SECOND-BEST PROPERTIES OF IMPLICIT SOCIAL SECURITY TAXES: THEORY AND EVIDENCE

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Abstract

This paper investigates the inter-temporal structure of implicit taxes that arise in unfunded pension schemes. We demonstrate that these tax rates are declining over the life cycle. Using German micro-data for men and married women we estimate periodic wage elasticities of labour supply in order to check the second-best properties of this timing of tax rates. An efficient taxation would require to decrease the excessive implicit taxes for married women and to implement an inversely "J-shaped" tax profile for male workers. This result contradicts the standard proposal to smooth the profile of implicit tax rates across the individual life cycle.

JEL Classification: D91, H21, H55, J22.

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1 Introduction

The Pareto efficiency of pay-as-you-go public pension schemes and the potential welfare gains from a partial or full transition to a funded systems have been investigated in much detail during the last decade.[1] The essence of this debate can be summarised as follows: Pay-as-you-go pension schemes involve an implicit or, sometimes, explicit tax—usually a wage tax—which is due to the absence of actuarial fairness. This is true for "flat-rate benefit" schemes as well as for "social insurance type" systems where benefits are closely linked to prior contributions, establishing some degree of "intra-generational fairness" at least.[2] In the latter case, however, distortions of individual labour–leisure decisions which are induced by this wage tax cannot be exploited to nourish a Pareto-improving transition path towards a fully-funded system. As long as lump-sum payments are ruled out as a means to ensure an efficient reform, an equivalent tax will be needed in order to service the (implicit) public debt which is inherited from the incumbent pay-as-you-go scheme. As a consequence, there is no instrument left to compensate the members of any generation involved in the transition process for their potential losses (Fenge, 1995).[3]

In this paper, we focus on a different question, namely on possible efficiency gains within the unfunded pension system. We investigate the inter-temporal structure of annual (or, in a sense, "marginal") implicit tax rates that arise within the life-cycle of each age-cohort, *i.e.* on an intra-generational level. In this perspective, a new kind of potential inefficiencies enters the picture which may be induced by unfunded pension schemes. The reason is that, against the background of a model of inter-temporal optimisation, the timing of implicit taxes can distort individual decisions regarding periodic labour supply. This point, which has been rarely looked at in the literature, may shed new light on the earlier debate regarding the efficiency of pay-as-you-go schemes. In order to fill this gap, we will discuss the problem both theoretically, applying optimum taxation results to a conventional "overlapping generations" model, and empirically, using micro-data from Germany for an econometric analysis of individual labour supply decisions.

For our analysis, we build on a recent contribution by Wrede (1999) who has extended the model of Fenge (1995) in a simple, but straightforward way. Instead of dividing the relevant life-span of an individual into two periods – a period of economic activity and old age[4] – he considers a three-period setting with separate labour–leisure choices for the first two sub-periods. Given the different horizons for discounting future pension claims in order to relate them to current contributions, it is obvious that, *ceteris paribus*, the effective tax rate individuals are facing may differ between these two sub-periods. Quite generally, it will be higher for young people than for elderly workers. In

[1] See Breyer (1989), Homburg (1990), Brunner (1994, 1996), Fenge (1995), or Fenge and Schwager (1995).

[2] Here, the term "intra-generational fairness" (Homburg and Richter, 1990) is meant to say that the tax-like portion of annual contributions is the same for all members of a given age cohort. For instance, this is a distinctive feature of the German public pension system where, abstracting from some minor elements entailing interpersonal redistribution, individual pension claims are proportional to the life-time profile of annual earnings, discounted by the growth rate of average wages.

[3] See Sinn (2000) for a broader review of the literature and an extended discussion.

[4] Actually, a period of childhood, or youth, may precede the active phase of life. However, as long as parental decisions on the number of children or on their expenses per child are not modelled, this period of life can safely be ignored.

fact, the tax-like portion of contributions can even be calculated on an annual level, thus yielding a full life-time profile of implicit taxes. With constant contribution rates, using reasonable assumptions on annual interest rates, the growth rates of the number of contributors and of individual wages, this profile will be downward sloping throughout the typical life cycle of an individual (Beckmann, 2000).[5]

From an analytical point of view, the stylised model employed by Wrede (1999) suffices to conclude that Fenge's (1995) original result can be generalised to a multi-period setting only if the internal rate of return to the contributions made by young and by middle-aged workers just differs by the interest factor – implying that, from an ex-ante perspective, the implicit tax rates imposed on their periodical wages are the same. In any other case, the question of whether or not there are opportunities for Pareto-improving reforms of existing pension systems appears to be open once again.

Several routes can be taken to proceed from this finding. Assuming identical labour supply functions for both sub-periods of economic activity, for instance, one might first of all look for a set of periodical contribution rates – or, alternatively, a set of age-related accrual rates – that is suited to meet the above condition. With some sense of realism, one may expect the interest rate to exceed the rate of payroll growth over the relevant periods of life. Given that, it might appear a natural result to have lower contribution rates or higher accruals for entrants of the labour force than for elderly workers.[6] On the other hand, if appropriate adjustments of the relevant parameters are not feasible, one might argue that the differential tax treatment of wages received early in the life cycle or later on gives rise to an additional inefficiency of existing pension schemes which has been overlooked so far.

Here, however, we will follow a third path: allowing for individual labour–leisure decisions to vary over the life cycle, we will explore the second-best properties of differing tax rates imposed on periodic wages which are implied in current pay-as-you-go schemes. Furthermore, we will relate our findings on the optimal structure of implicit tax rates to an econometric assessment of individual labour supply over the life cycle which is based on panel data for West Germany. The rest of this paper is therefore organised as follows. In section 2 we will outline the basic model of individual decisions in an OLG framework in the presence of a pay-as-you-go public pension scheme with intra-generational fairness. In section 3, the second-best problems that arise in this context are being

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[5] As in the earlier chapters of this study, the distinction between (ear-marked) contribution rates and (implicit) tax rates is important here: at the margin, the tax-like fraction of current contributions can be up to 100 per cent for pure "tax–transfer variants" of pay-as-you-go institutions, and most of this discussion will not make much sense in these cases. However, if pension claims are conditioned on the amount of earlier contributions to some extent, then part of these contributions is equivalent to private savings and the effective tax rate is lower than the contribution rate. – We disregard the possibilities that (a) individuals are forced to save more than they would have done without the public pension scheme or that (b) their portfolio of old-age provision is distorted by the pension claims in terms of the risks involved. In both of these cases, the effective tax rate would be larger than the one considered here.

[6] Denoting the (periodical, not annual) interest factor by $R = 1{+}r$ and the factor of payroll growth by $G = 1{+}g$, the precise condition for Wrede's (1999) three-period setting is this: *for a given age cohort*, the first-period contribution rate θ_1 and the second-period contribution rate θ_2 should differ according to $\theta_1 = \theta_2\, R/(R{+}G) < \theta_2$. At the same time, this difference must *not* be reflected within the formula governing pension benefits. Instead, it should carry over to differing rates of return. Note that for actual pension systems – far off a steady state, that is – requirements of this type are very hard to be met. This is true even if differences in contribution rates may be feasible *between* age cohorts *within a given time period*. An alternative way of producing the same result when contribution rates are uniform ($\theta_1 = \theta_2 = \theta$) is to differentiate between periods with respect to how contributions paid convert into benefits received later on. In this case, periodic accrual rates should be higher for period 1 than for period 2.

looked at in some detail. Sections 4 and 5 are devoted to the empirical parts of the study, setting out the methodology adopted for estimating individual labour supply functions for different age cohorts and reporting on the results obtained. The data base for the empirical parts of our exercise is given by pooled time-series data taken from the German Socio-economic Panel (GSOEP) for West-German employees, running from 1988 through 1998.[7] Section 6 concludes with a discussion of our findings and of the policy issues that may arise.

2 Individual labour supply and public pensions in a three-period OLG framework

The timing of implicit taxes over individual life cycles is highly dependent (i) on a given individual's labour force attachment and on his or her effective employment record; (ii) on the precise set of rules that govern the way in which pension entitlements are built up in a specific country; (iii) on changes in either contribution rates or (expected) benefit levels that occur at some point in time during the periods of labour force participation and/or retirement that are relevant for a given individual.

First of all, we will concentrate on the effects of the pay-as-you-go mechanism proper, abstracting from redistributory elements and other institutional details of existing public pension schemes as well as from any instationarities that may necessitate changes in the main parameters of the pension system. Thus, we are trying to highlight the inter-temporal structure of implicit taxes for a basic model of individual decisions in the presence of unfunded pensions. As a consequence, the pension scheme that will be modelled here is a prototypical "social insurance" system following the German example, based on a direct, time-invariant tax-benefit-link. Therefore, contribution rates (*i.e.*, explicit "social security taxes") are assumed to be constant over time. For this case, we will obtain a clear time-profile of (implicit) periodic tax rates which is constantly decreasing over the life cycle. The problems involved in this basic structure are relevant for a broader class of real-world cases, especially for those (typically males) who are in principle willing to work on a full-time basis over their entire working life.

Among the host of potential complications we will then turn to the particular problems involved in a potential "gender tax-gap" that arises from the treatment of married couples in many public pension schemes. There, "second earners" (typically women) are often subjected to rules that were originally designed for non-working spouses, implying that individual benefits linked to any contributions they are making from actual earnings simply replace other, non-contributory benefits they would be entitled to receive as dependants or survivors. Deductions of this kind can be made on a one to one basis or at lower rates. In any case, they will add to the implicit tax rates that are built into the pay-as-you-go system as such, thus potentially affecting decisions of many women to participate in areas of the labour market that are covered by social old-age protection.

[7] For a brief description see Burkhauser et al. (1997).

a) The time structure of implicit taxation: the basic model

The overall setting for our analyses is that of a small open economy where in each period t the interest factor R_t is exogenously determined, also fixing the capital intensity and the wage rate w_t. For the ease of exposition we confine our attention to members of a single generation and to three periods of their lives (effectively overlapping with the life-span of other generations). In each generation entering the labour market in period *t* ("generation *t*") there are N_t individuals. Thus, individual members of generation 1 typically enter the labour force at the beginning of period 1; disposable time per period is normalised to unity such that their labour supply is l_1^1 and leisure is given by $1-l_1^1$. In period 2, they are elderly workers, supplying labour l_2^2. (Here, lower indices denote periods, while upper indices distinguish "young" workers in their first period of employment from "older" workers in their second period of employment.) They retire and are entitled to receive pensions p_3 in period 3. Periodic consumption is denoted by c_1^1 through c_3^3, respectively. In the first two periods of life, individuals consume part of their wages, while period 3 consumption is nourished from old-age pensions and, if appropriate, from pure life-cycle savings – implying that there are no bequests.

If the pension system involves no intra-generational redistribution, all individuals in generation 1 can be taken to be identical. *Ex ante*, each of them faces the following problem:

$$\max_{c_t, l_t} U(c_1^1, c_2^2, c_3^3, 1-l_1^1, 1-l_2^2) \tag{1}$$

subject to the inter-temporal budget constraint

$$c_1^1 + \frac{c_2^2}{R} + \frac{c_3^3}{R^2} = (1-\theta)w_1 l_1^1 + \frac{(1-\theta)w_2 l_2^2}{R} + \frac{p_3}{R^2}. \tag{2}$$

In the life-time budget constraint, life-cycle savings that are used to transfer resources across periods in order to establish the optimal structure of periodic consumption just cancel out.[8] For simplicity, we assume the interest factor R to remain constant across periods, while wages w_t may differ due to technological change. The parameter θ represents the rate of ear-marked contributions to be made to the pension scheme which operates on a pay-as-you-go basis. Given a constant θ, the individuals contribute a fixed portion of their current wages to finance for period 1 and 2 pensioners. Once they are retired, their pension is funded by the contributions of those who are actively working in period 3.

Two further simplifications can be made. First, the relative price of consumption in each period is determined solely by the interest factor R which, in turn, will not be affected in the following analyses. Thus, for generation 1 we may replace $c_1^1 + R^{-1}c_2^2 + R^{-2}c_3^3$ by the composite consumption

[8] Yet, they are needed – assuming that the optimum degree of consumption smoothing is not accomplished through public pensions alone.

good c_1. Second, the simple algebra of unfunded pensions and a stylised formula for individual benefit entitlements can be used to restate equation (2) in terms of the effective tax rates τ_t implied in θ. The periodic pay-as-you-go constraint of the pension system implies that pensions accruing in period 3 are given by $p_3 = \theta\, w_3(\bar{l}_3^2 N_2 + \bar{l}_3^1 N_3)/N_1$. Here, the $\bar{l}$-notation is meant to indicate that, as far as the determinants of the pension budget are concerned, labour supply is exogenous to any individual's maximisation problem because it is averaged over a larger number of agents belonging to subsequent age cohorts. Next, it is important to know how much of the full benefit can in fact be attributed to contributions made in each period of life. In a prototypical "social insurance" scheme, with strong tax-benefit links, the internal rate of return to earlier contributions $\theta\, w_t l_t$ can be written in terms of periodic accrual rates γ_t, or in terms of the corresponding factors $\Gamma_t = 1+\gamma_t$ used for indexing pension entitlements, with

$$\begin{aligned} \Gamma_2 &= \Gamma(g_2, n_1, n_2) \\ \Gamma_3 &= \Gamma(g_3, n_2, n_3). \end{aligned}$$

Here g_t is the periodic growth of wage rates (from period $t-1$ to t), and n_t is the growth rate of generation t over generation $t-1$. Thus, Γ_t is mainly determined by the well-known ingredients of the Aaron (1966) condition, *i.e.* the factors constituting aggregate payroll growth.[9] Given that, we can go back to equation (2) and substitute for p_3 a definition of individual pension benefits which is based on periodic accruals $\Gamma_2\Gamma_3\theta\, w_1 l_1 + \Gamma_3\theta\, w_2 l_2$, such that the inter-temporal budget constraint reduces to

$$c = (1-\tau_1)w_1 l_1 + \frac{(1-\tau_2)w_2 l_2}{R}, \tag{2a}$$

where

$$\tau_1 = \theta\,\frac{R^2 - \Gamma_2\Gamma_3}{R^2} \quad \text{and} \quad \tau_2 = \theta\,\frac{R-\Gamma_3}{R}$$

[9] In a benefit formula modelled on German institutions, for instance, where all periods of economic activity have equal weights and the amount of benefits related to each period is determined by the ratio of individual wages over average wages earned in this period, periodic rates of return are given by

$$\begin{aligned} \Gamma_2 &= (1+g_2)\frac{2+n_1}{2+n_2}\frac{(1+n_2)\bar{l}_2^1 + \bar{l}_2^2}{(1+n_1)\bar{l}_1^1 + \bar{l}_1^2} \\ \Gamma_3 &= (1+g_3)(1+n_2)\frac{2+n_2}{2}\frac{(1+n_3)\bar{l}_3^1 + \bar{l}_3^2}{(1+n_2)\bar{l}_2^1 + \bar{l}_2^2}. \end{aligned}$$

Considering the simple structure of our model, this may appear surprisingly complex. Assuming for simplicity that population growth n and periodic labour supply l^1 and l^2 are constants, these rates of return boil down to $\Gamma_2 = (1+g_2)$ and $\Gamma_3 = (1+g_3)(1+n)(1+n/2)$, respectively. For a decomposition of the internal rate of return in unfunded pension schemes into periodic factors like Γ_2 and Γ_3, explaining the asymmetry of Γ_t with respect to n, see Beckmann (2000).

are the effective (benefit-adjusted or "implicit") tax rates. If $\Gamma_t < R$ is assumed throughout, then both these effective tax rates are positive,[10] and $\tau_1 > \tau_2$ (as was argued in the introduction). Note that the difference between periodic rates of τ_t can be really substantial. Assuming that n_t is zero throughout, that wage growth is 2 percent on an annual basis (amounting to $g_t = 0.49$ over a period of 20 years), that the annual interest rate is 4 percent (such that $R-1=1.19$), and that the contribution rate θ is 20 percent, τ_1 would be 10.8 percent (54 % of period 1 contributions), while τ_2 would be 6.4 percent (32 % of period 2 contributions). It may not be unreasonable to conclude that this will affect individual decisions regarding periodic labour supply.
The above maximisation problem can finally be solved to obtain the implicit utility function

$$V\big((1-\tau_1)w_1,\,(1-\tau_2)R^{-1}w_2,\,R,\,I\big) \tag{3}$$

where net wages $(1-\tau_t)R^{1-t}w_t$ and the interest factor R are the relevant prices, and $I \equiv (1-\tau_1)w_1 + (1-\tau_2)R^{-1}w_2$ is full income for $l_t = 1$, imputing the net wage to any amount of leisure consumed.
For the purpose of our study, the most important result is that

$$\frac{\partial V}{\partial \tau_t} = -\frac{\partial V}{\partial(1-\tau_t)} = -\lambda R^{1-t} w_t l_t < 0 \tag{4}$$

by Roy's identity, $\lambda > 0$ being the marginal utility of leisure, goods consumption, or – speaking most generally – of income. Irrespective of their precise timing, taxes on wage income (or, subsidies for leisure) distort the first-best allocation and, as is well-understood, decrease the welfare of all individuals affected. If this burden exceeding the pure tax payments cannot be avoided, one should at least attempt to minimise it. In order to do so, the main instrument is given by the time structure of τ, *i.e.* τ_1 and τ_2.

b) A gender tax-gap

In our basic model, the way we represented the rules regarding how individual pension entitlements are determined in many pay-as-you-go schemes is largely appropriate if we argue against the background of a rough three-period model, each period of time spanning something like 20 years, and if

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[10] Beckmann (2000) points to an interesting asymmetry between the two main determinants of Γ_t – *i.e.* the growth factors of individual wages, $1+g_t$, and cohort size, $1+n_t$ – which may affect the sign of τ_t. Since in a German-type pension scheme, all annual contributions participate in long-term population growth in terms of their internal returns, τ_t may well become negative for years that are located rather late in the individual life cycle, even though none of the standard ("non-Aaron") assumptions regarding r, g, and n is violated and the life-time rate of τ is positive. The only condition is that $1+n_t$ must be sufficiently larger than one over the relevant periods of time. This is mostly overlooked in analyses building on two-period OLG models. In a three-period setting it may still be irrelevant with respect to τ_2 which, in fact, represents an aggregate rate for, say, 20 years. *A fortiori* this is true if we assume n_t to be close to unity in an ageing society.

we look at individuals who are basically willing to pursue a full-time working career over their entire phase of economic activity.

If, instead, we would spell out individual life-cycles on an annual basis, periodic accruals would exhibit many non-linearities in most existing pension schemes. Important reasons are given by minimum qualification periods, benefit rules of the "best x out of y years"-type, special early retirement programmes, *etc.*[11] Some of these aspects are also relevant if we look at individuals with more fragmented employment records. In addition, we would then have to take into account the way in which spells of (registered) unemployment, temporary disablement, or (limited) parental leaves are treated when it comes to calculating individual pension benefits. For instance, if we look at individuals with long part-time careers the differentiation of accrual rates across earnings brackets or regulations regarding minimum pensions for those with many years of low contributions become important.

These considerations lead us to another point we are willing to deal with in more detail. In many existing public pension schemes, there is a potential "gender tax-gap" implying systematic differences across males *vs.* females regarding both their implicit life-time tax rates and their implicit annual tax rates. One reason why both τ and τ_t might be *lower* in the case of women is that, in most industrialised countries, life-expectancy is considerably higher for females than for the average male. In current public pension schemes, this is next to nowhere reflected by gender-specific benefit formulae which would follow from actuarial principles. However, for women who are not working on a full-time basis throughout their active periods of life, this effect can be more than offset by features like the following:

– In the US and Japan, there are non-contributory benefits for spouses of retirees if the former have no employment record of their own.[12] If a married woman takes up work – temporarily or part-time, and usually at lower wage rates than the average male – she will forego (part of) the benefits that are linked to her marital status. In other words, she will effectively have to pay contributions without a corresponding increase in her full pension claim.
– In many more countries, including Germany, a woman who stayed out of the labour market most of her life is at least entitled to receive survivor benefits once her husband is deceased. Again, these benefits are reduced if the woman holds pension claims of her own, and part of her contributions is lost on benefits foregone.

Therefore, as long as the woman's earnings do not exceed a relevant threshold – *i.e.*, if her own pension claims are not simply too high for any of these "benefit testing" procedures to be relevant at the margin – the implicit tax rates she is facing can be much *higher* than those for men. (In fact, τ can be up to 100 percent if the different types of benefits are cleared on a one to one basis.) The basic problem is that, in both of the cases mentioned above, working women are subjected to rules that were designed for the case of non-working housewives and mothers which were rather wide-

[11] Note that many early retirement programmes that have been established during the 1980s and 1990s were intended to allow younger people to enter the labour market instead of becoming unemployed. However, these programmes have largely proven ineffective and are now scaled back. With "best x of y" rules, the number of years x which qualify for full pension benefits is now typically extended to approach the maximum number of active years y.

[12] In the US, dependants' allowances can be up to 50 percent of the insured person's benefit and thus are far more important than in the case of the Japanese *kokumin nenkin*.

spread in earlier times. Today, these rules may no longer be appropriate for the majority of (married) women. Furthermore, they may now create disincentives against a fundamental trend of socio-economic change, discouraging women with (less than) average earnings capacities to extend their labour force attachment even if they want to.[13]

If we want to state these problems more formally, we come up against certain limitations of our simple three-period model. In its basic form, the model does neither allow for variations in life-expectancy, nor can it easily be extended to cover an additional period of time for survivant spouses. For the case of married women with earnings that fall in the range where reductions of their individual pension entitlements matter we will therefore consider the following scenario, supposed to cover both the existence of dependants' allowances and survivor benefits in a simple, stylised way. At the same time, we will abstract from differences in life expectancy for an instant.

Building on a simple "male-chauvinist" model of household labour supply, we may take pension benefits that are granted to dependants and survivors and are linked to the employment record of the "first earner" in the household as being included in the husband's budget set.[14] For his wife, these benefits will then be exogenously given as a benefit component $\overline{p}_3$, while earnings-related benefits are subject to a special (say, linear) discount δ, with $0 < \delta \leq 1$, such that $p_3^f = \overline{p}_3 + (1-\delta) p_3(\theta\, w_1^f l_1^f, \theta\, w_2^f l_2^f)$. Now, disregarding $\overline{p}_3$ in order to avoid double counting with respect to the full benefit of the household and plugging in $p_3^f - \overline{p}_3$ in the woman's life-time budget constraint, which is otherwise similar to equation (2), we obtain

$$(2b) \qquad c = (1-\tau_1-\delta) w_1^f l_1^f + \frac{(1-\tau_2-\delta) w_2^f l_2^f}{R},$$

with $\tau_1 + \delta$ and $\tau_2 + \delta$ being the effective, benefit-adjusted tax rates. It is easy to see that, in this version, implicit taxes imposed on women who are married will always be higher – by $\delta > 0$ – than those falling on the benchmark-case of married ("first-earner") men. Given this particular tax structure, married women will then decide whether or not to participate in the labour market, either on a full-time or a part-time basis, in periods 1 and 2.[15]

Of course, differences in life-expectancies are ignored here. However, the undisputed fact that on average women tend to live longer than males can be off-set by another aspect which becomes apparent in our stylised setting. For married women who are actively working, the expected value of

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13 It should be stressed here that we are primarily concerned with non-contributory benefits that are linked to just being married, not to being a mother. In the context of pay-as-you-go pension schemes, benefits of the latter type may serve a specific function in rewarding investment in human capital, *i.e.* in future workers and contributors (see Sinn and Werding, 2000; Werding 2001). In these cases, alleviating potential conflicts between labour force participation and child care without creating particular incentives or disincentives to do one thing or the other is clearly a matter of its own.

14 In other words, they will be included in the amount of benefits $p_3^m = p_3(\theta\, w_1^m l_1^m, \theta\, w_2^m l_2^m)$ which we mainly considered in the previous sub-section.

15 Here, we shun the introduction of more complex models of household time allocation, taking into account other decision rules, like those related to joint optimisation or mutual altruism, as well as introducing household production as a third option for using time instead of working in the labour market or consuming leisure. Qualitatively, models of this kind would lead to the same result.

survivor benefits that their husbands will be entitled to receive is very low – in fact, it will be zero for the typical "second earner" female in most existing pension schemes. (By definition, the same is true for women who never marry, while most of our other considerations do not apply in these cases.) The diverging effects considered here – higher life-expectancy of women, low expected survivor benefits accruing to the husbands of working women, and several types of reductions in their own benefits – need not cancel out. Ultimately, the existence and size of what we called a "gender tax-gap" is an empirical issue to which we will turn now, based on an empirical illustration of the profile of implicit tax rates for typical males and (married) females in the case of Germany.

c) Empirical illustration: the structure of implicit taxes in the case of Germany

In sub-section a) we essentially showed that, in a generic unfunded pension system modelled on the German *Rentenversicherung*, implicit tax rates falling on individual members will constantly decrease over the life cycle provided that (i) contribution rates (*i.e.*, explicit "social security taxes") are constant over time and (ii) the benefit formula (or, rather, the tax-benefit link) remains unchanged. Obviously, under real-world conditions things will be a bit more complicated. In Germany, the benefit level has increased from some 60 percent to a current 70 percent of current wages during the 1960s and 1970s;[16] it has then been roughly constant until very recently and is now expected to go down again to about 63 percent until the year of 2030. At the same time, contribution rates were at 14 percent in the early 1960, then went up to a current 19.3 percent (2000) and, given the current legal framework, are expected to approach 25 percent by 2050 (see section 2.2 a).

Given these instationarities, the effective time structure of implicit taxes for each age cohort, if evaluated at an annual level, may be rather different from the simple profile predicted in our earlier three-period model. Using the CESifo Pension Model, we are able to calculate the relevant time profiles over a full working-age period of 45 years for all age cohorts starting from those born in 1929 to those born in 1999.[17] Using life expectancy data for male individuals in order to determine the length of the retirement period and including survivor benefits for the remaining life-span of their widows,[18] the results can be taken to represent the life-time profiles of implicit taxes for representative (married) males in each cohort. Since the full picture – with 71 individual graphs – may easily appear to be confusing, we confine our attention to just eight birth cohorts (born 1929, 1939, *etc.*) in figure 1.

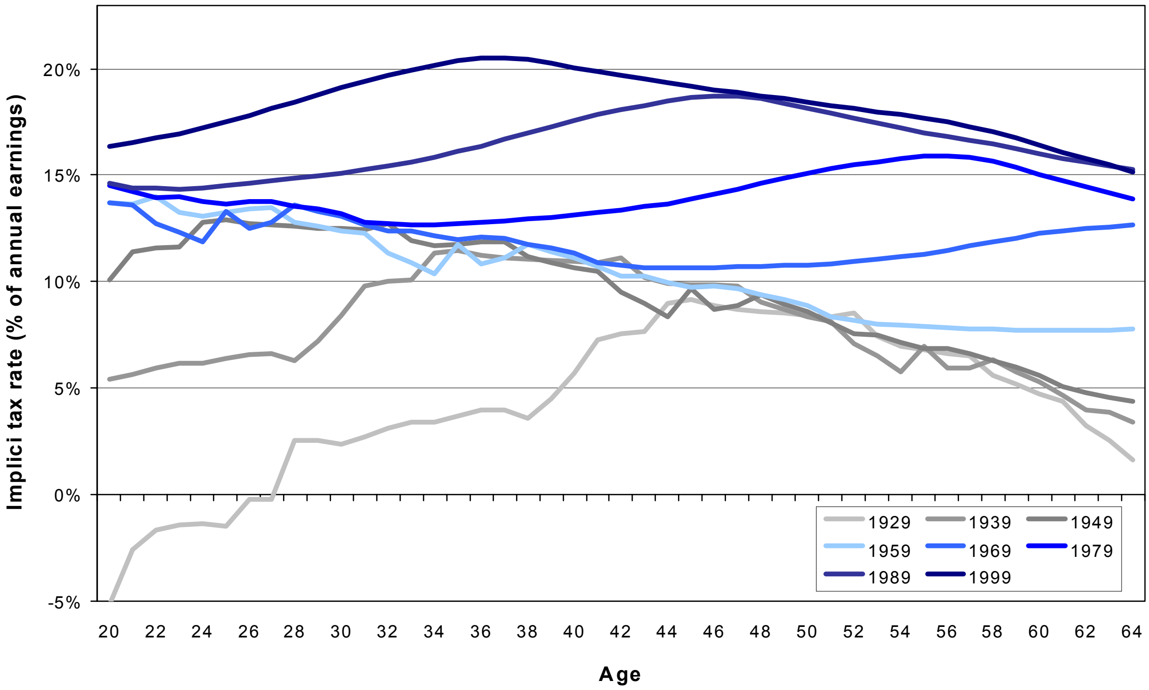
[16] Here, the benefit level is measured in terms of pensions (net of taxes, which are largely absent for a typical pensioner) taken as a percentage of current average net earnings, assessed for an individual with a complete full-time work record who earns average wages throughout the time spent in employment.

[17] For the assumptions regarding the standardised work biographies see the appendix.

[18] Thus, our calculations conform to the simple "male-chauvinist" model of household labour supply suggested in sub-section b).

Figure 1

Actual implicit tax rates over the life-cycle: the case of Germany (men)



Source: CESifo Pension Model.

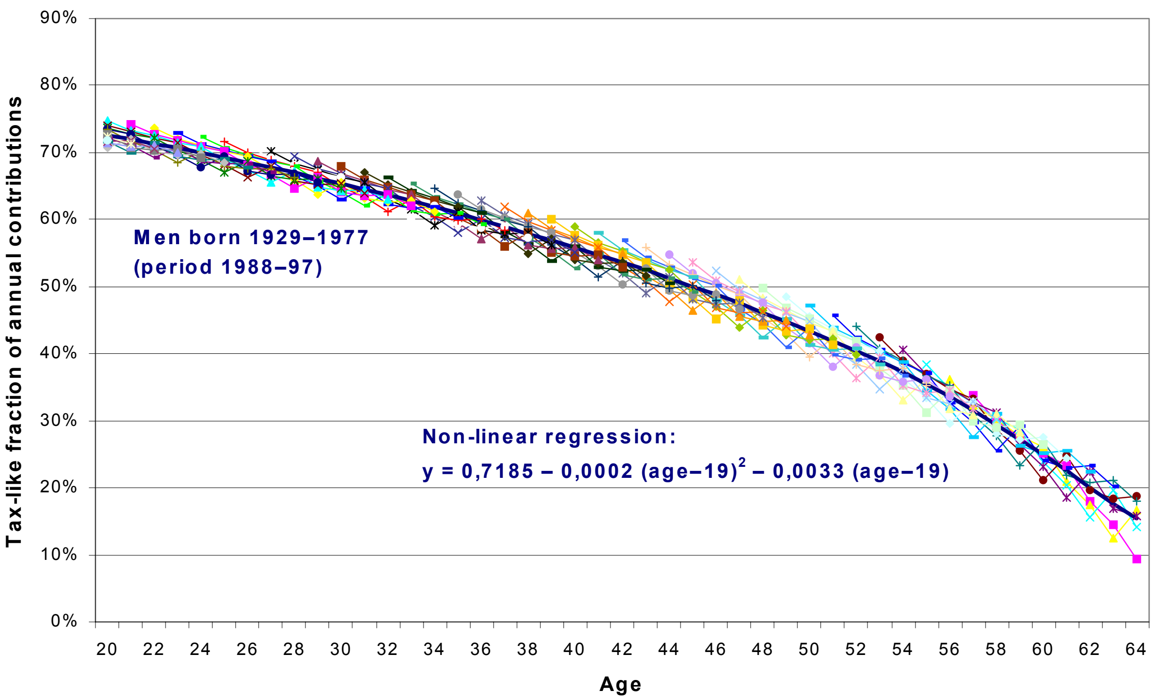
It is easy to see that older age cohorts, *i.e.* those born 1929 through 1949, have benefited from the expansion of the German public pension scheme that took place in the after-war period. During their early years in employment, these cohorts had to pay rather low contribution rates, while they are now entitled to receive pension benefits at a level which may well turn out to represent the all-time peak within our full projection horizon.[19] For the age cohort born 1959, we have a very simple pattern of effective annual tax rates that are slowly, but constantly, declining over time. All age cohorts born 1969 and after are negatively affected – though each at a different stage of their life cycle – by the up-swing of contribution rates and the down-turn of benefit levels which are projected to take place in the coming decades, the main reasons being demographic ageing and the policy responses taken so far. In each case, however, we also observe the fundamental downward trend that was predicted in our simple baseline model, once the parametric changes have been made and the system settles to a new "equilibrium". In a sense, our theoretical predictions are thus confirmed by the empirical example, although lots of disturbances of the fundamental time pattern of implicit taxes have to be conceded.

Interestingly enough, if we look at a smaller set of age cohorts who will effectively enter our subsequent empirical analysis (those born 1929 through 1977) and at the ten years that are effectively covered by our sample period (1988 through 1997), things turn out to be less complicated. If, instead of calculating tax rates as a percentage of annual earnings, we look at the tax-like fraction of

[19] The negative tax rates observed for the first years of employment of these individuals clearly reflect part of the "inaugural gains" which always arise if an unfunded pension scheme is introduced or expanded.

annual contributions,[20] figure 2 illustrates what happens to typical males who are at different stages of their life cycles in the period of time from which the data used in our econometric analysis are actually taken.[21] Here, we also display the time structure of τ_t for all individual birth cohorts considered in order to demonstrate that they really follow a clear-cut pattern. Building on these individual profiles for each birth cohort, we are able to construct an artificial life cycle spanning 45 years which is effectively made up by a series of overlapping sub-periods of economic activity, each with a maximum length of ten years, for all the cohorts considered.[22] As a bold line, the figure exhibits the result of a non-linear regression that was fitted to the series of actual taxes. For individuals contained in our data set, the tax-like fraction of contributions constantly decreases from about 72 percent in the first year of employment to about 17 percent in the year before retirement. This clearly conforms with our description of the basic problem we are concerned with.

Figure 2
Actual implicit taxes in Germany for the period 1988–1997: men



Source: CESifo Pension Model.

Turning to similar calculations for the case of women, we have to take into account that females can expect to live longer on average than males. On the other hand, the women's own pension claims

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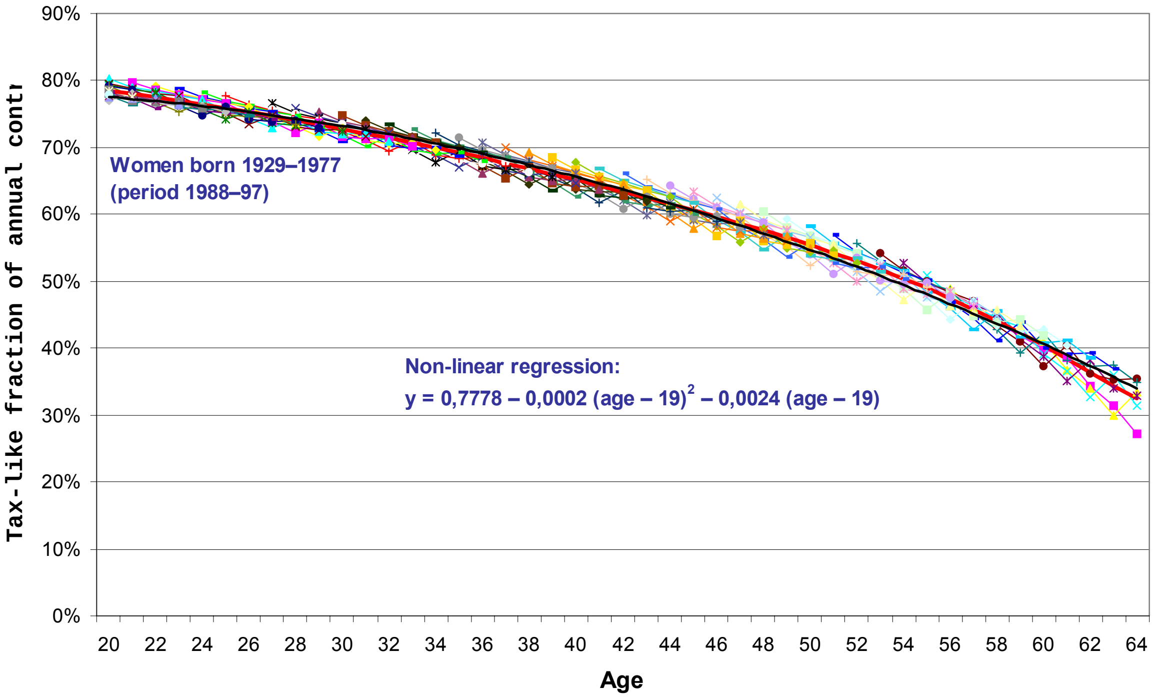
[20] In terms of our earlier analysis, this fraction is something like $(R^t - G^t) / R^t$, now evaluated at an annual level (see equation 2*a*). The portion is directly relevant for our empirical set-up because it indicates what part of contributions made to the public pension scheme has to be subtracted when calculating net wages.

[21] This is the 1988–97 interval; for more details, see section 3.

[22] Effectively, the oldest cohort included in figure 2 is born in 1924, assumed to be in their last year of employment in 1988, then aged 64. In our empirical model, we effectively dropped individuals aged 60 and over, thus starting with the birth cohort of 1929.

will rarely extend to benefits for survivant spouses and, at the same time, are reduced if they coincide with survivor (and/or spouse) benefits that originate in their husbands' pensions. The net effect of these diverging trends in the case of the German public pension scheme is illustrated in figure 3, concentrating again on implicit taxes faced by (married) women born 1929 through 1977 in the 1988–1997 period and expressing these taxes implied in the pension scheme as a percentage of contributions paid in each year in employment.[23]

Figure 3
Actual implicit tax rates in Germany for the period 1988–1997: married women



Source: CESifo Pension Model.

Comparing the results displayed in figures 2 and 3 shows that, at each point in time during the active span of life, actual implicit taxes falling on female workers (who are married) are higher than for their male counter-parts.[24] This is mainly what we expected based on our theoretical considerations.

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[23] Note that, by the construction of the formula governing individual pension benefits in Germany, the profile shown in figure 3 is not only relevant for women who are actively participating in the labour market over their full working-age period of life. With more fragmented work records, women are subject to the same, uniform profile – their years in employment alternating with longer periods of inactivity.

[24] For women who stay single over their entire life time, the effects of higher life-expectancy and the absence of survivor benefits their spouses would be entitled to receive next to cancel out. Thus, their life-time profile of actual implicit tax rates is rather similar to that of typical males. Since we will not deal with this very heterogeneous subgroup in the following, because it is hard to identify in an empirical context, we drop the results obtained for single women.

3 Implicit taxes and optimal taxation

In our basic model for full-time earners, two goods (leisure $1-l_t$ consumed in periods 1 and 2, respectively) are being taxed, while one (goods consumption c) is not.[25] In addition, we have seen that the taxes that are effectively imposed on periodic wages will generally differ across periods t. This relates our analysis to a series of standard results from the theory of optimum taxation which are best summarised by Sandmo (1974; see also Atkinson and Sandmo, 1980).

In the tradition of optimal-taxation theory, public authorities are assumed to maximise utility V (equation 3) subject to the additional constraint that tax revenues $\tau_1 w_1 l_1 + \tau_2 R^{-1} w_2 l_2$ have to meet a given amount of T. Here, T is the effective net tax to be levied from individuals in a given generation across their life cycle – discounted at period 1 values – in order to keep the public debt implied in the pay-as-you-go pension scheme on an equilibrium path. The size of T depends on the difference between aggregate wage growth and the interest rate, as well as on the level of pensions (or the replacement ratio) which is present in the contribution rate θ. In other words, T is an implicit tax on actuarial returns to earlier contributions; it is required to make the periodic budget of the pension system, and the debt hidden behind it, just grow by the rate of payroll growth – thus making sure that θ can be held constant over time, provided that all other conditions for a steady state are fulfilled.

Formulating the problem of optimum taxation in terms of a conventional Lagrangean leads to the following set of first-order conditions:

$$\text{(5)} \qquad \frac{\partial V}{\partial \tau_t} - \mu \left(\tau_1 w_1 \frac{\partial l_1}{\partial \tau_t} + \tau_2 R^{-1} w_2 \frac{\partial l_2}{\partial \tau_t} + R^{1-t} w_t l_t \right) \equiv 0,$$

$\mu > 0$ being the Lagrange multiplier associated with the revenue constraint discussed above. Utilising (4) and rearranging terms, we can rewrite these conditions as

$$\text{(6)} \qquad \tau_1 w_1 \frac{\partial l_1}{\partial \tau_t} + \tau_2 R^{-1} w_2 \frac{\partial l_2}{\partial \tau_t} = -\frac{\lambda + \mu}{\mu} R^{1-t} w_t l_t = -\nu\, R^{1-t} w_t l_t .$$

By inspection of equation (6) we can now spell out a number of results regarding the optimal structure of τ_t, *i.e.* the optimal timing of implicit taxes.

First of all, differentiating the individual budget constraint (2*a*) with respect to τ_t, yields

$$\text{(7)} \qquad \frac{\partial c}{\partial \tau_t} - (1-\tau_1) w_1 \frac{\partial l_1}{\partial \tau_t} - (1-\tau_2) R^{-1} w_2 \frac{\partial l_2}{\partial \tau_t} + R^{1-t} w_t l_t \equiv 0 .$$

Solving (7) for $R^{1-t} w_t l_t$ and substituting the result into (6) we obtain

[25] Alternatively, c may be taxed at a fixed rate which is completely outside our focus.

(8) $$\left(\tau_1(1-\nu)+\nu\right)w_1\frac{\partial l_1}{\partial \tau_t}+\left(\tau_2(1-\nu)+\nu\right)R^{-1}w_2\frac{\partial l_2}{\partial \tau_t}=-\nu\,\frac{\partial c}{\partial \tau_t}\,.$$

It is immediate from equation (8) that, if $\partial c/\partial \tau_t = 0$, optimal tax rates should be uniform across time with $\tau_1 = \tau_2 = -\nu/(1-\nu)$. In this case, we may thus state

Proposition 1a ("lump-sum taxation"):
If goods consumption is completely inelastic with respect to taxing labour, then a linear tax on life-time income is optimal.

The intuition for this result is simple. With inelastic expenses on *c*, the tax levied on wage income effectively turns into a (proportional) tax on life-time consumption. In optimum, it should not distort the individual's choices between labour and leisure over the two periods considered here and, therefore, assumes the properties of pure lump-sum taxation.

According to Sandmo (1974), there is a broader class of cases where the optimal tax structure is linear across time. For instance, the scenario for proposition 1a to be true can be considered a special case where, in general, $\partial c/\partial \tau_t$ is not zero but depends linearly on period 1 and period 2 wage income ($\partial c/\partial \tau_t = \; = -\gamma\, R^{1-t} w_t l_t$).[26] Again, a proportional tax structure can be constructed, with $\tau_1 = \; = \tau_2 = -\nu/(1-\gamma-\nu)$, which solves a condition corresponding, *mutatis mutandis*, to equation (8). A preference mapping which supports this result – perhaps, one among others that are not as well received in theory – has the following properties: utility must be weakly separable between consumption and labour (leisure) and homogeneous in the latter, representing a homothetic indifference map for period 1 *vs.* period 2 leisure demand (labour supply). This leads to

Proposition 1b ("uniform taxation"):
If there is *no*, or *no special*, relationship of complementarity or substitutability between earning wage income in period 1 or 2, respectively, and consuming goods, the optimum tax on life-time income is also linear.

The simple assumption that labour supply functions are identical across periods is just another special case of this variety. However, none of the cases captured by our propositions 1a or 1b appears to be very realistic. As a matter of fact, Sandmo's (1974, p. 705) conclusion that "proportionality will be the exception rather than the rule" appears to be valid also in the present context, with regard to the optimal structure of wage taxes on an inter-temporal level.

In an attempt to be more general, we should certainly allow for $\partial c/\partial \tau_t$ to be of arbitrary form. If, in fact, we impose no further restrictions at all on the basic optimum taxation problem, we can start by rewriting equation (6) as

[26] *I.e.*, the substitution term must be zero or must also depend linearly on wage income if we expand $\partial c/\partial \tau_t$ in terms of the Slutsky decomposition. (Note that the income effect is always linear in $R^{1-t}w_t l_t$.)

(6*a*)
$$\sum_{s=1}^{2}\tau_s R^{1-s} w_s \frac{\partial l_s}{\partial \tau_t} = -\nu R^{1-t} w_t l_t, \qquad t = 1, 2$$

(see, *e.g.*, Atkinson and Stiglitz, 1980, ch. 12, for a canonical treatment of the "Ramsey tax problem"). Note that the term $\partial l_s / \partial \tau_t$, capturing both "own-price" and "cross-price" effects, is equal to

$$\frac{\partial l_s}{\partial \tau_t} = -\frac{\partial l_s}{\partial\big((1-\tau_t)R^{1-t}w_t\big)} R^{1-t} w_t = \big(l_t \frac{\partial l_s}{\partial I} - S_{st}\big) R^{1-t} w_t$$

by the Slutsky expansion, where

$$S_{st} = \left.\frac{\partial l_s}{\partial\big((1-\tau_t)R^{1-t}w_t\big)}\right|_{\bar{u}} \equiv S_{ts}$$

are the (symmetrical) substitution terms, evaluated at a compensated level of utility. Applying these intermediate results to (6*a*) and rearranging yields:

(9)
$$\sum_{s=1}^{2}\tau_s R^{1-s} w_s S_{ts} = \big(\nu + \sum_{s=1}^{2}\tau_s R^{1-s} w_s \frac{\partial l_s}{\partial I}\big) l_t, \qquad t = 1, 2\,.$$

The term in brackets on the right-hand-side of (9) is independent of t and can therefore be replaced by ξ. Defining the compensated price elasticities

$$\varepsilon_{ts} = \frac{(1-\tau_s)R^{1-s} w_s}{l_t} S_{ts}$$

and, as it is usually done, switching the notation to tax rates imposed on wages *net*-of-taxes, $\tau_t /(1-\tau_t)$, leads to

(10)
$$\sum_{s=1}^{2}\frac{\tau_s}{1-\tau_s}\varepsilon_{ts} = \xi, \qquad t = 1, 2$$

or, written in matrix form,

(10*a*)
$$\mathbf{S}\,\boldsymbol{\tau} = \begin{pmatrix} \varepsilon_{11} & \varepsilon_{12} \\ \varepsilon_{21} & \varepsilon_{22} \end{pmatrix} \begin{pmatrix} \tau_1/(1-\tau_1) \\ \tau_2/(1-\tau_2) \end{pmatrix} = \begin{pmatrix} \xi \\ \xi \end{pmatrix} = \boldsymbol{\xi}\,.$$

Using Cramer's rule, we can then solve for the optimum tax rates which are given by

(11) $$\frac{\tau_1}{1-\tau_1}=\frac{\xi}{\det\mathbf{S}}(\varepsilon_{22}-\varepsilon_{12}) \quad \text{and} \quad \frac{\tau_2}{1-\tau_2}=\frac{\xi}{\det\mathbf{S}}(\varepsilon_{11}-\varepsilon_{21}),$$

respectively (taking for granted that $\det\mathbf{S}=\varepsilon_{11}\varepsilon_{22}-\varepsilon_{12}\varepsilon_{21}>0$). The optimal timing of effective tax rates is therefore characterised by

(12) $$\frac{\tau_1}{1-\tau_1}=\frac{\varepsilon_{22}-\varepsilon_{12}}{\varepsilon_{11}-\varepsilon_{21}}\frac{\tau_2}{1-\tau_2}.$$

I.e., the relation between optimal tax rates to be imposed on period t wages depends inversely on the compensated price elasticities of labour supply in periods t, modified by compensated price effects with respect to period $s \neq t$ wages. To sum up, we may state

Proposition 2 ("Ramsey rule"):
In the general case, wages should be taxed more heavily in those periods of an individual's working life where

- the compensated elasticity of labour supplied with respect to the same period's net wages (*i.e.*, the own-price effect) is low if compared to that in other periods of life;
- the compensated elasticity of labour with respect to other period's net wages (the cross-price effects) are relatively low.

This result is closely related to the well-known Ramsey rule (see, for instance, Sandmo, 1987), demanding that, in order to minimise distortions, the set of taxes should essentially be chosen so as to make the role of substitution effects as small as possible.

Finally, an important special case captured by equation (12) is obtained if cross-price effects are assumed to be absent. If $\varepsilon_{ts}=0$, with time indices $s \neq t$, ε_{tt} can be abbreviated to read ε_t and condition (12) reduces to

(13) $$\frac{\tau_1}{1-\tau_1}=\frac{\varepsilon_2}{\varepsilon_1}\frac{\tau_2}{1-\tau_2}.$$

In this case, we may state

Proposition 3 ("inverse elasticity rule"):
If no cross-price effects are induced by taxing periodic wage income, then the optimum tax rate in each period is inversely proportional to the (compensated) elasticity of the same period's labour supply with regard to net wages. The more elastically labour is supplied in period t, the lower should be τ_t^*.

Certainly, this is the most popular result in the theory of second-best taxation which can be applied to the inter-temporal structure of wage taxation. If high tax rates are to be imposed on wages in those periods of a working life where they imply the smallest changes in (compensated) labour supply, then the overall substitution effects are clearly being minimised.[27] Thus, if the effective tax rates implied in public pension schemes differ between early stages of an individual's working life and later years – as was shown to be true in section 1 for pay-as-you-go systems with intragenerational fairness – this tax structure may be fairly rational, provided that the elasticities of periodic labour supply also vary in an appropriate manner.

Building on the theoretical discussion of the inter-temporal structure of implicit tax rates, we will now follow Sandmo's (1974, p. 705) advice that "empirical explorations of optimal tax structures will be valuable contributions to further study of this problem" – late but, perhaps, not too late in applying his original results to our particular problem. In doing so, our main ambition is this: we want to address the question of whether the current structure of effective tax rates implied in pension systems like the German pay-as-you-go scheme can – at least, in principle – be rationalised as reflecting typical differences in the elasticity of individual labour supply over time. In advance, however, we have to note that inter-temporal cross-price effects are very hard to handle in an empirical context. Given the limitations for a tractable empirical set-up, in fact, we have to dispense with tests on proposition-2-type rules for the optimal tax structure from the very beginning. Instead, we will concentrate on estimates for responses of periodic labour supply to current net wages (*i.e.*, to "own" prices), checking how the timing of implicit tax rates conforms to the (compensated) "inverse elasticity" case. The simple structure of our three-period model and the strong assumption regarding $\varepsilon_{ts} = 0$ may be rough stylisations. Yet, we think that proposition 3 constitutes a useful, and mildly realistic, hypothesis which can be subjected to empirical testing.

Applying the basic rules of optimum taxation to gender-specific differences, if any, in both the level and timing of τ is straightforward. It is of course optimal to impose higher tax rates on those groups of individuals who will respond less elastically than others in terms of their (inter-temporal schedule of) labour supply. In section 2 we have argued that, in many existing pension schemes, there is a "gender tax-gap" by which implicit tax rates are higher for (married, "second-earner") women than for (married) men. Therefore, the relevant rules involved in current pension systems

[27] It should be noted that equation (13) is a variant – more precisely to be called the "*compensated* inverse elasticity rule" – which is immediate from the Ramsey rule. A slightly differing, though perhaps even more familiar, variant is given by the "*uncompensated* inverse elasticity rule", building on the alternative restriction that uncompensated, not compensated cross-price elasticities are zero: assuming that $\partial l_t/\partial\tau_t = 0$ and defining uncompensated (own-)price elasticities to be η_t, equation (6) can easily be rearranged to confirm that now

$$\frac{\tau_1}{1-\tau_1} = \frac{\eta_2}{\eta_1}\frac{\tau_2}{1-\tau_2} \tag{14}$$

defines an optimum. Since the intuition behind the "compensated" inverse elasticity rule is much easier to understand – substitution effects are distortionary, while pure income effects are not – we confine our attention to the version derived before.

The fact that the two rules do not coincide unless income effects turn out to be zero does not indicate that they openly contradict each other. Different simplifying assumptions apparently yield different results. What is more puzzling about the second version of the inverse elasticity rule is why uncompensated price elasticities should matter at all in an optimum-taxation context. Sandmo (1987) solves this puzzle by demonstrating that, if the specific assumptions to be made are valid, the "uncompensated" version effectively reflects the idea behind the Corlett-Hague rule of optimal taxation: at closer scrutiny, it is not substitution across taxed goods but rather substitutability or complementarity between taxable goods and leisure that drives this result.

are only consistent with basic optimality conditions if labour supply is less elastic for the former in a systematic fashion. Again, this is ultimately an empirical question.

4 Empirical evidence: methodology and data

In the empirical parts of this chapter, we build on the theoretical analysis provided in section 3, trying to evaluate whether the timing of annual implicit tax rates in unfunded pension systems roughly conforms with the inverse elasticity rule derived before. As we have seen in section 2, the implicit tax rate tends to decrease over the individual life cycle – at least, this will be true when periodic contribution rates are kept constant.[28] We therefore have to check for the existence of a corresponding pattern of individual labour supply, which should become more elastic over time for the optimality conditions to apply. In any case, we need to estimate the elasticity of labour supply for different periods of a typical life cycle with respect to taxes imposed on wages or, which amounts to the same, with respect to net wages. As an anxillary issue, we will also look at differences in the relevant elasticities between males and females.

a) The research strategy

To the best of our knowledge, empirical investigations into the time structure of wage elasticities of individual labour supply are largely lacking. What existing econometric studies usually show is that, based on static models of labour supply, labour force attachment is generally declining with age, controlling for a number of other socio-economic variables.[29] Where age-related regressors are also included in a quadratic form (or as a polynomial of higher order), estimated time-patterns of individual labour supply are a little more complicated but, as a rule, labour force participation and/or the amount of labour supplied are monotonically decreasing starting from some year of age – usually around the late 20s or early 30s. Essentially, this corresponds to what one may think plausible in this context, observing that once young individuals have completed their education they mostly do not hold tangible wealth; they are faced with credit-rations that are rather strict; and they should be eager to exploit their fresh qualifications because early spells of non-participation and non-employment can have lasting effects for their future wage rates and hence will decrease their life-time earnings considerably.

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[28] In addition, we have demonstrated that the same unambiguous trend holds for the case of Germany, in spite of substantial changes of contribution rates, if we concentrate on the age-related tax profile that is relevant for individuals who have been actively participating in the labour market during the 10-year period from 1988 through 1997 (see figures 2 and 3).

[29] For studies on the case of Germany, see Franz (1985), Strøm and Wagenhals (1991), Untiedt (1992), Kaltenborn (2000), or Buslei and Steiner (1999, ch. 4). International surveys can be found in Killingsworth (1983, ch. 3 and 4), Pencavel (1986) or Killingsworth and Heckman (1986). Note that the first three studies concentrate on labour supply of women. In an empirical context, the determinants and patterns of labour supply of a typical male are mainly regarded to be less interesting.

Apparently, we cannot stop here. Regarding the role of age for periodic labour supply, too much information is lost if estimates are based on a single pooled regression for individuals sampled across all age cohorts. One way of refining these results would be to leave the pooled estimation as it is, but to evaluate the elasticity of labour supply with respect to wages not for the full sample or at sample mean values for all independent variables. Instead, one could distinguish between several age groups, calculating the relevant elasticity for young and elderly workers in separation or at sample means for each of these sub-groups. However, this simple approach is still demanding too much of existing results that are based on static models were samples are pooled across all age groups. As a matter of fact, the problem we are interested in deserves additional research.

The most elegant approach to estimating $\partial l_t / \partial w_t$ (and calculating compensated elasticities σ_t) would be to rely on a fully developed dynamic (*i.e.*, life-cycle) model of individual decisions and to derive a consistent set of periodic labour supply functions allowing for some variation in wage elasticity over time (see, for instance, Heckman and MaCurdy, 1980; Browning, Deaton and Irish, 1985; Mulligan, 1998; Ziliak and Kniesner, 1999). Unfortunately, for this type of analysis to yield a structural model that can be tested empirically one has to assume separability between labour–leisure on the one hand and goods consumption on the other hand. In other words, the theoretical assumptions that are needed for an empirical implementation effectively take us back to the scenario required for proposition 1*b* to be true. We know beforehand that, given this particular set of assumptions, a linear tax structure over periodic wages would be optimal. If we want to avoid this inconsistency between the theoretical model and the empirical set-up used in our analysis, there is no easy way out. Therefore, we will effectively drop the notion of a full inter-temporal framework. Instead, we will consider labour supply in one period of life as being completely separated from labour supply in other periods – simply checking whether the wage elasticity of labour supply is higher for younger individuals than for older ones.

The basic approach then is to split a full sample of individuals (aged 20–59, for instance) into two or more broad age groups (for example, "young" workers aged 20–39 and "older" workers aged 40–59, *etc.*) and to consider a series of standard, static regressions regarding the labour supply behaviour of each of these groups in separation. This simple methodology – and the underlying problem that is circumvented rather than solved here – explains why we will be unable to test for the relevance of a proposition-2-type tax structure: with two or more separate regressions for periodic labour supply it will be impossible to control for any cross-price effects.

It is easy to see that a major problem involved in this approach will be in dealing with potential cohort-effects. Lacking appropriate micro-data which cover the full life cycle of just one age-cohort, the individuals divided into several sub-samples by age groups will also differ with respect to their year of birth. Therefore, it is perfectly possible that any differences in labour supply showing up in our estimates are not pure life-cycle effects. Instead, different generations can just follow different habits and norms regarding labour force participation. For instance, the preferences of younger people may be systematically biased towards consuming leisure if compared to those of older people. In this case, cohort-effects could effectively dominate an age-related trend which, if considered in isolation, would fit in well with the conditions for an optimal time structure of implicit taxes derived before. Given the long period of time spanned by our data, however, there may be a possibil ity to overcome this kind of problem, separating life-cycle form cohort effects to a certain extent at least.[30]

b) Econometric model and methods

Basically, the empirical approach follows the model employed in section 3. We assume that individuals maximise utility with respect to their consumption of goods and leisure observing a budget constraint. The form of the utility function as well as the budget constraint are assumed to be known, thus determining the structure of the individuals' labour supply function. In principle, the parameters of the utility function turn into a number of coefficients for all the determinants of individual labour supply that are captured by the model. These coefficients can then be estimated empirically.

In an empirical context, individual labour supply has two important dimensions. First, individuals have to decide whether or not to participate in the labour market. A decision that is logically posterior, but may be much more important in terms of individual responses to wage taxation, is that on how many hours of work to supply in a given period of time. In the following, we will mainly concentrate on the latter aspect, investigating how the actual amount of labour supplied by men and women in different age groups is affected by their net wage rate and, hence, by implicit taxes imposed on wage earnings through a pay-as-you-go pension system.[31] But before estimating labour supply functions in terms of hours worked and calculating the relevant wage elasticities, we have to work ourselves through a number of preliminary steps.

For individuals who are employed their wage rate (gross of taxes) is easily observable. For non-employed individuals this piece of information is lacking. Excluding the latter from a randomly assigned sample would involve a "sample selection bias" since the selection between those employed and those non-employed will not be exogenous with respect to the wage rate. In order to cure this problem we will follow Heckman's (1979) two-stage procedure. At the first stage, participation probabilities for all individuals (both employed and non-employed) are estimated, dropping wages from the set of exogenous variables because they are not observable in the case of the non-employed. This gives us a probability for the observation of a wage rate which can be used to correct for the sample selection bias when estimating a wage function over all individuals in employment. At the second stage, the wage function is estimated and applied to imputing wage rates for the non-employed based on the fact that they share a lot of characteristics with employed individuals.

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[30] This is also true for a third type of effects – "period effects" – which may arise in econometric analyses based on pooled time series that are rather short. For a survey on these issues, see Mayer and Huynink (1990); for an empirical treatment of cohort effects, see Boockmann and Steiner (2000).

[31] As a matter of fact, the pure participation decision is influenced by a number of institutional details other than implicit tax rates arising from the basic benefit formula embodied in a given pension system. If the focus would be on participation *vs.* non-participation, special rules applying to early retirement would be very important. In addition, other regulations that may influence the choice between an extended period of training and labour market entry would have to be taken into account. All these incentive effects are important, deserving an individual treatment. Here, however, we want to avoid these peculiarities by concentrating on individual in those age groups (20–59) where they can be expected to be of minor significance. Given that, we may safely confine our attention on the effects of the simple profile of implicit taxes (see section 1) on individual choices regarding hours worked on a regular basis.

More specifically, we estimate a function of (hourly) real gross wage rates W_{it}. We then take estimated gross wages for all individuals in order to simulate the corresponding net wages. For the simulation of (changes in) net household income, we rely on a simplified model of the German tax-transfer system, based on the tax simulation tool provided by Schwarze (1995). Effectively, our simulation tool covers the main types of taxes and social security contributions as well as the most important transfer programmes that are in operation in Germany.[32] Of course, we are careful in including only the tax-like portion of social security contributions in the relevant deductions (see section 2 c).

Here, two further problems arise demanding discussion. First, note that in the presence of progressive taxation and transfers that are both determined at the household-level, *hourly* net wages are not defined at an *individual* level. Instead, (increments in) net household income through (changes in) labour force participation are heavily influenced by public transfers, or transfer reductions, and the progressive nature of taxes imposed on wage earnings, including wages earned by the partner, if any. We therefore use the information on hourly gross wages obtained from our wage estimation in order to calculate "marginal" increases in net household income for the hypothetical case that the individual is working one additional hour per week.

The second problem follows immediately from this procedure. If, due to progressive (household-level) taxes and transfer reductions, net wages w_{it} are given by non-linear increases in real household income they are in fact no longer fully exogenous with respect to the number of hours actually worked. In other words, estimates that use "marginal" net wages in the sense laid out above as an explanatory variable for labour supply h_{it} observed at an individual level can be seriously distorted. In order to take care of this potential endogeneity problem, we therefore use mean values of hours worked ($\bar{h}_{it}$) when simulating (changes in) household net income that may be relevant for decisions to work an extra-hour, given the individual's gross wage W_{it}. Mean values are taken from appropriate sub-groups of individuals (formed by age, qualification, and the number of children living in the household), thus re-establishing exogeneity of w_{it} to the extent needed.

We can then turn to the estimation of a labour supply function. Since reliable information on the "desired" number of hours worked is rarely existent it is conventional to use hours actually worked instead which are easily observable. At the same time, actual working hours are clearly a censored (*i.e.*, non-negative) variable – even if the desired number of hours may be not. The standard procedure applied to investigating labour supply in terms of hours supplied is therefore given by the Tobit model (suggested by Tobin, 1958), where the desired number of hours h_{it}^* is introduced as a latent, uncensored variable and the actual number of hours h_{it} is assumed to be equal to h_{it}^* if $h_{it}^* > 0$, while it is zero otherwise. Desired hours h_{it}^* can then be considered the dependent variable in a simple index function like $h_{it}^* = \boldsymbol{\beta}_t' \mathbf{x}_{it} + \upsilon_{it}^h$, where $\mathbf{x}$ is the vector of independent – individual- and time-specific – variables that are assumed to influence the amount of labour supplied, $\boldsymbol{\beta}$ is the vec

[32] For an overview, see the „Primer on German Institutions" by Haisken-De New and Haisken-de New (1998). The Schwarze (1995) simulation model includes taxes levied on income (*Einkommensteuer*, "*Solidaritätszuschlag*") and contributions related to public pensions (*gesetzliche Rentenversicherung*), public health care insurance (*gesetzliche Krankenversicherung*), long-term care insurance (*Pflegeversicherung*) and unemployment insurance (*Arbeitslosenversicherung*). We augmented the simulation tool to cover the transfers provided in terms of social assistance benefits (*Sozialhilfe*) and housing benefits (*Wohngeld*).

tor of coefficients to be estimated for these exogenous variables, and υ^h is an independent and normally-distributed stochastic error variable ($\upsilon_{it}^h \sim N(0,\sigma_h^{\;2})$). Building on an economic model of labour supply $\mathbf{x}$, among other things, should include the individual's net wage w_{it} and net household income in the sense explained above.

Applying the Tobit model of labour supply to the corrected – and, hopefully, unbiased – sample of persons who are both employed or non-employed, the expected value for the censored variable h_{it} for an individual i in period t is then given by

$$E(h_{it}|\mathbf{x}_{it}) = \Phi\left(\frac{\boldsymbol{\beta}_t'\mathbf{x}_{it}}{\sigma_h}\right)\left(\boldsymbol{\beta}'\mathbf{x}_{it} + \sigma_h \frac{\phi(\boldsymbol{\beta}_t'\mathbf{x}_{it}/\sigma_h)}{\Phi(\boldsymbol{\beta}_t'\mathbf{x}_{it}/\sigma_h)}\right),\; i = 1,\ldots,I, \quad t = 1,\ldots,T\,,$$

where ϕ and Φ, respectively, represent the density and the distribution function for the standardised normal distribution.

Since observable values h_{it} are censored, the marginal impact of changes in $\mathbf{x}_{it}$ is not just given by the relevant coefficients $\beta_t^{\,j} \in \boldsymbol{\beta}$. Consequently, individual- and time-specific elasticities of labour supply with respect to net wages $w_{it} \in \mathbf{x}_{it}$ are calculated from

$$\eta_{it}^w = \frac{\partial E(h_{it}|\mathbf{x}_{it})}{\partial w_{nt}} \cdot \frac{w_{nt}}{h_{it}} = \beta_t^w \Phi\left(\frac{\boldsymbol{\beta}'\mathbf{x}_{it}}{\sigma_h}\right) \cdot \frac{w_{it}}{h_{it}}$$

and are then estimated by $\hat{\eta}_{it}^w = \hat{\beta}_t^w \Phi(\hat{\boldsymbol{\beta}}'\mathbf{x}_{it}) \cdot w_{it} / h_{it}$, where a hat indicates estimated values of coefficients and results derived from these estimates. Note that, in fact, these elasticities derived from the estimated coefficient for net wages just represent uncompensated wage elasticities. Therefore, they have to be decomposed into income and substitution effects in a way that is explained below. The latter will then give us the compensated elasticities we are most interested in. As a last step to take, individual elasticities can then be aggregated using the relevant schedule of (cross-section and two-period longitudinal) weights in order to obtain representative estimates.[33]

c) Data (pooled time series)

Our econometric analysis is based on micro-data taken from the "German Socio-Economic Panel" (GSOEP). The GSOEP is a longitudinal survey, organised in four sub-samples, covering a total of about 8,000 households and 15,000 individuals. Meanwhile, a maximum of 15 waves (1984–1998) is available for evaluation.[34] For the purpose of our study, we will pool the series of annual data provided by the GSOEP to form a number of appropriate sub-samples because, given current panel

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[33] For each "observation" – *i.e.*, for each individual in each year – we are effectively using information on annual amounts of income that are collected retrospectively in subsequent waves of a panel survey. Therefore, we have to correct the weights attached to individuals in a cross-section perspective by the probability of "survival" from period t to period t+1. – Note that, here, individuals with $h_{it} = 0$ have to be excluded. The reason is that their η^w will be infinite as a purely formal implication of the way it is calculated.

[34] Some additional information regarding the GSOEP data-set is included in the appendix.

length, we cannot fully exploit their time-series structure. In doing so, we will exclude the first four waves (1984–1987), among other things because during these early years some definitions of variables and some of the procedures involved in processing data have been changed. Taking into account the use of retrospective data, we will effectively cover information regarding the years of 1988 through 1997 only – for 10 years, that is.
In addition, we will confine our attention to West-German households of German nationality. Thus, we want to ensure that our results are not distorted by the process of social and economic change that is going on in East Germany in the aftermath of re-unification, or by idiosyncratic features in the behaviour of foreigners and immigrants. Since our focus is on labour force participation, we select individuals aged 20–59, looking at males and (married) females in turn because our theoretical considerations are most relevant for these two groups of individuals. Finally, we exclude all persons who are self-employed or civil servants because in Germany, among other things, these individuals are subject to a very different treatment with respect to old-age provision. We also exclude those who are already in retirement. The general idea of all these restrictions is to have a sample of individuals who are as homogenous as possible, without reducing the number of observations by too much. At the same time, we are trying not to preclude any further sub-groups which might be relevant for the overall problem.

d) Variables

In our estimates, there are two endogenous variables: the real rate of hourly gross wages and the actual number of hours worked, respectively. The latter is used as a proxy for the "desired" amount of labour supply in the final Tobit model and is accounted for on a weekly basis. As was explained before, the former is needed for imputing gross wages to persons who are not employed as the point of departure for simulating net wages and net household income.
Exogenous variables that are assumed to determine labour supply can be grouped by the time-variant and individual effects that they are expected to cover. Basically, period-specific effects that are common to all individuals, are captured by a dummy variable "year of survey" (*i.e.*, panel wave). In addition, potential business cycle effects are represented by annual rates of unemployment which can also be interpreted as a proxy for changes in labour demand and other features of the labour market situation that may vary over time. Individual determinants can be traced back to variables like completed levels of schooling and professional training, years worked in full-time employment (as a proxy for actual job experience, used as a non-linear regressor in our estimates),[35] living with a partner and with children (grouped by particular age brackets and/or measured by the total number of children in the household).
With regard to the individual budget constraint, two further variables are clearly important: net household income (including income derived from wages earned by the spouse, capital income, public transfers *etc.*) and the net wage earned if the individual's labour supply is extended by one

[35] In the final model, age (which might be useful as a proxy for potential job experience) was dropped from both the wage equation and the labour supply model. It turned out that, with non-linear use of job experience, an age variable became superfluous.

hour. In order to avoid a potential endogeneity problem regarding the relation between net wages and the number of hours worked, we evaluate both these variables at mean values of hours actually worked, calculated from a larger group of "similar" individuals (identified by age, qualifications, and household structure) – but given the individual's gross wage rate and all other types of income accruing to his or her household.

When estimating the wage equation the ("Heckman") sample selection variable λ_{it} enters as an additional regressor. As a consequence, the final list of variables used in our estimates reads as follows (see table 1). Note that some of these variables are dropped in individual estimates because problems of collinearity arise.[36]

Table 1
List of variables included in the econometric model

Symbol	Definition		
Dependent variables			
h	Actual n° of hours worked per week (if missing: n° of hours contracted)		
W	Real hourly gross wage (at 1995 DM)		
Independent variables ...		... explaining	
		h	*W*
Const	Constant	x	x
A_{1989} – A_{1998}	Year of survey (series of dummy variables): 1 = observation taken from panel wave 19xx; 0 = otherwise	x	x
Urate	Unemployment rate: average of year of survey	x	x[a]
Partner	Cohabitation status (dummy variable): 1 = married or living with a partner; 0 = otherwise	x	x
*Child*3, *Child*4-6	Children aged 0–3 or 4–6, respectively (dummy variable): 1 = living with children in the relevant age bracket; 0 = otherwise	x	x
NChild	N° of children (aged less than 16) in the household	x	x
QSchool	Level of qualification #1 (dummy): 1 = secondary schooling completed; 0 = otherwise	x	x
QProf	Level of qualification #2 (dummy): 1 = vocational training completed; 0 = otherwise	x	x
QUniv	Level of qualification #3 (dummy): 1 = academic degree completed; 0 = otherwise	x	x
JobExp	Job experience: n° of years in full-time employment (also included as $JobExp^2$, $JobExp^3$, *i.e.* in quadratic form *etc.*)	x	x
E_0	Annual real net household income (at 1995 DM):[b] evaluated at $\overline{h}$ (*i.e.*, the average amount of hours worked by a sub-group of individuals that are "similar" with respect to age, qualifications, and household structure).	x	

[36] However, this is mainly true for some of the "year of survey" dummies only.

w	Real net wage (at 1995 DM):[b] Δ in net household income over E_0 if the individual increases labour supply $\bar{h}$ by one hour a week.	x	
λ	Sample selection variable (Heckman correction)		x

a Variable contained in the "reduced-form" participation model used on the first stage of the Heckman (1979) procedure.

b See sub-section 4 b) for further details.

e) Cohort effects

As we have stated before, one major problem involved in our research strategy will be given by potential cohort effects. When pooling data that cover a time span of ten years and splitting the pooled data into two broad age groups for a first round of estimates, much of the "life-cycle" effects on the wage elasticity of labour supply that show up in our results may effectively been driven by the fact that "young" and "older" workers belong to different age cohorts. These cohorts may differ with regard to labour force attachment from the very first day of their working-age period of life. Clearly, this potential distortion must be taken into account when interpreting the results in the light of our basic problem.

Note, however, that in a pooled sample which is based on annual survey data ranging from 1988 to 1997 the two sub-groups defined by the age brackets 20–39 and 40–59 will overlap. "Older" workers are made up by the cohorts born from 1929 to 1957, while "young" workers are born between 1949 and 1977. As a consequence, 9 cohorts will be contained in both age-related sub-samples, moving from the young to the older group of workers during the survey period. If compared to full sub-sample length this overlap is clearly a small one. At face value it cannot be used for controlling potential cohort effects in a systematic way. Nonetheless, the structure of our data in terms of periods and cohorts covered – with many potential overlaps – can be exploited to trace back any cohort effects in much more detail.

Building on our basic estimates for the two sub-samples of "young" and "older" workers, we will therefore proceed in the following direction. We split the pooled sample into two sub-samples I and II, covering the panel waves of 1988–1992 and 1993–1997, respectively. In addition, we consider a larger number of age groups, consisting of 5 birth cohorts in each panel wave. Given these operations, we have that all birth cohorts belong to different age groups in the two sub-samples: in sample I, they are aged 20–24, 25–29 *etc.*, while in sample II the same individuals are aged 25–29, 30–34 *etc*. In addition, all age groups are represented by two different groups of birth cohorts, one to be taken from sample I and another from sample II. The structure of the two-dimensional classification which is obtained in this way is illustrated in table 2. Here, age groups are listed in columns and birth cohorts are listed in rows. The shaded cells indicate which of the potential combinations are effectively covered by our data that are contained in either of the sub-samples I and II.

Within the above structure, the procedure of estimation is essentially the same as before. We only concentrate on smaller groups of individuals now. Given that we have filled the table with all the results we are looking for – *i.e.* with estimates for the elasticity of labour supply with respect to wages for each of the above birth cohorts and age groups – we may then interpret any differences that show up in vertical direction as cohort effects, while horizontal differences can be mainly attributed to life-cycle effects regarding labour supply. Of course, our results regarding life-cycle effects have to be interpreted with some care. The reason is that controlling for cohort effects in the way suggested here inevitably boosts the role of time (and business-cycle) effects. All in all, this piece-meal approach gives just a rough picture of what we are really interested in. Nevertheless, it will shed some light on the overall question of whether the timing of tax rates implied in unfunded pension schemes within an individual life cycle conforms to optimum taxation rules – at least by its basic structure.

Table 2:
Wage elasticities of labour supply – structure of the results

		age groups					
		20–24	25–29	30–34	...	50–54	55–59
birth cohorts	1969–77	II					
	1964–72	I	II		***life-cycle effects***		
	1959–67		I	II			
	1954–62	***cohort effects***		I	...		
	...				...	...	
	1934–42					I	II
	1929–37						I

5 Individual labour supply of younger *vs.* elderly workers (West-Germany 1988–1997): the results

The focus of our investigations is on typical time-patterns of the wage elasticity of labour supply over individual life cycles, *i.e.* on differences between "young" and "older" workers (aged 20–39 and 40–59, respectively) or between a larger number of age groups (defined over 5-year intervals). Regarding the number of hours worked, we will treat the cases of (all) men and (married) women belonging to different age groups in separate estimates, thus attempting to explore the optimality of the inter-temporal structure of implicit tax rates in some detail. For simplicity, the wage regressions run as an intermediate step are pooled within (but not across) the two groups differentiated by gender. As a side issue, we will also look at general differences regarding the levels and trends of wage elasticities across genders.

a) Descriptive statistics

We start by listing some simple summary statistics regarding the variables included in our empirical model (plus some other useful information), grouped by the larger age-cohorts of "young" vs. "older" workers that will be considered in the following (see tables 3a and b).

Some of the facts that are evident from tables 3a and b are clearly an artifact of our selection of individuals and our definition of age groups. This is not only true for the result that individuals in higher age-brackets are indeed older than "young" individuals. For similar reasons, the latter are also much more likely to live with small children, while the latter have longer job experience. Nonetheless, among the other variables considered, differences of this kind may be relevant to some extent for the individual probability to enter employment and to work for a given amount of time per week. One may note in passing that – irrespective of the children's age – young males have about the same number of kids living in their households as older males, while on the side of married females there is a pronounced difference regarding this number across the women's age groups. Young women are more likely to live with kids than anybody else, while for older women this probability ranges close to that for men.

Table 3a
Descriptive statistics: men by age groups

Characteristics	Men aged 20–39		Men aged 40–59	
	Sample means	Std. dev.	Sample means	Std. dev.
Age	29.0	5.43	49.4	5.89
N° of children	0.65	0.97	0.62	0.96
Job experience (years)*	8.1	5.73	27.3	7.92
Hours worked per week*	37.0	8.95	38.6	7.05
Gross hourly wages*,**	32.82	16.84	39.02	19.93
Marginal net hourly wages*,**	15.74	12.13	21.97	12.92
Other net household income*,**	19,385	8,659	23,283	11,016
Other net household income**	18,469	8,297	22,987	10,553
Net household income*,**	34,693	19,522	48,458	26,250
Net household income**	31,569	19,326	45,674	26,035
N° of observations	9,369		5,720	
Employed	76.1 %		84.2 %	
Living with a partner	72.3 %		92.0 %	
Living with children aged 0–3	6.0 %		1.3 %	
Living with children aged 4–6	3.5 %		1.8 %	
Secondary schooling completed	89.9 %		96.4 %	
Vocational training completed	65.2 %		80.4 %	
Academic degree completed	11.3 %		11.7 %	

* Mean values referring to individuals in employment only. ** In 1995 DM.

From the number of hours worked per week it is easy to see that, as in many other countries, married women who are employed work less on average than males. At the same time, there are no major differences across (within-gender) age groups regarding this variable. Without many exceptions, men participate in the labour market on a full-time basis, while for women in employment the number of hours worked per week averages at about 70 per cent of a full work-load.

Table 3b
Descriptive statistics: married women by age groups

Characteristics	**Married women aged 20–39**		**Married women aged 40–59**	
	Sample means	**Std. dev.**	**Sample means**	**Std. dev.**
Age	31.8	4.55	48.3	5.53
N° of children	1.44	1.09	0.51	0.83
Job experience (years)*	6.7	4.76	12.4	9.35
Hours worked per week*	27.0	11.91	26.0	11.18
Gross hourly wages*,**	23.04	12.43	22.96	11.37
Marginal net hourly wages*,**	10.13	8.23	10.35	7.51
Other net household income*,**	32,877	19,454	35,530	18,384
Other net household income**	34,383	20,364	37,006	22,276
Net household income*,**	42,880	23,102	46,926	22,766
Net household income**	39,856	22,495	43,394	24,700
N° of observations	4,388		4,028	
Employed	50.7 %		53.9 %	
Living with a partner	100 %		100 %	
Living with children aged 0–3	12.9 %		0.7 %	
Living with children aged 4–6	8.1 %		1.0 %	
Secondary schooling completed	92.4 %		95.4 %	
Vocational training completed	74.9 %		65.1 %	
Academic degree completed	5.8 %		3.7 %	

* Mean values referring to individuals in employment only. ** In 1995 DM.

Similarly, the participation rate of women is clearly lower than that of men, while differentiation by age is again much smaller. More precisely, there is some difference across age brackets regarding the fraction of individuals in employment in the case of males, while the difference is much smaller in the case of women. The former may be explained by the fact that, given our definition of age brackets, many of the "young" men may not have completed their formal period of training, whereas "older" men certainly should have. The latter is slightly puzzling since the same should hold for young women who, in addition, should be more likely to be on a parental leave than older women. Controlling for availability for labour force participation, the fraction of young women working may therefore be considerably higher than for older women. This, however, would fit in well with other evidence on one of the most visible trends in labour force attachment to be observed not only in Germany but, even stronger, in many other industrialised countries.

This story may be supported when we look at gross hourly wages of individuals in employment. There is clearly a gender wage-gap, but it is much smaller for young individuals than for older workers. In fact, young males earn lower wages than older males – an interesting question being whether this can be explained by (lack of) training on the job only or, as is largely assumed to be true, by the fact that seniority rules play some role for the level of individual compensations in Germany. By contrast, gross hourly pay of young married women exceeds that of women in the higher age-bracket by a small margin. Of course, part of the explanation lies with the higher qualifications of young females if compared to older females. With the exception of academic degrees, the former have even (more than) caught up with young males in terms of qualifications completed, while older women are less qualified than their male counterparts. Regarding comparisons of qualification between young and old it should again be noted that the picture drawn here may be incomplete, at least regarding academic qualifications, if individuals in lower age-brackets are still on their way of finishing a degree. Thus, the numbers given in table 3a need not contradict, and those in table 3b can be taken to confirm, the well-known long-term shift towards higher levels of skills that are both offered and demanded on the labour markets of industrialised nations.

"Marginal" wage rates are calculated as the net pay earned through an extra-hour of work, evaluated at appropriate group-averages for the number of hours worked on a regular basis, given the individual's wage rate gross-of-taxes and net household income to be derived from other sources of income. The values obtained correspond to reasonable assumptions. In Germany, marginal tax rates can easily exceed 50 per cent. They turn out to be lower for older individuals than for the young (among other things because the implicit tax rates involved in the pension system are declining substantially over a typical life cycle). At the same time, marginal tax rates are much higher for married women than for men, which mainly reflects the effects of progressive taxation at the household-level (plus higher taxes implied in public pensions). This conclusion is also confirmed by differences across the two sexes regarding other net household income, reflecting their different roles as "first" and "second earners" in many households. Further differences regarding this variable which can be observed between each of the two age groups are again easily explained by life-cycle effects in terms of increasing capital income and seniority effects regarding the partners' wage, if appropriate.

Finally, differences in sample means for other net household income – and, consequently, between total net household income – between those employed and those non-employed may be due to various selection effects that have to be controlled for in the following. It is, however, interesting to see that other net household income is slightly higher for employed males than for non-employed males, whereas it is lower for employed females than for non-employed females. The latter is consistent with the usual assumption of a negative income effect with respect to labour force participation, while similar effects are seemingly absent in the case of men.

b) The wage equations

As explained before, information on gross wages is available only for individuals who actually are employed. However, restricting attention to these individuals in order to estimate the wage elasticity with respect to hours of work supplied involves a potential sample selection bias and may therefore lead to distorted results. Building on the Heckman (1979) procedure, we therefore have to impute gross wage rates – and to calculate corresponding net wages that effectively enter individual labour supply decisions – based on wage equations estimated for the censored samples of those individuals (males and married females) for whom wages are observable, including the sample selection variable λ derived from a reduced-form model of participation probabilities.[37]

Table 4 represents the results of OLS regressions of real hourly gross wages against a sub-set of independent variables that are taken to be relevant here (the full set of variables listed in table 1 as regressors for W_{it} enters the anxillary Probit model of the participation decision).

Table 4
Estimates for the wage equation: men and married women

Variable[a]	Coefficients[b]	*t*-Statistics
a) Men		
Qschool	0.978	0.67
Qprof	3.214 ***	4.78
Quniv	23.550 ***	28.58
JobExp	1.662 ***	10.86
JobExp²	- 0.054 ***	- 6.03
JobExp³	0.001 ***	3.43
λ	- 0.790	
N° of observations	15,089	
censored obs.	4,289	
prob (χ > 0)	0.000	
a) Married women		
Qschool	3.531 ***	3.37
Qprof	4.492 ***	5.58
Quniv	12.188 ***	6.63
JobExp	0.893 ***	3.73
JobExp²	- 0.005	- 0.34
JobExp³	- 0.0002	- 0.82
λ	15.770	
N° of observations	8,416	
censored obs.	4,569	

[37] The results of reduced-form estimates of participation probabilities are available on request from the authors. In order to ease the exposition of our results, we excluded them from this report.

prob ($\chi > 0$)	0.000	

a Results obtained for the constant and for "year of survey" dummies are not reported.
b Asterisks denote significance at a 10*, 5**, and 1*** percent level, respectively.

In both estimates, next to all variables included are significant and all signs of coefficients are as expected. In the case of males, the lowest level of qualifications ("secondary schooling completed") turns out to have a small, and insignificant, impact on wages, while higher qualifications are clearly important. The overall effect of job experience (which enters in a non-linear fashion) turns out to be positive for males during their first 23 years in (full-time) employment, then eventually becoming negative, while it is positive for women throughout their work career. In the case of women, the non-linear use of this variable yields insignificant results. Finally, in our wage estimate for males the selection variable is not significant (std. dev.: 0.45) and has a negative impact on wages, while it is highly significant and positive in the case of females (std. dev.: 1.46).

c) The labour supply model

Finally, we consider the results of our Tobit estimates regarding the number of hours worked on a regular basis, now including simulated "marginal" net wages and information regarding net household income as additional regressors. Furthermore, we now have to distinguish between the age-groups defined before, concentrating first on the larger sub-groups of cohorts aged 20–39 and 40–59, respectively.[38]

The estimates for the hours-worked model of labour supply are represented in tables 5a and b. In the case of men, significant variables in both age classes are given by living with a partner and with children under 3 years, the total number of children living in the household, unemployment rates (used as a proxy for labour demand), higher levels of qualification, and increases in real net income through working an extra-hour a week. Coefficients estimated for the *Partner* and the *NChild* variables are positive throughout. Living with children aged less than 3 years has a negative impact on labour participation of older males, in contrast to a positive impact for the case of younger males (where the coefficient for the "*Child*4–6" variable is negative, instead).

Apparently, lower levels of qualifications become less important as a determinant of participation in the case older workers (where holding an academic degree even has a negative impact on the amount of labour supplied). Similarly, current job experience matters a lot more for the young than for elderly workers (where it is borderline-significant only as a linear regressor). The overall impact of this variable on labour supply is positive throughout for both age groups. Another observation is that the (negative) role of unemployment rates is much more pronounced for older individuals than for the young.

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[38] The results related to a larger number of groups, aged 20–24, 25–29, *etc.*, each represented by two sets of birth cohorts taken from separate sub-samples, are available from the authors upon request.

Table 5a
Estimates for the hours-worked model: men

Variable[a]	Men aged 20–39		Men aged 40–59	
	Coef.[b]	*t*-Stat.	Coef.[b]	*t*-Stat.
Partner	2.752 ***	6.25	1.578 **	2.20
*Child*3	2.121 **	2.25	- 4.274 *	- 1.92
*Child*4–6	- 1.158	- 1.04	0.643	0.33
Nchild	0.694 ***	2.82	2.435 ***	8.34
Qschool	2.789 ***	4.45	1.106	0.74
Qprof	3.535 ***	7.73	1.469 **	2.32
Quniv	3.192 ***	5.00	- 2.017 **	- 2.25
JobExp	6.674 ***	29.88	0.598 *	1.69
$JobExp^2$	- 0.621 ***	- 21.82	- 0.024	- 1.48
$JobExp^3$	0.018 ***	17.78	0.0004	1.58
Urate	- 0.341 **	- 1.93	- 1.078 ***	- 5.04
E_0	1.99e-05	1.33	7.47e-05 ***	5.92
w	0.081 ***	3.56	0.367 ***	14.41
N° of observations	9,369		5,720	
censored obs.	2,242		903	
prob (χ > 0)	0.000		0.000	
Pseudo R^2	6.70 %		3.91 %	

a Results obtained for the constant and for "year of survey" dummies are not reported.
b Asterisks denote significance at a 10*, 5**, and 1*** percent level, respectively.

From an economist's perspective, two major determinants of individual labour supply should be the wage rate and household income. Remember first that, in order to avoid a potential endogeneity problem, we effectively evaluated the net wage earned through an additional hour of work as well as the net household income, including income other than wage earnings, at a "normalised" number of hours worked based on appropriate group averages, given the individual's gross wage. The coefficients estimated for wage rates w both are highly significant and positive, which is precisely what one would expect. If looked at the other way round, taxing wages should therefore reduce labour supply – at least when we consider the "uncompensated" effect. The coefficient of household income E_0 is significant on a 1-percent-level in the case of older workers, while it is insignificant for young workers. Considering the importance of early stages in a work career for effective life-time income, this may be largely plausible. Against a theoretical background, a result that is more striking is that income effects appear to be positive in both cases considered here – an outcome not un common in empirical studies of labour supply for males.[39] All in all, the results obtained from our estimates are not too unconventional, although it appears that labour supply behaviour of young individuals is captured much better by the model than that of older workers.

Table 5b
Estimates for the hours-worked model: married women

Variable[a]	Married women aged 20–39		Married women aged 40–59	
	Coef.[b]	*t*-Stat.	Coef.[b]	*t*-Stat.
*Child*3	- 18.511 ***	- 12.83	- 1.406	- 0.38
*Child*4–6	- 0.712	- 0.46	- 4.205	- 1.19
Nchild	- 9.383 ***	- 23.90	- 3.247 ***	- 6.95
Qschool	- 4.238 ***	- 2.70	- 2.927	- 1.51
Qprof	- 1.213	- 1.25	- 0.307	- 0.41
Quniv	- 5.251 ***	- 3.10	- 12.546 ***	- 5.95
JobExp	1.956 ***	4.21	- 0.022	- 0.09
$JobExp^2$	- 0.221 ***	- 3.65	0.030 *	1.77
$JobExp^3$	0.018 ***	17.78	- 0.0005	- 1.46
Urate	0.009 ***	4.24	0.341	1.09
E_0	- 8.8e-05 ***	- 5.94	- 9.0e-05 ***	- 5.89
w	1.089 ***	20.59	1.717 ***	32.41
N° of observations	4,388		4,028	
censored obs.	2,163		1,855	
prob ($\chi > 0$)	0.000		0.000	
Pseudo R^2	7.36 %		7.74 %	

a Results obtained for the constant and for "year of survey" dummies are not reported.
b Asterisks denote significance at a 10*, 5**, and 1*** percent level, respectively.

Turning to the parallel estimates run for married females (see table 5b), the picture to be drawn based on our results is slightly different – the main similarity being that the model again seems to be more fitting to the case of young women than to those in the higher age category. Now, variables that are significant in both age groups are given by the number of children living in the household, the highest level of (academic) qualification, job experience (taken in quadratic form), net household income and, again, increments in net household income through an extra-hour of work per week – *i.e.*, the marginal net wage.

This time, all child-related variables have a negative coefficient, which is easily explained through child-care obligations and scarce supply of institutional day child care in Germany. Apparently,

[39] For broader surveys, see the references made in footnote 29. – Note also that the overall impact of the income variable on labour supply is weak: according to our estimates, an increase in net household income by 10,000 DM (by roughly 30 per cent, that is) would lead to a 0.2 or a 0.75 increase, respectively, in the number of hours worked per week.

both aspects are more relevant for labour supply decisions taken by married females than by males. Surprisingly, the coefficients related to all levels of qualifications considered in our estimate now also exhibit negative signs. (In fact, we are lacking any explanation why women who are more qualified tend to work less hours, controlling for all other variables.). As in the case of men, the overall impact of current job experience (included as a non-linear regressor) is positive throughout. As in the previous cases, it is also more important, both in terms of coefficients and significance, for young women.

The behaviour of variables representing marginal net wages and net household income is as one would expect, building on an economic model of labour supply. In the case of married women, all the relevant coefficients are highly significant. The estimator for the w-coefficient is positively signed – again predicting that wage taxation reduces the amount of labour supplied ("uncompensated" effect). Furthermore, the coefficient of E_0 now turns out to be negative, thus indicating the regular income effect arising from theoretical considerations. We may thus conclude that labour supply decisions taken by (married) women are more in line with the assumption of optimising behaviour, given wages and household income that is derived to a large extent from other sources than the individual's own labour force participation.[40] Again this is a common observation in empirical studies, contrasting with the "irregular" results that are often obtained for men.

d) Wage elasticities of labour supply

Building on our estimates for the labour supply model and concentrating on effects that show up in terms of the number of hours worked, we can then determine the elasticities of labour supply with respect to net wages we are ultimately interested in.

As was mentioned before, we can derive the level and, to some extent, the significance of "uncompensated" effects η^w from the coefficients obtained for w in our estimations of the Tobit model.[41] But in order to test for whether the ratio of periodic implicit tax rates, τ_1 and τ_2, is related to the wage elasticities observed for "young" vs. "older" workers in accordance with the "inverse (compensated) elasticity rule", it is the *compensated* wage elasticities ε^w we have to determine. From a theoretical perspective, the uncompensated elasticity of labour supply with respect to wages can be split into an income effect and a substitution effect – *i.e.*, the compensated wage elasticity – according to

$$\eta^w = \frac{\partial h}{\partial w}\frac{w}{h} = \underbrace{\left(\frac{\partial h}{\partial E_0}\frac{E_0}{h}\right)\frac{wh}{E_0}}_{\substack{\text{Income} \\ \text{effect}}} + \underbrace{\left(\frac{\partial h}{\partial w}\frac{w}{h}\right)_S}_{\substack{\text{Substitution} \\ \text{effect}}} = \eta^{E_0}\frac{wh}{E_0} + \varepsilon^w$$

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40 At the same time, the role of income effects for individual labour supply is again limited: an increase in net household income by 10,000 DM now leads to a 0.9 decrease in the number of hours worked a week in both age groups.

41 Building on the decomposition explained below, the „significance" of our estimation for the compensated wage elasticity will not only depend on the *t*-statistics obtained for the *w*-coefficient, but also on the t-statistics for the E_0-variable. In cases where both variables are highly significant, this will not make a difference. Where *t*-statistics differ, however, we will ignore this complication.

by the Slutsky decomposition. In theory, the substitution effect is usually expected to be positive, while the income effect (basically determined by the income elasticity of labour supply) should be negative. The direction of the combined effect and therefore the sign of η^w is open. As we have seen in the previous sub-section, we cannot expect all the results to be well-behaved in the above sense in an empirical context with detailed regressions for men and women in different age brackets.

In order to see in some detail what happens within our econometric model, we will calculate η^w from the coefficient for *w* and decompose it into the income and substitution effects defined before. (Note that the income effect can be derived from the coefficient estimated for E_0 and the pure substitution effect ε^w can then be determined as a residual.) The final results are estimations for men and married women which are included in table 6.

Table 6
Compensated wage elasticities of labour supply:
"young" vs. "older" workers

	Men aged 20–39	**Men aged 40–59**
Compensated wage elasticity (ε^w)	0.040 ***	0.246 ***
Income effect	0.000	0.002 ***
Uncompensated elasticity (η^w)	0.040 ***	0.247 ***
	Women aged 20-39	**Women aged 40-59**
Compensated elasticity (ε^w)	0.489 ***	0.789 ***
Income effect	- 0.001 ***	- 0.001 ***
Uncompensated elasticity (η^w)	0.488 ***	0.788 ***
Asterisks denote significance at a 10*, 5**, and 1*** percent level, respectively.		

Table 6 shows that (compensated) wage elasticities obtained for "older" males and married females are higher than for those in the younger age brackets. In fact, this is the result expected beforehand, based on the casual observation that labour force attachment gets weaker near the end of the working-age period for a number of reasons.[42] In both cases, the (within-gender) difference in elasticities appears to be really substantial. At the same time, we observe a remarkable difference in wage elasticities across the two gender groups which applies to both the age categories considered here. We will return to the latter observation in the discussion of our results, concentrating first on an in-depth investigation of what can be regarded the relevant life-cycle effects.

[42] Note that those already receiving disability benefits or early retirement pensions were excluded from our sample. At the same time, we are unable to control for the fact that some who would be entitled to receive the same types of benefits may still go on working, nor can we deal in a similar fashion with some other forms of (partial) "early retirement" that are more hidden – for instance, that are effectively financed through unemployment benefits.

In order not to arrive at premature conclusions, we should take into account that both periods of working age considered here are highly aggregated. As a matter of fact, the group of "young" workers aged 20–39 mixes those who are still students (at best, working on a limited basis in order to expand their budget) with individuals who are just entering the labour force and others who are in the midst of their career. Similarly, the group of "elderly" workers aged 40–59 includes workers who are at the height of their working life as well as those who are already approaching retirement.

In order to work out the potential differences in labour supply behaviour across all of these different groups in some more detail, we therefore proceed from our basic findings by looking at a larger number of age brackets that are more narrowly defined, at the same time attempting to disentangle pure life-cycle effects from potential cohort effects. As a caution, one should keep in mind that empirical observations regarding individual decisions on labour supply rarely follow a simple and clear-cut pattern that is easy to interpret against the background of theoretical considerations. Tables 7a and b contain the values estimated for the compensated elasticity ε^{w} for the case of eight groups of birth cohorts which move from one 5-year age bracket to another over two sub-samples I and II, covering the panel waves of 1988–1992 and 1993–1997, respectively.

At a first glance, it is not easy to interpret these results – nor to relate them to the optimality conditions derived in section 3, given a particular schedule of implicit tax rates that are continuously declining from early stages of the working period of life to retirement age.[43] What we observe are some irregularities – like negative, though insignificant, wage elasticities mixed with positive ones in the case of males – and movements from one cell to another that are seemingly erratic and produce no unambiguous trend over the life cycle. Keeping in mind, however, the distinction between life-cycle effects, to be derived from adjacent cells in a horizontal direction, and potential cohort effects which show up in a vertical direction, we can finally detect something that at least comes close to meaningful life-cycle patterns of wage elasticities for both males and females. This is illustrated in figure 4.

[43] We will return to this issue in the next section.

Table 7a
Wage elasticities of labour supply over the life cycle: men

Birth	**age groups**							
Cohorts	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59
1969–77	0.089***							
1964–72	0.053	0.074**						
1959–67		0.011	0.014					
1954–62			- 0.064	- 0.011				
1949–57				- 0.026	0.006			
1944–52					- 0.008	0.159***		
1939–47						0.163***	0.154***	
1934–42							0.134**	0.396***
1929–37								0.593***
Asterisks denote significance at a 10*, 5**, and 1*** percent level, respectively.								

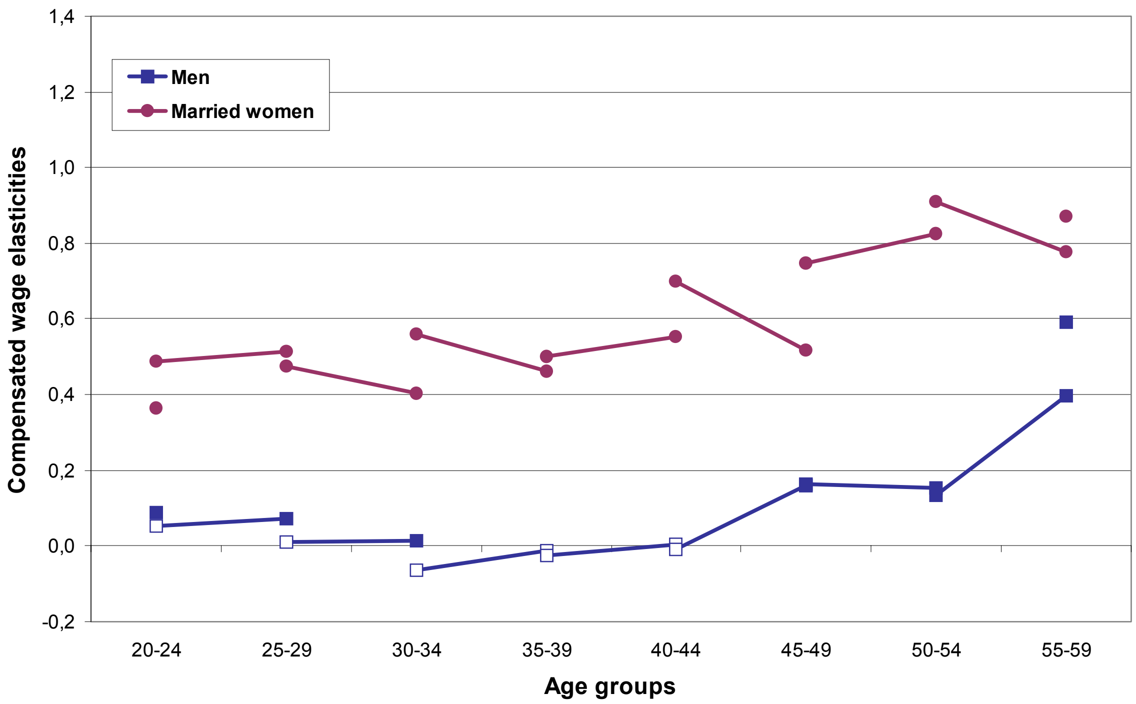
Table 7b
Wage elasticities of labour supply over the life cycle: married women

Birth	**age groups**							
Cohorts	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59
1969–77	0.366***							
1964–72	0.489***	0.513***						
1959–67		0.474***	0.403***					
1954–62			0.558***	0.462***				
1949–57				0.500***	0.553***			
1944–52					0.699***	0.517***		
1939–47						0.747***	0.825***	
1934–42							0.909***	0.776***
1929–37								0.871***
Asterisks denote significance at a 10*, 5**, and 1*** percent level, respectively.								

In figure 4, we effectively present two estimates for the wage elasticity of labour supply for each age group of both men and (married) women. Each of these pairs is being taken from different birth cohorts we are following from sub-sample I to sub-sample II. Values for two successive age brackets that are derived from the same set of birth cohorts are connected by a line. (Estimates that are significant at least on a 5-percent level are highlighted by filled circles and boxes; in case the results are not significantly different from zero, these symbols are empty.) Now, building on our earlier considerations, upward and downward movements in a horizontal perspective should be attributed to the life-cycle effects we are actually interested in, while vertical distances may be taken to represent cohort effects.[44]

Figure 4

Wage elasticities of labour supply over the life cycle



Source: GSOEP (waves 1988–97); CESifo estimates.

Interpreting the results shown in figure 1 with some care, the main conclusions we can arrive at are the following:

– In the case of males, the compensated elasticity of labour supply with respect to net wages is slightly higher for young individuals, aged 20–29, than for men in subsequent age groups, aged 30-44. In addition, the estimates obtained for the very young appear to be rather reliable in terms of statistic significance.

– In contrast, some of the estimated elasticities for middle-aged men (those in age brackets 30–44), turn out to be negative by a small margin. At the same time, they are not significantly different from zero. These results are not too much surprising: these are the prime aged men (in terms of labour force attachment, that is) who are characterised by participation rates which, in many industrialised countries, are very close to 100 per cent. Building on our analyses, they are very likely to work anyway, irrespective of the economic incentives to do so.

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[44] On the other hand, horizontal movements can be affected by period effects – *i.e.*, differences between the sub-periods 1988–1992 and 1993–1997 – which may be imperfectly controlled by our "year of survey" dummies and by aggregate unemployment rates for each year.

- For males aged 45 and over, wage elasticities of labour supply go up. Again, these results are highly significant for all the groups of birth cohorts that fall in this category. In other words, men who are approaching retirement are more likely to respond to economic incentives than (all) younger men. As a consequence, implicitly taxing wages earned by these individuals must be expected to have a stronger impact on the amount of labour supplied than implicitly taxing wages earned by younger individuals.
- For married females, the wage elasticity that follows from our estimates is highly significant across all age groups. For younger women, aged 20–39, it exhibits next to no life-cycle trend. However, as in the case of men, the wage elasticity starts to increase from the age brackets of those 40–49 and does so over all subsequent age groups.
- Furthermore, across all age brackets considered here the elasticity of labour supply with respect to wages is at a remarkably higher level for married women than for men. This observation reflects a common result in many econometric studies where female labour supply often reacts more flexibly to changes in the net wage.

In addition to these observations it should be noted that, in figure 4, vertical differences between the estimates of labour supply elasticities are close to zero in the case of men. We therefore conclude that in our estimations cohort effects for males taken from different birth cohorts are negligible. For married women, on the other hand, we may have detected cohort effects which, for some of the age groups considered, explain the differences in estimates based on each of the two sub-samples. As a rule, younger women tend to be less responsive to wages in terms of their labour supply than those born earlier when looked at during the same stage of their life cycle.

6 Is the structure of implicit taxation optimal?

The final question we have to tackle is whether the actual pattern of implicit tax rates (see section 2) can be found to be optimal if evaluated against the background of both our theoretical and empirical results. More precisely, we have to ask whether the inter-temporal structure of τ_t, and the gender-specific differences, correspond to the "inverse elasticity rule" stated in our proposition 3 (see section 3). Building on the premise that the assumptions needed to establish the "inverse elasticity rule" as the relevant criterion of optimal taxation are sufficiently realistic, we know that the ratio of implicit tax rates (imposed on wages *net*-of-taxes) applying to the case of "young" versus "older" workers should be equal to the inverted ratio of (compensated) wage elasticities. In principle, the same condition should hold for the case of taxing males *vs.* females (both regarding the inter-temporal structure and regarding simple life-time averages of implicit tax rates). We will now look at each of these issues in turn.

Concentrating first on the inter-temporal structure of τ and on the rough distinction between two broad age categories, the results we obtained are summarised in table 8. Once again, the relevant tax rates τ_t are calculated using the CESifo Pension Model, while ε_t^w is known from table 6.

Table 8
The time structure of implicit taxes and inverted wage elasticities: "young" vs. "old" workers

Men	$\frac{\tau_{20-39}}{1-\tau_{20-39}}\frac{1-\tau_{40-59}}{\tau_{40-59}} = 1.55$	$\frac{\varepsilon_{40-59}}{\varepsilon_{20-39}} = 6.15$
Married women	$\frac{\tau_{20-39}}{1-\tau_{20-39}}\frac{1-\tau_{40-59}}{\tau_{40-59}} = 1.35$	$\frac{\varepsilon_{40-59}}{\varepsilon_{20-39}} = 1.61$

Let us start by looking at males. It appears that the ratio of implicit tax rates for the two broad sub-periods of working age is too low to approach an efficient solution in terms of the inverse-elasticity rule. This is true in spite of the declining profile of implicit tax rates obtained for the German public pension scheme – concentrating on the age cohorts considered in our estimates and for the sample period (see figure 2). In other words, the implicit tax rates for "young" workers could be increased, or the rates for "older" workers could be decreased, in order to establish an efficient solution.

Table 9a
The time structure of implicit taxes and inverted wage elasticities over the life cycle: men

Implicit taxes		**Wage elasticities**
τ_t	$\frac{\tau_t^{net}}{\tau_{t+1}^{net}} \equiv \frac{\tau_t}{1-\tau_t}\frac{1-\tau_{t+1}}{\tau_{t+1}}$	("life cycle effects" derived for a given birth cohort)
$\tau_{20-24} = 13.40$	$\tau_{20-24}^{net}/\tau_{25-29}^{net} = 1.06$	$\varepsilon_{25-29}/\varepsilon_{20-24}^{**} = 1.39$
$\tau_{25-29} = 12.73$	$\tau_{25-29}^{net}/\tau_{30-34}^{net} = 1.07$	$\varepsilon_{30-34}/\varepsilon_{25-29} = 1.27$
$\tau_{30-34} = 11.96$	$\tau_{30-34}^{net}/\tau_{35-39}^{net} = 1.09$	$\varepsilon_{35-39}/\varepsilon_{30-34} = 0.17$
$\tau_{35-39} = 11.07$	$\tau_{35-39}^{net}/\tau_{40-44}^{net} = 1.11$	$\varepsilon_{40-44}/\varepsilon_{35-39} = -0.23$
$\tau_{40-44} = 10.06$	$\tau_{40-44}^{net}/\tau_{45-49}^{net} = 1.14$	$\varepsilon_{45-49}^{***}/\varepsilon_{40-44} = -19.88$
$\tau_{45-49} = 8.92$	$\tau_{45-49}^{net}/\tau_{50-54}^{net} = 1.18$	$\varepsilon_{50-54}^{***}/\varepsilon_{45-49}^{***} = 0.95$
$\tau_{50-54} = 7.59$	$\tau_{50-54}^{net}/\tau_{55-59}^{net} = 1.27$	$\varepsilon_{55-59}^{***}/\varepsilon_{50-54}^{**} = 2.96$
$\tau_{55-59} = 5.93$	(not defined)	(not defined)

Again, however, we should take into account that *within* the two broadly defined age groups wage elasticities might vary a lot. In order to evaluate the inverse-elasticity rule in more detail, we therefore look at the life-cycle structure of implicit taxes and labour supply elasticities for the larger number of age brackets defined over 5-year intervals (tables 9a and b).

Since for the age brackets ranging from 30 to 44 years of age our estimates regarding wage elasticities of labour supply are insignificant (and mostly exhibit an implausible sign) we should concentrate on the extremes. It is easy to see that the changes in implicit tax rates imposed on men aged 20–29 and 45–49 appear to be close to the optimum if measured by the inverted ratios of labour supply elasticities during the relevant periods of time. The fact that workers who are gradually approaching retirement are effectively taxed at lower levels through participating in an unfunded pension scheme turns out to be largely appropriate, taking into account the increase in wage elasticities estimated for these individuals.

Within this overall trend, things are slightly different with respect to the implicit tax rates placed on men aged 50–54. Our results imply that – according to the inverse elasticity rule – the (relatively low) implicit tax rate for these individuals is still too high if gauged by the inverse ratio of wage elasticities. This confirms our earlier finding, based on broader age groups, that "older" workers should be taxed even less than they actually are within an optimally designed structure of implicit taxation. Otherwise, besides choosing one of the various routes into early retirement,[45] elderly workers are likely to avoid working over-time hours and will try to reduce their work-load through part-time work if their effective tax burden appears too high.

Returning to the results presented in figure 4, one may note that workers who are at the early stages of their working life – those aged 20–29 – also react slightly more elastically to changes in net wages than workers who are in the midst of their working career. Given that, our findings suggest that the implicit tax profile should not be decreasing throughout the life cycle. Instead, implicit tax rates for very young workers should be smaller than for workers who have settled in their jobs. Absent adjustments of this type, the structure of implicit taxes involved in the public pension scheme may effectively create a barrier to fully participating in the labour market for those subjected to the high tax rates falling on job entrants in a German-type pension system.

Building on figure 4 we may also observe that – irrespective of the erratic movements in inverse elasticity ratios – the level of implicit tax rates imposed on males aged 30–44 will not matter too much from an optimum taxation perspective. Here, the elasticity of labour supply with respect to wages is close to zero, so that excess burdens of taxation will be very small. (In theory, this implies that these individuals could be taxed at a 100 percent rate without creating many distortions.)

Turning to married females, we may conclude from table 8 – for the comparison of "young" vs. "older" women, that is – that here the overall structure of implicit tax rates across the life cycle is roughly consistent with the inverse elasticity rule. As in the case of males, the tax rates imposed on women in the 40–59 group could be even lower if compared to the result obtained for women aged 20–39. However, considering the small difference between the ratios of implicit tax rates and inverted wage elasticities, firm conclusions regarding any inefficiencies might be overdrawn.

[45] To be sure, this is an option that is not considered in our empirical model where we concentrate on labour supply in terms of hours worked. Studying participation decisions taken by older workers in the presence of early retirement programmes which have been defined in many countries, implying an increase in implicit tax rates to more than 100 percent if the alternative is to retire now or later without any corresponding adjustment in the level of annual pension benefits, is clearly an important issue of its own (see, for instance, Brinch, Hernæs and Strøm, 2001).

If we look at the timing of implicit taxes imposed on married women in more detail similar cautions apply. Nonetheless we may state that actual tax rates that apply to married women are constantly declining over their life cycle, while inverted ratios of wage elasticities are sometimes smaller than one, thus indicating that an optimal tax schedule should increase for some age groups. A possible explanation for the younger age groups is that these are women in their prime age of fertility who respond to economic incentives when choosing the time they spend in employment while taking care of small children. Similar things apply to older women who are mainly beyond their fertile age (but, like those aged 40–44, perhaps are willing to take up work again following an extended parental leave).

Table 9b

The time structure of implicit taxes and inverted wage elasticities over the life cycle: married women

Implicit taxes		**Wage elasticities**
τ_t	$\frac{\tau_t^{net}}{\tau_{t+1}^{net}} \equiv \frac{\tau_t}{1-\tau_t}\frac{1-\tau_{t+1}}{\tau_{t+1}}$	("life cycle effects" derived for a given birth cohort)
τ_{20-24} = 14.67 %	$\tau_{20-24}^{net}/\tau_{25-29}^{net}$ = 1.04	$\varepsilon_{25-29}^{***}/\varepsilon_{20-24}^{***}$ = 1.05
τ_{25-29} = 14.15 %	$\tau_{25-29}^{net}/\tau_{30-34}^{net}$ = 1.05	$\varepsilon_{30-34}^{***}/\varepsilon_{25-29}^{***}$ = 0.85
τ_{30-34} = 13.55 %	$\tau_{30-34}^{net}/\tau_{35-39}^{net}$ = 1.06	$\varepsilon_{35-39}^{***}/\varepsilon_{30-34}^{***}$ = 0.83
τ_{35-39} = 12.86 %	$\tau_{35-39}^{net}/\tau_{40-44}^{net}$ = 1.07	$\varepsilon_{40-44}^{***}/\varepsilon_{35-39}^{***}$ = 1.11
τ_{40-44} = 12.09 %	$\tau_{40-44}^{net}/\tau_{45-49}^{net}$ = 1.09	$\varepsilon_{45-49}^{***}/\varepsilon_{40-44}^{***}$ = 0.74
τ_{45-49} = 11.21 %	$\tau_{45-49}^{net}/\tau_{50-54}^{net}$ = 1.11	$\varepsilon_{50-54}^{***}/\varepsilon_{45-49}^{***}$ = 1.10
τ_{50-54} = 10.19 %	$\tau_{50-54}^{net}/\tau_{55-59}^{net}$ = 1.16	$\varepsilon_{55-59}^{***}/\varepsilon_{50-54}^{***}$ = 0.85
τ_{55-59} = 8.91 %	(not defined)	(not defined)

On the other hand, a general impression to be derived from figure 4 is that the wage elasticity of female labour supply tends to increase for those aged 40 and over. Thus, the cohort effects that show up in this graph suggest that, on the whole, a declining tax profile is largely appropriate for these older age groups. In this sense, the elasticity ratios derived in table 9b may be slightly misleading, because they abstract from these cohort effects, concentrating on life-cycle effects across each pair of successive age brackets.

If we put these findings together, being careful not to overstate our case, we may thus conclude that the optimal time structure of implicit taxes should follow an inversely "J-shaped" pattern. It is true that this result is more obvious in the case of men than in the case of married women. Abstracting from discretionary changes in contribution rates or benefit levels that are rarely intended to actively shape the life-cycle structure of implicit tax rates, actual tax profiles that arise in many existing pay-as-you-go pension schemes are constantly declining over a typical life cycle. In other words, the current timing of τ_t may be roughly consistent with optimality conditions for the case of middle-aged and older workers. But the high taxes imposed on young individuals and the slow decrease of tax rates falling on workers who are about to enter retirement may indeed constitute problems in terms of efficiency.

So far, we have focused on the issue of an optimal timing of implicit tax rates, treating men and (married) women in isolation. As a last step to take, we should also spell out our final results regarding the (non-)optimality of the "gender tax-gap" that may exist in many public pension schemes. In order to do so, it is mainly cross-gender differences between implicit tax rates and wage elasticities we have to look at, rather than their structure over time. We therefore restrict our attention to the structure of τ_t and ε_t across males and females based on the two broad age groups considered in table 8.[46] The results are shown in table 10.

Table 10
The structure of implicit taxes and inverted wage elasticities across genders: men vs. married women

"Young" individuals	$\frac{\tau_{20-39}^{females}}{1-\tau_{20-39}^{females}} \frac{1-\tau_{20-39}^{males}}{\tau_{20-39}^{males}} = 1.127$	$\frac{\varepsilon_{20-39}^{males}}{\varepsilon_{20-39}^{females}} = 0.082$
"Older" individuals	$\frac{\tau_{40-59}^{females}}{1-\tau_{40-59}^{females}} \frac{1-\tau_{40-59}^{males}}{\tau_{40-59}^{males}} = 1.294$	$\frac{\varepsilon_{40-59}^{males}}{\varepsilon_{40-59}^{females}} = 0.312$

As is already immediate from figure 4, the result obtained here is strong and simple. Since women in both age groups are much more responsive to taxes in terms of their labour supply, implicit tax rates imposed on married women should always be lower than those imposed on men. (Taking at face value the results displayed in table 10, their tax rates should range between one tenth and one third in proportion to those for men.) However, given the usual "second-earner" status of many women and the widely-used reductions in their pension benefits if the latter coincide with survivor benefits (and, in countries like Japan and the US, additional spouse benefits accruing when their husbands are still alive) actual tax rates for women are much higher (1.1 times higher for young individuals and 1.3 times higher for the old) as the tax burden falling on men. In this case, the "inverse elasticity rule" of optimal taxation is obviously violated.

[46] From the results presented in tables 7 and 9, it would be easy to derive a richer picture for the case of males *vs.* females building on our 5-year age brackets. Since we are generally reluctant to use our findings for very detailed policy prescriptions – like, for instance, point estimates regarding an optimum tax schedule – we will not make use of this option.

7 Discussion

Now, what have we learned from our investigation into the structure of implicit taxes that are involved in virtually any unfunded pension scheme? And what, if any, are the policy implications of our findings? The answers clearly depend on how reliable we take our empirical results to be. If we restrict our attention to the scenario which corresponds to the simple 3-period model employed in the theoretical analysis, our conclusion might be as follows: Since in real-world pension schemes, implicit tax rates must be expected to decrease over the life cycle, some support for the optimality of current pay-as-you-go pension schemes can be derived from the observation that the wage elasticity of labour supply tends to increase over the same span of time for both males and females. The decline in tax rates might be even sharper than it actually is in the case of men, while it is largely appropriate in the case of women. In any case, our estimates basically add to the efficiency results reported in previous studies that were concerned with other aspects of unfunded (*vs.* funded) pension systems.

At the same time, our results point to up to three potential sources of inefficiencies entailed in many existing public pension schemes. When investigating the time-structure of implicit taxes in some more detail, one problem is given by the fact that the peak level of implicit taxes is usually falling on very young individuals. Another problem is constituted by the level of implicit taxes falling on individuals near their retirement age. Surprisingly, the problem here is not that this level of taxation is lower than for younger individuals, but that it may still be too high considering the concomitant increases in the wage elasticity of labour supply. A third, and perhaps most obvious, problem arises from the higher level of implicit taxation which is relevant in general for the case of a typical second-earner – *i.e.*, mainly for married women.

The latter problem falls in the same class as a number of other well-known distortions of similar type that are created through progressive household-level taxation, child-related benefits that are inversely related to household income (or decrease with the number of hours worked by the mother), *etc*. Therefore, it may not rank highest on the agenda if strengthening the incentives for women to participate in the labour market is considered an issue. (Note that the role of these reforms is essentially in removing current fiscal *dis*incentives, rather than pushing women into employment by means of subsidising their labour supply.) Nonetheless, there may be reasons to redefine rules that govern the treatment of married couples in existing public pension schemes and, in particular, to reconsider the wide-spread use of (“non-contributory”) survivor or spouse benefits. In general, the key to solving these problems will be in determining individual pension claims much more on the basis of individual accounts—for instance, with mandatory contributions to be paid for spouses who are not working. It can be expected that for one-earner couples the burden involved in public pension schemes would then go up. For all other individuals – men and women living in a two-earner household as well as single males and females – it may go down because the relation between contributions and contributory benefits should improve, *ceteris paribus*.

For the first type of problem mentioned above – excess burdens created through high implicit tax rates for those who are just entering the labour force – the empirical evidence obtained through our estimates is much weaker. Nonetheless, the existence of this problem is not implausible. Under real-world conditions, it can take on several disguises. Young people may prefer to work on a limited basis only, staying in the education system for a longer period of time than is needed to invest in future productivity or to complete a degree for signalling purposes.[47] Also, they can explore the various routes to avoiding taxes, manipulating their number of hours worked that are subject to the public pension scheme. For instance, young individuals may choose to enter into the shadow economy or they can evade into new types of self-employment if the latter is a strategy for not paying social security taxes. This is one of the reasons why the German government has recently subjected quite a number of self-employed persons to compulsory membership in the public pension system. In Japan, simple non-compliance with the obligation to pay contributions appears to be an option that is chosen by a growing number of (young) employees. From an economic point of view, most of these alternatives are at least superior to simply reducing work effort. Nonetheless, they may put public pension schemes under substantial financial pressure. Things will be even worse in the future if the prospect is that contribution rates and, hence, implicit tax rates will go on to increase over the next 20 to 30 years as a consequence of demographic ageing.

Finally, regarding the problem that implicit tax rates may also be "too high" for those who are just about to enter retirement, our findings again are stronger. In practice, there are several routes for older workers who want to exit from the labour market. Income-support programmes, which were originally designed to deal with other contingencies, are used in many countries to finance early withdrawal in one way or another – sometimes allowing for a partial exit. For example, some degree of disability may qualify for benefits that are paid to make up for a reduction in the regular work load. Similarly, there are programmes where part-time work of elderly workers is subsidised through unemployment insurance benefits or even from the pension budget. Availability of these various benefits increases the disincentives to work prior to the earliest age at which full old-age pensions become available. In any case, older workers can respond to any disproportions between their net pay and the elasticity of their labour supply by reducing over-time work (or asking for compensations that are not officially recorded).

If we take these problems to be serious ones, they should be solved by reducing the implicit tax rates involved in public pensions for young and very old workers. In theory, this can be done using either of the two instruments that are mostly relevant for the level of τ_t: annual contribution rates as well as annual accrual rates can be differentiated across age groups. In both cases, there are additional constraints to be observed, making sure that overall revenues and overall expenditure are not affected and that the present value of individual contributions and benefits over the full life cycle must not be altered. Still, this leaves some degrees of freedom for manipulating the level of annual tax rates, reducing contribution rates or increasing periodic accruals in the relevant periods of life that are compensated by appropriate adjustments in the full life-time structure of implicit tax rates that apply to other age groups.[48]

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47 If looked at the other way round, one might interpret the higher taxes falling on young individuals as an indirect way of subsidising higher education since they reduce the opportunity cost of extended periods of training. Yet, there should be better ways to produce a similar effect using instruments located outside the public pension scheme that are more targeted.

48 Remember that, at least in the case of males, we found middle-aged individuals to be rather inelastic when responding to higher (implicit) taxation.

In practice, differentiating contribution rates by age may be harder to accomplish than varying accrual rates. The reason is that administrative costs on the side of employers who would then have to consider the age structure of their employees when paying social security taxes will matter much more than similar effects resulting from changes in the benefit formula. Without much complications, the latter can be handled by the social security administration. As a consequence, the Austrian example of attributing higher pension claims to contributions made at the age of 31–45 – if redirected to other years of age – may indicate one sensible way of dealing with the problems that were discussed here, thus approaching an optimal time-profile of implicit tax rates.

We should not stop without raising a more fundamental issue. In our analyses, we have constantly assumed that individuals optimise over their entire life-span, exhibiting perfect foresight with regard to all socio-demographic trends, all possible changes in the economic environment, and all the relevant policy options. If we look at actual patterns of implicit tax rates obtained for the German public pension scheme and for all the age cohorts born from 1929 to 1999 (figure 2), we may have doubts as to whether these profiles are really predictable with sufficient accuracy for all the individuals affected. In addition, even if we take it for granted that the life-cycle profiles of implicit tax rates are basically predictable – as is a natural assumption to make for an economist – one may doubt all the more that politicians will be able to actively manage these patterns guided by the optimality conditions derived before.

Among other things, figure 2 illustrates that any changes in the system, expected or not, can create a disturbance that hits up to 70 cohorts at a time, each being in a different stage of their life cycle. In order to install an "optimal" structure of implicit tax rates, effects of this kind have to be avoided. In fact, the structure of contribution rates or accruals that are optimally differentiated must not only hold *within* a given period of time. Instead, it must be designed to hold over the full period of labour force participation, plus retirement, of a given age cohort. It is easy to see that optimality conditions of this kind are very hard to be met in real-world pension schemes. Furthermore, it becomes apparent that adapting public pension schemes to optimum taxation rules may involve a huge loss in flexibility regarding short-term adjustments, which is often cited as being one of the main advantages of unfunded pension schemes when compared to the rigidities involved in funded systems that are built on actuarial principles. On the other hand, inasmuch as "short-term flexibility" effectively means susceptibility for (myopic) political manipulations, this need not be a serious drawback.

All in all, our results do not make a strong case against the efficiency of existing pay-as-you-go pension schemes. Yet, they highlight some details where improvements may be needed, in particular with respect to the excessive implicit taxation of married women and to the sub-optimal (*i.e.*, high) taxation of very young and very old workers. While women should be subjected to an individual treatment – and not just to rules applying on a household-level – when defining their pension benefits, all individuals should effectively be taxed conditional on their age, for instance by applying lower annual contribution rates or higher accrual rates to those at both ends of the age distribution. In a way, our results thus contradict a standard proposal that suggests to smooth the profile of implicit tax rates across the individual life cycle.

Appendix

a) Description of the German Socio-economic panel (GSOEP)

The GSOEP is a longitudinal survey, organised in four sub-samples, covering a total of about 8,000 households and 15,000 individuals. Meanwhile, a maximum of 15 waves (1984–1998) is available for evaluation.

The four sub-samples of the GSOEP are:

– Sample *A* ("West Germans") includes private households living in West Germany with a head of the household of German nationality or of foreign nationalities that are not part of sample *B*;
– Sample *B* ("Foreigners") includes private households living in West Germany headed by persons of Italian, Greek, Yugoslavian, Spanish, or Turkish nationality (*i.e.* the main ethnic groups of foreigners living in Germany);
– Sample *C* ("East Germans") includes private households in East Germany with a German head of the household;
– Sample *D* ("Immigrants") includes a small number of private households in which at least one person is immigrated to West Germany since 1984.

In 1998 an additional sample *E* has been introduced in order to overcome panel mortality and to expand the data base. It includes about 800 private households in West Germany and 200 Households in East Germany.

Three survey instruments are essential for the GSOEP:

– One questionnaire which has to be filled in on an annual basis, addressing a number of questions that are relevant at the household level (housing, wealth, transfers, *etc.*; including information on children in the household, who cannot answer the questionnaire by themselves).
– A second questionnaire which has to be answered annually by each person in the household who is at least 16 years old at the beginning of the survey year. Here, quite a lot individual socio-economic features are covered, including labour force participation and earnings.
– In addition, the full biography and employment-record of each individual aged 16 and over has to be reported once a person enters the survey. Afterwards, this type of information is up-dated in each survey year.

In some of the panel waves, additional questions are included in the survey, focusing on specific issues. In our analysis, however, we can rely on the information that is collected on a regular basis.

b) Standardised work biographies

As a representative agent in each age cohort, we constructed an individual with a stylised biography and working-career (see table) which we did not alter over time (*i. e.* across generations).

The standardised agent considered in the model: basic assumptions for the case of Germany

Age 20–52	Full-time labour force participation with average earnings → contributions paid to the pension scheme on a full-time basis	33 years
Age 53–64	Reduced probability of full-time participation → reduced contributions based on 83.4 % of full-time earnings → 16.6 % of (full) disability benefits received	12 years
Age 65–74	Period of retirement → old-age pension benefits payable based on prior work-record and earnings	10 years
Age 75(–86)	Individual dies at age 75 → survivor benefits payable to the survivant spouse	11 years

Basically, we consider a male (blue or white-collar) worker who enters his active period of life at age 20 and then earns the average of all workers throughout his career. He is fully active until some year in his 50s when he is regarded as being disabled with some positive probability. With what is left of his working capacity, he goes on working until age 65. Upon retirement, he is entitled to an old-age pension accruing to himself and, where appropriate, to his spouse. When he dies, his widow will receive a widows' pension for some more years if these are contained in the respective pension scheme.[49] As a result, the three main types of pension benefits – disability pensions, old-age pensions, and survivor benefits – are included in our model.

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