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SHIFTING THE TAX BURDEN FROM LABOUR TO CAPITAL IN GENERAL EQUILIBRIUM

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ABSTRACT: This study analyses the effects of shifting the base of pension contributions from wages to the capital stock. The framework used is an open economy numerical overlapping generations model. The measure reduces markedly the capital-labour ratio, but the decrease in the capital stock and production leaves no room for higher employment. Currently living generations suffer a welfare loss because of the tax capitalisation effect. From the point of view of future generations, the welfare outcome depends on the openness of the economy. Higher substitutability between domestic and foreign goods and bonds more likely generates a reduction in welfare. On the other hand, lower substitutability means that part of the welfare loss can be transferred abroad. Therefore, globalization and European integration reduces the possibilities to benefit from the shift in the tax structure even at the expense of the other countries.

KEY WORDS: Capital income taxation, labour income taxation, numerical overlapping generations model

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TIIVISTELMÄ: Tutkimusongelmana on se miten työanantajan työeläkemaksun alentaminen ja puuttuvan eläkemenojen rahoituksen korvaaminen uudella pääomakannan arvoon sidotulla verolla vaikuttaa kansantalouteen ja sukupolvien väliseen tulonjakoon. Tutkimusvälineenä käytetään numeerista limittäisten sukupolvien mallia. Tulosten mukaan toimenpide lisää selvästi työvoiman käyttöä suhteessa pääomaan, mutta pääomakanta ja tuotanto vähenevät niin paljon, ettei toivottua työllisyyden lisääntymistä saada aikaan. Nykyiset sukupolvet kärsivät lisäksi hyvinvointitappion, koska pääomavero kapitalisoituu yritysten arvoon. Tulevien sukupolvien kannalta uudistuksen hyvinvointivaikutukset riippuvat talouden avoimuudesta. Mitä laajempaa on ulkomaisten ja kotimaisten hyödykkeiden ja joukkolainojen korvattavuus, sitä todennäköisempää on hyvinvoinnin heikkeneminen. Toisaalta, mitä vähäisempää on korvattavuus, sitä enemmän hyvinvointimenetystä voidaan siirtää ulkomaille. Näin globalisaatio ja talouden integraatio heikentävät mahdollisuuksia hyötyä verorakenteen muutoksesta edes muiden maiden kustannuksella.

ASIASANAT: Pääomakantavero, työn verotus, numeerinen sukupolvimalli

YHTEENVETO

Tutkimuksessa tarkastellaan työn verotuksen keventämisen ja vastaavansuuruisen pääomaverotuksen kiristämisen vaikutuksia kansantalouteen ja hyvinvointiin. Lähtökohtina ovat toisaalta poliittinen keskustelu nykyisestä työtulojen korkeasta veroasteesta ja sen ennakoidusta noususta väestön ikääntyessä ja toisaalta ristiriita optimaalisen verotuksen kirjallisuuden ja numeeristen mallien tulosten välillä pääomatulojen verotuksen tasosta.

Verotuksen teoreettisessa kirjallisuudessa on löydettävissä ehtoja, joiden vallitessa optimaalinen pääomatulojen veroaste on nolla. Jotkut numeeristen mallien simulointitulokset osoittavat kuitenkin hyvinvoinnin vähenevän, jos pääomatulojen verotusta kevennetään ja työtulojen verotusta kiristetään. Näin on erityisesti silloin, kun säästäminen ei ole herkkä veron jälkeisen tuoton muutoksille, mutta työvoiman tarjonta on herkkä veron jälkeisen palkan muutoksille. Tällöin pääomamarkkinoilla säästämisen verotuksella aiheutettu vääristymä on vähäinen verrattuna työmarkkinoilla palkkaverolla aiheutettuun tarjonnan vähenemiseen.

Tässä tutkimuksessa kiinnitetään erityistä huomiota siihen, miten talouden avoimuus vaikuttaa edellä mainittuihin tuloksiin. Kuten hyvin tunnettua, säästämisen ja investointien verotuksella on avoimessa taloudessa erilaiset vaikutukset. Koska tavoitteena oli muuttaa työn ja pääoman hintasuhdetta tuotannossa, tutkimuksessa tarkastellaan työeläkemaksun alentamista ja menetettyjen tulojen korvaamista pääomakantaan kohdistuvalla uudella verolla: Vero on samanluonteinen kuin ns. robottivero, jonka on toivottu lieventävän työllisyysongelmia.

Tulosten mukaan toimenpide lisää selvästi työvoiman käyttöä suhteessa pääomaan, mutta pääomakanta ja tuotanto vähenevät niin paljon, ettei toivottua työllisyyden lisääntymistä saada aikaan. Nykyiset sukupolvet kärsivät lisäksi hyvinvointitappion, koska pääomavero kapitalisoituu yritysten arvoon. Tulevien sukupolvien kannalta uudistuksen hyvinvointivaikutukset riippuvat talouden avoimuudesta. Mitä laajempaa on ulkomaisten ja kotimaisten hyödykkeiden ja joukkolainojen korvattavuus, sitä todennäköisempää on hyvinvoinnin heikkeneminen. Toisaalta, mitä vähäisempää on korvattavuus, sitä enemmän hyvinvointimenetystä voidaan siirtää ulkomaille. Näin globalisaatio ja talouden integraatio heikentävät mahdollisuuksia hyötyä verorakenteen muutoksesta edes muiden maiden kustannuksella.

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1. Introduction[1]

Background

Recent political discussion has considered the issue of whether the low tax rates on capital incomes in relation to the high tax rates on labour incomes is one of the reasons why there are incentive problems to participate in the labour market and to favour the use of capital in production. It has been suggested that the distorted price ratio should be corrected by shifting the tax burden from labour to capital.

A totally contradictory discussion topic amongst the tax authorities and scholars is whether capital incomes can and should be taxed at all in open economies. Since capital can move freely between countries in search of the best possible yield, raising the tax rate to levels markedly higher than in neighbouring countries can lead to extensive reallocation of capital. A country might end up in a situation in which the higher tax rate on capital generates fewer tax receipts and either lower real wages or weaker employment.

The relevance of the questions is emphasised by two trends seen in industrialised countries. The interdependence of national and regional financial markets is continuously increasing both because of the more global view of investors and because of the institutional decisions to promote the capital movements. An extreme example of the latter is the creation of the Economic and Monetary Union (EMU).

Another common feature of the OECD economies is the unfavourable demographic trend. The ratio of retired people to the active population will rise rapidly over the next two decades. While most of the pensions systems are based on a pay-as-you-go principle, the ageing of the population adds pressure to raise the pension contribution rates markedly. As a result, the taxation of labour threatens to increase further from the currently high rates[2].

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[1] The core economic model used was the same as that used in Forss et al. (1998). I thank Jukka Lassila and the participants of the FPPE seminar on December 12-13 1997 for useful comments, Eija Kauppi for her efficient programming and Anthony de Carvalho for checking the language. This study has been financed by the Yrjö Jahnsson Foundation and the Central Pension Security Institute. The support is gratefully acknowledged.

[2] The options for pension policy are studied, e.g., in Broer and Lassila (1997) and in Lassila and Valkonen (1999b).

Theoretical arguments

The issue of whether or not to tax capital incomes is not new, but the theory of optimal taxation still has few results to offer politicians. The results seem to be sensitive to the assumed structure and dynamics of the economy.

The contributions of Judd (1985) and Chamley (1986) show that when individuals are altruistic, the optimal capital income tax tends to be zero in the long run. This outcome results from using models with infinite horizon households.

Bernheim (1999) surveys the corresponding results in an overlapping generations economy. The main conclusion is that if certain conditions are met, the capital income tax should be zero in the long term. These conditions are that the government should have enough instruments to aim for intergenerational redistribution and that household preferences must be weakly separable into leisure and consumption and homothetic in consumption. If the first condition is not met, capital income taxes can be used to adjust capital intensity to correspond to the golden rule.

From the point of view of our analysis, it is useful to note that the nested CES structure in household preferences, used in the Auerbach-Kotlikoff-type model (like ours), does not meet the criteria of separability. Therefore we cannot draw firm conclusions about the optimality of taxing saving even in a closed economy version of our model.

The optimal rate of capital income taxation depends also, in a complicated way, on the openness of the economy. In a small open economy, a source tax on capital incomes is a tax on investments (if the incomes are generated by a capital stock). Correspondingly, a residence tax is a tax on saving. In practice, there are no pure principles followed, but mixtures of policies. Haufler (1997) summarises the theoretical literature by noting that the capital income tax should be zero if the residence principle cannot be enforced world-wide and capital is perfectly mobile. This is because if the source principle is followed, taxes are shifted fully to labour. Production efficiency is, however, promoted by taxing labour directly.

The conditions for improved production efficiency are that all goods are taxable and there are constant returns to scale. With decreasing returns to scale production efficiency requires that pure profits can be taxed away (Christiansen et al. 1994). A tax on the production factors might provide a partial substitute, if pure profits or all commodities are not fully taxable (Slemrod 1990).

There is one more aspect that should be discussed. The openness of capital markets and the substitutability of assets varies. This has interesting implications on taxation. It might be helpful to classify the various possibilities.

First, in a closed economy, it does not matter whether saving or investments are taxed, both investment and saving decisions are distorted. Second, if only bond markets are perfectly competitive internationally and domestic households are the dominant owners of the firms, taxation of interest incomes is a subsidy to capital, since the tax lowers the required rate of return. In an extremely open economy, foreign agents own a major part of the shares and determine the required rate of return on investments. In this case, it is the taxation of these investors which is important for the market value and investments of the domestic firms. On impact, the taxes on capital income of domestic households distort only saving decisions.

Also, introduction of a pure investment tax can, at least temporarily, affect saving in an open economy. The first link is a revaluation of the existing capital stock, which causes a discrepancy between actual and optimal wealth. Another link is created if the labour market is not perfectly open. In this case, the reduction in the capital stock lowers wages and limits saving for old age. Furthermore, the balanced budget condition of the government requires that other taxes or expenditures must be changed. In an overlapping generations economy, this balancing measure shifts the generational incidence of taxation and creates permanent saving effects.

Earlier results from numerical models

The lack of robust outcomes in the theory of optimal taxation has directed more attention to numerical models and shifts in existing tax structures. We discuss next the outcomes of two simulation analyses, which are comparable to ours.

The closed economy numerical OLG study by Auerbach and Kotlikoff (1987) considers a shift from income taxation to wage taxation, i.e. capital income taxation is abolished. The measure improves the welfare of the current elderly generations, but reduces the utility of the young and future household cohorts. Since the initial gains are small compared to the future losses, the overall welfare outcome is negative.

One reason for the result is that in the simulation the elasticity of intertemporal substitution of consumption (0.25) is markedly lower than the elasticity of substitution between consumption and leisure (0.8). In other words, the capital income tax distorts the saving decision less than the wage tax distorts the labour supply decision. If the difference between these two parameters is narrowed, the tax shift may also generate a minor improvement in welfare. The results of the study also confirm the importance of the initial tax level. The welfare impacts are much larger, when the initial tax level is higher.

An example of a corresponding open economy study is Perraudin and Pujol (1991). The authors simulated the effects of reducing savings taxation and raising wage taxation. On impact, households suffer a welfare loss in the long term. Short-term results and the overall welfare effects are not reported. In their baseline case, exports are price elastic and capital movements are interest rate elastic.[3]

The sensitivity analysis with small open economy assumptions (the export price and domestic interest rate are determined abroad) generates a markedly larger long-term reduction in the welfare of domestic households. This is because in the baseline case the export price rises,

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[3] In the model of Perraudin and Pujol (ibid.), foreign investors participate only in the bond markets. Furthermore, in their paper, the link between savings taxation and the required rate of return on investments is broken by assuming that the government owns the capital stock. Bovenberg and Goulder (1993) present a model in which foreigners also own shares of the domestic firms. This new link allows for international welfare transfers via capitalisation of taxes in share prices.

shifting part of the welfare loss abroad, and the interest rate falls, raising the discounted value of lifetime incomes[4].

The baseline model has a rather large difference between intertemporal substitution of consumption (0.8) and the elasticity of substitution between consumption and leisure (2.2). The sensitivity analysis shows that widening the gap increases the welfare loss, just as in the Auerbach-Kotlikoff study. The authors point out that the initial level of government debt also affects the welfare outcomes. The bigger the debt is, the larger is the revenue loss due to the lower interest income tax and the higher is the wage tax rate necessary to compensate the lost tax receipts.

These two simulation studies show that a reduction of capital income tax and a hike in the labour income tax is likely to lower welfare. This outcome seems, however, to be sensitive to the initial tax structure and to the reactions of the agents to price changes.

The elements of this study

There are two starting points in our study. The first is the current Finnish political discussion about fair and efficient distribution of the tax burden between labour and capital. The recent tax reform introduced a dual income tax system, in which the taxation of capital and labour incomes were separated. Corporate and personal capital incomes are now taxed at the same low flat rate. Large public expenditures require that labour incomes are heavily taxed. In addition, the generous pension system is financed by a high pension contribution rate. The disparity between paid contributions and received pension benefits implies that the pension contributions distort the labour supply decision. The problem is aggravated by the expected substantial increase in the contribution rate over the next three decades, see Klaavo et al. (1999).

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[4] The authors note that the inverse correlation between household welfare and interest rate is due to the concentration of transfers in the retirement period. The importance of the international welfare transfer due to shifts in terms of trade has been detected also, e.g., by Broer and Westerhout (1993).

The second starting point is the observation that the results of the two above discussed simulation studies do not describe accurately enough the relevant choices in the Finnish framework. This is because the topic of the discussion is whether employment and welfare can be promoted by using tax policy to shift costs from labour to capital in an open economy. Especially the contributions to the social security system have been considered to be harmful for employment.

The method we use is to simulate the impacts of the tax shift with a computable OLG model calibrated to the Finnish economy (FOG). The precise measure is to unexpectedly lower the private sector employers' pension contribution rate by 10 percentage points and to compensate the revenue loss to the pension fund by introducing a new capital stock tax.

We are especially interested in the implications of the openness of the economy. In the baseline model, we assume that the domestic interest rate is the same as that in international bond markets and, also, the price of the exported good is determined abroad. Therefore, the only price which adjusts is the domestic wage rate. As a first sensitivity analysis, we study a case in which the country has some monopoly power in export markets. The second sensitivity analysis looks at the impacts of the tax shift, when both the terms of trade and the domestic interest rate are determined endogenously. The latter feature is introduced by linking the difference between the domestic and foreign interest rate to foreign net debt.

The structure of the paper is as follows. The next section describes the critical features of the general equilibrium model used in the analysis. A more detailed description of the model is provided in Appendix 1. Section 3 explains how the new capital stock tax has been modelled. The fourth section includes the description and interpretation of the simulation results. The conclusions are presented in the last section.

2. Description of the relevant features of FOG

The political discussion about the optimal combination of capital and labour income taxation suffers from vagueness of the concepts and a lack of a consistent economic framework. One

of the benefits of using a numerical model is that it compels the user to define explicitly the policy used and the structure and functioning of the modelled economy. The main weakness of the models is that they are still highly stylised compared to the versatile actual economies they represent. Therefore, the model user must understand thoroughly the importance of the limitations and simplifications of the model when evaluating the simulation results.

Model structure

Our analysis is based on an Auerbach-Kotlikoff-type, perfect foresight numerical overlapping generations model (FOG). There are five sectors: households, enterprises, a government, a pension fund and a foreign sector. The labour, goods and capital markets are competitive and prices balance demand and supply period-by-period. There is no money or inflation in the model. The unit period is five years.

The household sector consists of 14 overlapping generations. They make utility maximising lifetime plans for consumption, labour supply and bequests when they enter the model. The enterprise sector consists of small listed forward-looking companies, which maximise the value of their shares. The representative firm decides about investment and the use of labour. Investments cause adjustment costs, and the investment decisions are based on a tax-adjusted Tobin's q-theory. The capital stock in the model is always in full use because the cost of capital is independent of the capacity utilisation rate. Current period investment does not increase the capital stock until the next period.

The general government collects taxes and uses the proceeds to hire workers and to pay transfers to households and the interest costs of the public debt. A value-added tax balances the budget. The pension institutions finance pensions using contributions and capital income from the pension fund. The pension system is balanced before the reform period-by-period with the employers' contribution rates. Pensions are indexed partly to wages and partly to consumer prices.

Households and firms take the prices of products and factors as given. The domestic good is used as an intermediate good in production, in investments and consumption, and is also exported. The imported good is supplied at a fixed price. The substitutability between the domestic and foreign product largely determines the price reactions of the domestic good. In the baseline case, the exported and imported goods are perfect substitutes.

The wage is formed in a labour market, wherein a fixed amount of labour is first shifted to the public sector and the rest is available to the private firms. The firms demand labour according to the labour productivity condition. In labour market equilibrium, the wage and pension contribution of the private sector employer corresponds to the value of the marginal product of labour. In the model's perfectly functioning labour market, the incidence of pension contributions is mainly on labour.

Financial markets in the model are divided into bond and stock markets. Domestic households are the sole owners of the firms. The arbitrage condition determining the pricing of shares equates the after-tax yield of shares with that of bonds. The base case simulation is performed assuming that the foreign interest rate completely determines the domestic one. The interest rate is passed on to the required rate of return of the domestic firms' capital stock both directly via the interest rate of corporate debt and indirectly via the required rate on equity capital. The effects of fixing the domestic interest rate are checked with an additional simulation in which the difference between the domestic and the foreign interest rate depends on the amount the net foreign debt deviates from its initial equilibrium value.

Calibration

The model is calibrated to imitate the main features of the Finnish economy[5]. The precision of a calibration in a typical dynamic CGE model is not very strict. This is due to the limited number of parameters used and the large variation which econometric studies give to the estimates of those parameters. Therefore, the steady state from which we start can be produced with several different combinations of parameter values, which are still within the limits of the generally accepted range.

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5 The calibration is discussed in more detail in Valkonen (1999).

As noted above, earlier studies have put much emphasis on the relation between the intertemporal and intratemporal elasticity of consumption. The intertemporal elasticity, which determines the sensitivity of household saving to the net yield, is not so important in our case because taxation of saving is not changed[6]. The general opinion about the likely value of the parameter is that it is close to zero largely because of the contribution of Hall (1988). On the other hand, cross-sectional studies like Blundell et al. (1994) generate markedly higher values than time-series studies. Our choice was to use a value of 0.5. The intratemporal elasticity between consumption and leisure is chosen to be 0.75, which is close to the value used by Auerbach and Kotlikoff (1987), but somewhat lower than the unitary elasticity estimated for Finland by Törmä and Rutherford (1993).

Substitutability between capital and labour in production is the third important parameter, considering our aim to study the effects of the tax shift. Törmä and Rutherford suggest a value of 0.7 for the nontradable sector and a value of 0.9 for the tradable sector. This can be contrasted to the study of Rowthorn (1996), which surveys 33 studies and finds a median value of 0.58 for the substitution elasticity. We have used the value of 0.7.

A large price elasticity of the exported good leads to a loss of goods price autonomy in the economy. We use this assumption in the base case simulation, but also analyse the effects of the policy measure when the long-run price elasticity of export demand is -4, which is in line with Tarkka and Willman (1990).

3. Definition and implementation of the capital stock tax

The modelled tax system roughly describes the existing taxation of listed firms in Finland. The capital incomes generated by the firm are first taxed with a corporate income tax and at the household level with personal capital income taxes. The tax base of the corporate income tax is the value added minus labour costs, interest costs and depreciation. Tax depreciation is modelled to correspond to the actual depreciation of the capital stock. The imputation system

[6] However, even though the return on saving remains intact in the baseline case, a shift in the tax structure changes the timing of taxation during a given lifetime and thereby affects saving decisions.

compensates for the corporate tax paid on distributed profits in the taxation of households, eliminating the double taxation of dividends. Dividends and interest incomes are taxed once but retained earnings twice: first with corporate taxation and, after raising the value of the firm, with a capital gains tax at the individual level.

The simplest way to finance pension costs with capital income taxation would be to raise the current tax rates and to direct the incomes generated to the pension system. This is not, however, a very efficient way to change the price ratio of productive capital and labour. In addition, it has the unpleasant side effect of reducing saving, thereby increasing the net foreign debt of the economy. The outcomes of this type of tax hike depend also on the financing strategy of the firms, see Lassila and Valkonen (1998).

The other possibility is to raise only the corporate income tax rate. This measure distorts, nevertheless, both the profit distribution and investment financing decisions and contradicts the idea of levelling the playing field in capital income taxation.

The third alternative is to set a totally new tax on corporate activity. The broadest possible tax base would be a sales tax without any allowances, but it would also tax the use of labour. The political discussion about the tax distortions shifting the price ratio of labour and capital has led to the suggestion of introducing a robot tax. This is a tax on the capital stock, and the idea is to change the price ratio to be more favourable for the use of labour. It is aimed especially at the type of capital which has been seen as the most efficient substitute for labour. We cannot differentiate in the model between various forms of capital or study, e.g., the productivity implications of capital vintages. It turns out, however, that even the introduction of this general version of the capital stock tax creates interesting implications.

From the point of view of firms, the role of the new tax is most clearly seen when the determination of dividends is examined. The firms finance the investments with retained earnings and debt, allowing the dividends to be a residual from the cash flow equation (1):

$$
\begin{aligned}
D_t &= (1-\tau_t^F)\left[p_t^F(F_t - G_t) - (1+\tau_t^l)w_t L_t^F - r_{t-1}^d B_{t-1}^F\right] \\
&\quad + \tau_t^F d\, p_{t-1}^K K_{t-1} - p_t^K I_t + (B_t^F - B_{t-1}^F) - \tau_t^K p_{t-1}^K K_{t-1}.
\end{aligned} \tag{1}
$$

The first term within the brackets is the sales revenues of the firm $p_t^F F_t$. The costs deductible in corporate taxation are investment adjustment costs $p_t^F G$, labour costs $(1+\tau_t^l)w_t L_t^F$ and the interest costs $r_{t-1}^d B_{t-1}^F$. In addition, the income corresponding depreciation is tax-free, which is considered by using the tax allowance $d\, p_{t-1}^K K_{t-1}$. Investment costs are $p_t^K I_t$, and the increase in debt is $B_t^F - B_{t-1}^F$. The last term is the new tax on capital stock $\tau_t^K p_{t-1}^K K_{t-1}$. The tax base is the capital stock in use during the current period, valued at the repurchasing price of a capital unit in the previous period. The tax rate τ_t^K is assumed to be endogenous in the simulations and is determined by the additional income needed to balance the incomes and expenditures of the private sector pension fund.

The capital stock tax reduces by the full amount the dividend yield of the firms' shares. Implementation of the new tax affects the amount distributed as dividends via another route as well. The employer's pension contribution rate is modelled to be deductible in corporate income taxation, but the new capital stock tax is not. Therefore, the new tax broadens the corporate income tax base significantly. The aggregate effect of the two taxes is to reduce dividends and thereby to lower the market value of the existing capital stock and to raise the required rate of return on new investments.

The next step is to consider the effects of the new tax on the pension system of the model. Actually, there are two systems, one for private sector and one for public sector employees. The pension systems can be classified as defined-benefits systems, in which the basis of the pensions are the pension wage and the replacement rate. There are also funds, which have been collected earlier, but the systems operate currently in accordance with the pay-as-you-go principle. Before the new tax is implemented, the incomes and expenditures are balanced period-by-period with the contribution rates of the employers.

The simulated measure is to lower the contribution rate of the private sector employer. The lack of revenues in the pension system will be collected with the new capital stock tax.

Furthermore, the private sector pension fund will be balanced with the new tax, and the employers' contribution rate is fixed. The amount necessary to cover the missing revenues is:

$$(2) \quad \tau_t^K p_{t-1}^K K_{t-1} = P_t^F - (1 + r_{t-1}) H_{t-1}^F - (\tau_t^e + \tau_t^l) w_t L_t^F \ .$$

The term on the left-hand side of the equation represents the receipts from the new tax, which adjust to cover the difference between pension expenditures P_t^F, interest incomes from the fund $(1 + r_{t-1}) H_{t-1}^F$ and collected contributions $(\tau_t^e + \tau_t^l) w_t L_t^F$.

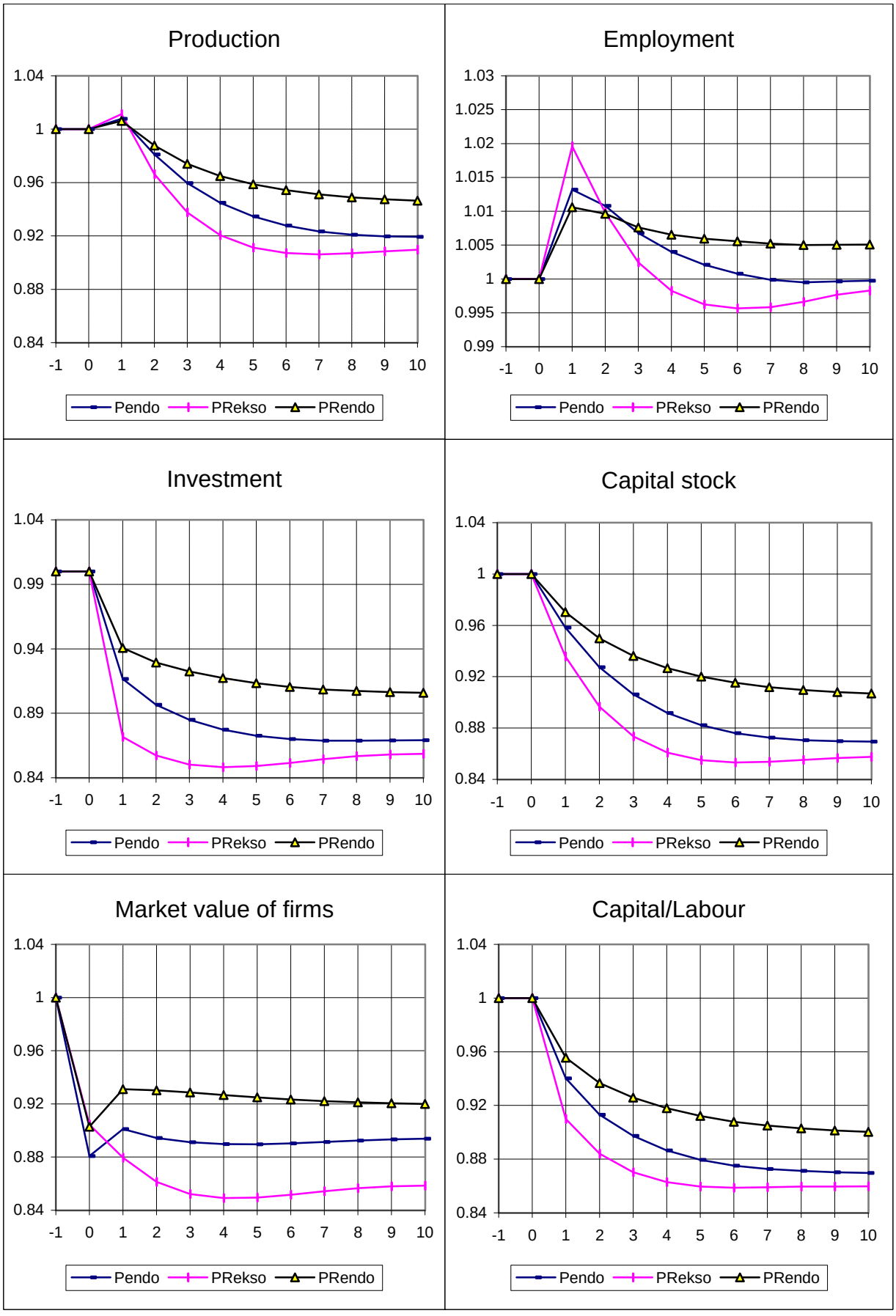
4. Simulation results

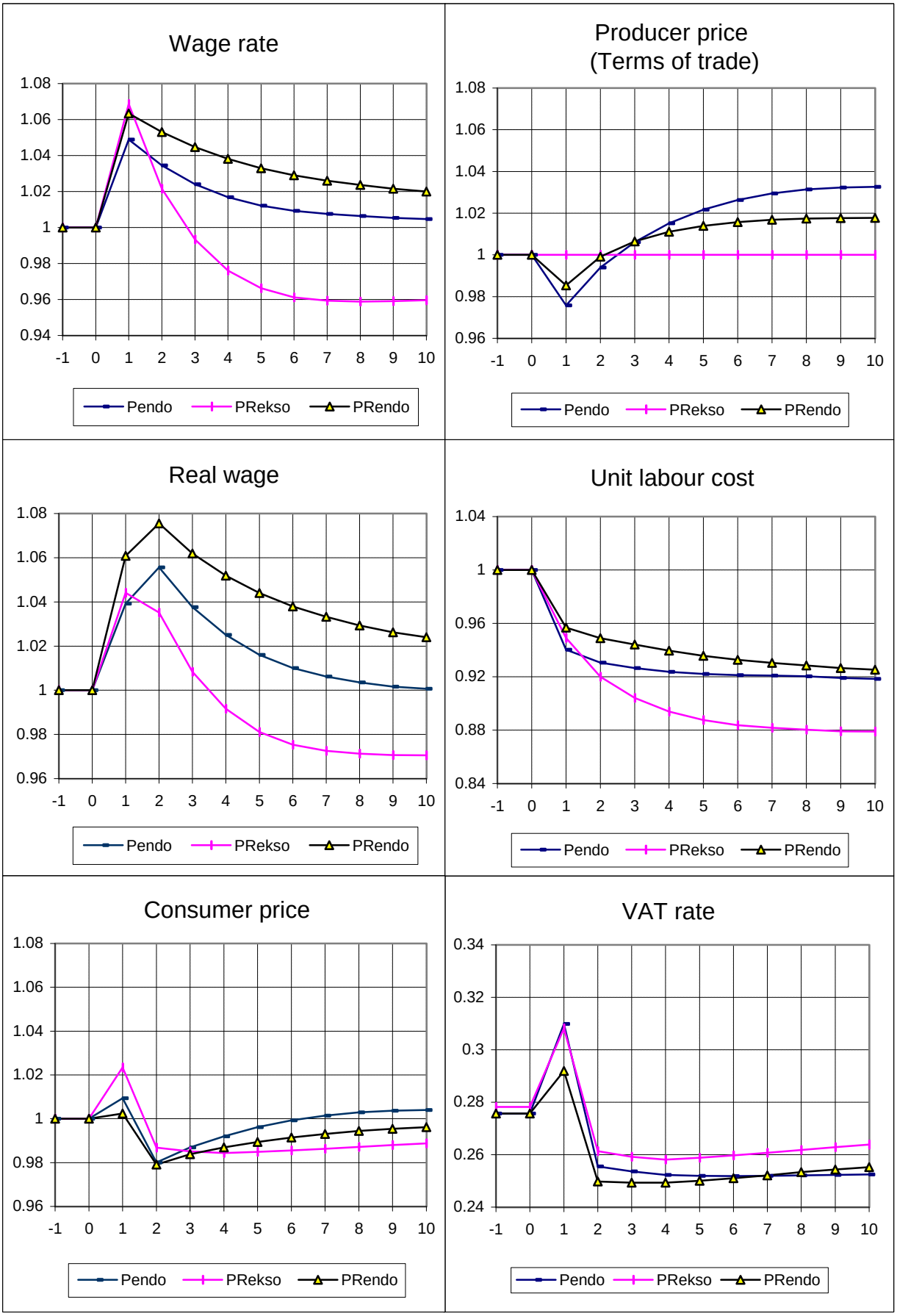
4.1 Baseline case: a small open economy

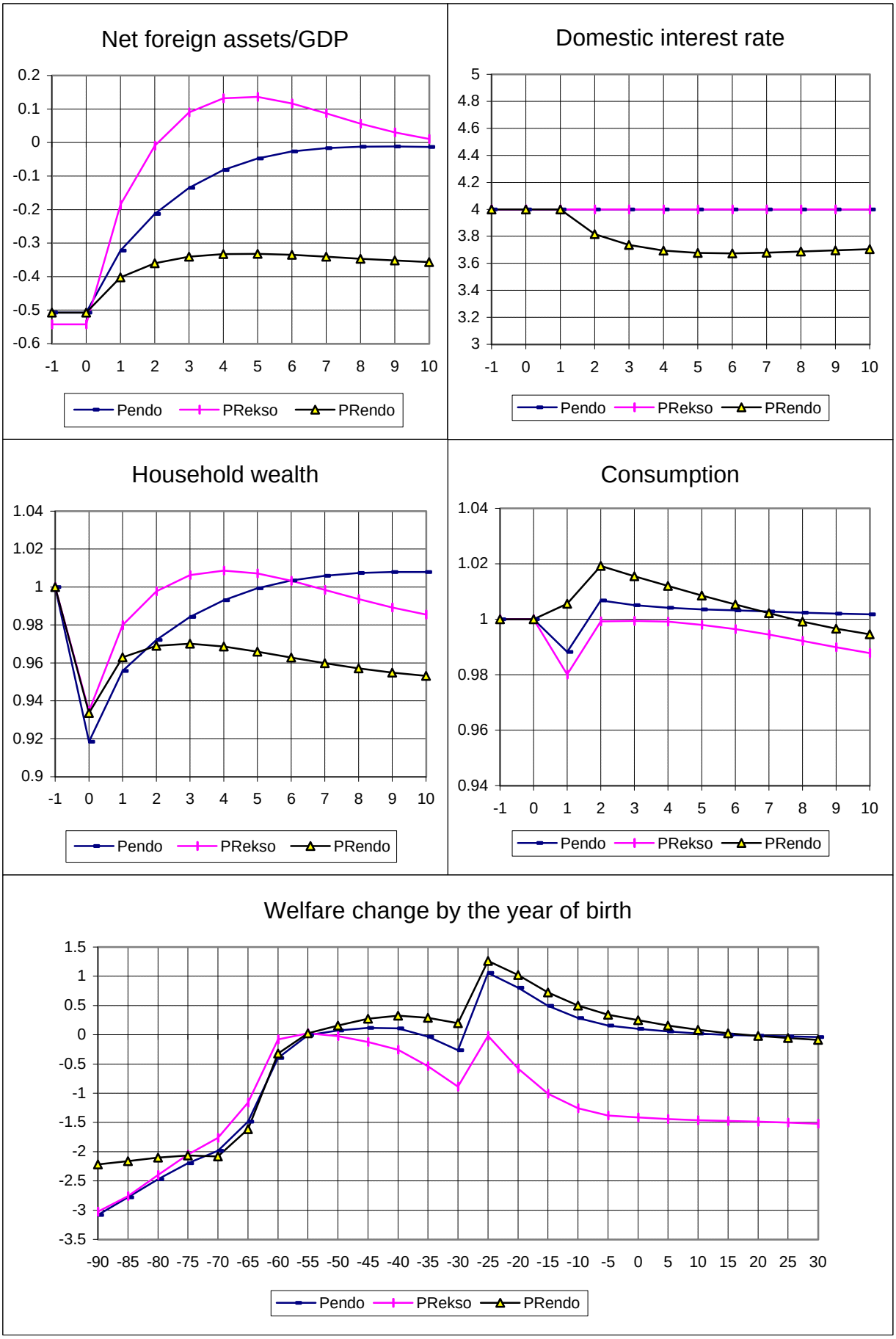
We study as a baseline case the policy measure using a small open economy parametrisation in which the economy takes the interest rates and the price of the domestic good as given from abroad. The measure is, as mentioned above, to unexpectedly lower the private sector employers' pension contribution rate by 10 percentage points and to compensate the revenue loss to the pension fund by introducing a new capital stock tax.

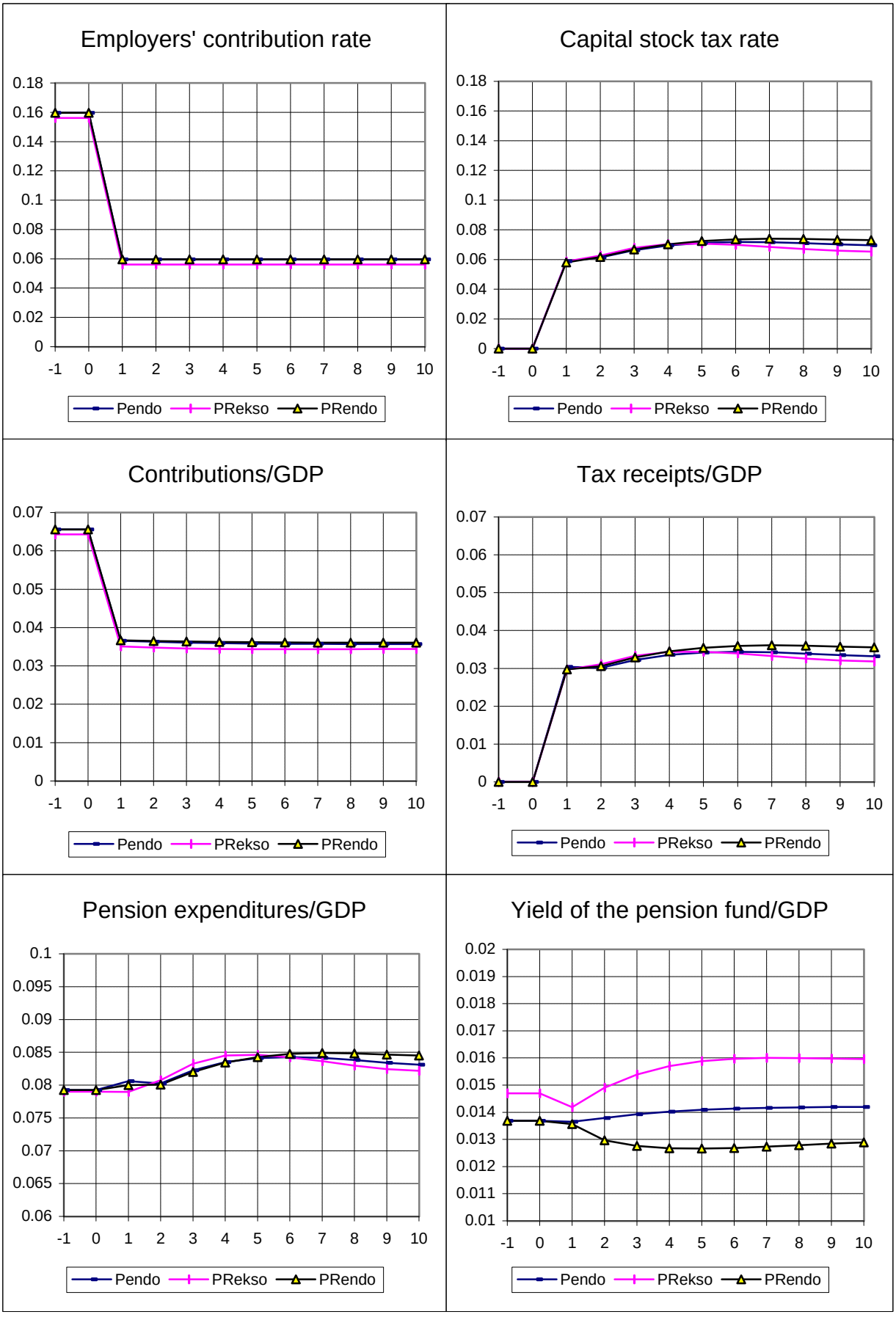
The baseline case is presented in the following figures with the legend *PRekso*. The figures should be interpreted as follows. Taxes, contribution rates and the variables related to the value of GDP are expressed as percentage points. The utility figure shows relative compensated variations by generations. They are measured as logarithmic differences between the new discounted lifetime consumption expenditures and the consumption necessary to achieve the baseline utility at the new prices. Therefore, positive numbers express a welfare gain. The remaining figures describe percentage deviations from the initial steady state. The number -1 depicts the initial steady state. The unexpected tax change is implemented at time point 0, which is just before the first period starts. Stock prices and thereby household wealth are the only variables that react immediately. One period is five years, so the time span in the figures is 50 years.

A SHIFT FROM A LABOUR INCOME TAX TO A CAPITAL STOCK TAX




Wage rate
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Producer price
(Terms of trade)
1.08
1.06
1.04
1.02
1
0.98
0.96
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Real wage
1.08
1.06
1.04
1.02
1
0.98
0.96
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Unit labour cost
1.04
1
0.96
0.92
0.88
0.84
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Consumer price
1.08
1.06
1.04
1.02
1
0.98
0.96
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
VAT rate
0.34
0.32
0.3
0.28
0.26
0.24
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo


Net foreign assets/GDP
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Domestic interest rate
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Household wealth
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Consumption
1.04
1.02
1
0.98
0.96
0.94
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo
PRekso
PRendo
Welfare change by the year of birth
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30
Pendo
PRekso
PRendo


Employers' contribution rate
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo PRekso PRendo
Capital stock tax rate
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo PRekso PRendo
Contributions/GDP
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo PRekso PRendo
Tax receipts/GDP
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo PRekso PRendo
Pension expenditures/GDP
0.1
0.095
0.09
0.085
0.08
0.075
0.07
0.065
0.06
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo PRekso PRendo
Yield of the pension fund/GDP
0.02
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.01
-1 0 1 2 3 4 5 6 7 8 9 10
Pendo PRekso PRendo

The initial impacts of the tax shift can be divided into two parts. The reduction in the employers' contribution rate allows wages to rise markedly in the short term, because the value of the marginal product of labour remains approximately unchanged at the previous level, but aggregate labour costs diminish. Later, when the fall in the capital stock has reduced the marginal productivity enough, the real wage falls below its original level. Households react to the path of the real wage by initially increasing labour supply and reducing it later.

The introduction of a capital stock tax raises the required rate of return on capital. Therefore investments and the stock market value of existing capital fall. Those households living at the time of the implementation of the policy measure notice that their wealth is lower. While the optimal amount of wealth is still almost the same, and part of the tax burden has been shifted from working age to old age, households increase their savings. The saving incentive is especially strong in the first period because of the high value-added tax rate, which is known to fall later. Also, the trends in wages support saving.

When the aggregate saving rate increases and the value of the investment decreases, the economy starts to reduce its external debt. Once firms have adjusted their investments to the new lower level and households have adjusted their lifetime saving to the fall in real wages, the current account surplus vanishes.

The taxation of capital gains is symmetric, i.e. households receive in the first period a compensation equal to the tax rate times the capital loss caused by the fall in stock prices. This compensation reduces tax receipts markedly and compels the government to initially raise the value-added tax rate. The tax rate falls, however, after the first period because of the increased receipts from the corporate income tax and the labour income tax. In the long term the need for tax receipts is lowered by the diminishing labour costs of the government due to the lower wages.

The simulations show that, in a small open economy, partial substitution of the employers' pension contribution with the capital stock tax does markedly lower unit labour costs in the long term, but has no significant effect on employment. Capital is replaced by labour because of the change in the price ratio, as expected. The decline in the capital stock is, however, large

enough to reduce the overall demand for labour at the initial wage. Since households aim to maintain their lifetime incomes, the labour market balances in the long term with nearly the initial level of employment and a lower real wage.

Another important observation is that, in spite of the short-term positive effect of rising real wages, working-age generations suffer somewhat from the policy measure because of the negative wealth effect caused by the fall in the market value of firms. The welfare improving effect of the wage increase is transferred incompletely to the pensions because the indexation is only partial. The negative wealth effect is stronger the older the household is due to the higher share of firms' stocks in these households' asset portfolios. Those who start their working careers just after the implementation of the capital stock tax lose only a little, because, although they have no wealth, they benefit the maximum time from higher wages. The overall utility outcome is unambiguous: since no generations gain, the measure should be rejected.

4.2 Case 2: fixed interest rate and endogenous terms of trade

It is interesting to compare the previous results to the case in which the domestic and foreign goods are not perfect substitutes, i.e. when the exported amount affects the price of the domestic good. Econometric estimations of the price elasticity of exports show that demand is relatively robust to changes in prices, at least in the short term. While the small open economy version studied above described exports as a kind of residual, obtained by subtracting domestic demand from production, in this version the terms of trade affects both the demand for the exported and the imported good. This case is presented in the figures with the legend *Pendo*.

The policy measure initially leads to a sharp fall in domestic demand for the home good, just as in the case of fixed prices. Excess supply is, however, mitigated by the fall in the price of the good, which induces agents to replace the imported good with the domestic one. Another element limiting excess supply is that firms foresee the longer-term improvement in the terms of trade. The expected higher profitability allows for a higher capital stock than in the fixed-price case.

When the capital stock has been reduced enough and consumption revived, the relation between the amount of production and domestic demand reverses and the price of the domestic good rises above its initial level. This gain in the terms of trade supports the wage rate so that real wages do not fall markedly below the original level even in the long term.

The welfare effects on the elderly household generations are roughly similar to those in the previous case. This is because the outcome is dominated by the slump in the market value of the capital stock. For the young and future domestic households, the welfare effects follow the path of real wages. The result is less detrimental due to the permanent improvement in the terms of trade, which transfers part of the utility loss abroad.

4.3 Case 3: Both the terms of trade and the domestic interest rate are endogenous

The next case is to study the effects of the policy measure in an economy in which export demand is price elastic and the domestic interest rate reacts to changes in net foreign debt.
It can be justified by the home preference in investor portfolios, which has been detected by many studies. The simulation results using this model version are presented in the figures above with the legend *PRendo*.

The policy measure immediately increases household saving and reduces investments, causing a surplus in the current account. The reduction of net foreign debt below its initial level lowers the domestic interest rate permanently. This interest rate reaction lowers the required rate of return on firms' capital stock and mitigates the negative effects of the capital stock tax on the optimal amount of capital. On the other hand, the return on household saving is also lower, as well as optimal wealth. With a larger capital stock and less household wealth, the economy ends up having less of an improvement in its foreign debt position compared to the previous cases.

The welfare effects are now interesting. The fall in the interest rate supports the capital stock and allows the real wage and employment to rise above their initial level also in the long run. It also limits the fall in share prices, thereby also limiting the initial negative wealth effect.

But the return on household saving is now lower, reducing considerably capital incomes. The utility loss of the oldest generations is dampened, but the combined impact of the higher labour incomes and lower capital incomes leaves the welfare of the future generations unchanged.

5. Conclusions

The starting point of our study was, on one hand, the political discussion about the employment implications of the current tax structure and, on the other, the implications of optimal tax theory, suggesting that taxation of capital incomes is most likely harmful. We also discuss two simulation studies, which suggest that shifting the tax burden from capital to labour reduces welfare. We claim that the results of these simulation studies depend strongly on the structure and parametrisation of the models.

The exact measure that we analyse is to lower unexpectedly the private sector employers' pension contribution rate by 10 percentage points and to introduce a new capital stock tax. The aim was to sharply change the price ratio of labour and capital. The method we use is to simulate the macroeconomic and welfare impacts of the tax shift with a computable OLG model.

The results show that shifting the tax burden does increase the relative amount of labour in production, but because the overall amount of capital falls markedly, there is no room for higher employment. The ultimate measure of the desirability of the shift is welfare. While there are no generations that benefit in the small open economy case but many that lose, the definite answer is that the shift should be avoided.

Our aim in choosing the small open economy assumption for the base case was to demonstrate the effects of the policy measure in an economy which is integrated in the world economy . In the Finnish case, joining EMU speeded up the process. But markets will never be as complete as to abolish all the differences between domestic and foreign prices. The alternative simulations with price-elastic demand for the exported good and supply of foreign financial capital shows that endogenising prices limits the scale of the short-term reactions

markedly. Also the welfare effects are less negative for domestic households, because part of the welfare loss can be transferred abroad. This transfer would have been more extensive had foreign ownership of domestic firms been allowed in the model. Furthermore, in this case the intergenerational welfare shift between the domestic current and future generations would have been smaller. The possibility to transfer part of the utility loss abroad does not, however, change the negative outcome of the overall welfare evaluation.

The remaining important question is which features of the tax system and economic behaviour dominate the outcomes. If we compare our results to those of Auerbach and Kotlikoff (1987), the main differences are that they use a closed economy model and allow the elasticity of substitution between labour and leisure to be markedly higher than the intertemporal elasticity of consumption. This feature is evident also in the open economy study of Perraudin and Pujol (1991). Another important difference compared to our model is that they shift the tax burden between labour income taxation and savings taxation, while we analyse the impacts of a capital stock tax. Therefore, the saving and investment implications are not similar. A third central assumption is that the government owns the firms in the Perraudin-Pujol model.

As a justification of our parameter choices, one might note that even though the recent studies have emphasised that the intertemporal elasticity is likely to be low, the same kind of trend in the empirical results apply also to the intratemporal elasticity. Furthermore, the difference between the elasticity parameter values is not so important in our simulations, since the capital stock tax does not reduce the after-tax yield on saving.

Perraudin and Pujol (1991) also claim that reducing savings taxation and increasing labour taxation causes an even higher welfare loss in a small open economy than in the case of endogenous terms of trade and interest rate. The fact that in our case the introduction of the capital stock tax is less beneficial for the domestic households when the economy is more open emphasises the difference between savings and investment taxation.

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Appendix 1: The Model

Household behaviour

Households maximise the utility from consumption and leisure in different periods and the bequest that they give. The life-cycle plan is the solution to the following problem:

$$\text{(A 1)} \qquad \max_{c,l,B} \quad \sum_{t=1}^{T} \frac{1}{1-\frac{1}{\gamma}} \frac{U_t^{1-\frac{1}{\gamma}}}{(1+\delta)^{t-1}} + \mu \frac{[B(1-\tau^B)]^{1-\frac{1}{\gamma}}}{(1+\delta)^{T-1}}$$

subject to budget constraint:

$$\text{(A 2)} \qquad \begin{aligned} &\sum_{t=1}^{T_w}(1-l_t)e_t w_t(1-\tau_t^w-\tau_t^e)R_t + \sum_{t=T_w+1}^{T} Z_t(1-\tau_t^w)R_t + R_2 B_2(1-\tau_t^B) + \sum_{t=1}^{T} S_t \\ &= \sum_{t=1}^{T} c_t p_t^C(1+\tau_t^C)R_t - R_T B_T \end{aligned}$$

and subject also to the determination of pensions Z. U_t is the periodic utility:

$$\text{(A 3)} \qquad U_t = (c_t^{1-\frac{1}{\rho}} + \alpha l_t^{1-\frac{1}{\rho}})^{\frac{1}{1-\frac{1}{\rho}}}.$$

Households do not know the length of their lives. The possibility of early death is considered by discounting future consumption and incomes by a factor which includes both the after-tax interest rate and the age-specific survival probability n_t (incomes and expenditures are discounted to the moment the household enters the model):

$$\text{(A 4)} \qquad R_t = n_t \prod_{s=0}^{t-1} \frac{1}{1+r_s^d(1-\tau_{s+1}^r)} \quad , \qquad t = 1..T.$$

The variable c_t describes consumption, p_t^C its price, l_t is leisure, and of the constant parameters γ is the elasticity of intertemporal substitution, δ is the rate of time preference and ρ is the elasticity of substitution between consumption and leisure. Households receive a net bequest $B(1-\tau^B)$ at the age of 25 (period 2) and give a bequest B_T before dying. The parameter μ determines the strength of the joy-of-giving bequest motive. The aggregate amount of generation specific transfers S_t is related to the value of aggregate consumption. The number of periods T is 14: the unit period is five years. A life-cycle plan is made at the age of 20, and people plan to retire at the age of 60.

Pensions are determined by pension wage, replacement ratio and indexation. The pension wage is linked to the lifetime earnings. The replacement rate relates the first pension to the pension wage. Indexation determines how the rise in consumer prices and wages is considered during both working years and retirement.

Let the normal working time be:

$$\text{(A 5)} \qquad 1 - l^p = \frac{1}{T_w} \sum_{t=1}^{T_w} (1-l_t)$$

and the pension wage:

$$(A\ 6) \qquad w^p = \frac{\sum_{t=1}^{T_w} \Phi_t(1-l_t)e_t w_t^{\varphi}\left[p_t^C(1-\tau_t^C)\right]^{1-\varphi}}{1-l^p} w_{T_w+1}^{\varphi}\left[p_{T_w+1}^C(1+\tau_{T_w+1}^C)\right]^{\varphi-1}, \qquad \text{where}$$

$\sum_{t=1}^{T_w} \Phi_t = 1$ and $0 \le \varphi \le 1$.

The pension Z in period t is now:

$$(A\ 7) \qquad Z_t = \theta(1-l^p)w^p\left(\frac{w_t}{w_{T_w+1}}\right)^{\psi}\left[\frac{p_t^C(1+\tau_t^C)}{p_{T_w+1}^C(1+\tau_{T_w+1}^C)}\right]^{1-\psi}, \quad \text{where} \quad 0 \le \psi \le 1.$$

The weights Φ determine the pension rights averaging period. If the worker stays in one firm, the averaging period consists of the last four years, which would roughly mean that Φ_8 is equal to unity and all other weights are equal to zero. In practise, due to moves between firms and also due to some technical reasons all coefficients are positive, but Φ_8 is the largest. The number of working periods T_w is 8 in the baseline scenarios. The term e_t describes work efficiency, which varies with age. It makes the life-cycle wage-income profile hump-shaped. The yearly accrued pension rights are indexed during working periods to wages and consumer prices with weight φ. The corresponding indexation weight during pension periods is ψ.

The model uses a technical assumption of insurance contracts to distribute the inheritance of the untimely dead households to the survivors of the same generation. The insurance contract is actuarially fair so that the insurance institution does not make any profit.

The budget constraint says that discounted lifetime wage and pension income equals discounted consumption expenditure. Households start with no wealth and leave no wealth upon death. The terms τ^w, τ^C and τ^r are tax parameters and τ^e is the employees' pension contribution rate. The actual equations of the model are the first-order conditions derived from the optimisation problem.

The household sector consists of 14 households, of different age, in each period. Total consumption, labour supply, transfers and pensions received and taxes paid are aggregated from individual household decisions.

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 and employment are made to maximise the firm's market value. The firm takes the prices, demand for production and supply of factors at given prices, and production technology and taxation as given. Intermediate and capital goods are cost minimising CES composites of domestic and imported goods.

Gross production is a combination of value added F_t, net of investment adjustment costs G_t and the composite intermediate good in fixed proportions:

(A 8) $$Y_t = \frac{F_t - G_t}{1-\zeta}.$$

The production function F is a standard CES function of capital and labour:

(A 9) $$F_t = A\left[\varepsilon K_{t-1}^{(1-1/\beta)} + (1-\varepsilon)(\nu^t L_t^F)^{(1-1/\beta))}\right]^{\frac{\beta}{\beta-1}},$$

where ν is the rate of productivity growth of labour. In the process of installing new capital some production is lost due to investment adjustment costs. These quadratic installation costs depend positively on the investments and negatively on the amount of capital.

(A 10) $$G(I_t, K_{t-1}) = \xi \frac{I_t^2}{K_{t-1}}.$$

We assume that the firms' debt stock B_t^F at the end of period t is restricted to a fixed ratio b of the replacement value of the firm's capital stock. This imitates the practise of using the capital stock as collateral for loans, or a target debt-to-capital ratio:

(A 11) $$B_t^F = b p_t^K K_t$$

The determination of the firm's value is based on an arbitrage condition, which says that the expected after-tax yield on investment in firms' shares must be equal to the after-tax interest rate:

(A 12) $$r_t^d (1-\tau_{t+1}^r) V_t = (1-\tau_{t+1}^D) D_{t+1} + (1-\tau_{t+1}^g)(V_{t+1}^E - V_t)$$

where the left-hand side describes the returns when amount V_t is invested in bonds at the end of period t. Interest income is paid and taxed at the rate τ_{t+1}^r in the beginning of period $t+1$. Investment in firm's shares gives dividend income D_{t+1} and expected capital gains, $V_{t+1}^E - V_t$, which are taxed respectively at tax rates τ_{t+1}^D and τ_{t+1}^g during the same period[1].

Solving the equation forward and ruling out bubbles gives the value of the firm as a discounted sum of tax-adjusted values of future dividends:

(A 13) $$V_t = \sum_{s=t+1}^{\infty} \frac{1-\tau_s^D}{1-\tau_s^g} D_s \prod_{v=t+1}^{s} \frac{1}{1+r_{v-1}^d \left(\frac{1-\tau_v^r}{1-\tau_v^g}\right)}.$$

The next step is to define the dividend policy. Let's start with the definition of the firm's after-tax earnings:

(A 14) $$E_t^A = (1-\tau_t^F)\left[p_t^F (F_t - G_t) - (1+\tau_t^l) w_t L_t^F - r_{t-1}^d B_{t-1}^F\right] + \tau_t^F d\, p_{t-1}^K K_{t-1} - \tau_t^K p_{t-1}^K K_{t-1}.$$

The first term inside the brackets is the value added of the firm net of investment adjustment costs[2]. Earnings are reduced by labour costs and the interest costs of the firm's debt. The first

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1 Taxing the capital gains on accrual simplifies the analysis considerably.

2 Note that investment adjustment costs are deductible in taxation.

term to the right of the brackets is the depreciation allowance, which corresponds to real depreciation. All other allowances are included by using an effective average corporate tax rate. The last term is the new capital stock tax.

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

$$\text{(A 15)} \quad D_t = E_t^A + (B_t^F - B_{t-1}^F) - p_t^K I_t,$$

where the sources of finance are after-tax earnings and an increase in the firm's debt. The proceedings are used to finance investment costs and the rest is distributed as dividends.

The end-of-period capital stock is the sum of investment during the period and the depreciated capital stock from the previous period:

$$\text{(A 16)} \quad K_t = K_{t-1}(1-d) + I_t.$$

Firms choose the optimal amount of investment and use of labour to maximise the price of the firms' shares. The problem can be presented as maximising in the beginning of the period the tax-adjusted dividends net of share issues plus the value of the firm at the end of the period subject to the amount of initial capital stock and conditions (A 8) - (A 11) and (A 14) - (A 16) as follows:

$$\text{(A 17)} \quad \text{Max}_{\text{L,I,K}} \quad \frac{1-\tau_t^D}{1-\tau_t^g} D_t + V_t.$$

If there are no unexpected shocks, there is no need to revise the optimal plan and it will be followed forever.

Three of the four first-order conditions of the constrained optimisation are used as model equations. The first equation (A 18) implies that investments should be carried out until the marginal benefit from an additional unit of investment equals the marginal cost, adjusted for the effects of financial policy. 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, which can be written as:

$$\text{(A 18)} \quad I_t = \frac{\left(\frac{\lambda_t}{p_t^K} - \frac{1-\tau_t^D}{1-\tau_t^g}\right) K_{t-1}}{\frac{1-\tau_t^D}{1-\tau_t^g}(1-\tau_t^F) 2\xi p_t^F}$$

The optimality condition of capital (A 19) says that capital should be installed until the after-tax 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 describing the path of the shadow value of the capital (A 19):

(A 19)

$$\lambda_t = \left\{ \frac{1-\tau^D_{t+1}}{1-\tau^g_{t+1}} \Big[(1-\tau^F_{t+1})(p^F_{t+1}(F_{K_t} - G_{K_t}) - r^d_t b p^K_t) - b p^K_t + \tau^F_{t+1} d p^K_t K_t - \tau^K_{t+1} p^K_t \Big] \right.$$

$$\left. + \frac{1-\tau^D_t}{1-\tau^g_t} b p^K_t (1 + r^d_t \frac{1-\tau^r_{t+1}}{1-\tau^g_{t+1}}) + \lambda_{t+1}(1-d) \right\} \left(1 + r^d_t \frac{1-\tau^r_{t+1}}{1-\tau^g_{t+1}} \right)^{-1}.$$

The third condition (A 20) says that the marginal benefit of an extra unit of labour should cover wage costs plus the employer's social security contribution:

(A 20) $$p^F_t F_L = (1+\tau^l_t) w_t .$$

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 the capital in the leveraged firm as follows:

(A 21) $$V_t = K_t \lambda_t - \frac{1-\tau^D_t}{1-\tau^g_t} B^F_t$$

where B^F_t is the firm's debt. The value of the firm jumps whenever unexpected news about the firm's future profitability enters the market. Households are the sole owners of firms and changes in their wealth change life-cycle plans immediately.

Pension institutes

Pensions are financed with contributions collected both from workers and employers and with capital incomes from the pension funds. The employers' contribution rates are endogenous before the policy measure and balance the budgets each period. After the tax shift the capital stock tax balances the incomes and expenditures.

Government

The government collects various taxes and uses the proceeds to make transfers to households and 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. Revenues and expenditures of the government are balanced every period with a value-added tax.

Foreign sector

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

(A 22) $$X_t = x_t \nu^t \left(\frac{p_t^d}{p_t^m} \right)^{\sigma^X} .$$

A large negative value for the elasticity implies that a small country has to adjust to the price level of international markets. Export markets are assumed to grow at the same rate ν as the domestic productivity of labour.

The imported good is used in consumption, investment and as an intermediate good in production. Its price is determined in international markets. It is an imperfect substitute for the domestic good. Demand conditions are described by a CES structure.

The supply of foreign capital depends on the domestic interest rate. A fall in net foreign assets below their initial level lifts the domestic rate above international rates.

(A 23) $$r_t^d = r_t^f - \frac{A_t^f - A_0^f}{\varpi} \quad .$$

The extreme values of the parameter ϖ allow, on the one hand, for perfect capital mobility and, on the other, for a financially closed economy.

Markets

The model includes four markets, which clear every period. In the labour market, firms demand labour according to the marginal productivity of labour rule. Households' aggregate labour supply is divided between public and private employment. The wage rate is determined by equating supply and demand in the labour market:

(A 24) $$L_t = L_t^G + L_t^F .$$

Firms are sole suppliers in the market of the domestic good . The product is used by other firms as part of the composite intermediate and investment goods, by households as part of the composite consumption good and by foreign agents. The demand of domestic agents and the prices of the composite goods are determined by a cost minimising procedure. The following describes as an example the procedure in the consumption good case (see, e.g., Keuschnigg and Kohler 1994).

Minimising the unit cost (price) of a composite good:

(A 25) $$p_t^C = \min_{c_t^d, c_t^m} \left\{ p_t^d c_t^d + p_t^m c_t^m \right\}$$

subject to a CES-form substitutability restriction:

$$\text{(A 26)} \qquad \left[\upsilon^C (c_t^d)^{(1-\frac{1}{\sigma^C})} + (1-\upsilon^C)(c_t^m)^{(1-\frac{1}{\sigma^C})} \right]^{\frac{\sigma^C}{(\sigma^C-1)}} = 1$$

leads to the optimal unit cost (price) of the composite good:

$$\text{(A 27)} \qquad p_t^C = \left[(\upsilon^C)^{\sigma^C} (p_t^d)^{1-\sigma^C} + (1-\upsilon^C)^{\sigma^C} (p_t^m)^{1-\sigma^C} \right]^{1/(1-\sigma^C)} .$$

Demand for the domestic good per unit of the composite consumption good c_t^d is calculated by differentiating the unit cost function with respect to the price of the domestic good:

$$\text{(A 28)} \qquad c_t^d = \left[\frac{\upsilon^C p_t^C}{p_t^d} \right]^{\sigma^C} .$$

The aggregate demand of the domestic good for consumption is respectively $C_t c_t^d$.

The export demand conditions are explained above. The equilibrium condition which determines the price of the domestic good is thus:

$$\text{(A 29)} \qquad Y_t = \zeta Y_t v_t^d + C_t c_t^d + I_t i_t^d + X_t .$$

The domestic demand of the fixed-price imported good is also determined by minimising the costs of the composite goods. The perfectly elastic supply adjusts to demand in this market:

$$\text{(A 30)} \qquad m_t = \zeta Y_t v_t^m + C_t c_t^m + I_t i_t^m .$$

The price of the imported good serves as a numeraire in the model.

The fourth market is the capital market. In this market, saving 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. Foreign agents are restricted to participation in the bond market only. Total saving is the sum of domestic saving and foreign portfolio investments. The domestic interest rate r^d balances the markets.

The parallel stock equilibrium can be written as:

$$\text{(A 31)} \qquad W_t + H_t^F + H_t^G = V_t + B_t^F + B_t^G + A_t^f$$

where W_t is household wealth, H_t^F and H_t^G are the values of the pension funds' assets, V_t is the market value of the firm, B_t^F is the firms' debt, B_t^G is the public debt and A_t^f is the net foreign assets of the country.

Appendix 2 List of model variables and parameters

Variables

	FIRMS
K	capital stock of the firms
Y	gross production of the domestic good
G	installation costs
F	value added
p^F	price of the value added
V	value of the firms
D	dividends
B^F	firms' debt
I	investments
E^A	earnings
λ	shadow value of the capital
	PRODUCT MARKETS
i^d	demand of the domestic good in investment use
i^m	demand of the imported good in investment use
p^K	price of the composite investment good
c^d	demand of the domestic good in consumption use
c^m	demand of the imported good in consumption use
p^C	price of the composite consumption good
v^d	demand of the domestic good in intermediate use
v^m	demand of the imported good in intermediate use
p^v	price of the composite intermediate good
p^d	price of the domestic good
p^m	price of the imported good
	FOREIGN TRADE AND INTEREST RATE
X	exports
m	imports
A^f	net foreign assets
r^d	domestic interest rate (yearly)
	LABOUR MARKETS
L^F	private employment
L^G	public employment
L	aggregate labour supply
w	wage rate

	HOUSEHOLDS
c	consumption of one household
C	aggregate consumption
l	leisure of one household
U	utility of one household
W	aggregate household wealth
B	bequest
	PENSION SYSTEMS
τ^{l}	private sector employer's pension contribution
l^{p}	average leisure
w^{p}	pension wage
Z	pension
H^{F}	value of the private sector pension fund's assets
H^{G}	value of the public sector pension fund's assets
τ^{K}	capital stock tax
	GOVERNMENT
B^{g}	public debt
τ^{C}	value added tax
S	transfer to households

Parameters

personal income tax	τ^w	0.3
dividend income tax	τ^D	0
interest income tax	τ^r	0.14
capital gains tax	τ^g	0.28
corporate income tax	τ^F	0.28
bequest tax	τ^B	0.1
employee's pension contribution	τ^e	0.05
depreciation rate (yearly)	d	0.09
installation cost parameter	ξ	2
share of the value of firms' capital financed by debt	b	0.6
input-output coefficient for the composite intermediate good input	ζ	0.1
labour share parameter of the value added production fuction	ε	0.35
elasticity of substitution between labour and capital	β	0.7
growth rate of labour productivity (yearly)	ν	0.0
scale parameter for value added	A	1
share parameter of domestic good for consumption	υ^C	0.7
share parameter of domestic good for investment	υ^K	0.7
share parameter of domestic good for intermediate use	υ^v	0.7
elasticity of substitution between imported and domestic good in consumption	σ^C	0.99
elasticity of substitution between imported and domestic good in investment	σ^K	0.99
elasticity of substitution between imported and domestic good in intermediate use	σ^v	0.99
scale parameter of export demand	x	0.6
price elasticity of export demand	σ^X	-4
foreign interest rate (yearly)	r^f	0.04
sensitivity parameter of capital movements	ϖ	3
elasticity of intertemporal substitution of consumption	γ	0.5
elasticity of substitution between consumption and leisure	ρ	0.75
rate of time preference (yearly)	δ	0.01
leisure preference parameter	α	0.81
bequest preference parameter	μ	1.6
age-dependent working efficiency	e	0.5 - 1.3
share of full pension to pension wage (replacement rate)	θ	0.55
pension indexing parameter for the pension periods	ψ	0.2
pension indexing parameter for the working periods	φ	0.5