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WAGE FORMATION BY MAJORITY VOTING AND THE INCENTIVE EFFECTS OF PENSIONS AND TAXATION*

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We study median voter wage-setting and its dependence on pensions and taxation in a centralized monopoly union framework using a dynamic computable general equilibrium model with overlapping generations structure. We show that the higher is the earnings-related PAYG pension benefit level, the lower is the wage the voter chooses, for two reasons. Firstly, if the voter claims high current wages his lifetime wage income falls, which will lead to lower pensions, and the advantages of lower pension contributions go to future working generations. Secondly, the median voter has to pay higher contributions both because the current wage bill falls and because current pensions may increase due to indexation. Both these generational effects lead the median voter to choose lower wages, which leads to higher employment. When we compare median voter wage setting with labour markets where wages adjust to equate supply and demand, the difference is bigger when the incentives to work are stronger in the market equilibrium, and gets smaller when the incentives are weaker. When e.g. the pension benefits and the corresponding payroll tax are increased, the voting equilibrium wage level approaches the market equilibrium wage. Similar results are obtained with respect to labour and consumption taxes. (JEL: J51, H55, D58)

1. Introduction

The effects of pensions on the economy are usually studied in an overlapping-generations framework and assuming that labour markets clear. Both pension benefits and pension contributions are included in these analyses, which often deal with the incentive effects of benefit rules and possible pre-funding on labour supply and saving. Important contributions are Samuelson (1958) and Aaron (1986). Research has increasingly used simulation methods such as dynamic computable general equilibrium (CGE) models since the pioneering work of Auerbach and Kotlikoff (1987), see, e.g., Feldstein (1998) and Siebert (1998).

The overlapping-generations framework has also been widely used in tax analysis. Labour income taxes, consumption taxes and capital income taxes automatically have different dy-

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namic roles. Theoretical contributions include Atkinson and Stiglitz (1976) and Atkinson and Sandmo (1980), and CGE applications are, e.g., Auerbach and Kotlikoff (1987) and Broer and Westerhout (1993).

Another widely used approach in tax analysis is based on trade union behaviour and bargaining. This research has not provided many robust insights on tax issues, partly because there is a wide range of models derived from the trade union or bargaining approach, and partly because taxation in its various forms and channels of influence is an extremely difficult subject to study. Pension contributions are present as part of payroll taxes, but pension benefits are absent.

Usually analytical studies of tax effects in bargaining models yield ambiguous results, unless specific restrictions are put on e.g. the union's objectives or parameter values. The results may also depend on the details of the tax system, as, e.g., Koskela and Schöb (1999) show concerning the composition of wage and payroll taxes. One result is theoretically well-established: tax progression is good for employment if wages are set by bargaining, but bad for employment if wages adjust to clear the supply of and demand for labour (see, e.g., Koskela and Vilmunen, 1996), but even this might not hold if hours of work are included. Empirical studies based on the bargaining approach, such as Tyrväinen (1995), must weigh up the different and conflicting tax effects.

Wage bargaining models have seldom incorporated an overlapping-generations structure. Huizinga (1990) considers efficient bargaining, where both wages and employment are agreed upon. In his model the union utility is the sum of the utilities of the members. Hawtrey (1990) combines trade unions and capital formation in an overlapping generations framework, modifying the Solow-Swan growth model. Workers live and work for two periods, and positive population growth ensures that the median voter belongs to the younger generation. There is no retirement and thus no pension system. Capital is owned by a separate group of people, capitalists. Hawtrey emphasizes the dynamic interaction between the union's decisions and capital formation.

Intertemporal CGE models usually assume that labour markets clear: wages adjust to equate the supply of and demand for labour. A notable exception is Jensen et al. (1996). Their model includes a Blanchard – Kiyotaki (1987) type labour market, and a household sector where the probability of death is independent of age.

The median voter approach in trade unions is not new. Blair and Crawford (1984) give a critical assessment of some applications in the 1970s. They stress that the conditions for the existence of a voting equilibrium are extremely stringent in models with choice spaces of dimensionality two or larger. Layard, Nickell and Jackman (1991, p. 86) state as one of their stylized conclusions that 'Union democracy means that unions maximize the welfare of the median member'. Applications are scarce, though. Renström and Roszbach (1995) study employee share ownership in an economy with one monopoly union for each firm. In their analysis union members differ in exogenous stock endowments. Booth (1995) gives a short overview of the median-voter approach to wage bargaining. She has used the approach herself to explain the individual decision to join a union. Outside trade union models, there are several applications of majority voting to taxation, from the 1970s onwards, and to pensions, see e.g. Lassila and Valkonen (1995) and Azariadis and Galasso (1996).

This study aims to analyse the effects of pensions and taxation so that both the overlapping-generations dynamics and trade union decision making are included. A novel feature in this paper is to incorporate a trade union with median-voter wage setting into an overlapping-generations framework of the Auerbach-Kotlikoff (1987) type. This model type has become popular in policy analysis, as it can be adapted rather easily to different institutional structures and other country-specific features (see, e.g., the articles in Broer and Lassila, 1997) while ensuring that the analysis is explicitly based on optimising behaviour by economic agents.

The median voter approach is almost directly applicable to a numerical OLG model. Workers differ in age, and their gains and losses from higher wages differ also, because the length of

remaining working years, wealth, accumulated pension rights etc. differ. The median voter approach has the advantage of exactly defining the target of the trade union: no additional assumptions are needed as all relevant information is included in the households' utility functions. The approach also defines the dynamic aspects of the trade union's decision: the horizon is that of the median voter. Only one feature needs to be added to the model: a mechanism or rule stating how employment is divided among households. There are at least two obvious candidates. One is to divide employment equally among all households, the other is to leave some households entirely unemployed, and divide total employment among a smaller group. We shall use the first option because of its simplicity.

We show that there is an equilibrium wage level in our model which the majority of workers wants neither to increase nor decrease. This wage is higher than the market-clearing equilibrium wage, and correspondingly employment is lower. How big this difference is depends on many features of the economy, such as the substitutability of labour and capital in production, price elasticities between foreign and domestic goods in consumption, investment, intermediate use or in the export markets, and individual preferences between leisure and consumption. The difference is smaller when taxation and the pension system discourage individual work incentives. When, e.g., the pension benefits and the corresponding payroll tax are increased, the voting equilibrium wage level approaches the market equilibrium wage. Similar results are obtained with respect to labour and consumption taxes.

Our analysis stresses the importance of intergenerational aspects. For example, the higher is the earnings-related PAYG pension benefit level, the lower is the wage the median voter chooses, for two reasons. Firstly, if the voter claims high current wages his lifetime wage income falls, which will lead to lower pensions, and the advantage of lower pension contributions goes to future working generations. Secondly, the median voter has to pay higher contributions both because the current wage bill falls and because current pensions may increase due to indexation. Both these generational transfer effects lead the median voter to choose lower wages, which leads to higher employment.

The paper is organized as follows. Section 2 provides simple analytical examples of median-voter wage setting, to provide intuition of the basic features before proceeding to the complex simulation environment. In Section 3 the behaviour of individuals, both as members of trade unions and as households, is described and the median voter approach is specified. Section 4 discusses the features of the voting equilibrium. The incentive effects of pay-as-you-go (PAYG) pensions in the voting equilibrium are compared to those with labour-market clearing in Section 5. Incentives and taxation are discussed in Section 6, and concluding remarks are presented in Section 7.

2. *Basic features of median-voter wage setting*

Like most union or bargaining models, the median voter approach also focuses on wages and employment. Employment comes indirectly as leisure; the median voter is an individual who values leisure and works only to facilitate consumption. From this angle, the trade union is an institution to whom the households have delegated their decisions concerning the amount of leisure, while keeping consumption decisions to themselves. When the trade union makes the leisure decisions, by setting wages which determine employment, it also considers the resulting consumption possibilities. The leisure – consumption outcome is different from what it would be if the households were to make both decisions directly. The choices are affected by taxes and the pension system, again differently when there are trade unions and when there are not.

This section tries to give intuition about the main features distinguishing the median voter approach from either assuming balancing atomistic labour markets or using the trade union approach without the median voter. Besides the leisure – consumption choice mentioned above, we highlight some crucial dynamic issues.

Firstly, the median voter is a different individual in each period, and each median voter must form expectations concerning future median voters' decisions and how they depend on current decisions. Secondly, the current wage affects capital formation and thus future wage and employment possibilities. Thirdly, pensions are inherently dynamic and create links both between periods in each generation's life cycle and between different generations.

Dynamic wage and employment effects

Consider an economy where all households care about consumption *c* and leisure *l*. Assume that each household lives two periods and has a lifetime utility function *U*. To simplify, assume that the household cannot freely borrow and lend, so there are two budget constraints.

$$(1) \quad U = u(c_1, l_1) + \beta u(c_2, l_2)$$

$$(2) \quad (1 - l_1)w_1 - c_1 = 0$$

$$(3) \quad (1 - l_2)w_2 - c_2 = 0$$

where *w* is the wage rate. The price of the consumption good is set to unity, so *w* also represents the relative price of leisure and consumption. The total amount of time the household can allocate for work and leisure is also set to unity. The household's discount factor β is defined as $\beta = (1+\delta)^{-1}$, where δ is the positive rate of time preference. If the labour market equates the households' supply of and firms' demand for labour, the household decides both *c* and *l* optimally, taking *w* as given. This yields a familiar condition for the consumption – leisure choice (partial derivatives are denoted by subindices).

$$(4) \quad u_{l_i}/u_{c_i} = w_i \qquad i = 1, 2$$

Let us now assume that the wage rate is set by a trade union. The firms' demand for labour then determines total employment, of which the share of each household is $e = 1–l$. Households can now only decide consumption optimally, given *l* and *w*. The optimal solution is to spend total wage income on consumption. There is one household, however, who is the median voter in the trade union. Assuming that it belongs to the young generation, its wage-setting problem is

$$(5) \quad \max_{w_1} U$$

subject to (2) and (3) and

$$(6) \quad 1 - l = e = e(w), \quad e_w < 0$$

As the median voter the household decides the wage, taking into account the employment effect. It doesn't consider consumption here, but assumes that as a household it, as other households, will make an optimal consumption decision. Inserting the budget constraints into the utility function yields the following first-order condition.

$$(7) \quad dU/dw_1 = u_c(e + e_w w_1) - u_l e_w + \beta(u_c(e + e_w w_2) - u_l e_w)\frac{dw_2}{dw_1} = 0$$

Besides the current consumption and leisure effects, the solution depends on the expected effect of w_1 on the second period's median voter's decision; an issue which will be discussed at length in Section 4. Disregarding the possibility that by chance $\beta\frac{dw_2}{dw_1} = -1$, which is outside the median voter's realm of influence, the only stationary solution[1], where $w_1 = w_2 = w$, is clearly

$$(8) \quad u_c(e + e_w w) - u_l e_w = 0$$

With slight manipulation of (8) we have the following leisure – consumption relation, where μ is the elasticity of employment w.r.t. the wage rate.

$$(9) \quad \mu = e_w(w)w/e(w)$$

$$(10) \quad u_l/u_c = w(1 + 1/\mu)$$

[1] *We assume overlapping generations: in each period there is both a young cohort and an old cohort in the economy. This facilitates a stationary equilibrium.*

Since μ is negative, the marginal utility of leisure is lower in relation to the marginal utility of consumption than in the atomistic labour market case (4). With decreasing marginal utilities this implies that there is now more leisure in relation to consumption than there would be if the median voter household could freely choose both *l* and *c*, taking *w* as given. But the median voter cannot freely choose *l* (by choosing *w*), he internalizes the employment effect of his decision. The other households cannot choose *l* at all, it is given to them. The households would like to work more with the wage rate *w*, but are restricted by the firms' demand for labour.

Notice that, for an interior solution, the employment elasticity μ in (10) must be less than minus one. Otherwise it would always pay for the union to increase the wage somewhat more, as households could have both more leisure and more consumption. If the elasticity is a decreasing function of the wage rate, with values between zero and minus one for lower wages and values below minus one for higher wages, we know that the leisure-valueing monopoly union described above would set a higher wage than a wage-bill maximising trade union. Maximising the wage bill, with a wage rate where $\mu = -1$, would maximise consumption, but the trade union here is willing to trade some of that consumption for more leisure.

The direct effect of the current wage decision on the future wage decision is not the only way future employment is affected. One of the most important channels is that wage decisions can affect the capital stock, which affects future wage decisions, and so on (for an empirical monopoly-union application see Holm, Honkapohja and Koskela, 1994). To illustrate this, assume that employment depends also on the capital stock, which in turn adjusts slowly and depends on the wage prevailing in the previous period.

$$e = e(K, w) \tag{11}$$

$$K = K(w_{-1}), \qquad K_{w-1} < 0 \tag{12}$$

Assuming for simplicity that now the wage in the second period is unaffected by the current period wage decision, condition (7) becomes

$$dU/dw_1 = u_c(e + e_w w_1) - u_l e_w + \beta(u_c e_K K_{w-1} w_2 - u_l e_K K_{w-1}) = 0 \tag{13}$$

Evaluating (13) in a stationary situation, the analogue of condition (10) becomes more complicated:

$$u_l/u_c = w(1 + \tfrac{1}{\mu + \beta\kappa}) \tag{14}$$

where $\kappa = e_K K_{w-1} w/e$ is the partial elasticity of employment w.r.t. the wage rate via the capital stock.

The right-hand side of (14) also includes the dynamic wage effect on capital stock and thus on future employment, in addition to the direct employment effect of the wage. Had we included the expected effect on the second period wage decision, it would have intertwined with the capital stock effect and further complicated the result. The examples demonstrate that dynamic employment effects are important for the median voter's decision-making.

The effects of taxes

Let us now assume that the government collects three types of taxes: a proportional wage tax, at a rate τ^w, a value-added tax τ^c on consumption, and a payroll tax τ^z. These taxes change the relative price of consumption and leisure, and the change is different from the households' and median voter's points of view. Now the household's budget constraint is

$$(1 - l)w_i(1 - \tau^w) - (1 + \tau^c)c_i = 0 \quad , \quad i = 1, 2 \tag{15}$$

and employment depends on the price of labour

$$1 - l_i = e_i = e((1 + \tau^z)w_i) \quad , \qquad i = 1, 2 \tag{16}$$

Instead of equation (10), the median voter's optimal decision now leads to the following leisure – consumption relation.

$$u_l/u_c = \tfrac{(1-\tau^w)}{(1+\tau^c)} w(1 + \tfrac{1}{\mu}) \tag{17}$$

As previously, the first term on the right side expresses the price ratio of leisure and consumption from the household's point of view. Wage and consumption taxes affect this ratio. The second term gives the employment elasticity effect, which now includes the payroll tax: $\mu = e_w((1+\tau^z)w)(1+\tau^z)w/e(w)$. The payroll tax thus affects the median voter's decision through the internalized employment effect. If households were to choose both consumption and leisure, they would neglect the payroll tax, but it would still affect the outcome because the market-clearing wage would depend on it.

Pensions

Future wage decisions may be important for the median voter even if he will then be retired. Earnings-related pensions connect the working periods of the lifecycle to the retirement periods. Working creates a right to receive pension benefits in the future. Contributions are paid from wage income, and used to pay for the pensions of current pensioners. Thus there are effects within and between lifecycles.

Consider again the decision setting of the period 1 median voter in a two-period lifecycle context. Now we assume that he will be retired during the second period ($l_2 = 1$). The constrained maximisation problem is as follows.

$$(18) \quad \max_{w_1} U = u(c_1, l_1) + \beta u(c_2, 1)$$

subject to the budget constraint and the demand for labour:

$$(19) \quad (1 - l_1)w_1 + z_2/(1+r) - c_1 - c_2/(1+r) = 0$$

$$(20) \quad 1 - l_1 = e_1 = e_1((1+\tau^z)w_1)$$

As the saving effects of pension systems are an important issue, we have now allowed saving. The sign of saving in period one and in period two is not constrained, so there is only one dynamic budget constraint (19).

By setting the wage rate the median voter determines his employment and thus leisure in period 1. The amount of leisure in period 2 is fixed: the current median voter will be retired and thus all his time is leisure. But he may still have to consider the second-period median voter's decision, because his pension z may depend on it. The benefit formula is

$$(21) \quad z_2 = \theta(1 - l_1)w_1\left(\frac{w_2}{w_1}\right)^{\lambda}$$

where θ is the pension replacement rate, relating the pension benefit to beneficiary's wage income. The higher θ is, the less households need to save for the retirement period, and less saving affects the wage and employment possibilities. λ is the indexation parameter with possible values of 0 (no indexation of pension benefits to current wages) and 1 (full indexation to current wages).

With no indexation, the budget constraint is

$$(22) \quad (1 - l_1)w_1 + \theta(1 - l_1)w_1/(1+r) - c_1 - c_2/(1+r) = 0$$

If the median voter is also an average household and there is no population growth, we can express the pension institute's budget constraint as (23). The equation says that, because it is a PAYG system, the contributions collected during period 1 are paid to current pensioners, whose pension benefits are determined by their earnings in period 0.

$$(23) \quad \tau^z(1 - l_1)w_1 = \theta(1 - l_0)w_0$$

When making his decision, the current median voter need not think about the wage during period 2; it doesn't affect his welfare since, with $\lambda = 0$, neither his wage income in period 1 nor his pension income in period 2 depend on the wage in period 2.

If the pension benefits are fully indexed to current wages, the household's and the pension institute's budget constraints change significantly:

$$(24) \quad (1 - l_1)w_1 + \theta(1 - l_1)w_2/(1+r) - c_1 - c_2/(1+r) = 0$$

$$(25) \quad \tau^z(1 - l_1)w_1 = \theta(1 - l_0)w_1$$

Now the current median voter's pension will depend on the next median voter's wage decision, so the possible effect of this period's wage

on next period's wage must be taken into account. Another link now is that the current wage affects current pensions. The median voter knows that if he sets a higher wage, the current payroll tax rate must be increased: current pensions grow proportionately to the wage but the wage bill grows less. The change in the payroll tax rate will in turn also affect employment.

Combining median-voter wage setting in trade unions and overlapping-generations dynamics in analysing the effects of pensions and taxation brings about several issues. The examples above have illustrated three: expected future wage decisions, dynamic employment effects via the capital stock, and the dynamic nature of pensions.

An analytical approach would prove extremely difficult if not practically impossible unless some of the issues are dropped out. We have chosen another approach: we start from an existing overlapping-generations macro model and include the trade union in it. The dynamics of the capital stock are well known, and the pension system with its effects on saving are analysed extensively in earlier studies. Households' lifecycle contains several periods both in working-years and in retirement, facilitating a more realistic description of the time spans which in wage agreements is only one or several years but in pension systems several decades. The price to pay for this approach is that the results cannot be easily interpreted.

3. The simulation model

The model we use in simulations is the FOG model[2], modified to include a trade union with majority-voting wage setting. FOG is a dynamic general equilibrium simulation model with an overlapping-generations structure. It is an open economy version of Auerbach-Kotlikoff type of models, and has been used to analyse pension policies (Lassila et al., 1997a, Forss et al., 1998), other social transfers (Lassila and Valkonen, 1998), taxation (Valkonen, 1997 and 1999), globalisation (Lassila and Valkonen, 1999a) and ageing (Lassila and Valkonen, 1999b). In what follows we explain the basic structure of the model. For a detailed description of the model, see Lassila et al. (1997b).

3.1. Households

The economy has overlapping generations of households, each maximising lifetime utility U with respect to consumption. The maximisation problem is

$$(26)\quad \max_c U = \sum_{t=1}^{T} \frac{1}{1-\frac{1}{\gamma}} \frac{u_t^{1-\frac{1}{\gamma}}}{(1+\delta)^{t-1}}$$

where the periodic utility function is

$$(27)\quad u_t = (c_t^{1-\frac{1}{\rho}} + \alpha_0 l_t^{1-\frac{1}{\rho}})$$

and maximisation is subject to the budget constraint (28) stating that discounted lifetime wage income, pensions z and transfers E equal discounted consumption expenditure:

$$\begin{aligned}(28)\quad & \sum_{t=1}^{T_w}(1-l_t)w_t(1-\tau_t^w)(1+r)^{-(t-1)} \\ & + \sum_{t=T_w+1}^{T} z_t(1-\tau_t^w)(1+r)^{-(t-1)} \\ & + \sum_{t=1}^{T} E_t(1+r)^{-(t-1)} \\ & - \sum_{t=1}^{T} c_t P_t^C(1+\tau_t^c)(1+r)^{-(t-1)} = 0\end{aligned}$$

where c is consumption, l is leisure, and of the constant parameters γ is the elasticity of intertemporal substitution of the composite commodity u, δ is the rate of time preference and ρ is the elasticity of substitution between consumption and leisure. The household lives for T periods and works the first T^W periods. Labour incomes are taxed at a rate τ^w and the VAT rate is τ^c. P^C denotes consumer prices (see Equation A 21 in Appendix 2). Incomes and expenditures are discounted with an exogenous interest rate r.

Leisure l is determined by total employment L^T (see Appendix 2), which is divided equally among all working-age households, whose number is N^w, according to Equation (29). Utility maximization is also subject to the rules of the pension system, described in Section 5.1. The transfers are taken as given by the households.

[2] *The name is abbreviated from Finnish Overlapping-Generations Model.*

$$(29) \quad 1 - l_t = L_t^T / N_t^w$$

As a reference, we shall also look at competitive labour markets without trade unions. There the supply of and demand for labour balance, and households do not take leisure as given but instead maximise U with respect to both consumption c and leisure l.

3.2 The trade union

We assume that there is one nationwide trade union. It is a monopoly union, i.e. it sets wages independently and employers have no say in the outcome. Employment is determined by firms. Trade union membership is compulsory. This is to avoid problems of whether or not it is advantageous for all workers to be members.

In each period the members decide the wage of that period. The voting procedure is not specified, we simply assume that the outcome is such that the majority of members do not want to change it.

Each member bases his/her voting on lifetime utility considerations. When comparing the wage alternatives for the current period, they calculate their combinations of leisure and optimal consumption, and the resulting period utilities, for all the periods of their remaining lifetime, subject to their budget constraint during their remaining lifetime. Then they aggregate period utilities in their lifetime utility function and choose the wage that yields the highest lifetime utility. In these calculations they take into account all the general equilibrium effects, of which they have perfect foresight.

Formally, the median voter maximises the utility of the rest of his life, with respect to the wage in the period in which he is the median voter. Without loss of generality we denote both the age group and the period by m in the following formulas. The problem is

$$(30) \quad \max_{w_m} U = \sum_{t=m}^{T} \frac{1}{1-\frac{1}{\gamma}} \frac{u_t^{1-\frac{1}{\gamma}}}{(1+\delta)^{t-1}}$$

subject to the budget constraint

$$(31) \quad W_{m-1} + \sum_{m}^{T_w}(1-l_t)w_t(1-\tau_t^w)(1+r)^{t-m} + \sum_{T_w+1}^{T} z_t(1-\tau_t^w)(1+r)^{t-m} + \sum_{m}^{T} E_t(1+r)^{t-m} - \sum_{m}^{T} c_t P_t^C(1+\tau_t^c)(1+r)^{t-m} = 0$$

where W_t is financial wealth at the end of period t, subject to the rules of the pension system which determine z (see Equations 33–35), and subject to the general equilibrium effects that come from the total model (see Section 3.3. and Appendix 2).

We may write the overall condition for optimal wage setting as follows.

$$\begin{aligned}(32) \quad \frac{dU}{dw_m} = {} & (\Sigma_m^T \frac{u_t^{-\gamma^{-1}}}{(1+\delta)^{t-1}} u_{l_t} \\ & - \Omega \Sigma_m^{T_w} w_t(1-\tau^w)(1+r)^{t-m}) \frac{dl_t}{dw_m} + \Omega \frac{dW_{m-1}}{dw_m} \\ & + \Omega \Sigma_m^{T_w}(1-l_t)(1-\tau^w)(1+r)^{t-m} \frac{dw_t}{dw_m} \\ & + \Omega \Sigma_{T_w}^{T}(1-\tau^w)(1+r)^{t-m} \frac{dz_t}{dw_m} \\ & - \Omega \Sigma_{t=m}^{T} c_t(1+\tau^c)(1+r)^{t-m} \frac{dP_t^C}{dw_m} \\ & - \Omega(\Sigma_{t=m}^{T} c_t P_t^C(1+r)^{t-m} \frac{d\tau_t^c}{dw_m} \\ & + \Sigma_{t=m}^{T}(1+r)^{t-m} \frac{dE_t}{dw_m}) = 0\end{aligned}$$

The median voter considers what will happen if he increases the wage marginally. He feels the effects through six channels[3]. Rather than a rigorous tool of analysis, we use (32) as a list of terms, helping to describe the median voter's decision making on a general level.

The first term, divided into two rows, describes employment, and thus leisure, effects (the term Ω is the Lagrangian multiplier of the budget constraint). The assumption that firms determine employment after wages are set

[3] *The seventh channel is consumption, which changes in every period of the median voter's remaining lifetime. This is the result of his reoptimization as a consumer, and by the envelope theorem we know that the magnitude of this effect is zero.*

means that employees are not on their notional labour supply curve, and that wages and labour input are negatively correlated.[4] Unemployment is only indirectly present in our model: households would like to work more at the wage rate determined by the trade union, but are restricted by the demand for labour by firms. There are no unemployed people in the model, however, as employment is divided equally among working-age households. The critique by Lucas (1987, section 5) applies: representative agent macro models can tell us something about employment and wages, but have very little to say about unemployment, which is a concept dealing with disruptions in, or difficulties in forming, employer – employee relationships.

Second, the value of the median voter's financial wealth changes, as the stock market re-evaluates the future streams of dividends. When wages are increased, this comes as a surprise to the stock market and share prices immediately fall. The effects depend on the distribution of ownership of these shares. A part of the shares is owned by foreign citizens; the bigger this part is the less the median voter has to worry about the wealth effect. The domestically owned shares are assumed to be distributed equally among all households. Besides shares, households' financial wealth consists of firm and government bonds.

Third, wages change. The change in the initial period is decided by the median voter, but he must also consider what median voters in future periods will do. This is discussed in Section 4.

Fourth, the pension benefits that he will get in the future will change. The pension effects are dealt with in Section 5.

Fifth, consumption prices change. The price of the domestically produced good changes in relation to the price of the imported good, which is the numeráire in the model, to equalise supply and demand. Consumption goods are composites made of domestically produced and imported goods.

Sixth, consumption taxes or transfers change to balance the budget. The government's budget must be balanced in the present value sense. If a large share of public outlays is salaries, and the budget is balanced each period by e.g. transfers or VAT, then the voting outcome may be very near, or even below, the market wage. This is so because an increase in wages increases public outlays so much that the following cut in transfers leaves workers worse off than initially without the wage increase. In our simulations the government's budget is balanced by increased borrowing in the first period and by transfers thereafter.

Only the labour demand effects are usually included in the literature dealing with local bargaining. Of the effects in this study, the pension effects should also be taken into account under local bargaining, as wages and pensions are connected also at the individual level, and not only at the economy-wide level. Wealth effects could be ignored by local bargainers, unless their holdings are in the firms they work. The effects on the behaviour of future local bargainers, however, should be taken into account, especially if labour is immobile between sectors. Each local bargainer probably thinks that the effects of his own decision on consumer prices and taxes are too small to be taken into account. These general equilibrium effects are more relevant with highly centralized wage bargaining.

3.3 The rest of the economy

The rest of the economy in the FOG model is described in more detail in Appendix 2, but its main features are as follows

- a forward-looking value-maximizing firm sector, which chooses the optimal path of investment, use of labour and intermediate goods and produces the domestic good which can be exported and which is an imperfect substitute for the imported good
- a government sector, which collects taxes and produces public services which are provided free of charge (and, for simplicity, are not taken into account in individual utility considerations)

[4] *Oswald and Walker (1993) provide empirical evidence that this seems to hold for unionized workers, whereas for non-union workers the correlation seems to be positive, implying that they may be on their labour supply curve.*

– a pension institution, which pays the pensions and collects contributions from the employers. The employers' contribution rate is endogenous and balances the fund's budget each period (see Section 5.1)
– the rest of the world, with which goods can be traded and capital interchanged. The domestic interest rate is equal to the world interest rate.

4. Voting equilibrium

4.1 Market-wage equilibria and fixed-wage equilibria

When the model described above is used to study e.g. the effects of tax policies, it is usually assumed that there is full equilibrium, i.e. goods, financial and labour markets clear in each period, with all expectations fulfilled (see, e.g., Auerbach and Kotlikoff, 1987 and Broer and Lassila, 1997).

Here we try to illustrate how the outcome of the economy changes when wages no longer clear the labour market, but are instead set by the trade union, employment is determined by firms' labour demand, and total employment is distributed equally among all households whose members are of working age. We call this equilibrium a fixed-wage equilibrium, to separate it from the full equilibrium, later referred to as the market-wage equilibrium. Notice that there is a stationary fixed-wage equilibrium for any wage rate the trade union cares to set, irrespective of whether it is set by majority voting or in some other way. The voting equilibrium is just one special case of fixed-wage equilibria.

The numeraire in the FOG model is the imported good: its price is unity. Compared to the numeraire, the higher the wage level is in the fixed-wage model the less labour will be used as a production factor, and output is smaller. Domestically produced goods are more expensive relative to foreign goods. This induces substitution away from domestically produced goods, so the import content of consumer goods, investment goods and intermediate goods increases. The increase in the terms of trade decreases exports. Imports decline also, because the level of output, investment and consumption declines as higher wages imply lower employment. The decline in imports is smaller, however, than in exports. This is only consistent in equilibrium if foreign debt service costs are smaller, so net foreign debt is lower the higher the wage rate is. Although the capital-labour ratio is higher the higher wages are, the capital stock also declines with the level of output when wages are set at a higher level. It is not clear what happens to aggregate household wealth as both the capital stock and net foreign debt decline, although usually it declines as well.

4.2 Voting equilibrium

When the workers of some period decide the wage of that period, they try to take into account what future workers will decide and how future wage decisions depend on the current wage decision. This forms an infinite forward linkage, as the future decision makers will also consider the effects of their wage decisions on the decisions of the worker generations to come still further in time, and so on. The current median voter thus faces an enormous mental task.

The question is: Are there any circumstances under which the median voter can confidently predict the consequences on future wages of a particular choice for the current wage? Assume that there is: what kind of situation could that be? The median worker may think as follows: “I must make a decision, and I may as well start from some assumption concerning the path of future wages. I’ll make an optimal decision of the current wage, conditional on that path. Will the median voter of the next period decide the exact wage I have assumed? He will do that only under four conditions. One, he must reason like I do. He probably does, because he is just as rational as I am. Two, he must have the same assumption concerning wages from his time onwards. Three, the wage level I assumed he would set must be optimal for him, conditional on the assumed wage path during his future. Four, he must think that next median voter also fulfills these conditions. If these conditions are met for all the median voters to come, all that remains is to correctly assume the path of future wages.” Whether the path is found

also depends on the history of the economy, but the thinking process itself leads us to consider the concept of 'voting equilibrium'. That is what we define in this section and use throughout the rest of the paper.

Let $w_t^V(w_{t,t+1}^e, w_{t,t+2}^e, \ldots)$ be the wage set by majority voting in period t, given the expected future path of wages $w_{t,t+1}^e, w_{t,t+2}^e, \ldots$, expected by the voters in period t. By definition, the change in the (remaining) lifetime utility resulting from an increase in wages from w_t^V to $w_t^V+\varepsilon$ is not positive for the majority of working-age persons. Also, the utility from decreasing the wage to $w_t^V-\varepsilon$ is non-positive for the majority, for all ε.

Definition 1. A voting equilibrium path of wages is a sequence $\{w_t\}$, where (i) $w_t = w_t^V(w_{t,t+1}^e, w_{t,t+2}^e, \ldots)$ for all t, and (ii) $w_{j,t}^e = w_t$ for all t and for all $j < t$.

The first part in Definition 1 states that each wage on a voting equilibrium path is such that the majority of workers wants neither to increase it nor to decrease it, given the anticipated future wages. The second part states that voters in each period anticipate all future wages correctly.

Considering all time points simultaneously, the voting equilibrium path is analogous to a Nash equilibrium in noncooperative games: workers of any one period do not want to change their decision, if workers of some other period do not change their decision. If one takes the time structure into account, each median voter acts as a Stackelberg leader vis-à-vis the future median voters.

In what follows we concentrate on stationary equilibria, where the wage level, and all other things, remain constant in time.

Definition 2. A steady-state voting equilibrium is a voting equilibrium path where, in addition to the two requirements of Definition 1, also $w_t = \overline{w}$ holds for all t.

The procedure of finding the steady-state voting equilibrium in the simulation model is described in Appendix 1.

4.3 Multiple equilibria?

Voting models may have multiple equilibria. This is a standard problem in models where the level of pensions is determined by voting. Azariadis and Galasso (1996, p.65) describe the problem as follows: "Today's decisions depend on the expectations of how tomorrow's policymakers will react to situations they expect to prevail the day after tomorrow, and so on forever. Policy choice is indeterminate because there is no way to pin down the behaviour of the policymaker at $+\infty$." In their model, however, and in many similar models, changes in policy can be made without cost. Future policies are the main thing, in fact the only thing, the median voter has to take into account.

That is not the case in this study. Voting is now about wages, not pensions. As in all trade union models, wages affect the demand for labour. Thus changes in wage policy cannot be made without costs. Changes in wages affect current employment directly as well as future employment and labour income because the capital stock changes. Costs come also in the form of various general equilibrium effects.

Trade union models with overlapping generations have not paid attention to multiple equilibria. In her two-period model, Hawtrey (1990) lets the trade union be myopic in the sense that the first-period optimum is the choice in each period. She notes that in the real world the span between generations is in the vicinity of twenty to forty years. Hawtrey does not specifically mention any possibility of multiple equilibria due to expectations concerning future wage decisions or any other matter. Huizinga (1990, p. 84 footnote) deals with future wages briefly: "The important aspect is that the implicit agreement between the firm and the union is stationary and expected to be everlasting." In his model either party could always force the return to the setup in period 0, so the only believable contract is the one that duplicates the conditions of period 0 forever. This is in contrast to our model, where the adjustment of the capital stock is costly and slow. The trade union literature with majority voting also neglects multiple equilibria. Booth (1995) does not mention multiple equilibria in her median voter over-

view. Rehnström and Roszbach (1995) consider the changes dynamization would bring to their static analysis, but do not mention the possible multiple equilibria problem.

Studies using voting models usually cannot provide convincing evidence about uniqueness or its absence. Beauchemin (1998), studying fiscal policy in an intergenerational framework, uses numerical methods to verify the uniqueness of his model solutions. Our approach has been similar. The simulations we have carried out provide no hints of the existence of multiple equilibria. We cannot rule out their possibility in our model, but there are strong factors that limit the role of expected future wage decisions.

4.4 Leisure – consumption choice in the simulation model

As noted in section 2, the leisure-consumption trade-off is important in the median voter's decision-making. Here we describe this trade-off in our simulation model.

If in any steady state fixed-wage equilibrium we increase the wage for one period, the dynamic simulation shows the following pattern for the median worker. In the first period leisure increases as the demand for labour decreases, and this increases the utility of the worker. It is the dominant utility effect during the worker's remaining lifetime. During the following working periods leisure is also greater than it would have otherwise been, because the capital stock was adjusted downwards during the first period, and is not immediately raised to the original level because of adjustment costs, although wages have returned to the original level. These leisure effects after the first period are small compared to the first period effect. The total effect of a temporary wage increase and a longer-lasting decline in employment is a fall in discounted wage income during the remaining lifetime. The counterpart of the positive leisure effects on utility is the decline in consumption, which follows from the reduction in lifetime wage income. This consumption decline is smoothed over all periods of the remaining lifetime. The total effect on lifetime utility is the weighted sum of the leisure and consumption effects.

Basically, thus, the trade union trades consumption for leisure when it increases the wage level above the initial fixed-wage equilibrium level. More leisure is paid for in the form of reduced consumption. The crucial issue then is how these two items affect the utility of the household. The normal assumption is that both goods have declining marginal utility. That is also the case in our model. Additional leisure is more appreciated the less leisure there is, in relation to consumption, to begin with. If there is quite a lot of leisure to begin with, the utility of the household is not much increased by having more leisure.

4.5 Who is the median voter?

Union members are identical in all respects, except that they are in different phases of their life cycles. Among other things, that means that they have different numbers of periods ahead, and they have accumulated different amounts of financial wealth. In our simulations both these features cause the young cohorts to prefer higher wages to the older cohorts. Thus the endogenously determined median voter is the median-age worker.

A reassuring feature is that, qualitatively, the utility changes from a temporary wage increase are similar in all cohorts although quantitatively they differ. This means that the qualitative properties of the voting equilibrium in comparison to market-wage equilibrium are probably robust to the age of the median voter, although quantitative results could be more sensitive. If, however, the median voter changes as a result of a change in an exogenous or policy variable, the effects may become volatile. This does not happen in the simulations of this paper.

4.6 Sensitivity analysis

Steady-state sensitivity analysis concerning the relations between market-wage and voting-wage equilibria, with respect to households' behavioural parameters, firms' production function parameters and other parameters describing the economy, does not point towards any great sensitivity (see Table 1). In all cases considered, the voting-wage equilibrium had high-

Table 1. Market-wage and voting equilibria: sensitivity calculations.

Parameter	w	L	C	K	F	P^d	A^f	W	CV
basic	102.16	85.59	86.73	86.07	85.88	101.57	1.03	3.36	–3.73
$\gamma = 0.4$	102.20	85.43	86.67	85.92	85.72	101.60	1.84	4.21	–3.80
$\gamma = 0.75$	102.07	85.94	86.81	86.40	86.22	101.50	–0.96	1.27	–3.57
$\rho = 0.375$	100.35	97.39	97.51	97.48	97.45	100.25	–0.61	–0.24	–0.57
$\rho = 0.9$	103.61	77.29	79.04	78.01	77.72	102.61	2.07	6.00	–6.25
$\sigma = 0.6$	102.52	84.74	86.20	85.39	85.14	101.69	0.99	3.47	–3.92
$\sigma = 1.4$	101.85	86.52	87.39	86.86	86.72	101.44	1.06	3.22	–3.45
$\beta = 0.6$	105.51	70.74	73.19	71.77	71.47	103.46	–1.29	4.74	–14.72
$\beta = 0.9$	100.73	94.32	94.73	94.50	94.40	100.60	1.32	1.97	–0.48
$\sigma^E = -5$	105.18	82.91	85.24	84.00	83.56	103.75	–0.17	5.53	–4.03
$\sigma^E = -20$	101.05	86.03	86.70	86.27	86.18	100.76	1.52	2.63	–4.01
$s^F = 0.5$	103.16	79.70	81.21	80.35	80.09	102.29	1.18	4.58	–7.34
Budget rule:									
E	101.32	90.91	91.66	91.22	91.10	100.96	0.78	2.20	–1.40
τ^c	101.32	90.90	91.65	91.21	91.09	100.96	0.78	2.20	–1.41
B^G, τ^c	102.16	85.58	86.72	86.06	85.87	101.57	1.03	3.36	–3.73

Notes: The basic parameter values are: $\gamma = 0.5$, $\rho = 0.75$, $\sigma^E = -10$, $s^F = 0.333$ (see Equations 1, 2, A1 and A14. s^F is foreign owners' share of stocks). The figures express ratios of voting equilibrium values to corresponding market-wage equilibrium values. Net foreign assets and total household wealth are expressed in relation to private production, and the figures are percentage point differences between voting and market-wage equilibria. The budget rule tells how the public sector is balanced in the dynamic simulations describing the median voter's calculations. At "E" the budget is balanced by transfers and at τ^c by value-added taxes in all periods, at B^G, τ^c the first period balance is achieved by taking on debt, and from then on VAT is used. Compensated variation CV expresses the compensation needed to achieve the same lifetime utility in VW that prevails in corresponding MW. It is expressed as a percentage of discounted lifetime consumption expenditure, and a negative sign implies a welfare loss.

w = wage rate
C = total private consumption
F = production
A^f = net foreign assets
L = employment
K = capital stock
P^d = terms of trade (price of domestic good)
W = total household wealth

er wages, lower labour input, lower consumption levels, a lower capital stock, lower output and higher export prices than the market-wage equilibrium. It is possible, however, that there exist parameter values where the voting wage would be below the market wage[5], and most of the relations stated above would reverse. High values of the capital – labour substitution elasticity would probably produce that situation. In such a case the trade union would have to force people to work more than they would like to at the going wage and prices.

The trade-off of the union is, briefly, more leisure and higher wages today and more leisure tomorrow versus less consumption now and in the future. The crucial parameters are those that affect this trade-off strongly. The elasticity of substitution between capital and labour is obvious: the higher the elasticity, the easier it is for the firm to reduce labour demand after a temporary wage increase, and thus workers lose more income and consumption. The price elasticity of exports is important: with a high elasticity, the wage increase would hit exports badly and thus reduce output and labour demand. The price elasticity of imports works in a similar fashion: a high elasticity implies that domestic production is greatly reduced after the wage increase affects prices, as the imported good is used more in the consumption, investment and intermediate good. The reduc-

[5] *Hawtrey (1990, p. 90) concludes that in her model this situation is the prevailing one, as it is often wise for the union not to use its power to increase wages. The model is different from ours but the trade union faces an analogous trade-off between higher wages today and an increased capital stock tomorrow.*

tion in production means less employment and less labour income. The ownership of firms' shares is also important: the more foreigners own the shares, the less the median voter gives weight to the negative share value effects of wage increases. On the household side, the intratemporal elasticity of substitution is important. If the elasticity is high, households are more willing to sacrifice consumption to get more leisure, and the median voter, having the same preferences, drives the wage level higher.

5. *The effects of pensions on median voter's wage decision*

5.1 PAYG pension system

By replacing the labour-market equilibrium assumption with majority-voting wage setting behaviour, we could in principle use the simulation model to analyse, e.g., pension policies in a similar fashion as in, for example, Broer and Lassila (1997). The dynamic calculations are, however, very difficult with the median voter approach. We can gain insight of the way the wage formation assumptions affect the incentive effects of earnings-related pensions by doing some exercises with the steady-state market-wage and voting-wage equilibria.

When we compare voting equilibrium to market equilibrium, we do not want the employment division rule to affect the comparisons. Thus we adjust the model so that in the market equilibrium steady states all workers wish to have an equal amount of leisure, irrespective of their age. To achieve this, two conditions must be met. First, the price of leisure must be constant, so that there is no intertemporal substitution concerning leisure. Second, the real net interest rate faced by the households must equal the rate of time preference, so that there is no intertemporal substitution concerning consumption, because that would also be reflected in leisure. The latter is straightforward, we set $r = \delta$. Condition one is slightly more complicated, because the price of leisure includes, besides the net wage rate, also the present value of the future pension right that comes from working. What is required is that the PAYG pension right accrues steadily in time and yields interest, so that the present value of future pensions accruing from each period, discounted to that period, is constant. With these features, the market-wage equilibrium is a special case of fixed-wage equilibria.

For the person who started working in period 1 the pension z in period t is

$$(33)\quad z_t = \tfrac{1}{T_W}\sum_{s=1}^{T_W}\theta(1-l_s)w_s(1+r)^{t-s}\left(\tfrac{w_t}{w_s}\right)^{\lambda},\quad T_W < t \le T$$

The parameter θ expresses the pension replacement rate and λ is the indexation parameter of pensions to current wages. We consider only the limit cases when $\lambda = 0$, representing no indexation, and $\lambda = 1$, representing full indexation. From (33), the discounted pension right that accrues from marginal work during period s is the following:

$$(34)\quad \begin{aligned}&\sum_{t=T_W+1}^{T}(1+r)^{-(t-s)}\tfrac{dz_t}{d(-l_s)}\\ &= \tfrac{1}{T_W}\sum_{t=T_W+1}^{T}(1+r)^{-(t-s)}\theta w_s(1+r)^{t-s}\left(\tfrac{w_t}{w_s}\right)^{\lambda}\\ &= \tfrac{1}{T_W}\sum_{t=T_W+1}^{T}\theta w_s\left(\tfrac{w_t}{w_s}\right)^{\lambda},\quad 1 \le s \le T_W\end{aligned}$$

which is constant and independent from s in an equilibrium where $w_s = w_t = w$ for all s and t. The employers' contribution rate is determined by the pension institute's budget constraint. That is obtained by aggregating pensions and contributions over cohorts i.

$$(35)\quad \sum_{i=T_W+1}^{T} z_{i,t} - \tau_t^z\sum_{i=1}^{T_W}(1-l_{i,t})w_t = 0$$

5.2 PAYG pensions and the median voter's decision

Figure 1 shows the pattern between the market-equilibrium labour cost (wage rate + employers' pension contribution) and the voting-equilibrium labour cost, when the pension benefit level, as a percentage of wage income, is increased. The curves show that the higher the PAYG pensions, the lower are work incentives and wages. Actually, wages decline more rapidly than labour costs when the pension level

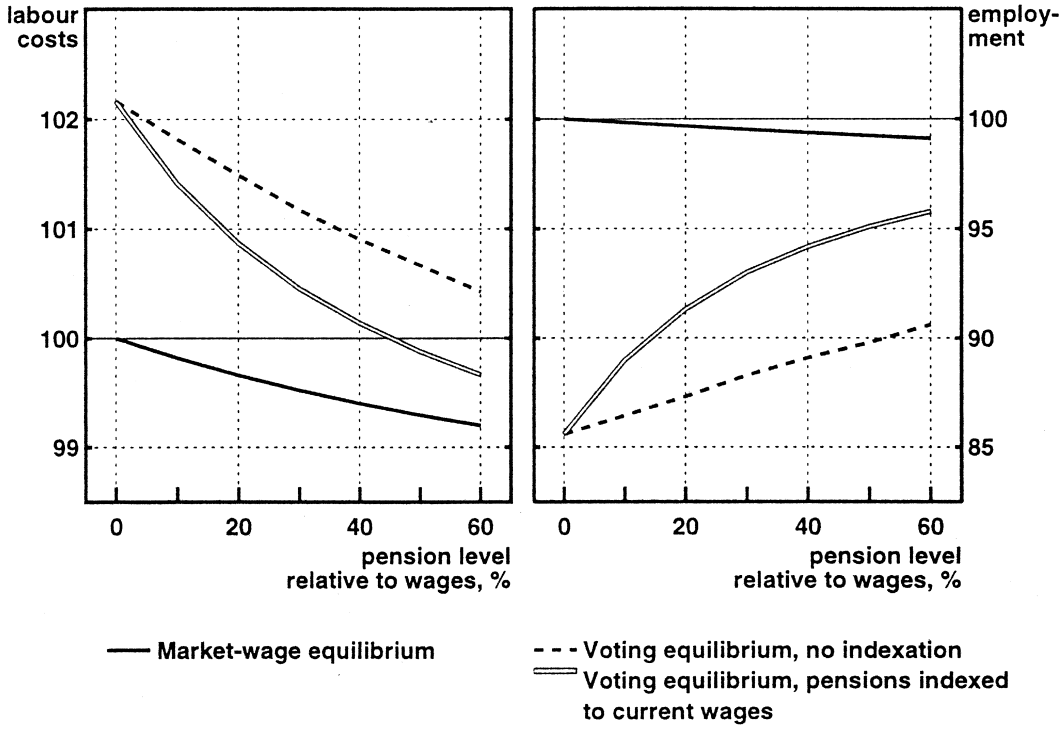

Figure 1. Effects of pension level on equilibrium labour costs and employment.

is increased, since the latter include pension contributions which increase. The voting-equilibrium wages approach the market-equilibrium wages when pension levels are higher. The second part of the figure shows the corresponding employment levels (see also Table 2).

In the market-wage equilibria, the increase in pension level decreases the work incentives of households. This is entirely a consequence of missing funding. The pension rule (Equation 33) itself has no distortive effect: rational households take the accruing pension rights into account, in the way shown in Equation (34), when they make labour supply decisions. If there were funding, exactly matching the accruing pension rights, and no indexing to current wages ($\lambda = 0$), the system would be actuarially fair, and the market-wage equilibria would be identical in all economically meaningful respects. Household wealth would be lower if pension rights were excluded, but the pension fund would match that exactly. Gross wages and the contribution rate would vary, but labour costs would be constant. Net labour incomes would differ in timing in households' lifecycles, but their discounted amount would be the same. But since no funds are collected, the interest income from funds is missing and a corresponding amount must be collected from current wages. This part of the employers' contribution rate is pure tax, and it distorts the labour supply decision.

The contribution rate effect of the missing fund is also present in the voting equilibria. But there are other effects also. The voter, thinking about the effects of a possible wage increase in the current period, balances in his mind the increase in leisure and the decrease in consumption, the latter being the consequence of a decline in discounted labour incomes. This decline is the sum of the increase in work income he receives in the first period and the decrease in each period during the rest of his working life. The aggregate effect of these on pensions is

Table 2. Market-wage and voting-wage outcomes with different replacement rates θ.

a) no indexation (λ = 0)

Parameter		*w*	*L*	*C*	*K*	*F*	P^d	A^f	*W*	τ^z	*CV*
θ = 0	*MW*	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
	VW	1.022	0.856	0.867	0.861	0.859	1.016	1.030	3.355	0.000	–3.730
θ = 10	*MW*	0.939	0.998	0.982	0.998	0.998	0.999	–12.622	–12.818	6.260	–1.310
	VW	0.958	0.864	0.860	0.868	0.867	1.013	–11.899	–9.949	6.260	–5.004
θ = 20	*MW*	0.886	0.997	0.965	0.996	0.996	0.998	–23.809	–24.176	12.516	–2.494
	VW	0.902	0.873	0.855	0.877	0.875	1.011	–23.329	–21.727	12.516	–6.119
θ = 30	*MW*	0.838	0.995	0.951	0.994	0.994	0.997	–33.795	–34.310	18.774	–3.569
	VW	0.852	0.883	0.852	0.886	0.885	1.009	–33.504	–32.242	18.774	–7.068
θ = 40	*MW*	0.795	0.994	0.937	0.992	0.993	0.996	–42.764	–43.409	25.032	–4.551
	VW	0.807	0.891	0.848	0.893	0.892	1.007	–42.617	–41.644	25.032	–7.998
θ = 50	*MW*	0.756	0.992	0.925	0.991	0.991	0.995	–50.864	–51.624	31.290	–5.451
	VW	0.767	0.898	0.845	0.900	0.899	1.005	–50.828	–50.110	31.290	–8.877
θ = 60	*MW*	0.721	0.991	0.915	0.989	0.990	0.994	–58.215	–59.079	37.548	–6.278
	VW	0.730	0.906	0.843	0.907	0.907	1.003	–58.260	–57.801	37.548	–9.636

b) full indexation (λ = 1)

Parameter		*w*	*L*	*C*	*K*	*F*	P^d	A^f	*W*	τ^z	*CV*
θ = 0	*MW*	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
	VW	1.022	0.856	0.867	0.861	0.859	1.016	1.030	–5.941	0.000	–3.730
θ = 10	*MW*	0.939	0.998	0.982	0.998	0.998	0.999	–12.622	28.270	6.260	–1.310
	VW	0.954	0.890	0.884	0.893	0.892	1.010	–11.964	25.004	6.260	–3.846
θ = 20	*MW*	0.886	0.997	0.965	0.996	0.996	0.998	–23.809	47.177	12.516	–2.494
	VW	0.896	0.913	0.891	0.915	0.914	1.006	–23.393	45.211	12.516	–4.516
θ = 30	*MW*	0.838	0.995	0.951	0.994	0.994	0.997	–33.795	60.711	18.774	–3.569
	VW	0.846	0.930	0.894	0.931	0.931	1.003	–33.538	59.458	18.774	–5.404
θ = 40	*MW*	0.795	0.994	0.937	0.992	0.993	0.996	–42.764	70.878	25.032	–4.551
	VW	0.801	0.942	0.893	0.942	0.942	1.001	–42.612	70.033	25.032	–6.388
θ = 50	*MW*	0.756	0.992	0.925	0.991	0.991	0.995	–50.864	78.795	31.290	–5.451
	VW	0.761	0.951	0.890	0.951	0.951	0.999	–50.782	78.213	31.290	–7.364
θ = 60	*MW*	0.721	0.991	0.915	0.989	0.990	0.994	–58.215	85.135	37.548	–6.278
	VW	0.725	0.958	0.887	0.957	0.957	0.998	–58.180	84.723	37.548	–8.315

Notes: The figures express ratios of market wage (*MW*) and voting equilibrium (*VW*) values to market-wage equilibrium base values (top row). Net foreign assets and household wealth are expressed in relation to private production, and the figures are percentage point differences between voting and market-wage equilibria and the base values. *CV* expresses the welfare loss compared to the base case. σ^z is the employer's pension contribution rate. For the other variables see Table 1.

negative. The advantage of this fall in pensions, in the form of lower contributions, does not come to the median voter but goes to future workers: there is a generational transfer. The higher the pension level, the higher is this transfer, and selfish workers react to this transfer by resorting to lower wage levels. There is also another generational transfer: a wage increase raises the pension contribution rate and this deteriorates the leisure – consumption trade-off of the median voter. The rise in the contribution rate follows from the fact that the labour income of the median voter falls. The rise is higher if current pensions are indexed to wages. Indexation also further reduces the median voter's own pension, as the current higher wage is replaced by the future wage which remains constant (see eq. 34). Both these generational effects work to the disadvantage of the median voter, and are greater the higher is the PAYG benefit rate and the higher is the degree of indexation of pensions to current wages.

Figure 1 shows that employment increases with the PAYG benefits, if wages are set by majority voting. Firms increase their demand for labour as labour costs decline. The market-wage level of employment also reflects the distortionary effect on households' labour supply, which dominates the labour demand increase by firms.

From the above reasoning, short aggregating periods of pension rights, at the end of individual's working life, may also contribute to higher employment than aggregating systems based on the whole working history of the worker. The loss of work income in future periods weighs more in the median voter's calculations if those future periods are crucial for the determination of the pension level.

The capital stock is also affected by the pension level. This is not due to saving effects: although household wealth declines and the net foreign asset position deteriorates with higher pension levels, interest rates do not rise because financial capital is assumed to be perfectly mobile internationally. The increase in capital stock in voting equilibria takes place because of output expansion: cheaper labour makes it profitable to produce more, and thus more capital is also needed. There are, of course, general equilibrium effects: part of the increased profitability goes abroad as the price of the domestically produced good slightly falls in relation to the foreign good, and this partly increases the cost of capital as the capital good price falls less than output price. There is some input substitution towards labour, but this substitution effect is smaller than the effect of the output increase.

Even though employment increases with PAYG, the utility of workers decreases with increasing pension benefits, as compensated variation results in Table 2 show. It is also noticeable that welfare is higher in every market-wage equilibrium than in the corresponding voting-wage equilibrium with the same pension level. Again, this applies to steady state comparisons. Further research should try to establish whether there is a voting-wage equilibrium path, described in Section 4.2., leading from the market-wage equilibrium to the steady-state voting-wage equilibrium. If there is, imagine that a nation-wide trade union is established in the market-wage equilibrium. The initial median voter would raise the wage and be better off, and probably would some of his successors. But gradually the capital stock would decline and other changes would occur, and future workers would be worse off than they would have been in the market-wage equilibrium.

6. *The effects of taxation on median voter's wage decision*

This section provides insight of the way the wage formation assumptions affect the incentive effects of taxation. As with the pension system in the previous section, this is done by describing simulations with the steady-state market-wage and voting-wage equilibria.

If the incentives in society are such that people work a lot, there is little leisure in the market equilibrium. In this case the trade union can increase the utility of its members by increasing wages, which leads to more leisure and less consumption. The wage level will be far higher than the market-equilibrium wage. But if the incentive system is such that not much work is done in the market equilibrium, the trade union cannot increase the utilities much by acquiring more leisure, and the wage level in the voting equilibrium will be closer to the market-equilibrium wage.

This simple explanation points to a general conclusion about the incentive effects of taxation and social security. Comparing the voting-equilibrium wage level and the market-equilibrium wage level, in the region where the former is higher than the latter, we thus expect to find that they are closer to each other

- the higher are labour income taxes used to finance larger transfers, and
- the higher are value added taxes used to finance larger transfers

The simulations (in Table 3) support these conclusions. Furthermore, sensitivity analysis shows that the taxation results are not very sensitive to those parameter values that showed the largest effects in Table 1. Still, as is typical with

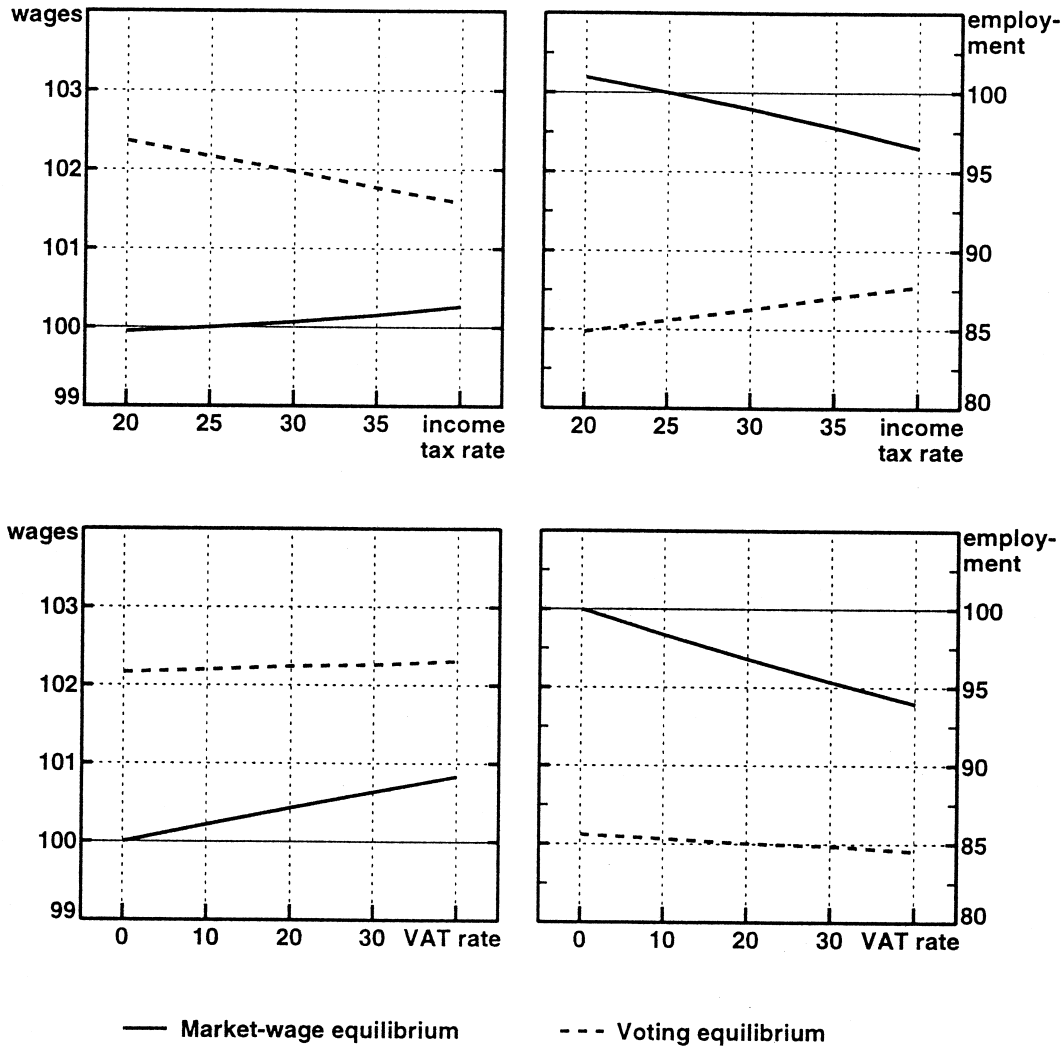

Figure 2. Effects on tax rates on equilibrium wages and employment.

a simulation approach, no generality can be claimed.

The effects of higher taxes, either income or consumption taxes, on the market-wage equilibrium outcomes are explained by the work incentives. The higher are taxes, the less rewarding is working: with higher income taxes the net wage is lower, with higher consumption taxes consumption prices are higher. In both cases the higher transfers compensate roughly for the income effects, so only the substitution effect, leisure becoming cheaper in relation to consumption, remains. More leisure is consumed, less work is done.

The voting equilibrium outcomes are not so straightforward. There is also a clear difference between labour taxes and consumption taxes: with the former, higher taxes mean lower wages and higher employment, with the latter slightly higher wages and correspondingly lower employment. To understand why, we must go through the median voter's choices in some detail.

Table 3. Market-wage and voting-wage outcomes with different taxes.

a) labour taxes (τ^w)

Parameter		*w*	*L*	*C*	*K*	*F*	P^d	A^f	*W*	*E*	*CV*
$\tau^w = 20$	*MW*	1.000	1.010	1.015	1.009	1.009	1.000	4.655	4.598	–6.080	0.420
	VW	1.024	0.849	0.866	0.854	0.852	1.017	5.940	8.480	–6.062	–3.480
$\tau^w = 25$	*MW*	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
	VW	1.022	0.856	0.867	0.861	0.859	1.016	1.030	3.355	0.000	–3.729
$\tau^w = 30$	*MW*	1.001	0.989	0.984	0.990	0.990	1.000	–4.660	–4.586	6.150	–0.465
	VW	1.020	0.863	0.868	0.867	0.865	1.014	–3.864	–1.744	6.136	–4.019
$\tau^w = 35$	*MW*	1.002	0.978	0.967	0.978	0.978	1.001	–9.327	–9.160	12.372	–0.987
	VW	1.018	0.871	0.870	0.875	0.873	1.013	–8.746	–6.845	12.349	–4.283
$\tau^w = 40$	*MW*	1.003	0.965	0.949	0.965	0.965	1.002	–14.003	–13.720	18.666	–1.583
	VW	1.016	0.877	0.870	0.881	0.880	1.011	–13.611	–11.912	18.638	–4.611

b) VAT (τ^c)

Parameter		*w*	*L*	*C*	*K*	*F*	P^d	A^f	*W*	*E*	*CV*
$\tau^c = 0$	*MW*	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
	VW	1.022	0.856	0.867	0.861	0.859	1.016	1.030	3.355	0.000	–3.729
$\tau^c = 10$	*MW*	1.002	0.984	0.984	0.984	0.984	1.002	–0.427	–0.191	10.000	–0.035
	VW	1.022	0.853	0.864	0.858	0.856	1.016	0.606	2.970	10.000	–3.923
$\tau^c = 20$	*MW*	1.004	0.968	0.969	0.969	0.969	1.003	–0.831	–0.367	20.000	–0.167
	VW	1.022	0.850	0.861	0.855	0.853	1.016	0.191	2.600	20.000	–4.143
$\tau^c = 30$	*MW*	1.006	0.953	0.955	0.955	0.954	1.005	–1.214	–0.531	30.000	–0.376
	VW	1.023	0.849	0.859	0.854	0.852	1.016	–0.228	2.202	30.000	–4.284
$\tau^c = 40$	*MW*	1.008	0.939	0.942	0.941	0.941	1.006	–1.580	–0.684	40.000	–0.645
	VW	1.023	0.845	0.855	0.850	0.848	1.017	–0.629	1.853	40.000	–4.524

Notes: The figures express ratios of market wage (*MW*) and voting equilibrium (*VW*) values to market-wage equilibrium base values (second row in (a), top row in (b)). Net foreign assets and total household wealth are expressed in relation to private production, and the figures are percentage point differences between voting and market-wage equilibria and the base values. Transfers *E* are expressed as a percentage of total consumption expenditure (excluding VAT). For the other variables see Table 1.

The median voter trades consumption for leisure, as noted in Section 4.4. The wage increase in the first period leads to lower employment during several periods. The higher the labour income tax rate is, the more unfavourable is this trade-off for the median voter: a small increase in the net wage produces a large reduction in employment, which is affected by the gross wage. Thus the reduction in lifetime gross incomes is bigger. Net incomes also fall substantially and consumption need be reduced accordingly. Thus the median voter tends to settle for lower gross wages if income taxes are higher. Because the higher income tax rate also means higher transfers, we should talk about "the effects of an increase in the marginal tax rate".

Higher consumption taxes do not affect the fall in lifetime incomes resulting from an increase in the wage in the first period. But this fall in income will result in a decline in consumption which is smaller in volume, because the price of consumption is higher with the higher VAT. This makes the overall trade-off between leisure and consumption slightly better for the median voter, and he claims higher wages. Remember that higher consumption tax revenues are paid back to the households in the form of transfers, so this is a "marginal VAT rate effect".

Taxation can, in principle, have similar effects on wage formation as pensions did in Section 5.2, as different taxes may be targeted at different phases of the life cycle. For instance, taxing pensions more heavily than wages may make the median voter assign less weight to future income and thus claim higher current wag-

Table 4. Sensitivity of pension and tax effects to key parameter values.

a) $\beta = 0.6$

Parameter		*w*	*L*	*C*	*K*	*F*	P^d	A^f	*W*	*E*
$\beta = 0.6$	*MW*	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000
	VW	1.055	0.707	0.732	0.718	0.715	1.035	–1.293	4.743	0.000
$\tau^w = 40$	*MW*	1.003	0.967	0.953	0.968	0.968	1.002	–10.278	–9.917	18.661
	VW	1.035	0.792	0.796	0.800	0.798	1.022	–11.198	–7.374	18.611
$\tau^c = 40$	*MW*	1.009	0.944	0.947	0.946	0.946	1.006	–1.440	–0.473	40.000
	VW	1.050	0.728	0.750	0.738	0.735	1.032	–1.944	3.569	40.000
$\theta = 60$,	*MW*	0.722	0.992	0.916	0.990	0.991	0.996	–41.963	–42.658	0.000
$\lambda = 0$	*VW*	0.749	0.788	0.745	0.795	0.793	1.019	–43.992	–40.730	0.000
$\theta = 60$,	*MW*	0.722	0.992	0.916	0.990	0.991	0.996	–41.963	–42.658	0.000
$\lambda = 1$	*VW*	0.729	0.933	0.867	0.934	0.933	1.002	–42.340	–41.982	0.000

b) $\rho = 0.375$

Parameter		*w*	*L*	*C*	*K*	*F*	P^d	A^f	*W*	*E*
$\rho = 0.375$	*MW*	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000
	VW	1.004	0.974	0.975	0.975	0.974	1.003	–0.607	–0.236	0.000
$\tau^w = 40$	*MW*	0.998	0.994	0.975	0.993	0.994	0.999	–14.426	–14.591	18.505
	VW	1.000	0.979	0.961	0.979	0.979	1.000	–14.773	–14.729	18.511
$\tau^c = 40$	*MW*	1.002	0.988	0.989	0.988	0.988	1.001	0.116	0.298	40.000
	VW	1.004	0.974	0.976	0.975	0.975	1.003	–0.250	0.126	40.000
$\theta = 60$,	*MW*	0.720	1.002	0.923	0.999	1.000	0.993	–58.010	–59.034	0.000
$\lambda = 0$	*VW*	0.721	0.988	0.911	0.986	0.987	0.994	–58.407	–59.241	0.000
$\theta = 60$,	*MW*	0.720	1.002	0.923	0.999	1.000	0.993	–58.010	–59.034	0.000
$\lambda = 1$	*VW*	0.720	0.999	0.921	0.996	0.997	0.993	–58.106	–59.087	0.000

c) $\sigma^E = -5$

Parameter		*w*	*L*	*C*	*K*	*F*	P^d	A^f	*W*	*E*
$\sigma^E = -5$	*MW*	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000
	VW	1.052	1.026	0.852	0.840	0.836	1.038	–0.168	5.532	0.000
$\tau^w = 40$	*MW*	1.005	1.003	0.950	0.966	0.965	1.004	–14.523	–13.949	18.667
	VW	1.037	1.019	0.860	0.866	0.863	1.027	–15.097	–10.983	18.633
$\tau^c = 40$	*MW*	1.017	1.008	0.945	0.943	0.941	1.012	–2.063	–0.242	40.000
	VW	1.052	1.026	0.847	0.837	0.832	1.038	–1.874	3.894	40.000
$\theta = 60$,	*MW*	0.716	0.992	0.911	0.987	0.989	0.989	–58.875	–60.619	0.000
$\lambda = 0$	*VW*	0.740	1.009	0.819	0.879	0.877	1.013	–60.758	–58.784	0.000
$\theta = 60$,	*MW*	0.716	0.992	0.911	0.987	0.989	0.989	–58.875	–60.619	0.000
$\lambda = 0$	*VW*	0.721	0.996	0.890	0.962	0.963	0.994	–59.221	–60.143	0.000

Notes: The figures express ratios of market wage (*MW*) and voting equilibrium (*VW*) values to market-wage equilibrium base values (top row). Net foreign assets and total household wealth are expressed in relation to private production, and the figures are percentage point differences between voting and market-wage equilibria and the base values. Transfers *E* are expressed as a percentage of total consumption expenditure (excluding VAT). For the other variables see Table 1.

es. This remains an area of future research. So does progressivity: Simulations (not reported here) show that progressive taxation has similar effects for voting-equilibrium wages and employment in this model to those reported by Koskela and Vilmunen (1996) for most bargaining-type models of wage formation and employment. Increasing progressivity, while keeping the total amount collected by the tax constant, makes the trade union choose lower wages and higher employment. It is not directly possible to compare the effects of progressivi-

ty between market-wage equilibria and voting-wage equilibria, because the employment division rule blurs the picture. Progressivity has effects only if there is redistribution between persons, or between periods in a person's life-cycle, which requires differences in period earnings. In market-wage equilibria this leads to a varying supply of labour either between periods or between persons, and the equal division of labour rule that is employed in the voting-wage equilibria causes itself differences between these two regimes, which intertwine with the effects of progressivity.

7. Conclusions

We have studied majority-voting wage-setting in an overlapping generations economy, using a numerical simulation model. Wages are set by a nationwide labour union where all persons in working age are members. Employment is determined by firms, and is divided equally among all workers. Households take employment as given, and determine their consumption and saving by maximizing lifetime utility under perfect foresight. Although employment is given and thus leisure also, leisure is an argument in the utility function.

If there were no trade union, each household would make its own decisions concerning leisure and consumption. Here the trade union makes the leisure-consumption choice for the households. Furthermore, its decision affects the terms of the choice, the trade-off that there is between leisure and consumption in each period. The current trade-off is affected by the previous choices, and the current choice will affect the trade-off of the current and future periods. There is a dynamic element: by increasing the wage, the trade-off is better for the union today but worse tomorrow. The combined effect is what counts.

The economy has an equilibrium wage level, which the majority of workers wants neither to increase nor decrease. We compare this voting equilibrium outcome to the full market-clearing outcome where wages adjust to equate the supply of and demand for labour. The voting outcome has higher wages and lower employment than the market-clearing outcome. How big this difference is depends on many features of the economy. The production technology has effects, especially the substitutability between labour and capital. Individual preferences concerning the substitution between leisure and consumption are important; one advantage of the median voter approach is that household preferences directly affect the trade union's decisions. The openness of the economy also affects wage outcomes: the easier it is to replace domestic products with foreign goods in consumption, investment, intermediate use or in export markets, the less room the trade union has to operate. Even if the interest rate is not affected by the wage decisions, there is still an openness issue in financial markets: the more foreigners own domestic shares, the less the trade union cares about the adverse share-value effects of wage increases.

Pension policies and tax policies have both saving incentive and work incentive effects. Without trade unions these incentives affect household behaviour. With a trade union the work incentives affect its decisions, while saving incentives still operate through households. The central incentive result of this study is that when we compare trade union wage setting with labour markets where wages adjust to equate supply and demand, the difference is bigger when the tax rates are lower, and gets smaller when taxes increase. When e.g. the benefits of a PAYG-type pension system are increased, and the corresponding payroll tax is also increased, the voting equilibrium wage level approaches the market equilibrium wage. Similar results are obtained with respect to labour and consumption taxes.

If wages are set by voting, the resulting level of employment is higher, the higher is the earnings-related PAYG pension benefit level. The reason is that if the voter claims high current wages his lifetime wage income falls, which will lead to lower pensions, and the advantage of lower pension contributions goes to future working generations, not the current median voter. Also, the median voter has to pay higher contributions both because the current wage bill falls and because current pensions may increase due to indexation. Both these gen-

erational transfer effects lead the median voter to choose lower wages, which leads to higher employment. This example shows that incentive effects of e.g. pension policies can be drastically different in a unionised economy from the effects in an economy with non-union labour markets. In this study, institutions do matter.

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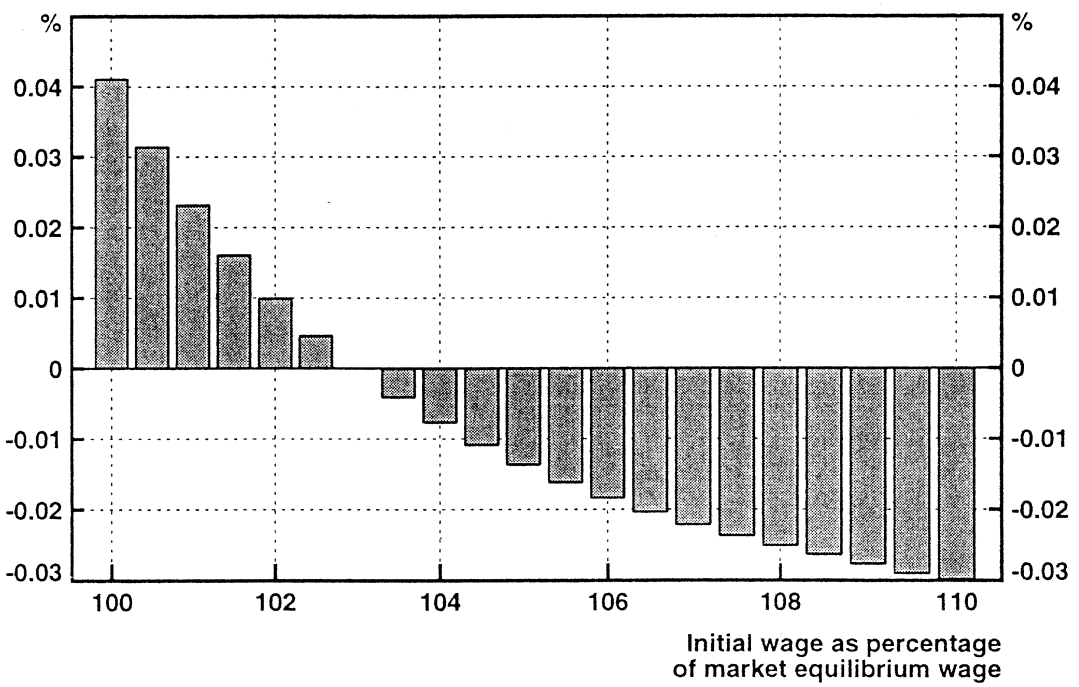
Appendix 1: How to find a steady-state voting equilibrium wage level

A steady-state voting equilibrium is found by trial and error. Starting from a stationary fixed-wage equilibrium, we increase the first-period wage slightly, find the new dynamic solution to the economy, calculate the compensated variations and see whether the majority gains or loses. If the majority gains, we calculate a new fixed-wage equilibrium with a higher wage, repeat the dynamic exercise and calculate the compensated variations. After some initial wage level the majority usually loses from a wage increase; then we have passed the voting equilibrium point. The exact point when the gains become losses also depends on the size of the first-period wage increase. Ideally we would like to make an infinitesimal change to the wage.

Figure 3 describes the outcome of a series of wage increase trials. Wages in the initial fixed-wage equilibrium are on the horizontal axis. They are related to the market-wage equilibrium outcome. The gains decline smoothly, and once wages are about three percent above the market-wage equilibrium level, the median voter suffers from a one-period wage increase.

A practical proof of the existence of a voting equilibrium is that it can be found in practice by the procedure described above. Uniqueness or its absence is probably very difficult to prove. Studies such as Azariadis and Galasso (1996) clearly show that multiple equilibria are possible. Nothing, however, has pointed towards multiple equilibria in the simulation experiments.

Notice that market-wage and fixed-wage equilibria can be found using only a steady-state model, but to find the voting equilibrium among the fixed-wage equilibria one needs a dynamic model.



Compensated variation as a percentage of discounted consumption expenditure during remaining lifetime

Figure 3. Relative gain from 0.5 percent one-period wage increase in age group 35–40

Appendix 2: The model

Firms

A representative small firm produces the domestic good using capital inherited from the previous period, intermediate goods and labour. Infinite horizon decisions of investment, employment and use of intermediate goods are made to maximise the firm's market value. The firm takes the prices, demand of production and supply of factors at given prices, and production technology and taxation as given. Intermediate and capital goods are costs minimising CES composites of domestic and imported goods. Investments are financed by retained earnings and debt.

The formulation of the production structure follows Keuschnigg and Kohler (1994). The structure applied in this study is essentially a one-sector version of a model intended for multisector use. The structure can be described as follows:

$$\text{(A 1)} \quad F_t = A\left\{\varepsilon K_{t-1}^{(1-1/\beta)} + (1-\varepsilon)L_t^{(1-1/\beta)}\right\}^{\frac{\beta}{\beta-1}}$$

$$\text{(A 2)} \quad G(I_t, K_{t-1}) = \xi\frac{I_t^2}{K_{t-1}}$$

$$\text{(A 3)} \quad Y_t = \frac{F(K_{t-1},L_t)-G(I_t,K_{t-1})}{1-\zeta}$$

The value-added production function F is a CES function of capital and labour. In the process of installing new capital some production is lost due to investment adjustment costs G. These installation costs depend positively on investments and negatively on the amount of capital. The use of the composite intermediate good is determined as a fixed proportion ζ of gross production Y.

Domestic households consider bonds and firms' shares as perfect substitutes in their portfolios. The arbitrage condition between (after-tax[6]) returns on bonds and shares is:

$$\text{(A 4)} \quad r_{t-1}V_{t-1} = D_t + V_t - V_{t-1}$$

where the left-hand side describes the invested amount yielding the domestic interest rate. On the right-hand side, the first term is the dividend income and the second term the capital gain.

The arbitrage condition can be transformed to a form where the market value of the shares equals the present value of expected future dividends:

$$\text{(A 5)} \quad V_t = \sum_{s=t+1}^{\infty} D_s \prod_{v=t+1}^{s} \frac{1}{1+r_v}$$

The dividends are a residual from the firm's cash flow identity:

$$\text{(A 6)} \quad D_t = P_t^F(F_t - G_t) - (1+\tau_t^z)w_tL_t - r_{t-1}B_{t-1}^f - P_t^K I_t + B_t^f - B_{t-1}^f$$

where the dividend in period t is determined by profits before depreciation minus investment expenditure plus any increase in corporate debt. Corporate debt is preferred when financing investments, but its use is limited to a fixed ratio of the replacement value of corporate capital.

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[6] *All corporate and capital income tax rates in the model have been set to zero and removed from the equations. Valkonen (1995, 1997) has used the same model for tax reform analysis.*

The firm chooses the optimal path of investment, use of labour and intermediate goods to maximise the current period dividend and the firm's value at the end of the period. If there are no unexpected shocks, there is no need to revise the optimal plan and it will be followed forever. Capital depreciates at a constant annual rate of d. The constraints of the maximisation are the initial capital stock and an equation describing its dynamics:

(A 7) $$K_t = K_{t-1}(1-d) + I_t$$

Three of the four first order conditions of the constrained optimisation are used as model equations. The first implies that investments should be carried out until the marginal benefit from an additional unit of investment equals the marginal cost. The marginal cost includes the price of a unit of capital plus the installation cost. The condition can be transformed to a q-theory investment equation (A 8). The optimality condition of capital says that capital should be installed until the return of an additional unit is large enough to cover the expenses of carrying the capital to the next period. These expenses include interest, depreciation and the change in the replacement price of capital. This condition is transformed to an equation (A 9) describing the path of the shadow value of capital. In a steady state this marginal productivity condition of capital can be written as (A 10). The terms within the brackets are the depreciation rate d and the interest cost of the capital stock. The two terms to the right of the brackets are based on adjustment costs linked to replacement investments.

(A 8) $$I_t = \frac{(q_t - P_t^K)K_{t-1}}{2\xi p_t^F}$$

(A 9) $$q_t = (P_{t+1}^F(F_K - G_K) + q_{t+1}(1-d))\frac{1}{1+r_t}$$

(A 10) $$F_K - G_K = \frac{P^K}{P^F}[d+r] + r\xi d + \xi d^2$$

The third condition says that the marginal benefit of an extra unit of labour should cover wage costs plus the employer's pension contribution:

(A 11) $$P_t^F F_L = (1+\tau_t^z)w_t$$

The fourth condition is a transversality condition ensuring that the discounted shadow value of capital goes to zero as time approaches infinity.

The market value of the firm is linked to the shadow value of capital in the leveraged firm as follows:

(A 12) $$V_t = K_t q_t - B_t^f$$

where B_t^f is the firm's debt. This link has been derived using the homogeneity of production and capital installation technologies. The value of the firm jumps whenever unexpected news about the firm's future profitability enters the market. Domestic households own a part $(1-s^F)$ of the firms. When the value of the firms jumps, and changes households' wealth, they reoptimise their life-cycle plans immediately.

The numerical values of the firm parameters applied in this study are the following: $\beta = 0.7$, $\varepsilon = 0.36$, $\xi = 6$, $\zeta = 0.1$, $d = 0.5$, $s^F = 0.333$. The household parameter values are: $\gamma = 0.5$, $\rho = 0.75$, $\delta = 0.01$, $\alpha_0 = 0.8$.

Government sector

The government collects income taxes from wages and from pensions Z, and consumption taxes, and uses the proceeds to pay interest on outstanding debt and to employ civil servants to produce public services. These services are provided free of charge and are not taken into account in individual utility considerations.

$$E_t + L_t^G w_t(1+\tau_t^z) + r_{t-1}B^G = (L_t w_t + Z_t)\tau_t^w + C_t P_t^C \tau^c \quad \text{(A 13)}$$

In the steady states, transfers are used to balance revenues and expenditures of the government every period. The share of public employment is 0.25 of the total employment in steady states. In dynamic simulations describing the median voter's calculations public employment is held constant throughout, the government holds all tax rates constant in the first period, and runs a deficit, and in the following periods balances the budget and freezes the public debt using transfers. Public debt in steady states equals zero.

Foreign sector

The model imitates a small open economy, where the export share of total demand is large. The amount exported depends on the price elasticity of foreign demand:

$$X_t = x\left(\frac{P_t^d}{P_t^M}\right)^{\sigma^E} \quad \text{(A 14)}$$

A large negative value for the elasticity implies that a small country has to adjust to the price level of international markets. The basic parameter values are: $x = 0.6$, $\sigma^E = -10$.

The imported good is used in consumption, investments and as an intermediate good in production. Its price is determined in international markets. It is an imperfect substitute for the domestically-produced good. The demand conditions are described by a CES structure.

Markets

The model includes four markets, which balance every period. The two labour market specifications have been described in the text. Total employment equals the sum of private employment and public employment (Equation A 15). In the domestic goods market, firms are the sole supplier. The product is used by other firms as a part of the composite intermediate and investment goods, by households as a part of the composite consumption good and by foreign agents. The demand of domestic agents is determined by a cost minimising CES structure. The equilibrium condition which determines the price of the domestic good is Equation A 16. Domestic demand for the fixed-price imported good is also determined by minimising costs of the composite goods (the price of the imported good serves as a numeraire in the model). The perfectly elastic supply adjusts to demand in these markets (Equation A 17). The fourth market is the capital market. In this market, savings and investment are balanced. The arbitrage condition of domestic households ensures that they are ex ante indifferent between investing their savings in bonds and in firms' shares. Total saving is the sum of domestic savings and foreign portfolio investments. Equation A 18 describes the parallel stock equilibrium.

$$L_t^T = L_t + L^G \quad \text{(A 15)}$$

(A 16) $Y_t = \zeta Y_t \, v_t^d + I_t \, i_t^d + C_t \, c_t^d + X_t$

(A 17) $M_t = \zeta Y_t \, v_t^M + I_t \, i_t^M + C_t \, c_t^M$

(A 18) $W_t = V_t + B_t^f + B_t^G + A_t^f$

where the unit demands are

(A 19) $v_t^M = \left(\frac{mP_t^C}{P_t^M}\right)^{\sigma^M} = i_t^M = c_t^M, \quad v_t^d = \left(\frac{(1-m)P_t^C}{P_t^d}\right)^{\sigma^M} = i_t^d = c_t^d$

The price of the domestic good P^d is endogenous and the price of the imported good serves as the numeraire in the model. Other prices are linked to them according to the following equations. The model facilitates the use of different share parameters m and price elasticities σ for consumption, investment and intermediate goods, but in this study we use the common values $m = 0.3$ and $\sigma^M = 0.99$ for all goods, which explains Equations (A19) and (A 22). P^H is the price of the intermediate good.

(A 20) $P_t^F = (P_t^d - \zeta P_t^H)/(1-\zeta)$

(A 21) $P_t^C = \left[m^{\sigma^M} (P_t^M)^{1-\sigma^M} + (1-m)^{\sigma^M} (P_t^d)^{1-\sigma^M} \right]^{1/(1-\sigma^M)}$

(A 22) $P_t^C = P_t^K = P_t^H$