit maximisation modified for the expected cost of recruitment: $f_l^{'} = w(1+\tau) + \frac{r+s}{q(\theta)}c$. After the employer and employee have formed a match, they have to decide about the payments accruing to each other. The standard assumption is that the rents associated to the match are shared between workers and firms as in a generalised Nash bargaining over wages. The equilibrium wage is determined maximising the payoff minus the threat point of one agent raised to a power β times the payoff minus the threat point of the other agent raised to 1-β. The surplus generated by the match is split among the two parties according to the relative bargaining strength. For the worker and the firm the payoffs coincide respectively with the value of being employed and the value of a filled job. Similarly, the threat points are the value for a worker of being unemployed and the value for a firm of not filling a job. In symbols the wage struck in a match solves the problem

$$\max_{w}\left(W\left(w(1-t_A)\right)-U\right)^{\beta}\left(J\left(w(1+\tau)\right)-V\right)^{1-\beta}$$

yielding the first order condition

$$\beta\left(J\left(w(1+\tau)\right)-V\right)\frac{\partial W}{\partial w}=(1-\beta)\left(W\left(w(1-t_A)\right)-U\right)\frac{\partial J}{\partial w}$$

which can be solved for w once the value W, U, J and V of the four possible states describing the match (employment, unemployment, filled job, vacant job) have been defined. The flow values of being employed, unemployed, filling a job and of a vacant job are[46]

$$rW = w(1-t_A)-s(W-U)$$
$$rU = b+\theta q(\theta)(W-U)$$
$$rJ = f_l^{'}-w(1+\tau)-s(J-V)$$
$$rV = -c+q(\theta)(J-V)$$

In equilibrium rents to vacant jobs should be driven to zero (i.e. no rents can be distributed to vacant jobs!), hence we have the "free entry" condition V=0 implying that $J=\frac{c}{q(\theta)}$: the value of the match J is increasing in the recruitment cost c and decreasing in the probability of filling a job. Plugging this condition in the value of filling a job (J) we obtain the zero profit condition $q(\theta)=c\frac{r+s}{f_l^{'}-w(1+\tau)}$ - i.e. the probability of finding a job equals the capitalised recruitment costs relative to the net return for the employer of an occupied job. Alternatively, the last expression says that the value of the match J equates the net gain for a firm from an employed worker. Substitution of the value functions in the solution of the bargaining problem gives the following consumer and producer real wage

$$w(1-t_A)=\frac{(1-\beta)b+\beta S(f_l^{'}+c\theta)\frac{1-t_A}{1+\tau}}{1-\beta(1-S)}$$

$$w(1+\tau)=\frac{(1-\beta)b\frac{1+\tau}{1-t_A}+\beta S(f_l^{'}+c\theta)}{1-\beta(1-S)}$$

[46] Each expression can be seen as the neutrality condition of being in one state.

where $S = \frac{1-t_m}{1-t_A}$ is an index of tax progression[47]. The wage is a weighted average of the unemployment benefit b and of the productivity of a match (marginal productivity plus the opportunity cost due to the saving of further search when the match occurred). Wages depend positively on the market tightness θ because the expected cost for the firm of finding another match increases with θ. For a given consumer average tax rate t_A, an increase in the payroll tax τ reduces the after tax wage $w(1-t_A)$, and is partially shifted onto higher labour costs. Also the labour demand (or the zero profit condition) shifts downward, because it reduces the value of the match. The net effect is lower after tax wage, lower tightness and higher unemployment. Finally an increase in the extent of tax progression raises the marginal cost of higher wages and induces wage moderation.

The degree of shifting depends on the relative bargaining strength. The higher is the bargaining strength of the employer the lower is the degree of shifting of payroll taxes on labour costs. This result occurs because when the bargaining strength of the employee is low the equilibrium wage is not far from the unemployment benefits b, which sets a floor in bargaining. When the actual wage is not far from the unemployment benefits the possibility for the firm of transferring higher pay-roll tax on the worker are limited. The same reason explains why wage moderation induced by tax progression decreases with the bargaining strength of the employer[48].

With unemployment benefits indexed to the after-tax wage (or taxed at the same rate as labour income), i.e. $b=\rho w(1-t_A)$, the consumer and the producer wage becomes

$$w(1-t_A) = \frac{\beta S}{(1-\beta)(1-\rho)+S}(f_l^{'} + c\theta)\frac{1-t_A}{1+\tau}$$

$$w(1+\tau) = \frac{\beta S}{(1-\beta)(1-\rho)+S}(f_l^{'} + c\theta)$$

In this case, the wage curve is steeper than with fixed (or untaxed) unemployment benefits when the degree of tax progression S is lower than the replacement rate ρ.

3) Efficiency wage models

[47] Note that S is different from the separation rate s.

[48] If the employer sets the wage (β is relatively low) then a high degree of tax progression does not moderate wage claims. Formally, the first derivative of the wage with respect to S is $\frac{\partial w}{\partial s} = \frac{\beta(1-\beta)}{[1-\beta(1-S)]^2}\frac{f^{'} + c\theta - b}{1+\tau}$. If the productivity of the match (including the opportunity cost due to the saving of further search when the match occurred is higher than the unemployment benefit), than $sign\frac{\partial w}{\partial s} = sign\partial\frac{\frac{\beta(1-\beta)}{[1-\beta(1-S)]^2}}{\partial\beta}$ which is always strictly greater than zero for β and *S* between zero and 1 . Therefore an increase in the bargaining power of the firm (a lower β) limit the wage moderation of the tax progression.

In this class of models, wages are both a cost factor and an incentive device. A higher after-tax wage increases the cost of production but also boosts worker's efficiency and labour productivity. Consequently, firms may find optimal to raise wage above the perfect competitive level to retain, motivate and attract workers. The representative firm chooses the level of wages and employment that maximises profits taking into account the effect of wages on workers' efficiency. In equilibrium the Solow condition states that the elasticity of the effort with respect to the wage is equal to one. Given the optimal wage, labour demand is determined equating the marginal productivity of labour to the wage:

$$\frac{e^{'}(w^{*})w^{*}}{e(w^{*})}=1$$

$$e^{'}(w^{*})f^{'}(e(w^{*})L)=w^{*}$$

Suppose that the effort function depends on the indirect utility of the wage offered by the firm relative to the indirect utility of the outside option (Van der Ploeg (2003))[49]:

$$e(w_i((1-t_A))=\left(V(w_i(1-t_A))-V(B(t_A)\right)^{\varepsilon}$$

Firms are assumed to have a linear production function in the effort function and labour: $Y_i=e_iL_i$. Substituting the effort function in the Solow condition and taking into account the relationship between average and marginal tax rate with general tax function, we get

$$\frac{V(w_i(1-t_A))-V(B(w,b,t_A))}{w_i(1-t_A)V^{'}(w_i(1-t_A)}=\varepsilon\left(t_A-t_m\right)$$

Maximisation of profits with respect to L_i yields $e_i=(1+\tau)w_i$. The outside reference wage equals to the unemployment benefits with probability u and to the wage in other firms with probability 1-u: $V(b(w,B,t_A))=w(1-t_A)(1-u)+bu$. When utility is given by the constant relative risk aversion type $V(w_i(1-t_A))=\frac{[w_i(1-t_A)]^{1-\gamma}}{1-\gamma}$, where γ is the degree of risk aversion, the Solow condition yields the equilibrium unemployment $u=\frac{1-[1-(1-\gamma)\varepsilon(t_A-t_m)]^{\frac{1}{1-\gamma}}}{1-b/w(1-t_A)}$. A higher efficiency wage effect (ε), a less progressive tax system, a higher unemployment benefits (b) raise unemployment. An increase in the after-tax wage $w(1-t_A)$ reduces unemployment.

When the replacement rate $\rho=b/w(1-t_A)$ is constant or the gross unemployment benefit b is taxed at the average tax rate t_A, a change in the marginal or average tax rate modifies unemployment only when the degree of tax progression changes. Contrary to what found for the perfect competitive model, a more progressive tax system (higher t_m-t_A) reduces the unemployment rate. Moreover, higher payroll tax rates do not affect equilibrium unemployment, implying that consumers bear the burden of the tax.

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[49] The indirect utility v(p,Y) is the maximum utility attainable at given prices and income :
$v(p,Y)\max u(c)\ \ s.t.\ pc\leq Y$

When the replacement rate is not fixed (either because the gross unemployment benefits are fixed or not taxed) the impact of average and payroll taxes depends on their effects on the consumer and the producer wages. Combining the equilibrium unemployment and the relationship between effort and labour cost we get the following expressions for the consumer and producer wages

$$w(1-t_A) = \left[\left(\varepsilon (t_m - t_A) \right)^{-\varepsilon} \frac{1+\tau}{1-t_A} \right]^{\frac{1}{(1-\gamma)\varepsilon - 1}}$$

$$w(1+\tau) = \left[\left(\varepsilon (t_m - t_A) \right)^{-1} \left(\frac{1+\tau}{1-t_A} \right)^{1-\gamma} \right]^{\frac{\varepsilon}{(1-\gamma)\varepsilon - 1}}$$

Log-linearisation gives

$$\log(w(1-t_A)) = -\frac{\varepsilon}{(1-\gamma)\varepsilon - 1} \log(\varepsilon (t_m - t_A)) + \frac{1}{(1-\gamma)\varepsilon - 1} \left[\log(1+\tau) - \log(1-t_A) \right]$$

$$\log(w(1+\tau)) = -\frac{\varepsilon}{(1-\gamma)\varepsilon - 1} \log(\varepsilon (t_m - t_A)) + \frac{\varepsilon(1-\gamma)}{(1-\gamma)\varepsilon - 1} \left[\log(1+\tau) - \log(1-t_A) \right]$$

Hence, higher payroll-taxes are shifted more on producers than consumers. When consumers are risk neutral ($\gamma=0$) who bears more the burden of the payroll tax depends on the efficiency wage effect being not too strong (in particular $\varepsilon<1$). Otherwise it is transferred more on producers than consumers. When $\gamma=1$, consumers bears 100% of the burden of the payroll tax.

In efficiency wages models, the producer wage is not a sufficient statistics for unemployment because wage restraint does not lead to lower unemployment since also effort depends on wages. The effect on unemployment depends on the unemployment benefit regime. When gross unemployment benefits are not indexed to the after tax wage $w(1-t_A)$ or not taxed, an increase in the payroll tax or in the average tax rate increases after-tax wage $w(1-t_A)$ and, thus, the replacement rate and raises the unemployment rate. When the gross unemployment benefits are taxed at the same rate as labour income the replacement rate is fixed and, independently of the level of taxation, the unemployment is high when the replacement rate is high.

In a model *a-lá* Shapiro and Stiglitz (1984), workers produce one unit of labour unless they shirk. With imperfect monitoring the firm also sets the wage to avoid shirking. The firm chooses the wage that makes optimal for the worker not to shirk (i.e. it satisfies the no shirking conditions). In equilibrium the wage paid by the firm is such that the expected value of working is equal to the expected value of shirking. The resulting unemployment is involuntary and acts as a workers' discipline device to avoid shirking or too frequent quits. As in the Walrasian case, the payroll tax shifts down the labour demand while it does not affect the wage offer. Hence, an increase in the tax reduces employment (along the no-shirking condition) and the equilibrium wage. If workers recognise the link between benefits and contributions, a payroll tax not only reduces the labour demand but also flattens the no shirking condition, reducing the impact on equilibrium employment

(Kugler and Kugler 2003). When this link is perfect, the shift in the labour demand is compensated by the flattening of the no-shirking condition (i.e. lower increase in wage is needed to give the "right" incentives to work). Employment does not change while the payroll tax is transferred on consumers.

4) Union bargaining models

Bargaining models (right-to-manage model or monopoly union model) emphasise the role of trade unions and collective bargaining in wage setting and in the determination of employment[50]. In these types of models unions are utilitarian (they care only about the welfare of their members) and small enough not to take into account the macro-economic consequences of their wage claims. Following a 'right to manage' model, unions and firms bargain over the wage level, taking into account the labour demand curve. Firms continue to choose the number of employees they wish once wages have been determined in the bargaining process. Wages solve the following Nash bargaining problem:

$$\max_{w}\left(V(w(1-t_A))-V(b(t_a))\right)^{\beta}\left(pf(l)-w(1+\tau)l\right)^{1-\beta}$$

The solution to this bargaining problem can be written:

$$\frac{\beta w(1-t_A)V'(w(1-t_A))}{\left(V(w(1-t_A))-V(B(t_a))\right)}=\frac{1-t_A}{1-t_m}\left[\beta\varepsilon+(1-\beta)\frac{w(1+\tau)l}{f(l)-w(1+\tau)l}\right]$$

The left hand side is the union's proportional marginal benefit to the bargain from a proportional increase in the wage. The first expression in the right hand side is the percentage reduction in employment due to the proportional wage increase (the union's marginal cost equals to the elasticity of the labour demand) weighted by union power β. The second represents the firm's proportional marginal cost (labour costs over total profits) weighted by firm's power 1-β. In equilibrium marginal benefits equal marginal costs. Increased progression raises the union's loss by pay rise in terms of the after-tax wage bill. It also raises the share of firms' labour cost over total profits. Hence, the marginal costs rise when the tax system becomes more progressive and there is an incentive for both parties to limit the wage struck in the bargain. This implies wage moderation and lower unemployment rate.

An increase in the payroll tax raises firm's marginal costs and employment falls. However, the higher payroll tax is not entirely shifted on firms. This can be seen comparing the solution of the right-to-manage model with that of the monopoly union model. The monopoly union coincides with the right-to-manage model when firm's bargaining power is zero (β=1). In this case, the union sets the wage, and the marginal costs of bargaining do not incorporate firm's marginal costs. An increase in the payroll tax leaves unchanged union's marginal benefits, implying that firms carry the burden of taxation[51]. With β different from zero, the burden of the payroll tax is shared between employers and employees proportionally to their relative bargaining power.

[50] See Booth (1995).

[51] For the monopoly union case see van der Ploeg (2003).

With constant relative risk aversion type preferences $V(w)=\frac{w^{1-\gamma}}{1-\gamma}$, $V(B)=\frac{B^{1-\gamma}}{1-\gamma}$ with $B(w,b,t_A)=(1-u)w(1-t_A)+ub$, the negotiated wage solves the expression

$$\frac{\beta(1-\gamma)}{1-\left[1-\left(1-\frac{b}{w(1-t_A)}\right)u\right]^{1-\gamma}}=\frac{1-t_A}{1-t_m}\left[\beta\varepsilon+(1-\beta)\frac{w(1+\tau)}{\frac{f(l)}{l}-w(1+\tau)}\right]$$

In this context, wage setting ultimately depends on the tax wedge the unemployment rate u and labour productivity $\frac{f(l)}{l}$. If the utility is linear in wages (risk neutral in this case, γ=0) and the production function linear in labour input we have[52]

$$\frac{\beta w(1-t_A)}{(w(1-t_A)-b)u}=\frac{1-t_A}{1-t_m}\left[\beta\varepsilon+(1-\beta)\frac{w(1+\tau)}{1-w(1+\tau)}\right]$$

The wage formation mechanism is not independent from the rules setting the unemployment benefits. When unemployment benefits are indexed to the after-tax wage (fixed replacement rate), the producer and consumer wage can be obtained from the previous expression taking into account that the replacement rate is fixed, i.e. b =ρ*w(1-t_A).

$$w(1+\tau)=\frac{\left(\frac{1}{(1-\rho)u}-\frac{\varepsilon}{S}\right)\frac{\beta}{1-\beta}S}{1+\left(\frac{1}{(1-\rho)u}-\frac{\varepsilon}{S}\right)\frac{\beta}{1-\beta}S}$$

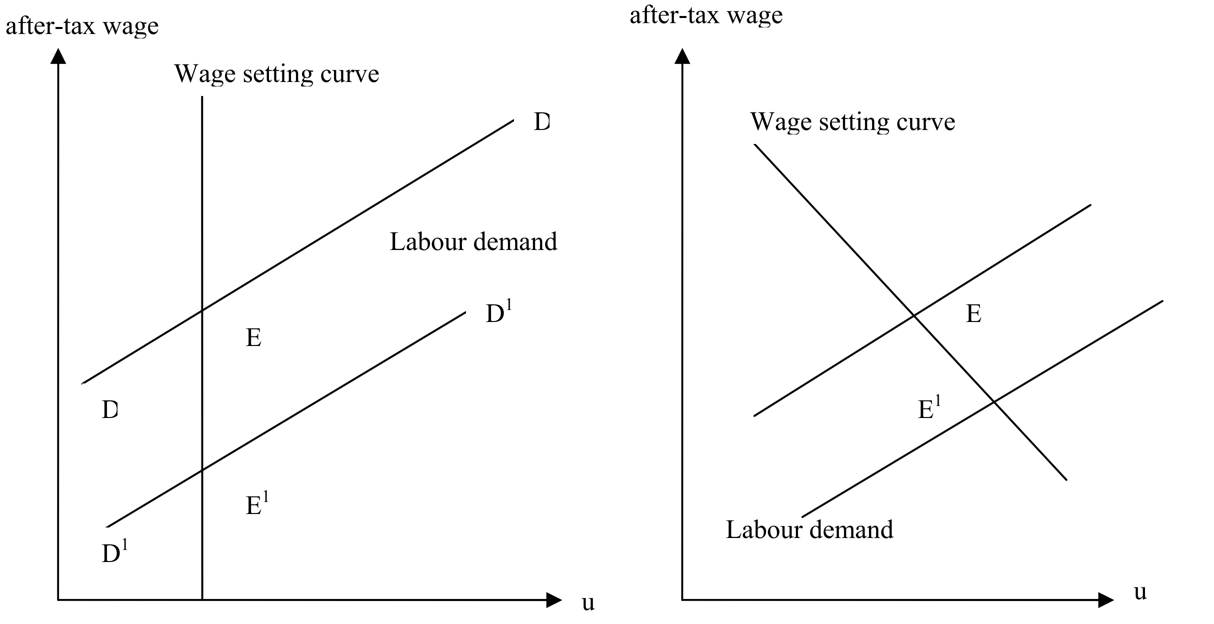
$$w(1-t_A)=\frac{\left(\frac{1}{(1-\rho)u}-\frac{\varepsilon}{S}\right)\frac{\beta}{1-\beta}S\frac{1-t_A}{(1+\tau)}}{1+\left(\frac{1}{(1-\rho)u}-\frac{\varepsilon}{S}\right)\frac{\beta}{1-\beta}S}$$

with $S=\frac{1-t_m}{1-t_A}$ is the index of tax progression. In this case, an increase in the replacement rate ρ or a less progressive tax system (lower S), raises labour costs (w(1+τ)). It can be shown that the relationship between the consumer wage (w(1-t_A)) and the unemployment rate is always downward sloping. Therefore, an increase in the payroll tax shifts downward the labour demand along a positively sloped wage setting curve. When unemployment benefits are indexed to the after-tax wage, an increase in the payroll tax

[52] For β=1, this expression coincides with the case of a utilitarian monopoly union. When the reservation wage is fixed and taxation is proportional to labour income, tax changes are completely born by the employer and there is a complete after-tax wage resistance (Holmlund *et al.* (1989)). This outcome is independent on whether or not labour supply (in terms of hours worked) is exogenous or endogenous (Kilponen and Sinko (2003)).

leads to a higher unemployment rate and lower after tax wage. This finding generalises the monopoly union case (e.g. Van der Ploeg (2003)), where an increase in the payroll tax is entirely transferred on consumers in the form of lower after-tax wage, the wage setting curve is vertical (see Figure 2 left panel).

Figure 2



Monopoly Union : indexed unemployment benefits   Right to manage: indexed unemployment benefits

It is worthwhile stressing that both perfect and imperfect competition models predict a negative impact of average labour taxation on employment, through an (at least partial) increase in labour cost and/or a decrease in net take-home wage. What differs is the mechanism driving the response. In competitive models it is the value of the labour supply elasticity which determines the shift of wages on labour costs. In imperfect competition models, the shift of labour taxes depends on the slope of the no-shirking or the real wage bargaining curve. Besides, coordinated national bargaining is closer to competitive markets (with inelastic labour supply) when unions internalise the effects on employment of their wage claims.

Econometric methodology

To differentiate between the short- and the long-run effect on wages of taxes social security contributions we need to use a dynamic specification. This form allows to model the short-run adjustment process and to determine the implied long-run wage elasticity when the short-run dynamics has completely been solved out. We consider the following dynamic fixed effect model

$$\begin{aligned} y_{i,t} &= \alpha y_{i,t-1} + \beta(L)x_{i,t} + \varepsilon_{it} \\ \varepsilon_{it} &= \alpha_i + \eta_t + u_{it} \end{aligned} \qquad (1)$$

α_i and η_t represent respectively unobserved country and time specific effect. The latter can be interpreted as capturing common aggregate shocks to real wages treated as time specific parameters. The individual and time specific effects are uncorrelated between each other and well-behaved:
$E(\alpha_i) = E(\eta_t) = E(\alpha_i \eta_t) = 0$ for i = 1,...N and t = 2,...T . x_{it} is a vector of explanatory variables some of which are jointly determined with the wages (and consequently endogenous); other variables can be weakly exogenous or predetermined.

The presence of lagged dependent variable in the model introduces a correlation between the right hand regressors:

$$E(\alpha_i y_{i,t-1}) = E(\alpha_i(\alpha y_{i,t-2} + \beta(L)x_{i,t-1} + \alpha_i + \eta_{t-1} + u_{it-1})) \neq 0 \qquad (2)$$

Hence, the traditional OLS estimator, or some more general non-spherical variant (GLS or Within), is biased and inconsistent. This happens because there are two sources of persistence - over individuals, due to the presence of the time invariant fixed effects, and over time due to the autocorrelated structure of the model – while the standard OLS/GLS type of estimator does not exploit all the available information, namely the moment conditions. When there are no exogenous variables, Nickell showed that the LSDV estimator of α is biased but asymptotically correct. The first difference wipes out the individual effect, but the OLS estimator is still inconsistent as

$$E((\Delta y_{i,t-1})(\Delta u_{i,t}) = E(\alpha \Delta y_{i,t-2} + \beta(L)\Delta x_{i,t-1} + \Delta\eta_{t-1} + \Delta u_{it-1})\Delta u_{i,t}) \neq 0 \qquad (3)$$

Judson and Owen (1999) showed that in macro panel with a large time dimension the bias of the fixed effect estimator can be sizeable and increases with the persistency of the dependent variable and decreases with T. Judson and Owen recommend the corrected FE estimator proposed by Kiviet (1995) and as second best the GMM-dif and the computationally simple Anderson and Hsiao.

Anderson and Hsiao proposed to remove the individual fixed effect taking the first difference and then using as instruments y_{t-2} or (y_{t-2}-y_{t-3}) since $E((y_{i,t-2})(\Delta u_{i,t}) = E(\Delta y_{i,t-2})\Delta u_{i,t}) = 0$ [53]. The AH-IV estimator is consistent but not necessarily the most efficient, as it does not exploits additional linear moment restrictions. Moreover, it assumes that the explanatory variables are strictly exogenous (i.e. uncorrelated with the error term at all leads and lags.

The **GMM estimator** allows for individual specific heterogeneity and endogeneity of explanatory variables. It is efficient and consistent in the class of IV procedures because it exploits all linear moment restrictions derived from the assumption of orthogonality between the transformed disturbances and lagged levels of the dependent variable. In GMM the number of instruments grows over subsequent cross-sections as the time dimension of the panel expands. Additionally explanatory variables can be or not correlated with the individual effects and also exogenous,

[53] However, the IV estimator based on lagged difference is less efficient than the IV based on the lagged level of the dependent variable (Arellano (1989)).

predetermined or endogenous. For each of these, the GMM estimator exploits further moment restrictions.

In small samples the GMM differenced estimator (Dif-GMM) is biased and inefficient when lagged variables are weakly correlated with first differences (i.e. the instruments are weak)[54]. The system-GMM (Arellano and Bover (1995) and Blundell and Bond (1998)) estimates systems of equation in levels and first differences with instruments respectively first differences and lagged levels.

1. First differenced GMM estimator

Consider the following dynamic fixed effect model

$$y_{i,t} = \alpha y_{i,t-1} + \alpha_i + u_{it} \qquad |\alpha| < 1 \qquad (4)$$

with $E(\alpha_i) = E(u_{it}) = E(u_{it}\alpha_i) = E(u_{is}u_{it}) = 0 \text{ for } t \neq s$. The model in first differences wipes out the individual effects, but the lagged dependent variables in first differences is correlated with the first difference if the error term. If we take the first difference then the first cross-section observed is for t=3: $\Delta y_{i,3} = \alpha \Delta y_{i,2} + u_{i3} - u_{i2}$. y_1 is a valid instrument as it is correlated with Δy_2 but not with Δu_3. Equally, for t=4, the second cross-section is $\Delta y_{i,4} = \alpha \Delta y_{i,3} + u_{i4} - u_{i3}$ and both y_1 and y_2 are instruments for Δy_3. Since both are uncorrelated with Δu_4. In this case lagged levels dated t-2 and earlier are valid instruments. Hence, the general moment conditions can be written as follows

$$E(y_{i,t-s}\Delta u_{it}) = 0 \text{ for t = 3,....,T and s} \geq 2 \text{ or in matrix form } E(\mathbf{Z'_i}\,\mathbf{\Delta u_i}) = 0 \qquad (5)$$

where Z_i is a matrix of instruments

$$\begin{array}{l} \text{Instrument Dated} \\ \text{t - 2} \quad \rightarrow \\ \text{t - 2 and t - 3} \quad \rightarrow \\ \\ \\ \text{t - 2, t - 3, t - 4...} \quad \rightarrow \end{array} \qquad \mathbf{Z_i} = \begin{pmatrix} y_{i1} & 0 & 0 & 0 & 0 & 0 & . & 0 \\ 0 & y_{i1} & y_{i2} & 0 & 0 & 0 & . & 0 \\ . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . \\ 0 & 0 & 0 & y_{i1} & y_{i2} & y_{i3} & . & y_{iT-2} \\ \\ \\ \end{pmatrix}$$

With the initial conditions $E(y_{i,1}u_{it}) = 0 \text{ for } i = 1,..,n \text{ and } t = 2,..,T$ they impose $\frac{(T-1)(T-2)}{2}$ moment restrictions.

When explanatory variables correlated with the individual specific effects are α_i included, the instruments available depends on the explanatory variables being

[54] In this case the instruments used in the GMM contain little information about the endogenous lagged dependent variable in first differences. In this sense the instruments are weak. Weak instruments also occur when the ratio between the variance of the unobserved individual effects α_{it} is relatively larger than the variance of u_{it}. See Alonso-Borrego and Arellano 1996).

strictly exogenous, predetermined or endogenous. Consider the following model with additional explanatory variables.

$$y_{i,t} = \alpha y_{i,t-1} + \beta x_{i,t} + \alpha_i + u_{it} \qquad |\alpha| < 1 \qquad (6)$$

If the x_{it} are **<u>strictly exogenous</u>** uncorrelated with past present and future disturbances (i.e. $E(x_{it}v_{is})=0$ for all t and s) but correlated with the individual effects (i.e. $E(x_{it}\alpha_i) \neq 0$), then x_{it} for t=1,2,…T are valid instruments for the equation in the first difference and each row of $\mathbf{Z_i}$ includes $[x'_{i1} \quad x'_{i2} \quad .. \quad .. \quad x'_{iT}]$ after y_{i1}. In addition to (5), the moment conditions are $E(x_{i,t-s}\Delta u_{it}) = 0 \text{ for s, t} = 1,....,\text{T}$ (6)

Instrument dated y	Instrument dated x
t - 2	t - 2, t - 3, t - 4,...
t - 2 and t - 3	t - 2, t - 3, t - 4,...
t - 2, t - 3, t - 4.....	t - 2, t - 3, t - 4,...

$$\mathbf{Z_i} = \begin{pmatrix} y_{i1}, x_{i1}, x_{i2} ... x_{iT} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & y_{i1} y_{i2}, x_{i1}, x_{i2} ... x_{iT} & \mathbf{0} \\ .. & .. & .. \\ \mathbf{0} & \mathbf{0} & y_{i1}, y_{i2}, ... y_{iT-2}, x_{i1}, x_{i2}, .., x_{iT} \end{pmatrix}$$

When the explanatory variables are **<u>predetermined</u>**, or weakly exogenous, contemporaneous correlation with the shocks is excluded but feedbacks from previous shocks are possible. In symbols $E(x_{it}u_{is}) \neq 0$ for s<t and zero otherwise. They are also correlated with the individual effects (i.e. $E(x_{it}\alpha_i) \neq 0$). The moment conditions are

$$E(x_{i,t-s}\Delta u_{it}) = 0 \text{ for t} = 3,...,\text{T and } 1 \leq \text{s} \leq \text{t - 1} \qquad (7)$$

In this case, $[x'_{i1} \quad x'_{i2} \quad .. \quad .. \quad x'_{is-1}]$ are valid instruments in the differenced equation for period s since x_{i1}.... x_{is-1} are uncorrelated with Δu_s.

Instrument dated y	Instrument dated x
t - 2	t - 2 and t - 3
t - 2 and t - 3	t - 2, t - 3 and t - 4
t - 2, t - 3, t - 4.....	t - 2, t - 3, t - 4, t - 5.....

$$\mathbf{Z_i} = \begin{pmatrix} y_{i1}, x_{i1}, x_{i2} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & y_{i1} y_{i2}, x_{i1}, x_{i2}, x_{i3} & \mathbf{0} \\ .. & .. & .. \\ \mathbf{0} & \mathbf{0} & y_{i1}, y_{i2}, ... y_{iT-2}, x_{i1}, x_{i2}, .., x_{iT-1} \end{pmatrix}$$

With **<u>endogenous</u>** explanatory variables, the contemporaneous correlation with current shocks is non zero and feedbacks from past shocks on current x are possible: $E(x_{it}v_{is}) \neq 0$ for s≤t and zero otherwise. The moment conditions are

$$E(x_{i,t-s}\Delta u_{it}) = 0 \text{ for t} = 3,...,\text{T and } 2 \leq \text{s} \leq t-1 \qquad (8)$$

and $\mathbf{Z_i}$ is

Instrument dated	
t - 2 →	
t - 2 and t - 3 →	
t - 2, t - 3, t - 4,... →	

$$\mathbf{Z_i} = \begin{pmatrix} y_{i1}, x_{i1} & \mathbf{0} & .. & \mathbf{0} \\ \mathbf{0} & y_{i1}, y_{i2}, x_{i1}, x_{i2} & .. & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & .. & \mathbf{0} \\ .. & .. & .. & .. \\ \mathbf{0} & \mathbf{0} & .. & y_{i1}, y_{i2}, y_{i3}, ..., y_{iT-2}, x_{i1}, x_{i2}, x_{i3}, ... x_{iT-2} \end{pmatrix}$$

In all cases pre-multiplying the model by $\mathbf{Z_i}$ and using the GLS estimator one gets the one-step Arellano and Bond consistent estimator[55].

2. System Estimator

Lagged levels are weak instruments for the regression equation in first differences when individual series are either highly persistent (i.e. when their DGP is almost *I(1)*) or when the variance of the individual specific effects α_i increases relative to the variance of the transitory shock ε_{it} (Blundell and Bond (1998)). When the instruments are weak the estimate of α is biased downward in small samples and the estimates of the coefficient imprecise[56].

To detect whether the instruments are weak Bond, Hoefler and Temple (2001) suggest comparing first difference GMM estimates with the OLS and the Within Group estimators. In AR(1) models the OLS estimate of α is biased upwards while Within Group is biased downward[57]. If the GMM differenced estimator is similar to the Within Group then this should be an indication of weak instrument and it would be more appropriate to estimate with the system-GMM. When explanatory variables other than the lagged dependent variable appear in the equation, the same result holds when these variables are uncorrelated with the individual specific effects α_i. The system estimator combines the regression in differences with the regression in levels. For the regression in differences the instruments are as in the Dif-GMM estimator. For the regression in levels the instruments are the lagged differences of the corresponding variables.

When the model AR(1) is mean stationary, so that the mean differs across individuals but is constant over time, the lagged differences are valid instruments for the equations in levels[58]. In symbols, the following T-2 moments condition are considered in addition to the moment conditions given in (5)

$$E(u_{i,t}\Delta y_{it-1}) = 0 \text{ for t} = 3,...,\text{T} \qquad (9)$$

[55] For a clear description of GMM see Baltagi (2000)
[56] The asymptotic variance of the coefficients obtained with the difference estimator rises with the persistency.
[57] See for example R. Blundell, S. Bond, F. Windmeijer (2000), *Estimation in Dynamic Panel Data Models: Improving on the performance of the Standard GMM Estimator*, IFS WP no. 12.
[58] Given that the lagged levels are used as instruments in the specification in differences, only the most recent difference is used in the equation in levels. Using other lagged difference would result in redundant moment conditions.

Instrument Dated
t - 2 →
t - 2 and t - 3 →
t - 2, t - 3, t - 4... →

$$\mathbf{Z_i} = \begin{pmatrix} y_{i1} & 0 & 0 & 0 & 0 & 0 & . & 0 & 0 & 0 & .. & .. & 0 \\ 0 & y_{i1} & y_{i2} & 0 & 0 & 0 & . & 0 & 0 & 0 & .. & .. & 0 \\ . & . & . & . & . & . & . & . & 0 & 0 & .. & .. & 0 \\ . & . & . & . & . & . & . & . & 0 & 0 & .. & .. & 0 \\ 0 & 0 & 0 & y_{i1} & y_{i2} & y_{i3} & \cdot & y_{iT-2} & 0 & 0 & .. & .. & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & .. & 0 & \Delta y_{i2} & 0 & .. & .. & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & .. & & 0 & \Delta y_{i3} & .. & .. & 0 \\ .. & .. & .. & .. & .. & .. & .. & .. & .. & & .. & .. & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & .. & 0 & 0 & 0 & .. & .. & \Delta y_{iT-1} \end{pmatrix}$$

Conditions 9 requires that Δy_{it-1} is uncorrelated with η_i. The validity of this additional restrictions can be tested comparing the Sargan test of over-identifying restrictions of the GMM system estimator with the Sargan test of over-identifying restrictions of the GMM difference estimator. The difference between the two Sargan test (Difference Sargan statistics) is distributed as a Chi-squared with m_s-m_d degrees of freedom. Where m_s and m_d are the number of moments conditions in the system and difference GMM estimators.

Data sources and definitions

In this study annual data (for the period 1980-2000) from the OECD *Taxing Wages* publication are used to construct the tax wedge (overall and its components: income tax, employers' social security contributions and employees' social security contributions). The components of the tax wedge are calculated by the OECD on the basis of a micro-simulation of national tax legislation. As a proxy of the tax burden on labour for a representative agent we use the tax wedge for a single production worker in the manufacturing sector, at the average wage level (that is, 100% of the Average Production Worker (APW) wage level). The tax wedge is defined as non-wage component of labour costs over total labour costs. It corresponds to the difference between the after-tax and the before-tax labour costs as a percentage of total before tax labour costs and is calculated as follows

$$WEDGE = \frac{(SSCL + SSCF + TAXY)}{GROSS\ WAGE + SSCF}.$$

To check the robustness of our findings to different measures of the tax burden, econometric estimates are reiterated by using implicit tax rates as calculated by DG ECFIN (see EC Economic Paper n. 146/2000 by C. Martinez-Mongay). These are so-called "backward looking" indicators, based on Mendoza-Razin-Tesar method, using aggregate figures from National Accounts and actual average tax revenues. While macroeconomic measures of tax indicators are generally easy to construct (and certainly easier thatn "forward looking" indicators based on the simulation of current rules), they suffer from the disadvantage that it is very hard to control for compositional change and endogenous effects. These two effects can generate a change in the overall size of the indicators even if the tax rules (which are the relevant policy variables) have not changed.

The remaining variables are all from the AMECO data base. Our dependent variable *RLCOMPCM* is the nominal compensation per employee for the total economy deflated with the price deflator of final consumption expenditure. The productivity measure (*LPRODMe*) corresponds to the GDP at 1995 market price per person employed. The price wedge (*LREALCM*) is calculated as the ratio between the deflator of private final consumption expenditure and the GDP deflator. The unemployment rate (*u)* is the harmonised unemployment rate. All variable but *u* are in logs. The tax wedge and its components used in the econometric analysis are defined as *log(l+x)* where x is the tax wedge or one of its components.

Centralisation of Bargaining

In the empirical analysis we test the role of centralisation running the same equation using information from three different sources. The first is based on the data set assembled by Golden, Lange and Wallerstein (henceforth GLW), the second on the taxonomy of Elmeskov, Martin and Scarpetta (1998) (henceforth EMS), the third on the labour market institutions data base by Nickell and Nunziata (2001) (henceforth NN).

In the GLW dataset, the bargaining level at which wages is determined is coded into 5 groups:

1 plant-level wage setting
2 industry-level wage setting without sanctions
3 industry level wage settings with sanctions
4 sectoral wage setting without sanctions
5 sectoral level wage settings with sanctions

To keep degree of freedom, the 5 groups have been reduced to three aggregating codes 2-3 and 4-5. Then we have created three dummy variables that map countries into the three categories low, medium and high. The EMS classification is a summary measure of centralisation/co-ordination and gives a prominent role to co-ordination in the case of sectoral wage bargaining. Finally, the *bargaining coordination 1* index by Nickell and Nunziata is an index with a range {1,3} constructed as interpolation of OECD data on bargaining coordination and it is increasing in the degree of coordination. Thus, GLW dataset provides information on the level of wage setting while EMS and NN gives more weight to co-ordination as a mechanism to increase consensus between collective bargaining. The GWL dataset contains information on all Member States but Greece, Ireland, Luxembourg and Portugal while in the NN the information for Greece and Luxembourg is not available.

The three indexes do necessarily convey the same information. The level of centralisation of wage setting refers only to the level at which bargaining takes place (firm, industry or economy-wide), while co-ordination occurs when the effects of wage setting on employment are taken into account. Hence, co-ordination may be also possible with intermediate levels of centralisation in the presence of inter-industry co-ordination between employers and employees.

Table	Bargaining level Goldberg, Lange, Wallerstein (2002)	Summary measure of centralisation/co-ordination Elmeskov Martin Scarpetta (1998)	Bargaining Coordination Nickell-Nunziata (2001)
Low	UK from 1980	Italy until 1991, UK from 1987	Italy until 1992; UK[4]; France until 1989[2]; Portugal until 1989[2];
Intermediate	Belgium 1979-1980 and 1987-1993; France 1979-2000; Finland 1980, 1983, 1988-1989,1994-1995, 2000; Sweden 1984, 1988, 1995-1997; Denmark 1981, Germany, Spain 1984, 1987-2000 Italy 1992-2000, Netherlands 1979, 1985-1989, 1991-1992, 1996-2000; Austria 1979-2000;	Belgium; France; Portugal; Finland since 1985; Sweden since 1991; Spain since 1996; Netherlands until 1981; Ireland until 1987; UK until 1986	Belgium; France from 1990; Portugal from 1990; Finland; Denmark[1]; Sweden[3]; Spain; Netherlands; Ireland until 1987; Italy since 1992;
High	Belgium 1981-1986, 1994-2000; Denmark 1979-1980; Denmark 1982-2000; Spain 1979-1983; 1985-1986; Italy 1979-1991; Netherlands 1980-1984, 1990, 1993-1995; Finland 1979, 1981-1982; 1984-1987; 1990-1993; 1996-1999; Sweden 1979-1983, 1985-1987; 1989-1994, 1998-2000; UK 1979	Denmark, Germany; Austria; Netherlands since 1982; Ireland since 1988; Italy since 1992; Finland until 1984, Spain until 1985; Sweden until 1990.	Germany, Austria, Ireland since 1988
[1] Gradually decreasing from 1980 to 1990 [2] Gradually increasing but below 2; [3] Gradually decreasing but above 2; [4] Gradually decreasing;			

LIST OF VARIABLES

RLCOMPCM: real labour costs
LPRODM: labour productivity
LREALCM: price wedge
LWEDGEM: tax wedge
LWEDGEMN: tax wedge when wedge is decreasing
LWEDGEMP: tax wedge when wedge is increasing
LINTAXM: income tax as % of gross wage
LSSCLM: employees' social security contributions as % of gross wage
LSSCFM: employers' social security contributions as % of gross wage
SSCM: social security contributions as % of gross wage
LPERSTAXM: (income tax + employees' social security contributions) as % of gross wage
U: unemployment rate

Table A1	Short-run wage equation: non-linear effects of tax wedge (Balanced panel 1979-2000)			
	OLS	**Within**	**Dif-GMM**	**Sys-GMM**
RLCOMPCM(-1)	0.98***	0.93***	0.93***	0.93***
LPRODMe	0.50***	0.49***	0.50***	0.48***
LPRODMe(-1)	-0.48***	-0.41***	-0.41***	-0.42***
LREALCM	-0.85***	-0.81***	-0.80***	-0.87***
LREALCM(-1)	0.59***	0.56***	0.55***	0.53***
LREALCM(-2)	0.32***	0.32***	0.35***	0.38***
LWEDGEMP	-0.003	0.16**	0.24***	0.11**
LWEDGEMN	0.020	0.19**	0.28***	0.13**
U(-1)	-0.0005*	-0.002***	-0.002***	-0.002***
Sargan Test	:	:	χ2(660)=348.7***	χ2(714)=551.9***
H0: Linear effects of wedge	χ2(2)=0.49 [0.48]	χ2(2)=1.63 [0.20]	χ2(2)= 2.31 [0.13]	χ2(2)= 0.92 [0.33]
Ar(1): m1-test	0.05	0.09	0.013	0.007
Ar(2):m2-test	0.89	0.55	0.23	0.21
Ar(3):m2-test	0.42	0.31	0.25	0.24
Obs.	300	300	300	300

m1 and m2 are tests of fisrt- and second- order serial autocorrelation asymptotically N(0,1); p-values reported. Note that in the case of the GMM-dif estimator the difference transformation generates MA(1) errors and, thus, with first order autocorrelation. However, the disturbances in the difference equation are 2nd order uncorrelated when the disturbances in the level equation are 1st order uncorrelated. m2 tests for second order autocorrelation in the first-difference residuals.
* Significant at 10% level; * * significant at 5% level; * * * significant at 1% level. In dif-GMM instruments are RLCOMPCMt-2, LWEDGEMPt-2, LWEDGEMNt-2 and all further lags. In Sys-GMM additional instruments for level equations are RLCOMPCMt-1 LWEDGEMP t-2, LWEDGEMN t-2.

Table A2	Short-run wage equation: endogenous explanatory variables – alternative measures of tax wedge[59] and implicit tax rate on consumption (Balanced panel 1979-2000)			
	OLS	**Within**	**Dif-GMM**	**Sys-GMM**
RLCOMPCM(-1)	0.98***	0.90***	0.87***	0.94***
LPRODMe	0.50***	0.53***	0.53***	0.51***
LPRODMe(-1)	-0.49***	-0.39***	-0.39***	-0.45***
LCITRM	-0.09**	-0.08**	-0.084**	-0.098*
LCITRM (-1)	0.07*	0.060*	0.06*	0.06
LCITRM (-2)	0.015	0.006	0.0042	0.012
LLITRM	0.12***	0.14**	0.14***	0.11*
LLITRM (-1)	-0.13***	-0.10**	-0.10***	-0.11**
U	-0.001**	-0.003**	-0.003***	-0.001**
Sargan Test	:	:	χ2(659)=386.5	χ2(724)=386.8
Ar(1): m1-test	0.06	0.08	0.009	0.063
Ar(2):m2-test	0.39	0.41	0.14	0.12
Ar(3):m3-test	0.10	0.12	0.09	0.07
Obs.	300	300	285	300

Specification tests as above. * Significant at 10% level; * * significant at 5% level; * * * significant at 1% level. Implicit tax rates calculated by Martinez-Mongay (2000) following Mendoza et al. (1994). See annex for data sources and definition.

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Table A3	**Implied long-run wage equation: alternative measures of tax wedge and implicit tax rate on consumption**			
	OLS	**Within**	**Dif-GMM**	**Sys-GMM**
LPRODMe	0.92 (8.29)	1.13 (2.83)	1.12 (2.62)	0.98 (17.0)
LCITRM	-0.21 (-0.44)	-0.14 (-0.75)	-0.15 (-1.05)	-0.39 (-1.26)
LLITRM	-0.54 (-1.41)	0.32 (-1.06)	0.33 (1.07)	0.03 (0.14)
U	-0.04 (-1.60)	-0.02 (-1.69)	-0.02 (-1.7)	-0.02 (-1.43)

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