Optimal Tax Progressivity in Unionised Labour Markets: What are the Driving Forces?

Stefan Boeters*

CPB, Netherlands Bureau for Economic Policy Analysis, Den Haag

January 2008

preliminary version prepared for the
2008 conferences of EcoMod (July) and IIPF (August)

Abstract

In labour markets with collective wage bargaining the progressivity of the labour income tax creates an important trade-off. On the one hand, wages are lowered and unemployment decreases, on the other hand, the labour supply decision of the individual is distorted. This trade-off is quantitatively analysed using a numerical model that builds on Sørensen (1999). I check a number of macroeconomic and institutional parameters for their quantitative significance for the results. In a second step, the model is calibrated to parameters of seven large OECD economies. Preliminary results suggest that the initial level of tax progressivity is one of the main drivers of the optimal level and that in all countries in the sample, the optimal level of tax progressivity is significantly higher than the actual one.

Keywords: labour taxation, tax progressivity, optimal taxation, collective wage bargaining, unemployment

JEL Code: H21, J22, J51, J64,

*Stefan Boeters, CPB, P.O. Box 80510, NL-2508 GM Den Haag, e-mail: s.boeters@cpb.nl.

1 Introduction

It has long been recognised that models of unemployment through collective wage bargaining produce an important trade-off with respect to tax progressivity. One the one hand, tax progressivity will change the trade-off between employment and wage income in the bargaining, with lower wages and lower unemployment as a consequence. This is prominent in the paper title of Koskela and Vilmunen (1996): "Tax progression is good for employment in popular models of trade union behaviour".[1] On the other hand, we have the traditional distortionary effect of the marginal tax rate on labour supply. The higher the marginal tax wedge, the higher the difference between the marginal product of labour and the marginal disutility of work, which produces deadweight losses.

This important trade-off has often be qualitatively described, but there are almost no attempts to quantify it: What is the optimal level of tax progressivity that balances the positive effect on the bargaining outcome with the negative effect on labour supply? The most serious approach to quantification in the literature is Sørensen (1999). Sørensen presents a small, stylised numerical model that captures both wage bargaining and labour supply, he calibrates this model to important macroeconomic and institutional parameters, and he numerically determines the optimal degree of tax progressivity. (The solution is, by the way, 0.72.). In the present paper, I extend this analysis. I systematically check the robustness of the results with respect to a number of parameters and modelling choices, and I calibrate the revised model to the macroeconomic and institutional indicators of seven large OECD economies.

In the systematic part, I am able to identify a number of important parameters that significantly influence the results and, even if we decide to remain at a very highly aggregated level of analysis, give scope for an improvement on the Sørensen model. In the institutional part, I show important differences between the OECD economies included in the sample. Even if many important factors have been identified, the results of the paper are still at a preliminary stage. I have not succeeded yet to trace the differences between the OECD countries back to particular differences

[1] However, Koskela and Vilmunen were not the first to describe this effect. The argument can be traced back to Hersoug (1984), Lockwood and Manning (1993) and Holmlund and Kolm (1995).

in the key calibration parameters. An important variable that is a candidate for a key driver of the results is the initial level of tax progressivity, because this level influences the whole calibration of the model. (Households and trade unions that show the observed behaviour at a high level of tax progressivity are different from agents that show the same behaviour with proportional taxes.

As they stand, the results indicate that in all seven OECD economies the optimal level of tax progressivity is significantly higher than the actual level. The results are preliminary in at least two respects: There might be factors that reduce the attractiveness of more progressive taxes (most likely: a less responsive wage bargaining function). And there might be a political support function that has its maximum closer to the actual tax structure than the representative ex-ante utility, which is used in the paper. Both these points will be further investigated in the next revision.

The fact that until now there is only one single paper that directly addresses the question of optimal tax progression in a labour market with collective wage bargaining is most probably explained by the fact that it forces us to leave the area of general and clear-cut analytical results. We cannot come up with illuminating analytical expressions that characterise the optimal point.[2] For an optimal tax analysis that involves two tax rates (in our case: the marginal and the average tax on labour income), we typically need two indicators per tax: its marginal effect on utility, and its marginal effect on the public budget. Particularly the latter quickly becomes very involved once we include the indirect effects through the changes in the tax bases of other taxes (which is necessary in general equilibrium). It is always possible to derive an analytical expression for these effects, but they quickly cease to provide any significant insight. Hence the shift to numerical models: Here we loose generality, but we can directly focus on parameters that can be shown to be *quantitatively relevant* in the situation at hand. Nevertheless, the choice in this paper, as with Sørensen (1999), is to remain with *simple* numerical models. The reason is that once we have identified a parameter that is quantitatively important, we don't want to stop at this point, but explain *why* it is important, and why the effect was qualitatively to be expected, even if we could not foresee that it would quantitatively drive the results.

[2] Of course, I must be more modest and say: *I* cannot come up with something like that. Perhaps this statement has some positive provocative impetus.

It should be clear at the outset that the trade-off between the moderating wage effect and the labour supply distortion effect is only a small detail of all the issues connected to tax progressivity in a labour market with institutional detail. To begin with, there are other theories of unemployment – most prominently search-and-matching theories and efficiency wage theories. In some respects, these theories have been shown to produce astonishingly similar outcomes (Pissarides, 1998, Sørensen, 1999), but this gives us no strong reason to assume that the results of this paper would carry over to those settings.

Second, there are other distortions, apart from the effect on labour supply, that run counter the wage moderating effect. Examples are Fuest and Huber (1998), who focus on the distortionary effect on human capital formation, Jacobson and Sørensen (2000), who describe the effects on dual labour markets, where only one sector is covered by collective bargaining, and Koskela and Schöb (2007), who stress the negative effect on workers' effort.

Third, the optimality of tax progressivity can also be assessed in different contexts. The classical approach within optimal taxation theory is Mirrlees (1971), who considers the incentive problems that arise with heterogeneous agents characterised by non-observable productivity differences (Mirrlees, 1971). This is one of the aspects of the general equity-efficiency trade-off (Tuomala, 1990). These aspects do not show up in the model of this paper, because, except for the difference between the employed and the unemployed, there is no heterogeneity between agents.

Finally, an important limitation of the aggregate approach is that it lacks detail. Labour market institutions and the tax and transfer system are only captured by a small set of aggregated indicators. It is in particular micro econometricians who tend to argue that such models miss the very essence of the labour market: heterogeneity. However, models at an intermediate level of complexity like the one of this paper should be mainly seen as an communication device. In fact, there are examples of models that combine microeconomically founded mechanisms of involuntary unemployment and demographic as well as institutional heterogeneity on the labour market: Jacobson and Sørensen (1997), Graafland et al. (2001), Aarberge et al. (2004), Arntz et al. (2006). Due to their complexity, the outcomes of such models are often difficult to explain and to decompose into effects that are qualitatively known form the theoretical literature. This interpretation work is simplified through a condensed and simplified "model of the model" (e.g. "Mini-MIMIC" (Bovenberg et al., 2000) as a complement to Graafland et al., 2001). It is in this tradition that the present paper is most appropriately placed.

The plan for the rest of the paper is as follows. In Section 2 I present the model of Sørensen (1999), from which I depart, and a particular way of visualising the core results of the simulations. Section 3 analyses how variations in a number of macroeconomic and institutional parameters influence the model outcomes. Section 4 calibrates the model to seven large OECD economies and compares the simulation results. Preliminary conclusions are drawn in Section 5. The appendix contains the algebraic details of the model, some additional sensitivity analysis [to be completed] and a list of data sources.

2 The basic model

My starting point is the right-to-manage variant of the collective wage bargaining model in the specification of Sørensen (1999).[3] This is a standard set-up for collective wage bargaining. Firms interact in monopolistic competition, and wage bargaining is between an employers' association and a utilitarian trade union in a small, representative sector. Sørensen (1999) departs from the standard setting (which would have fixed labour supply) by endogenising hours of work for the individual worker. This makes the model appropriate for analysing the trade-off between the wage moderating and the labour supply distorting effect of tax progression.[4] A full list of the model equations can be found in Appendix A.1.

[3] Sørensen (1999), in addition, is a comparative exercise and also covers the basic variants of the search-and-matching and the efficiency wage model as well as an efficient-bargaining version of the trade union model.

[4] The only other attempt for quantification of the trade-off that I know of is Holmlund and Kolm (1995, p. 439). This model is more ad-hoc and not fully documented, so I consider it less suited as a point of departure.

Fuest and Huber (1997) perform a welfare assessment in an analytical context. However, they use a model where the government can use tax progression to "force" the trade unions to accept full employment. This seems not a realistic option if we want to understand the situation in real economies.

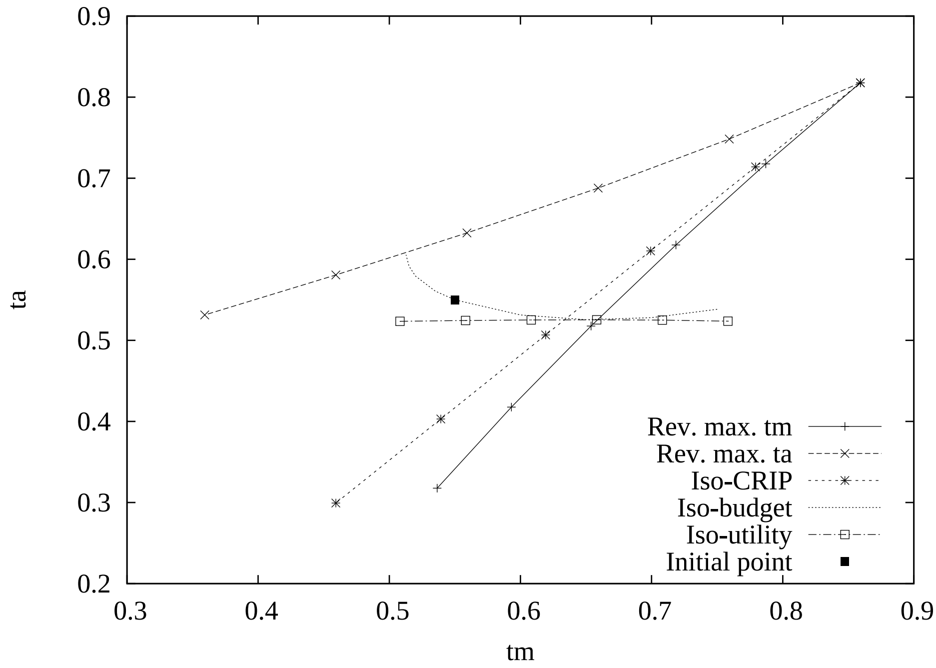

Figure 1: Space of efficient taxes in the basic model

Figure 1 presents the simulation results of Sørensen (1999) in a way that condenses a number of important effects in a single graph and will be used for the comparison with later model variants. The upper rightmost point of Figure 1, where the lines "Rev. max. tm" and "Rev. max. ta" meet, is the point of maximum tax revenue from the labour tax. We may call it "Leviathan point", because it is the point that a malevolent, exploitative dictator would choose. It is reached at tax rates of 82% for t_a and 86% for t_m (which corresponds to a CRIP of 0.77).[5] The lines "Rev. max. tm" and "Rev. max. ta" connect the points of partial revenue maxima. "Rev. max. tm" gives the points of maximum tax revenue through a variation of t_m, given that t_a is fixed at its respective value, and "Rev. max. ta" vice versa for t_a.[6] These two lines thus delineate the cone of (revenue-)efficient tax rates, which are a reasonable choice for actual tax structures.[7] The dot "Initial point" marks

[5] Tax rates will usually be rounded to full percentage points throughout the paper.

[6] Interestingly, these curves have a positive slope. The normal case that one would get with two taxes on different goods or factors of productions, is negatively sloped curves. See the figures in Boeters (2004).

[7] I call each possible combination of tax rates (t_m, t_a and possibly others) a "tax structure".

our point of departure, a proportional tax of 55%. Through this point, we can draw an iso-budget line ("Iso-budget"). In the cone of efficient tax structures, this line will be falling. In terms of tax revenue, higher levels of t_a can be traded off against higher levels of t_m. Where the iso-budget line meets the line of revenue-maximising t_a rates, it is vertical, because a further decrease of t_a does not lead to additional tax revenue any more, which could compensate for the revenue loss from a lower t_m. Analogously, the iso-budget curve is horizontal where it meets the "Rev. max. tm" line. Consequently, the initial tax revenue cannot be materialised with tax rates that are below about 53% for t_a and 51% for t_m. The iso-budget line summarises the set of choice options for the optimal taxation problem (at a given level of publicly provided goods). It remains to be determined which of these options should be chosen. This is depicted by the iso-utility line, which connects points of the same utility level from privately consumed goods, taking into account all general equilibrium interactions (i.e. adjusting wages and unemployment rates with changing tax structures). It turns out that the iso-utility line is virtually flat, i.e. the individual worker does only care about the average tax rate, not about the marginal one.[8] As a consequence, the optimal tax structure for a given revenue level lies almost at the outmost right point on the efficient segment of the iso-budget line. This is at 66% for t_m and 53% for t_a, which corresponds to a CRIP of 0.72, which reproduces Sørensen (1999).[9] As the line of revenue-maximising levels of t_m is steeper than a line of a constant CRIP level ("Iso-CRIP" is the line of the same progressivity as at the Leviathan point), we end up with a CRIP that is lower than at the Leviathan point (0.77).

An alternative way of visualising the optimal tax problem is by the marginal cost of public funds (MCPF) of the taxes involved.[10] This is shown in Figure 2. Here we see that t_a behaves quite conventional. It starts at infinity at the minimum value of t_a (51%), then steadily decreases for lower values of t_a (which are connected to

[8] In fact, the iso-utility line is not perfectly flat, but slightly concave.

[9] The CRIP (coefficient of residual income progression) is defined as $(1 - t_m)/(1 - t_a)$ and a usual indicator of tax progressivity. In a proportional tax regime, the CRIP is one, and the higher the progression of the tax schedule, the lower the CRIP.

[10] These have been numerically calculated by using different starting points on the iso-budget line of Figure 1, holding one tax fixed, changing the other tax by a very small amount, and dividing the equivalent variation by the additional tax revenue.

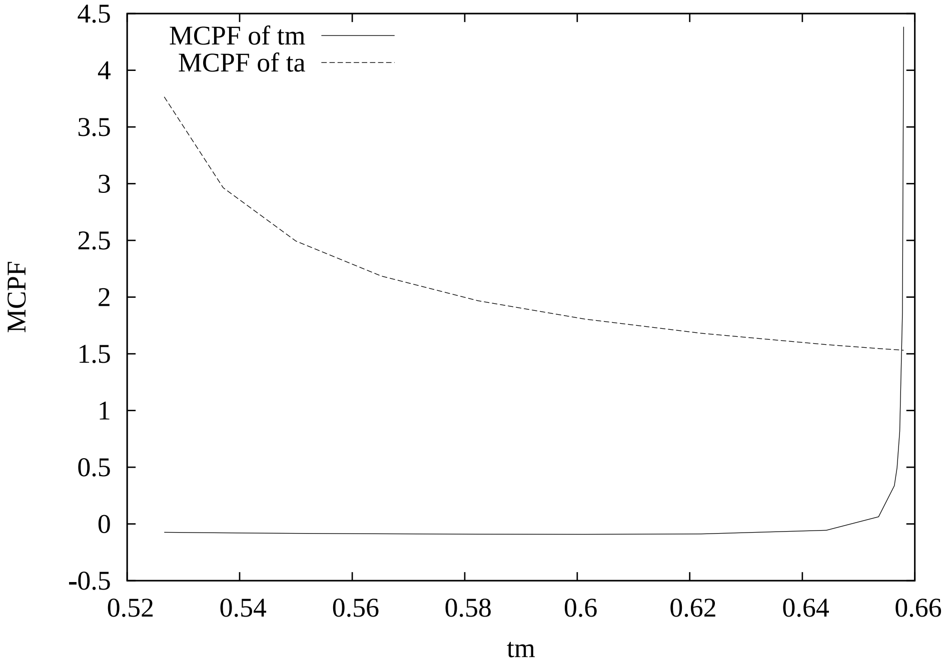

Figure 2: Marginal cost of public funds in the basic model

the higher values of t_m once we move from left to right in Figure 2) and remains above one, which indicates a excess burden of taxation. The MCPF of t_m, on the other hand, behaves rather untypical. It remains virtually constant and negative over a very broad range, and then abruptly turns very steep once we approach the (partial) revenue maximum. The optimal point is where the MCPF of both taxes are the same, which is – mirroring the inspection of Figure 1 – almost indistinguishable from the point where MCPF for t_m goes to infinity (the intersection with "Rev. max. tm" in Figure 1). This clarifies two additional points: First, over a broad range of t_m levels, we have a free lunch situation: An increase in t_m brings both higher tax revenue *and* higher private welfare. We may assume that politicians are particularly alert for such situations. If it should turn out that a careful calibration of the model leaves us in such a region, this would cast serious doubt on the appropriateness of the model for actual tax policy analysis. Second, on a more theoretical level, Figure 2 shows that although at the optimal point in Figure 1, the tangent to the iso-budget as well as iso-utility line is almost constant, it is not perfectly so. At the horizontal point, the MCPF of t_m are infinite. However, at the optimal point, they are the same as those of t_a, which is finite (namely, about 1.5). This highlights a particular important point of the type of numerical analysis offered in this paper. We wouldn't be able to demonstrate analytically that we should increase t_m up to its revenue maximum (because it is not precisely true). However, for getting a feeling for optimal tax structures and for comparing different settings in various model versions (see Section 3), this is an enormously important piece of information.

3 Extending the basic model

The model of Sørensen (1999) is not meant to be strictly empirical. However, it is calibrated to the extent possible with the degrees of freedom at hand to the stylised facts of a "typical western economy". This makes it possible to compare the outcome to tax rates observed in the real world, and to think about model modifications that increase the empirical fit. In particular, Sørensen chooses the following parameter values for calibration: a ratio of wage income to capital income of 7/3 ($\alpha = 0.3$), a profit mark-up factor (m) of 2.1, which together produces a labour demand elasticity of 1.5 (with reference to Symons and Layard, 1984). The net wage elasticity of individual work hours ($1/\delta$) is set to 0.1. Unemployment is at 10% and the replacement rate at 60%. The initial tax regime is composed of a proportional tax rate on labour of 55% (this is meant to include both employers' and employees' social security contributions as well as consumption taxes) and a 100% tax on profits.

3.1 Profit share

A counterfactual consequence of the Sørensen (1999) calibration is the extraordinarily high profit share that is implicit in the parameter choice. With a profit mark-up factor of 2.1, we arrive at a share of pure profits in total income of more than 50%. Together with capital income (which is also rent income, because capital is assumed fixed in the model), we end up with a profit share of 67%. However, we are not interested in realism as such. It is clear that with only a small number of parameters, the model will never be capable to capture all empirical characteristics of a real economy. We are interested in model realism only insofar as it turns out to be an

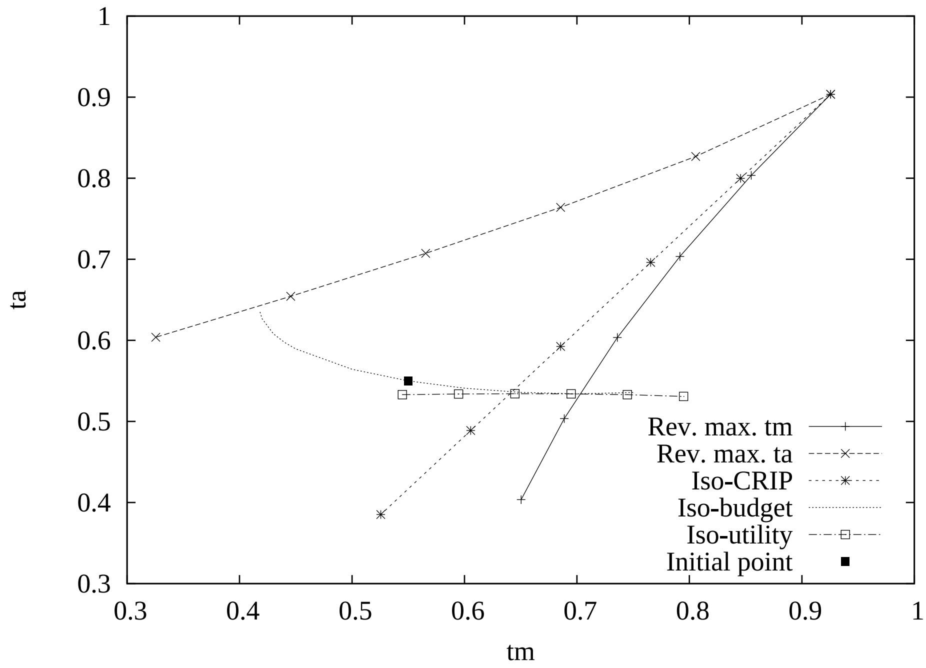

Figure 3: Model with lower profit share

important driver of model results, in our case: the optimal degree of labour income tax progressivity. We check this by replacing the mark-up rate of 2.1 by 1.1, which gives a share of monopoly profits of 10%, and a share of all profits of 37%.

First, note that all partial labour market effects of tax changes are completely unaffected by this change. The consequence of a partial, non revenue-neutral change of t_m or t_a are precisely the same as in the basic model. This is because the mark-up factor only enters the FOC of wage bargaining as a proportional factor on profit. As it affects total profits (in the denominator) in the same way as marginal profits (in the numerator), the effect precisely cancels out. However, the public budget consequences of tax rate changes are in fact affected, and considerably so. The budget consequences of a change in labour taxes are composed of two components, the revenue of the labour tax itself and the revenue of the profit tax, which is 100% in the basic model. (We return to this point in the next section.) If we increase labour taxes and go for the revenue maximising level, the revenue from the profit tax will earlier begin to shrink than the revenue from the labour tax, because in the former case, we only have the consequences of a shrinking tax base, whereas in the latter case, there is at the same time the effect of the tax rate increase. For the stopping point, the relative size of the tax bases is therefore relevant. The higher the profit tax base, the earlier the turning point of decreasing tax revenue will be reached. This is precisely what turns out in Figure 3, which is the analogue to Figure 1 for the basic model.

We see that the Leviathan point has moved to higher labour tax rates (because the tax base of the profit tax has shrunken relative to that of labour). Tax revenue is now maximised at tax rates of $t_m = 93\%$ and $t_a = 90\%$.[11] As a consequence, we are now farther apart from the Leviathan point with our initial situation of $t_m = t_a = 55\%$. As the cone of efficient tax structures is wider now, we are left with a broader choice set, extending from 42% to 70% for t_m. The iso-utility line is still almost flat, so that this extended choice set is again stretched almost to its upper limit for t_m. We end up with an optimal tax structure of $t_m = 70\%$ and $t_a = 53\%$. As t_a is not much changed compared to the basic model, the higher t_m directly translates into higher optimal tax progressivity. The optimal CRIP is now 0.66, considerably lower than the value of 0.72 from the basic model.

There is of course a follow-up problem of this model modification. The value of 2.1 for the profit mark-up factor was not an arbitrary choice in the basic model, but served to establish an empirically supported value of the elasticity of labour supply of 1.5. With a mark-up factor of 1.1, we now arrive at a labour demand elasticity of 2.7. However, the isolated consequences of this change on the wage bargaining system are nil. Appendix A.3 shows that as long as the factor income shares are constants (which they are in our model with Cobb-Douglas production and monopolistic competition on the goods markets), any parametric change in the labour demand elasticity will be exactly compensated through the calibration of the bargaining power parameter. Another way of putting this is that the elasticity of labour demand and the relative bargaining power of the parties are not independently identified in this model anyway, so we need not worry about an apparently "unrealistic" value of the labour demand elasticity.

[11] The CRIP at this point seems to be precisely the same as in the basic model (0.77), but I haven't tried to confirm this analytically.

3.2 Profit tax rate

In the basic model, we assumed that there is a 100 per cent profit tax, so that profits contribute completely to the public budget. In a strict optimal taxation environment, this can be justified, because the profit tax is non-distortive, so it should be driven to its maximum before any other, distortive, tax is raised. However, this is not likely to produce a realistic picture of actual tax structures. Actually, in the basic model with both an unrealistically high profit share and a 100 per cent profit tax, we end up with a share of tax revenue in total production of 84% (which is, as we have seen, not the maximum tax revenue yet). In Model 2 (lower profit share), this is lower at 70%, but still far beyond what we observe in actual economies. Anyway, the model focuses on labour market questions and is not meant to capture the trade-offs of capital taxation. So it can be combined with an exogenous rate of the profit tax that reflects choices that would result if one accounted for the distortions in capital taxation.[12] For the stylised model, I choose a profit tax rate of 25%.

Again, as with the profit share, the question arises, does this matter at all? And again, it does not for the partial labour market effects (which are identical to the basic model), but it matters a lot for the public budget and thus for the optimal tax structures.[13] The effect is similar as with the profit share, and it goes in the same direction. A lower profit tax means that the public budget depends more on the direct effects of labour taxation, and less on the indirect effects through a change in the profit tax base. The Laffer-efficient cone expands and the optimal tax structure moves in the direction of a higher t_m. In this setting, we end up with at Leviathan point of $t_m = 95\%$ and $t_a = 93\%$ (which gives again the same CRIP of 0.77) and an optimal tax structure of $t_m = 72\%$ and $t_a = 54\%$ (CRIP = 0.61).

A profit tax rate of less than 100 creates a new question: How are the after-tax profits distributed, do they have an impact on the wage bargain, and, if yes, how? In Figure 4, I have assumed that workers do not receive profit income, and that private profits are not accounted for in the welfare to be maximised. This can be interpreted either as a situation where all profits go to foreign shareholders, or as a

[12] In a dynamic model, the level of the optimal profit tax would be endogenous, of course, and depend on the choices with respect to labour taxation. This is beyond the model of this paper.

[13] In Boeters (2004), I make a similar point in the context of environmental tax reforms.

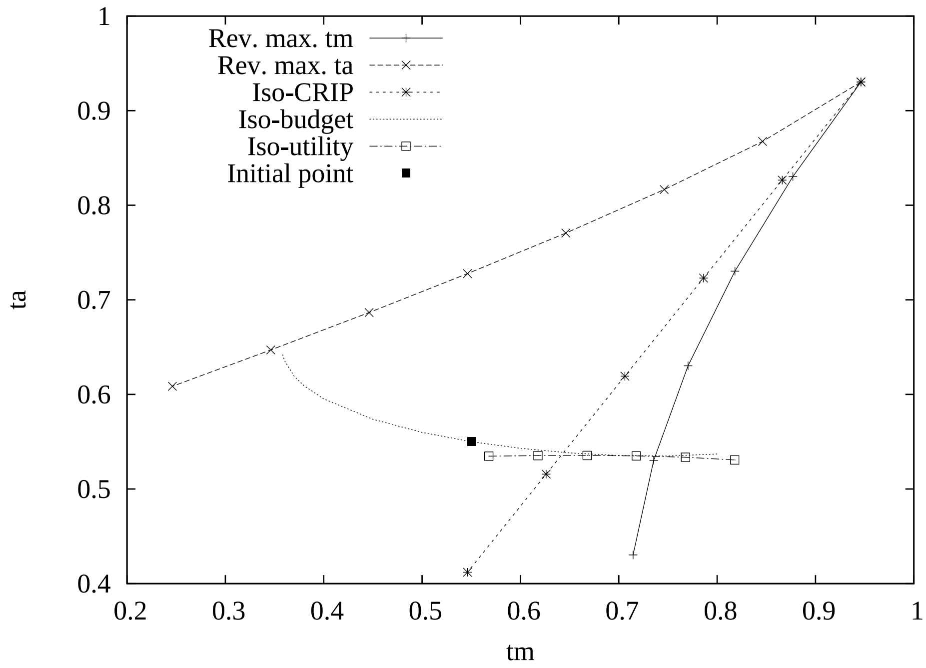

Figure 4: Model with lower profit tax rate

situation where the tax structure is set by a "labourist" government. Alternatively, we can assume that after-tax profits are part of the welfare to be maximised. Then the iso-budget line becomes a bit more downward-sloping, and the optimal point moves slightly to the left. This gives $t_m = 70\%$ and $t_a = 54\%$ (CRIP = 0.65).

Observe that in the utility function of the workers assumed so far, non-labour income of the workers does not matter for the labour supply decision, because the income elasticity of labour supply is zero. We will return to the problem of the distribution of profits in later model versions.

3.3 Consumption taxes

In the original Sørensen (1999) model, the average burden on labour income of 55% is meant to capture labour income taxes in a narrow sense as well as consumption taxes. In the static framework of our model, this is innocuous, because a general income tax is equivalent with a general consumption tax. However, lumping income and consumption taxes together makes it difficult to relate the model results to

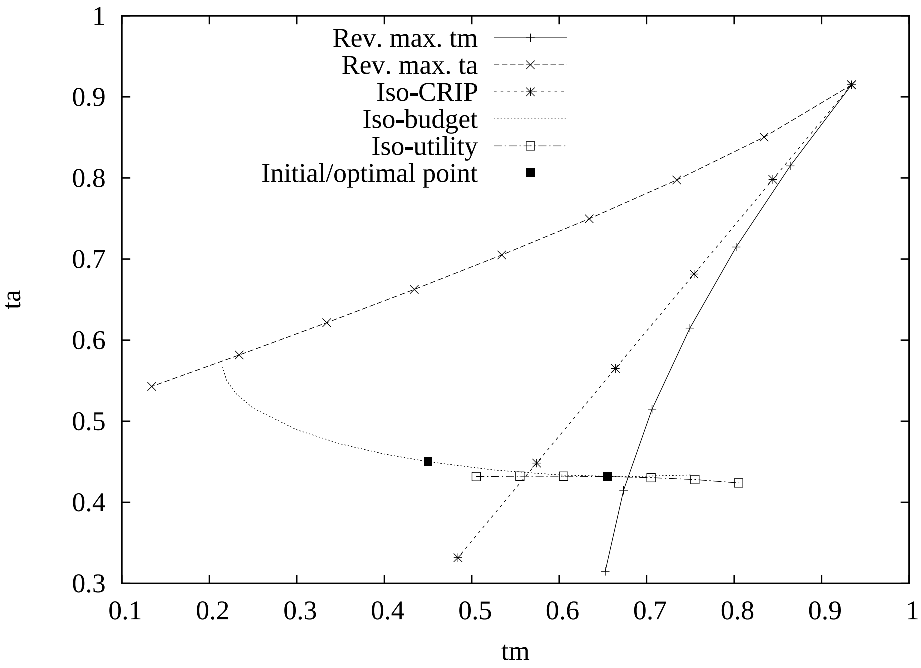

Figure 5: Model with consumption taxes

the actual situation of concrete countries, even more so if the consumption tax is proportional and the labour income tax is not. Therefore I introduce a separate consumption tax in the model. I choose a value of 0.45 for the pure labour income tax (which is still assumed proportional in the initial situation). The other taxes are adjusted so that the tax revenue as a share of production remains unchanged compared to the last model version. This means for the consumption tax: $t_c = (1-0.45)/(1-0.55)-1 \approx 0.22$. As the consumption tax also covers profit income, the profit tax is adjusted so that the tax burden on capital income remains constant: $t_p = 1-(1+0.22)(1-0.25) \approx 0.08$. The economic behaviour of this model is identical to the previous one. However, if we show the results in the (t_m, t_a) space, the picture changes, because the level of labour taxes is in general lower now. This is illustrated in Figure 5. The optimal CRIP is unchanged compared to the previous model versions. The optimal tax rates are lower now (but bear the same relation to the initial tax rates): $t_m = 66\%$ and $t_a = 43\%$ (CRIP $= 0.61$).

3.4 Extensive margin of labour supply

In the Sørensen (1999) model, labour is only flexible along the intensive margin (hours of work). However, there are two margins of labour supply, the second being participation (extensive margin). Distinguishing these two margins of labour supply is not only a requirement of realism, it is necessary because the economic mechanisms that govern labour supply along these two margins are completely different. The simplest way of modelling a flexible participation decision is through fixed costs of labour market participation, which are heterogeneous between individuals. The participation decision then consists of a simple comparison of the gain from participation (consumption from wage income corrected for the loss in leisure) and these fixed costs. What is relevant for this decision is thus the *average* tax rate at the optimal point of labour supply, not the *marginal* tax rate, which drives the intensive decision. It can easily be imagined that the tax reforms considered so far, which increased the tax progressivity by a higher marginal and a lower average tax rate, now lead to different outcomes. The lower average tax rate encourages labour supply at the extensive margin, which works against the distortions at the intensive margin. [Add explanation of the calibration of the extensive margin of labour supply and of the welfare calculations for the households entering or leaving the labour market.]

Figure 6 shows the effect of introducing the extensive margin of labour supply in the model. The model is calibrated to an elasticity of 0.2 at the extensive margin, following Kleven and Kreiner (2006).[14] This does induce some changes in the overall fiscal behaviour of the model. Most notably, the Leviathan taxes are now lower (reflecting the additional disincentive effect at the extensive margin) and the minimum feasible marginal tax is considerably higher (27% compared to 21% in variant 5). However, with respect to the optimal tax rates, there are virtually no changes. The optimal values of t_m and t_a are slightly lower, but rounded to full percentage points, they remain at their previous values of $t_m = 66\%$ and $t_a = 43\%$ (CRIP = 0.61).

[14]Kleven and Kreiner (2006, p.18-20) survey the current state of empirical evidence on the elasticity at the extensive margin. It is particularly difficult to calibrate a model with an representative agent to these elasticities, because they differ considerably by household type. The value of 0.2 is the aggregate average in Kleven and Kreiner's core scenario.

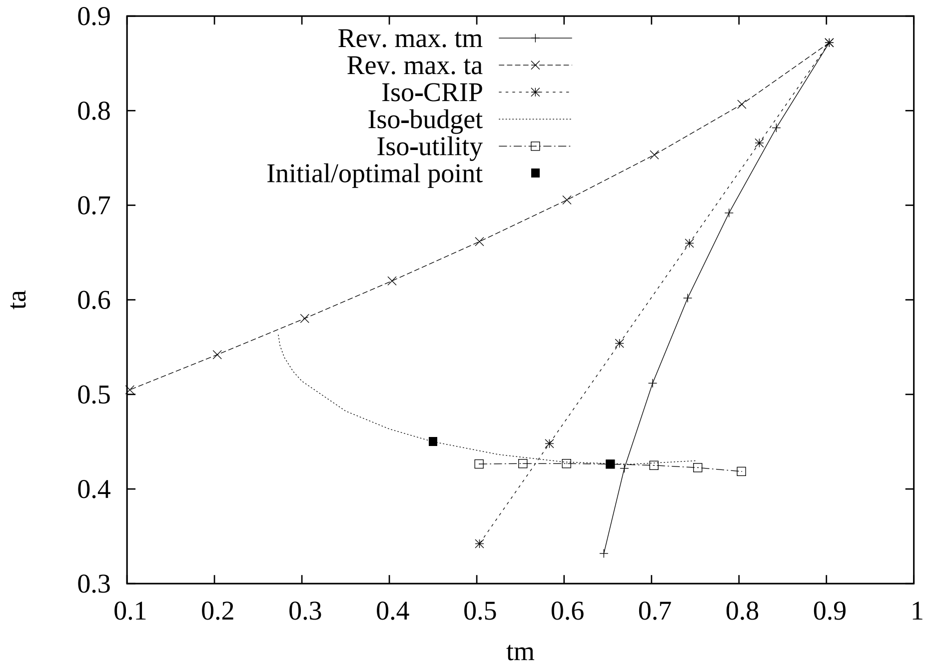

Figure 6: Model with extensive margin of labour supply

3.5 Income elasticity of labour supply

The additive separable structure of the utility function in Sørensen (1999) implies that the income elasticity of labour supply is zero, and that the compensated and uncompensated wage elasticities of labour supply are the same. As long as the tax schedule is proportional and the household only receives wage income, this can be defended (apart from the fact that it is not clear whether the single elasticity in the model should be calibrated to match empirical compensated or uncompensated elasticities). A more flexible specification is desirable for two reasons. First, although we start from a proportional wage income tax, we switch to considerably non-proportional ones in the course of the search for the optimal structure. Then income effects begin to matter. Second, income effects are relevant for the analysis of the model variant where the worker household does not only receive wage income but also capital income.

There is one slight complication in this model extension. For more involved utility functions, the first-order condition in Nash bargaining for the optimal hours becomes awkward. As a preliminary step, I therefore check the switch to a model version where the trade union only bargains over the wage, and the optimal working time is determined at the individual level. It turns out that this implies a slight recalibration of the model (because now the initial hours of work are higher, because the individuals are not restricted any more through the collective bargaining outcome), but that the comparative static results, including the optimal degree of tax progressivity, are virtually unchanged compared to the version where collective bargaining also covered the hours of work. (At the optimal point, t_m is on percentage point higher and the CRIP one percentage point lower than in variant 6.). I therefore proceed with the simpler version with only wage bargaining.

The additive separable utility function of Sørensen (1999) is now replaced by a CES utility function with consumption and leisure as arguments. This leaves us with two free parameters, the elasticity of substitution and the time endowment, to be chosen so that we match empirical values of the wage and income elasticity of labour supply.[15] The uncompensated wage elasticity of labour supply is chosen so that it matches the value of the basic model (0.1),[16] the income elasticity of labour supply is set at -0.1 (following Ballard, 2000, p.9). [There is one loose end in the calibration of the CES utility function. It turns out that if we assume, as in the basic model with the additive separable utility function, that the unemployed can enjoy all their non-working time as leisure, they are better off than the employed. Anyway, the issue to what extent non-working time of the unemployed should count as leisure, is hotly debated, also for political reasons. In the model of this section, I assume that half of the additional non-working time enters the utility function of the unemployed. This is checked for sensitivity in Appendix A.5.]

The consequences of this model modification are significant. Almost all parts of the graph of efficient tax structures have changed (Figure 7). To begin with, the Leviathan point is now at considerably lower tax rates than in all model variants before (at $t_m = 80\%$ and $t_a = 78\%$ (CRIP = 0.93). This tax progressivity at this point is much lower than in all previous versions. Furthermore, the cone of efficient

[15] The calibration procedure is described in Rutherford (1998) and Ballard (2000). Appendix A.4 gives a brief summary.

[16] The meta study of Evers et al. (2005) suggests a somewhat higher elasticity, but it is difficult to distil a "core" value from this study.

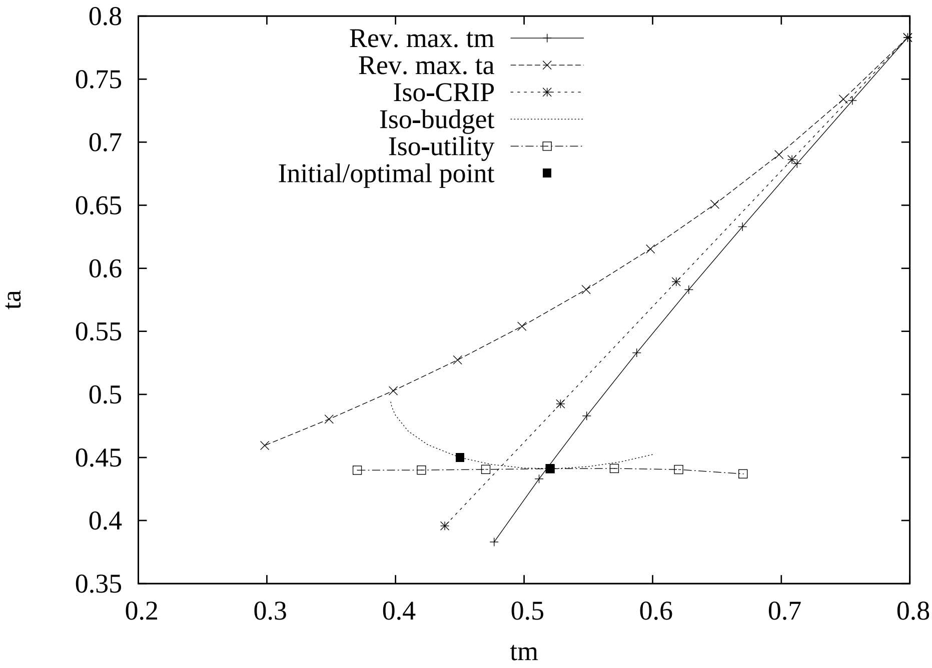

Figure 7: Income elasticity of labour supply calibrated

tax structures is a lot narrower now. Starting at proportional labour taxes of 45%, the range of t_m where both tax rates are Laffer-efficient only extends from 40% to 52%. The optimal labour tax structure is again at the very end of this range ($t_m = 52\%$ and $t_a = 44\%$, CRIP $= 0.86$). The CRIP at this point is at a totally different range from everything we saw in the earlier model variants. As the CES utility function is calibrated to the same extensive and intensive wage elasticities of labour supply, the difference of this model variant with the additive separable utility function must lie in the income elasticity of labour supply. Through the introduction of tax progressivity, we generate additional (quasi) lump-sum income. This reduces labour supply and therefore the tax revenue from labour taxation. The point where the average labour tax rate cannot further reduced is thus reached earlier than with a income elasticity of labour supply of zero.

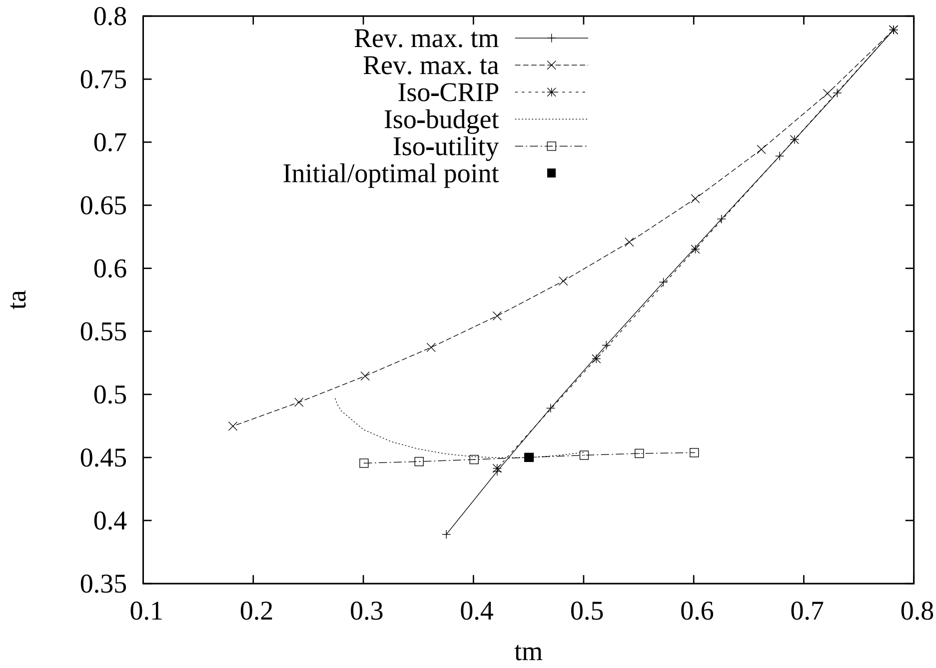

Figure 8: Model with lower initial unemployment

3.6 Initial level of unemployment

I have now reached my preferred specification, with the income shares at a reasonable level, the most important taxes in place (consumption taxes, profit taxes) and a labour supply specification that is as close to empirical estimates as it is possible at this level of aggregation. The model has been calibrated to a benchmark situation which is in a range which is plausible for industrialised countries. In this and the following sections, I check how the model outcomes vary if important characteristics of the initial situation are altered.

I start with the unemployment rate. 10 per cent, as assumed so far, is not unrealistically high, but currently rather at the upper bound of the situation in OECD countries. Figure 8 shows the situation that results if at the initial level unemployment is at half that value, 5 per cent.

Figure 8 is remarkable in several respects. The cone of efficient tax structures has again narrowed. The line of budget-maximising t_m rates is now almost identical with the iso-CRIP line. In addition, the whole spectre of efficient tax rates has shifted to the left. The basic mechanism is clear. With lower initial unemployment, there is less to be gained from higher tax progressivity. Most notably, the total amount of unemployment benefits saved is lower, so that there is less scope for reductions of the average labour tax rate. Qualitatively, the changes between the 5% and 10% unemployment scenarios were to be expected. Quantitatively, they are astonishing, however. We are left with an initial proportional tax (of 45%) which is Laffer-inefficient (to the right of the revenue-maximising t_m line. At the same time, the initial tax structure is almost precisely the optimal one ($t_m = 45.1\%$ and $t_a = 45.0\%$, CRIP $= 0.999$). Thus for the first time we have a situation where it is optimal to have (virtually) no progression, and where it is optimal to have a Laffer-inefficient marginal labour tax rate. [The latter needs definitely closer scrutiny. Is it possible that workers do not prefer a situation with both a lower marginal and average tax rate? In principle, this cannot be excluded, because unemployment is lower and the wage might be higher. However, even if confirmed, it remains a strange constellation.]

3.7 Indexation of unemployment benefits

In all model versions so far we have assumed that unemployment benefits are directly linked to the net wage income through a constant replacement rate. It is well known in the wage bargaining literature that the indexation rule for the unemployment benefits plays an important role for the bargaining outcome. If the benefit regime is governed by a fixed replacement rate, the relative difference between the income of the employed and the unemployed cannot be influenced through wage changes. Therefore adjustment to tax changes must use other channels. The principle alternative to a fixed replacement rate are unemployment benefits that are fixed in real terms (indexed to the consumer price index). In this case a wage cut immediately reduces the relative income position of the employed workers. [The same holds for tax rate changes.] These two alternatives have lucidly be contrasted in a numerical setting in Pissarides (1998).

Figure 9 shows the consequences when the indexation of unemployment benefits is half-and-half. Half of the benefits goes in line with the net wages, the other half with the consumption price index. Even then the consequences are drastic.

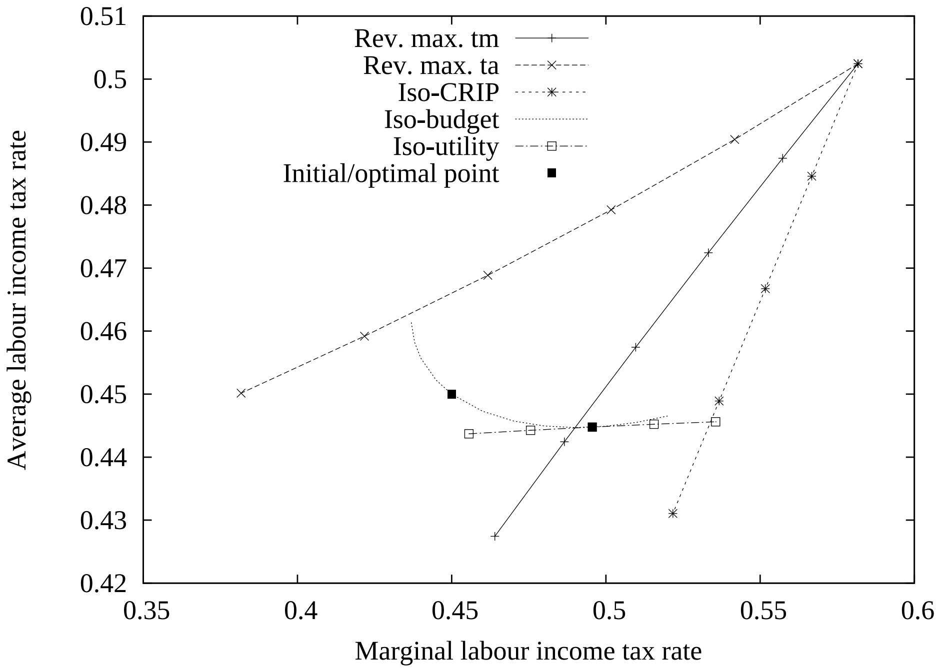

Figure 9: Unemployment benefits indexed to consumption prices

The Leviathan point shifts in the neighbourhood of the initial point. It is now at $t_m = 58\%$ and $t_a = 50\%$ (CRIP = 0.84). The line of revenue-maximising t_m is now to the left of the iso-CRIP line. The optimum is again at a point where t_m is slightly Laffer-inefficient: $t_m = 50\%$ and $t_a = 44\%$ (CRIP = 0.91).

An effect in that direction was to be expected, at least for t_a. A higher t_a now means that the relative income position of the employed deteriorates, leading to higher unemployment. This in turn limits the scope for the government to raise tax revenue. [It is more difficult to argue why also higher values of t_m become Laffer-inefficient.] The quantitative consequences of this change are astonishing, however. This is also the reason why I chose the mixed case for the presentation in Figure 9. If we go the full way to the other extreme, where unemployment benefits are completely indexed to the consumer prices, it turns out that already the initial situation with $t_m = t_a = 45\%$ is Laffer-inefficient. The whole exercise of performing a revenue-neutral tax reform from this stating point becomes then obsolete.

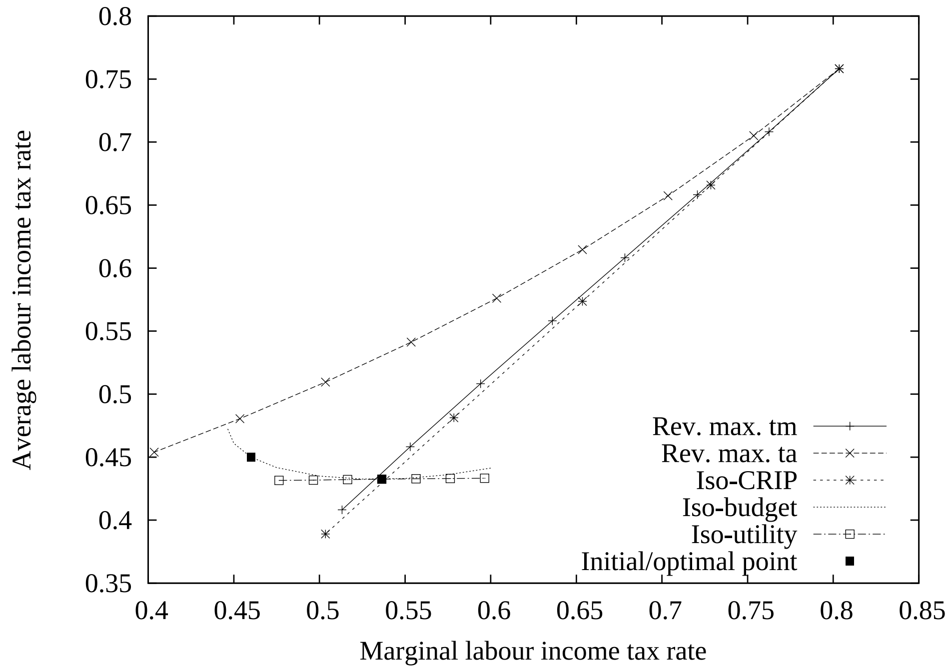

Figure 10: Progressive taxes in the initial situation

3.8 Progressive tax in the initial situation

Until now, we have assumed that the labour tax is proportional in the initial situation. This is clearly counterfactual, most countries do in fact have a progressive labour income tax. In Figure 10, I show the case of a slight change of the initial tax progressivity: a marginal tax rate of 46% instead of 45%. (As the marginal tax rate does not change the tax revenue, all the basic macroeconomic facts of our model economy can remain the same.) In order to increase the scope for changes, I return to Version 8, where unemployment benefits are fully indexed to the net wage. It turns out, however, that the scope for different initial degrees of tax progressivity are narrowly confined, nevertheless.

The small change from an initial $t_m = 45\%$ to $t_m = 46\%$ causes a considerable narrowing of the cone of efficient tax structures. At the initial level of tax revenue, the range of Laffer-efficient rates of t_m is now only from 45% to 54%. The Leviathan point is at $t_m = 84\%$ and $t_a = 76\%$ (CRIP $= 0.81$). The initial point is already very close to the edge where t_a becomes Laffer-inefficient. The optimal point is again at the very highest possible Laffer-efficient t_m of 54% ($t_m = 43\%$, CRIP = 0.82, which is, remarkably, slightly higher than at the Leviathan point). Already for another increase of the initial t_m from 46% to 47%, the initial point becomes Laffer-inefficient (moves above the line of revenue-maximising values of t_a), so that the question of an optimal revenue-neutral tax reform vanishes.

3.9 Summary of the model variations

We have seen that many modelling choices have a significant impact on the size of the cone of efficient tax structures and on the level of the optimal tax rates (as well as the resulting progressivity, expressed as the CRIP). Disturbingly, the more we enrich the model with realistic features, the smaller the scope for tax reforms that remain in the revenue-efficient range, and the more difficult it becomes not to end up with tax structures that are altogether Laffer-inefficient. Particularly, if we move to lower unemployment rates (Figure 8), unemployment benefits that are partly indexed to consumption prices (Figure 9) and tax structures that are progressive already in the initial situation (Figure 10), it becomes difficult to produce meaningful model outcomes. In the following section of this paper, I check to which extent this is relevant if we calibrate the model as closely as possible to the concrete macroeconomic and institutional values of some important OECD economies.

4 Calibration to OECD economies

For a further step towards a solid empirical underpinning of the analysis, I calibrate the model of the previous section to macroeconomic and labour market of seven large OECD economies. These are the five largest Western European economies, France (FRA), Germany (GER), Great Britain (GBR), Italy (ITA) and Spain (ESP), plus the USA and Japan (JPN). The latter two are meant to set the results in perspective, not necessarily to claim the appropriateness of the assumed labour market structure to these countries.

Table 1 reports the country specific parameters (the exact sources are given in Appendix A.6).

Table 1: OECD parameters

	FRA	GER	GBR	ITA	JPN	ESP	USA
s_L	0.601	0.593	0.654	0.473	0.594	0.545	0.627
t_C	0.182	0.155	0.162	0.151	0.069	0.142	0.041
t_L	0.430	0.392	0.259	0.427	0.269	0.340	0.263
t_K	0.266	0.131	0.352	0.249	0.198	0.169	0.246
CRIP	0.910	0.731	0.862	0.884	0.937	0.878	0.933
u	0.088	0.079	0.048	0.096	0.050	0.129	0.047
c	0.630	0.570	0.340	0.050	0.070	0.290	0.060

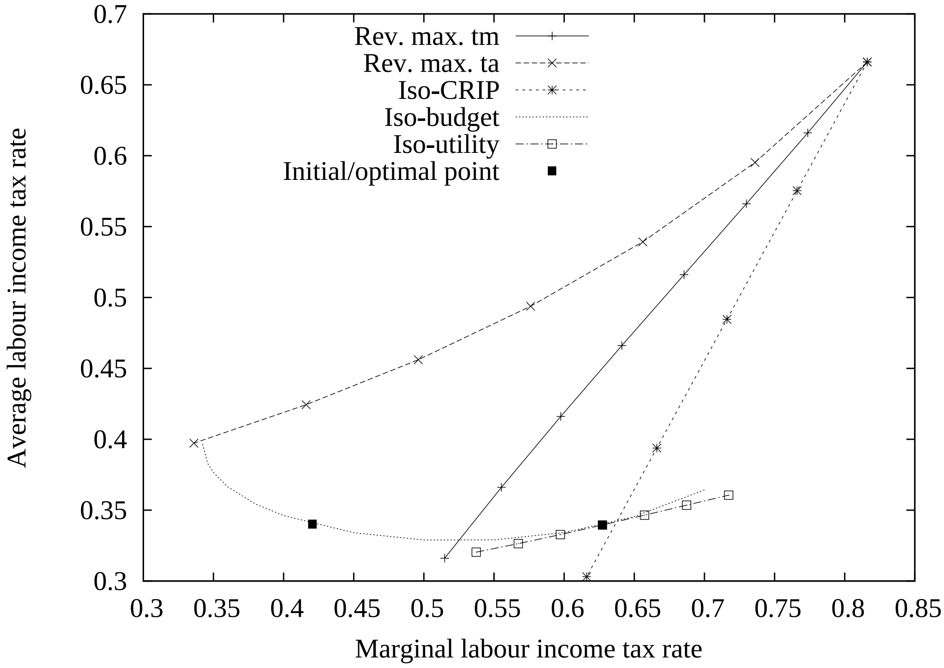

Figure 11: Efficient and optimal tax structures in Spain

In the following sub-sections, I discuss the different countries in the order of their closeness to the unspecified blueprint model of Section 2.

4.1 Spain

According to the OECD data, Spain is characterised by an intermediate level of taxes (both on labour and consumption), a relative low level of the replacement rate and the highest unemployment rate of the selection of countries in Table 1. We start at a point with $t_m = 42\%$ and $t_a = 34\%$. This produces a Leviathan point of $t_m = 82\%$ and $t_a = 67\%$ (CRIP = 0.55). This CRIP is far lower than all values that we had before at the Leviathan point. The optimal point is at $t_m = 63\%$ and $t_a = 34\%$ (CRIP = 0.56). Again the CRIP is (against the background of our previous exercises) astonishingly low. Although the cone of efficient tax rates is reasonably wide, $t_m \in [34\%, 53\%]$, the optimal t_m is far out in the region where the marginal revenue from the marginal tax rate is negative. Contrary to all what we observed in the basic model, the iso-utility line has a clearly positive slope.[17] This remains to be explained: Why should the representative consumer prefer a higher t_m even if this does not allow the government to lower t_a (because the labour tax basis expands)?

4.2 Great Britain

Great Britain is characterised by low labour taxes, a low unemployment rate and a moderate replacement rate. The starting point is $t_m = 36\%$ and $t_a = 26\%$. This produces a very narrow cone of efficient tax structures, $t_m \in [30\%, 40\%]$ and a very low CRIP at the Leviathan point: $t_m = 77\%$ and $t_a = 56\%$ (CRIP = 0.54). Although the iso-utility line is less upward-sloping than in Spain (but still with a considerably positive slope), the optimal point is far out in the revenue-inefficient range: $t_m = 52\%$ and $t_a = 27\%$ (CRIP = 0.64).

4.3 Italy

Italy is characterised by a high level of the labour tax and a particularly low replacement rate. The latter makes the model at hand somewhat questionable. If benefit

[17] The reasoning about the slope is still loose. Partly it is biased by different scales in the figures. In the appendix, I present a set of figures with standardised scales, which simplify the comparison. In the next revision of this paper, I will report numerical values of the slope.

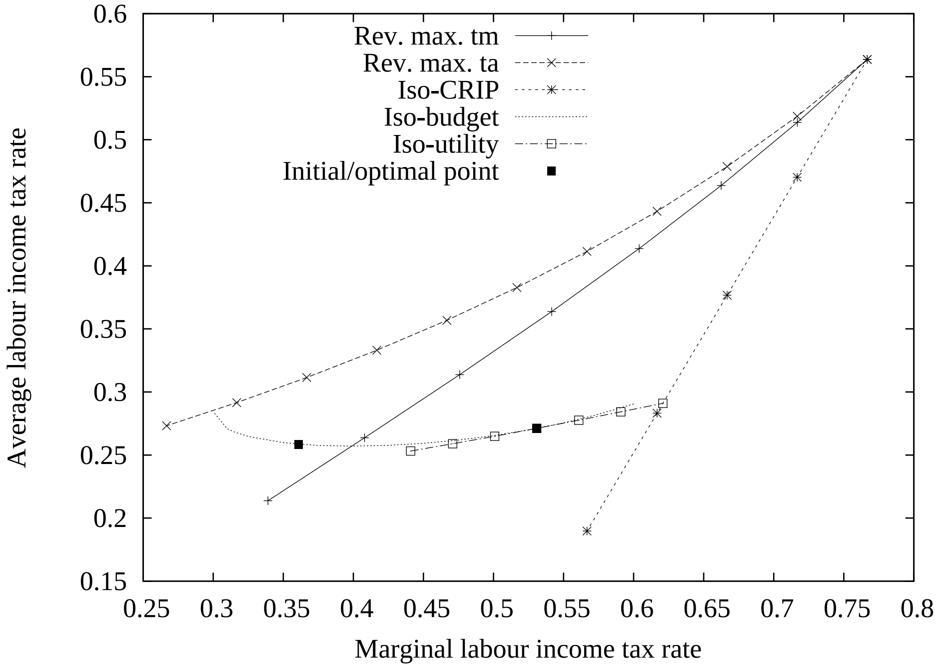

Figure 12: Efficient and optimal tax structures in Great Britain

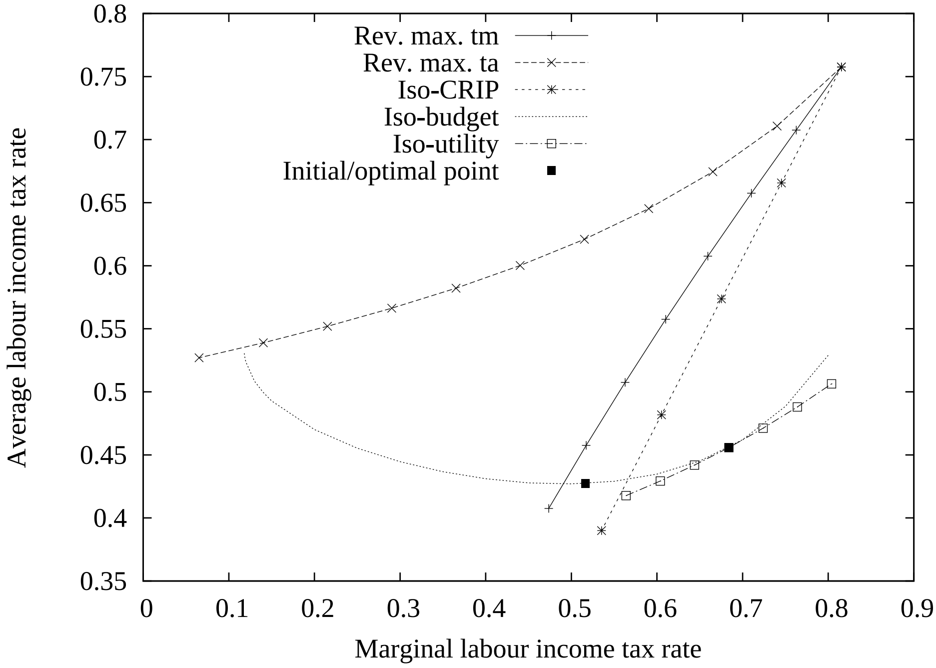

Figure 13: Efficient and optimal tax structures in Italy

payments are only covering five percent of labour earnings, then it is almost sure that the unemployed most get some resources from elsewhere: welfare transfers in kind, home production or within-family transfers. However, if we leave this aside for now and set up the model simply with the numbers in Table 1, the picture of Figure 13 emerges.

The cone of efficient tax structures is particularly wide, $t_m \in [12\%, 49\%]$, however, the initial point ($t_m = 52\%$ and $t_a = 43\%$) is already slightly to the right of it. At the Leviathan point, the labour tax considerably less progressive than in ESP and GBR: $t_m = 82\%$ and $t_a = 76\%$ (CRIP = 0.76). The optimal point is again far to the right: $t_m = 68\%$ and $t_a = 46\%$ (CRIP = 0.58).

4.4 France

For the next two countries, France and Germany, we encounter a particular problem: If we calibrate the model straight away with the given parameters, we arrive at a situation where the utility of the unemployed is higher than that of the employed. The precise reason for this is unclear. It definitely is connected to the level of the replacement rate. FRA and GER are the countries in our sample with by far the highest replacement rates. However, these rates are not higher than in the initial reference model of Section 2. Most probably the problems arise through the combination of the high replacement rate and a progressive tax in the initial situation. But again, this is not a straightforward reasoning: The tax progressivity (in terms of the CRIP) in FRA is the lowest of all European countries in the sample.

I react to this complication with an ad-hoc adjustment of the value of involuntarily unemployed time, which is an open calibration problem anyway. In the case of FRA, this value is lowered from an initial 0.5 to 0.25.In this setting, FRA starts with a tax structure where t_a is almost revenue-inefficient: $t_m = 48\%$ and $t_a = 43\%$. The cone of efficient tax structures is very narrow: $t_m \in [48\%, 54\%]$. The Leviathan point is at $t_m = 80\%$ and $t_a = 69\%$ (CRIP = 0.64). The optimal point is at $t_m = 57\%$ and $t_a = 40\%$ (CRIP = 0.72). From all the European countries, FRA comes closest to the flat iso-utility line that was something like a stylised fact in the basic model.

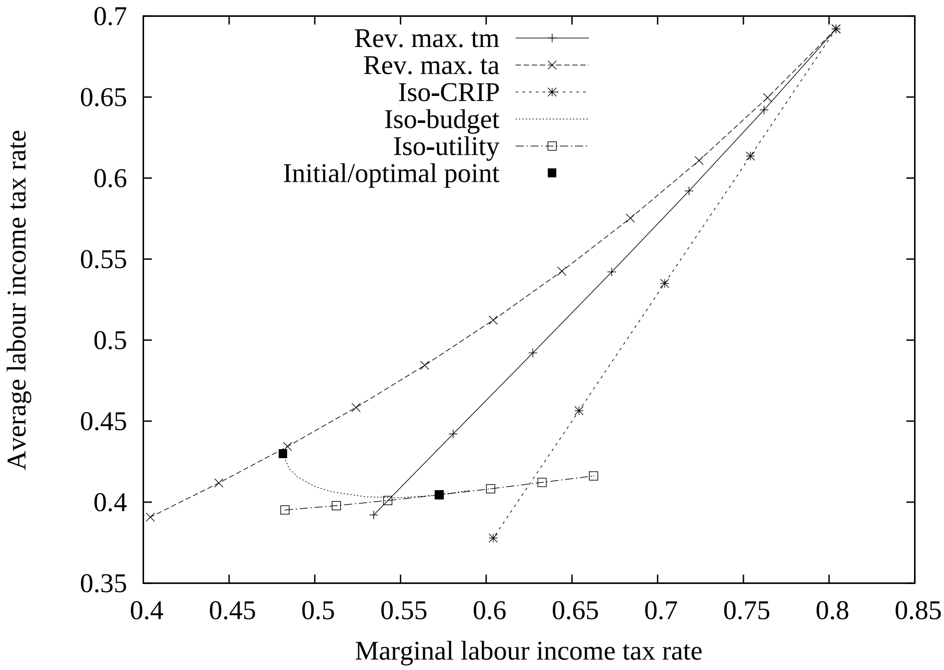

Figure 14: Efficient and optimal tax structures in France

4.5 Germany

In Germany, the problem with the utility reversal was even worse than in FRA. A relative utility of unemployed labour of 0.25, as in the case of FRA, was not sufficient to fix the problem, so I chose the extreme value of zero. Then we have: initial point: $t_m = 56\%$ and $t_a = 39\%$, Leviathan point: $t_m = 98\%$ and $t_a = 96\%$ (CRIP $= 0.68$). Cone of efficient tax structures: $t_m \in [41\%, 63\%]$. Optimal point: $t_m = 82\%$ and $t_a = 46\%$ (CRIP $= 0.32$). The iso-utility line is particularly steep in this case.

4.6 Japan

Japan and the USA are very similar, if we restrict the comparison to the key indicators in Table 1. Unemployment is low, the replacement rate is very low. Labour taxes are at a relatively low level and tax progressivity is moderate. As said earlier, extending the numerical exercises to these two countries is not meant to imply that the collective wage bargaining model is particularly appropriate here. It just broadens the scope of the comparative exercise. Note that USA and JAP are not

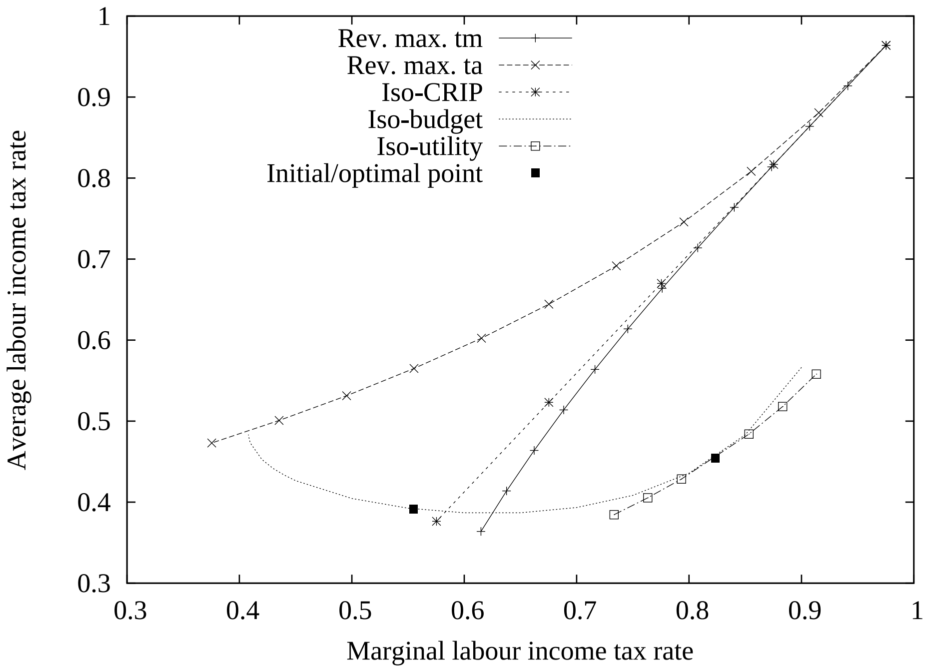

Figure 15: Efficient and optimal tax structures in Germany

characteristically different from *all* European countries in any *single* dimension: Unemployment is not lower than in GBR, the replacement rate is not lower than in ITA, the average labour tax is not lower than in GBR, and tax progression is not lower than in FRA. However, the combination of these parameters leads to a pattern of tax structures that is completely different from that in the basic model and the outcomes in all European countries.

In Figure 16, we have a situation where the line of budget-maximising values of t_m is considerably flatter than for all European countries. As a consequence, at the relevant level of tax revenue, there are almost no values of t_m that are revenue efficient. The initial point ($t_m = 32\%$ and $t_a = 27\%$) is far out in the inefficient range. Even if we lower t_m to zero, the necessary compensatory increase of t_a is negligible, and with positive t_m, we never reach the point that t_a becomes revenue-inefficient. The iso-utility line is almost horizontal, a pattern that we knew from the basic model, but which was lost with the European countries. As the iso-budget line is also very flat, we nevertheless end up far out in the revenue-inefficient range for the optimal tax progression: $t_m = 47\%$ and $t_a = 28\%$ (CRIP $= 0.74$). The Leviathan

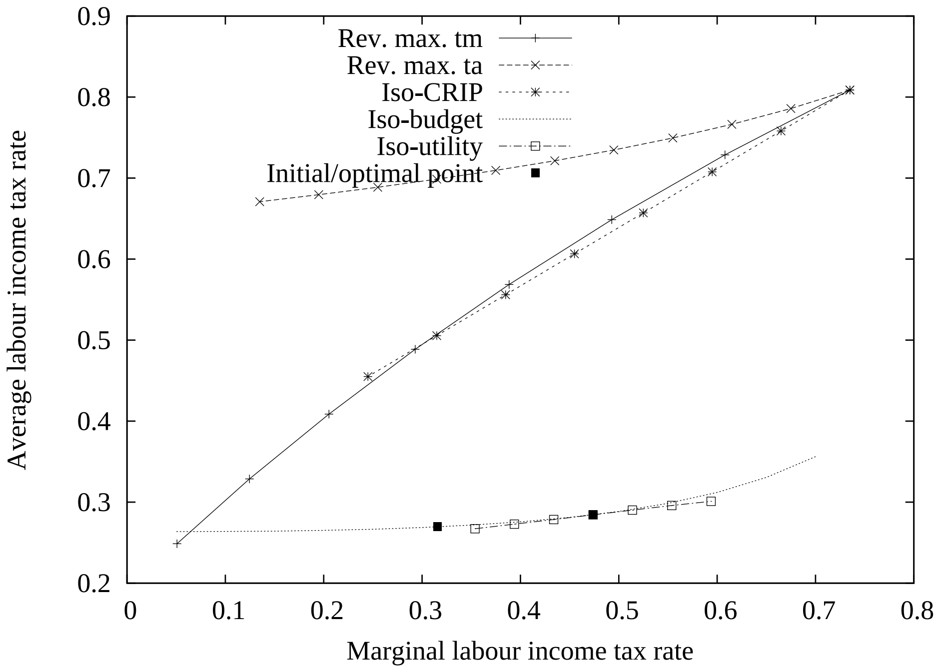

Figure 16: Efficient and optimal tax structures in Japan

point is at $t_m = 74\%$ and $t_a = 81\%$ (CRIP = 1.39).

4.7 United States of America

The picture for the USA is almost indistinguishable from that of Japan. This was to be expected given that the characteristic parameters in Table 1 are virtually the same. Here we have: initial point: $t_m = 31\%$ and $t_a = 26\%$. Leviathan point: $t_m = 73\%$ and $t_a = 81\%$ (CRIP = 1.41). Optimal point: $t_m = 47\%$ and $t_a = 28\%$ (CRIP = 0.74).

4.8 Summary of the country comparisons

At the present stage the country comparisons remain mostly descriptive. The following questions remain to be analysed and answered:

- What explains the huge variation in the steepness of the revenue-maximising

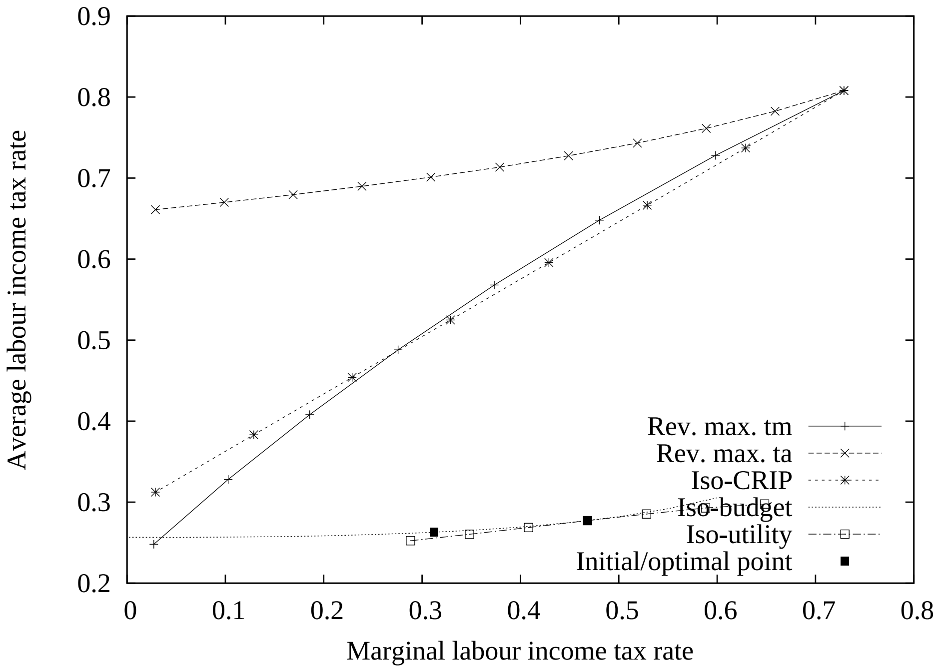

Figure 17: Efficient and optimal tax structures in the USA

t_m curve? When is the cone of revenue-efficient tax structures narrow, and when is it wide?

- What explains the steepness of the iso-utility curve? In particular: Why is it, contrary to the basic model, in so many cases clearly upward-sloping?
- Why is the iso-budget line so flat in JAP and USA?
- The most important drivers of the optimal tax progression seem to be the steepness of the iso-budget line and the steepness of the iso-utility line. What is the connection between the two?
- The CRIP at the Leviathan point is not systematically linked to the CRIP at the optimal point. Is the Leviathan point of any use for understanding the model, after all?

5 Conclusions

I have analysed the determinants of the optimal tax progression in a labour market with collective wage bargaining. This is done with the help of a numerical model, which is simple enough to keep the overview over the basic mechanisms, but complex enough to be calibrated to a number of behavioural and macroeconomic parameters, partly universal, partly country-specific.

The model is calibrated to match the following parameters: factor shares in value added, important macroeconomic tax quotas (consumption tax, labour tax, capital tax), unemployment rates, tax progressivity and replacement rate. The following behavioural parameters were additionally taken into account: wage elasticity of labour supply at the intensive and extensive margin, income elasticity of labour supply, labour demand elasticity.

The following drivers of the optimal tax progressivity could be identified in the generic model, which was calibrated to some set of average, reasonable set of parameters.

- The profit share and the profit tax rate are important, because they determine the amount of additional tax revenue from an expansion on the labour market, which in turn can be recycled in the course of a revenue-neutral tax reform.
- Consumption taxes have a similar role, because they contribute to the tax split between labour and capital/profit income.
- The extensive margin of labour supply is important, because it creates an expanding effect of a lower average tax rate. (In contrast to the expanding effect of the marginal tax rate at the intensive margin.)
- The income elasticity of labour supply is important for a similar reason, but in the opposite direction: A higher average tax rate leads to lower after-tax income and therefore to higher labour supply.
- The initial level of unemployment plays a significant role in the attractiveness of higher tax progressivity: Roughly, reductions in the unemployment rate will be in proportion to the original rate, so for low unemployment rate, the gain in

terms of saved unemployment benefits or a higher probability of employment becomes negligible.

- The indexation rule of the unemployment benefits is relevant in the following way: If benefits are not fully indexed to the after-tax wage, a lower average labour tax means that the replacement rate decreases, which exerts additional pressure on the wages.

- The initial level of tax progression seems to be of crucial importance for the simulation results. The basic model shows that already small variations in the initial degree of progressivity lead to significant shifts in the cone of efficient tax structures and in the optimal tax progressivity. The precise working mechanisms are not easy to pin down, because a change in the initial degree of progressivity has consequences for the calibration of the behavioural parameters (both in the utility function and in the wage bargaining function). This point requires further analysis.

The calibration of the model to the values of a number of large OECD economies produced only preliminary results and a number of open questions until now:

- There is a large variation between the countries in many respects: cone of efficient tax structures, Leviathan point and, particularly, in the optimal degree of tax progressivity.

- There are some countries that are reasonably close to the basic model: ESP, GBR, ITA. However, contrary to the basic model, the tax structure with optimal progressivity is far out in the revenue-inefficient range.

- For FRA and GER, the basic calibration set-up leads to a utility reversal (utility of the unemployed is higher than of the employed). This required adhoc adjustments, which still need to be checked for robustness.

- For JPN and USA, we get a radically different picture, which cannot easily be explained by any single macroeconomic or institutional parameter. This, too, has to be further investigated.

The most prominent result so far appears to be that in all countries the optimal level of tax progressivity is considerably higher than the actual one. This must be considered a very preliminary outcome and requires further checking. If there are gains from higher tax progressivity, why are they not recognised by the politicians. If we have any presumption at all, we would expect the optimal tax progressivity in the model to be lower than the actual one. This is because one of the politically relevant determinants of the actual tax progressivity are distributional concerns, which are completely absent from the model.

One could think of a number of modifications that might lead to a lower optimal tax progressivity in the model. The most likely is that the wage bargaining model overstates the flexibility of the wages as a reaction to tax progressivity. Unfortunately, empirical wage curve estimates turn out to be very unstable, so that it is difficult to find a good standard of comparison. Nevertheless, it could be illuminating to replace the wage bargaining equation in the model by wage curves that are more similar to empirical specifications.

A different line of reasoning could be that the optimal tax structures in the model would actually be (approximately) optimal for an representative ex-ante worker, who faces exactly the average unemployment risk. Actual tax policy, however, might be determined by the labour market insiders, whose unemployment risk is considerably lower, or even zero. It could be illuminating to calculate the tax structures that maximise the welfare of the employed workers, instead of the representative ex-ante worker.

Needless to say that at the present stage of the paper any idea for illuminating the results is highly welcome.

References

Aaberge, Rolf, Ugo Colombino, Erling Holmøy, Birger Strøm and Tom Wennemo (2004): Population ageing and fiscal sustainability: an integrated micro-macro analysis of required tax changes, Discussion Paper No. 367, Statistics Norway.

Arntz, Melanie, Stefan Boeters, Nicole Gürtzgen and Stefanie Schubert (2006), Analysing welfare reform in a microsimulation-AGE Model: The value of disaggregation, ZEW Discussion Paper No. 06-076, Mannheim.

Ballard, Charles L. (2000), How many hours are in a simulated day? The effects of time endowment on the results of tax-policy simulation models, Working Paper, Department of Economics, Michigan State University. Available at http://www.econ.msu.edu/faculty/ballard/HoursPaper.pdf.

Boeters, Stefan (2004), Green tax reform and employment: The interaction of profit and factor taxes, FinanzArchiv 60, 222-239.

Bovenberg, A. Lans, Johan J. Graafland and Ruud A. de Mooij (2000), Tax reform and the Dutch labor market: An applied general equilibrium approach, Journal of Public Economics 78, 193-214.

Evers, Michiel, Ruud A. de Mooij and Daniel van Vuuren (2005), What explains the variation in estimates of labour supply elasticities?, CESifo Working Paper 1633, Munich.

Fuest, Clemens, and Bernd Huber (1997), Wage bargaining, labor-tax progression, and welfare, Journal of Economics 66, 127-150.

Fuest, Clemens, and Bernd Huber (1998), Tax progression and human capital in imperfect labour markets, EPRU Discussion Paper 1998-03.

Fuest, Clemens, and Bernd Huber (2000), Is tax progression really good for employment? A model with endogenous hours of work, Labour Economics 7, 79-93.

Graafland, Johan J., Ruud A. de Mooij, André G.H. Nibbelink and Ate Nieuwenhuis (2001): MIMICing tax policies and the labour market, Elsevier, Amsterdam.

Gurgel, Angelo, Gilbert Metcalf, Nicolas Osouf and John Reilly (2007): Computing tax rates for economic modeling: A global dataset approach, MIT Joint Program on the Science and Policy of Global Change, Technical Note No. 11.

Hersoug, Tor (1984), Union wage responses to tax changes, Oxford Economic Papers 36, 37-51.

Holmlund, Bertil and Ann-Sofie Kolm (1995), Progressive taxation, wage setting and unemployment: Theory and Swedish evidence, Swedish Economic Policy Review 2, 423-460.

Jacobsen, Henrik and Peter Birch Sørensen (1997), Public finance reform with household and underground production, Working Paper, Institute of Economics, University of Copenhagen.

Jacobsen, Henrik and Peter Birch Sørensen (2000), Labour tax reform, the good jobs and the bad jobs, EPRU Working Paper.

Kleven, Henrik Jacobsen, and Claus Thustrup Kreiner (2006), The marginal cost of public funds: Hours of work versus labor force participation, CEPR Working Paper 5594.

Koskela, Erkki and Ronnie Schöb (2007), Tax progression under collective wage bargaining and individual effort determination, CESifo Working Paper 2024, Munich.

Koskela, Erkki and Jouko Vilmunen (1996), Tax progression is good for employment in popular models of trade union behaviour, Labour Economics 3, 65-80.

Lockwood, Ben and Alan Manning (1993), Wage setting and the tax system – theory and evidence for the United Kingdom, Journal of Public Economics 52, 1-29.

Mendoza, Enrique G., Assaf Razin and Linda M. Tesar (1994): Effective tax rates in macroeconomics. Cross-country estimates of tax rates on factor incomes and consumption, Journal of Monetary Economics 34, 297-323.

Mirrlees, James A. (1971), An exploration into the theory of optimal income taxation, Review of Economic Studies 38, 175-208.

Pissarides, Christopher A. (1998), The impact of employment tax cuts on unemployment and wages; The role of unemployment benefits and tax structure, European Economic Review 42, 155–183.

Rutherford, Thomas F. (1998), CES preferences and technology, in: GAMS MPSGE Guide, Washington: GAMS Development Corporation, 89-115. Available at http://www.gams.com/solvers/mpsge.pdf

Sørensen, Peter Birch (1997), Public finance solutions to the European unemployment problem?, Economic Policy 12, 223-251.

Sørensen, Peter Birch (1999), Optimal tax progressivity in imperfect labour markets, Labour Economics 6, 435–452.

Symons, James and Richard Layard (1984), Neoclassical demand for labour functions for six major economies, Economic Journal 94, 788-799.

Tuomala, Matti (1990), Optimal income taxation and redistribution, Oxford: Oxford University Press.

Appendix

A.1 Details of the Sørensen (1999) model

There is one representative household in the economy, whose utility is defined as a CES function over a set n of symmetrical goods, x_i. n is assumed "large", so that the consequences of the consumption of each individual good on macroeconomic variables can be neglected. The elasticity of substitution between each pair of goods is η:

$$u^h = \left(\sum_{i=1}^{n} (x_i^h)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{1}$$

The household maximises (1) subject to the budget constraint

$$\sum_{i=1}^{n} p_i x_i^h = I^h, \tag{2}$$

which results in the first-order condition

$$x_i^h = \frac{X^h}{n} \left(\frac{P}{p_i} \right)^{\eta}. \tag{3}$$

In (3), X^h is the composite commodity

$$X^h = n^{\frac{1}{1-\eta}} \left(\sum_{i=1}^{n} (x_i^h)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{4}$$

and P is the consumer price index

$$P = \left(\frac{1}{n} \sum_{i=1}^{n} p_i^{1-\eta} \right)^{\frac{1}{1-\eta}}, \tag{5}$$

so that

$$X^h = \frac{I^h}{P}. \tag{6}$$

Similarly, the government produces a public good, X^g, with a CES production technology

$$X^g = n^{\frac{1}{1-\eta}} \left(\sum_{i=1}^{n} (x_i^g)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}. \tag{7}$$

Inputs are chosen so as to minimise costs

$$G = \sum_{i=1}^{n} p_i x_i^g \tag{8}$$

subject to (7). This results in the same type of demand functions as for the households:

$$x_i^g = \frac{X^g}{n}\left(\frac{P}{p_i}\right)^\eta. \tag{9}$$

Firm i thus faces the output demand function

$$x_i = x_i^h + x_i^g = \frac{X}{n}\left(\frac{P}{p_i}\right)^\eta, \tag{10}$$

where $X = X^h + X^g$. The firm maximises its profits

$$\pi_i = p_i x_i - w_i L_i \tag{11}$$

in p_i, x_i and L_i subject to (10) and the production function

$$x_i = A L_i^\alpha, \tag{12}$$

treating X, w_i and P as exogenous. The maximisation results in the FOC

$$(1 - \frac{1}{\eta})p_i = \frac{1}{\alpha}\frac{w_i L_i}{x_i}, \tag{13}$$

which takes the form of a mark-up rule as the term on the RHS are the marginal costs of an additional output unit. At the same time (13) fixes the income shares at

$$s_L = \frac{w_i L_i}{p_i x_i} = \alpha(1 - \frac{1}{\eta}) \tag{14}$$

and $s_\pi = 1 - s_L$. Substituting (10) and (12) into (13) gives labour demand, which depends only on the sector-specific wage and the overall economic variables, X and P:

$$L_i = \left[\left(\frac{X}{n}\right)^{\frac{1}{\eta}} \frac{\alpha P}{m w_i} A^{\frac{1}{m}}\right]^{\frac{m}{m-\alpha}}. \tag{15}$$

Where m is the mark-up factor ($m = \frac{\eta}{\eta-1}$). The elasticity of labour demand is

$$\varepsilon_{L_i w_i} = -\frac{d\log L_i}{d\log w_i} = \frac{m}{m-\alpha}.$$

We now consider the symmetrical general equilibrium. It is characterised by (a) $p_i = P$, (b) $w_i = w$, (c) $x_i = \frac{X}{n}$ and $L_i = \frac{L}{n}$, for all i. This means, from (13),

$$P = \frac{m}{\alpha}\frac{wL}{X},$$

which, inserted into (15), gives aggregate employment as a function on the real wage

$$L = \left[\frac{n\alpha AP}{mw}\right]^{\frac{m}{m-\alpha}}. \tag{16}$$

Aggregate production immediately follows by inserting (16) into the production function. As only the real wage matters, we can normalise the aggregate price level at this stage: $P \equiv 1$.

A.2 Solution to the Nash-bargaining problem

The Nash bargaining problem in sector i is

$$\max_{w,h,L} \quad \Omega_i = \left[(U_i - \bar{U})N_i\right]^{k_i} \pi_i \qquad \text{s.t.} \quad w_i = BL_i^{\frac{\alpha-m}{m}}, \tag{17}$$

where B is a constant derived from (15) and

$$\begin{aligned} U_i &= w_i h_i - T(w_i h_i) - \frac{h_i^{1+\delta}}{1+\delta} \\ \bar{U} &= (1-u)U^a + uU^u \\ U^a &= \bar{w}\bar{h} - T(\bar{w}\bar{h}) - \frac{\bar{h}^{1+\delta}}{1+\delta} \\ U^u &= c\left[\bar{w}\bar{h} - T(\bar{w}\bar{h})\right] \end{aligned}$$

In the following, I simplify the tax notation by $t_m = T'(\cdot)$ and $t_a = T(\cdot)/(wh)$. The first-order conditions of (17) are (sector index dropped)

$$\frac{\partial \log \Omega}{\partial w} \; : \; \frac{kh(1-t_m)}{U-\bar{U}} - \frac{hN}{\pi} - \mu = 0 \tag{18}$$

$$\frac{\partial \log \Omega}{\partial h} \; : \; \frac{k\left[w(1-t_m) - h^{\delta}\right]}{U-\bar{U}} + \mu\frac{\alpha - m}{m}\frac{w}{h} = 0 \tag{19}$$

$$\frac{\partial \log \Omega}{\partial N} \; : \; \frac{k}{N} + \mu\frac{\alpha - m}{m}\frac{w}{N} = 0 \tag{20}$$

where μ is the Lagrange multiplier of the labour demand restriction, and use of the envelope theorem has been made for the expressions relating to π. (20) can be solved for μ:

$$\mu = \frac{km}{(m-\alpha)\,w} \tag{21}$$

Inserting this expression for μ into (19), we get

$$U - \bar{U} = wh(1-t_m) - h^{1+\delta}. \tag{22}$$

Using this and

$$\frac{s_L}{s_\pi} = \frac{whN}{\pi} = \frac{\alpha}{m-\alpha}$$

in (18) allows us to solve for the optimal hours, given the wage:

$$h^\delta = \frac{\alpha(1+k)}{\alpha+mk} w(1-t_m) = zw(1-t_m), \tag{23}$$

with $z = \alpha(1+k)/(\alpha+mk)$. Finally, using

$$\begin{aligned} U - \bar{U} &= u\left[(1-c)wh(1-t_a) - \frac{h^{1+\delta}}{1+\delta}\right] \\ &= uwh\left[(1-c)(1-t_a) - \frac{z(1-t_m)}{1+\delta}\right] \end{aligned} \tag{24}$$

and equating this with (22), we get an expression for u:

$$u = \frac{1-z}{\frac{(1-c)(1-t_a)}{(1-t_m)} - \frac{z}{1+\delta}}.$$

If we replace z here according to (23) by its components, we arrive exactly at expression (8) in Sørensen (1999).

A.3 Calibration of the Nash bargaining equation

(19) in combination with (21) and (24) gives

$$\frac{w(1-t_m) - h^\delta}{u\left[(1-c)wh(1-t_a) - \frac{h^{1+\delta}}{1+\delta}\right]} - \frac{1}{h} = 0 \tag{25}$$

As the initial situation is conceptualised to be a bargaining equilibrium, we must choose one of the variables contained in this equation for calibration. As there is a degree of freedom anyway, because we are free in the choice of the units for labour, we can fix w in the initial situation at an arbitrary value (conveniently $w = w_0 = 1$) and determine h so that (25) holds for the initial values (indexed with "0").

$$h_0 = \left(\frac{(1+\delta)w_0\left[u_0(1-c)(1-t_{a0}) - (1-t_{m0})\right]}{u_0 - 1 - \delta}\right)^{\frac{1}{\delta}}$$

By calibration, the initial value of h is thus fixed at a certain value, h_0, which does *not* depend on labour demand. The same is the case for the utility difference:

$$\begin{aligned} \left(U - \bar{U}\right)_0 &= u_0\left[(1-c)w_0h_0(1-t_{a0}) - \frac{h_0^{1+\delta}}{1+\delta}\right] \\ &= u_0w_0h_0\left[(1-c)(1+\delta) + (1-t_{m0})\right] \end{aligned}$$

The calibration of (20) requires then

$$\frac{kw_0h_0(1-t_{m0})}{\left(U-\bar{U}\right)_0}-\frac{s_L}{s_\pi}-k\varepsilon_{Lw}=0.$$

(s_L, s_π and ε_{Lw} are explained in Appendix A.1 and constant under the Cobb-Douglas assumptions of the model.) This means for the calibration of k:

$$k=\frac{s_L/s_\pi}{\frac{w_0h_0(1-t_m)}{\left(U-\bar{U}\right)_0}-\varepsilon_{Lw}}$$

If we use this value for k, the FOC of wage bargaining essentially becomes

$$\frac{wh(1-t_m)}{U-\bar{U}}=\frac{w_0h_0(1-t_{m0})}{\left(U-\bar{U}\right)_0},$$

which is completely independent of the values of s_L, s_π and ε_{Lw}. As long as these are constants, they play no role at all for the behaviour of the bargaining system, because any potential effect is fully compensated by the calibration of the bargaining power parameter, k. For ε_{Lw}, this is the only place in the model to appear, so it has no role to play at all. s_L, s_π, by contrast, also co-determine the tax revenue from labour and profit taxes, respectively. Therefore, they influence the model behaviour, even if not through the wage bargaining equation.

A.4 Labour supply calibration

In this appendix I explain the calibration of the CES utility function to empirical elasticities.

A.5 Value of involuntary leisure

This appendix performs a sensitivity analysis: What happens if involuntary leisure is more or less valuable to the unemployed?

A.6 OECD data sources

The entries in Table 1 have been generated in the following way:

- "s_L": share of labour in value added. From OECD "Annual National Accounts of OECD countries, Vol. 2", Issue 2005, Table 2: Gross domestic product: income approach. "1. Compensation of employees" / ("1. Compensation of employees" + "31. Gross operating surplus and gross mixed income"

- "t_C", "t_L", "t_K": effective average tax rates on consumption, labour and capital income. From OECD "Annual National Accounts of OECD countries, Vol. 2", Issue 2005, and OECD "Revenue Statistics", Issue 2004. Calculated as proposed in Mendoza et al. (1994) and further developed by Gurgel et al. (2007). In order to better fit the tax bases identified in the model of this paper, I have used the gross instead of the net capital income as basis for the capital (profit) tax. This gives substantially lower capital tax rates than those reported in the papers cited.

- "$CRIP$": coefficient of residual income progression. Calculated as $(1-t_m)/(1-t_a)$, where t_m and t_a are taken from OECD "Taxing Wages", Issue 2004, Single no child earning 100% of average production worker (APW), entries "153" and "144", respectively.

- "ur": standardised unemployment rate. From OECD "Labour Force Statistics", Issue 2005, entry "(ALFS) Total labour force, All persons, Unemployment, % total labor force".

- "rr": replacement rate. From OECD "Benefits and Wages",.Issue 2004, Table 3.3a. (p. 102) "Average of Net Replacement Rates over 60 months of unemployment 2001, for four family types and two earnings levels, in per cent", entry "without social assistance, no children, single person".