Labour and Product Market Reforms and Fiscal Deficit *

Juha Kilponen — Bank of Finland
Antti Ripatti — Bank of Finland

Revised: June 16, 2008

Abstract

Using a DSGE model of a small open economy we study the response of the economy and income tax rate, in particular, to the reforms in the labour and product markets. The model is non-Ricardian due to the distortionary taxation and built-in life-cycle features. We assume that the wage markup and the price margins are reduced by one per cent each. Both consumption and employment increase permanently. The public sector balances improve, allowing for roughly 1 percentage point cut in labour income taxes. Product market reform leads to a short-run reduction in consumption, leading to an intertemporal tradeoff in reform setting. More activist fiscal policy can dampen this tradeoff.

Keywords: competition, dynamic general equilibrium, public finance

JEL classification numbers: E60, C68

*This is a substantially revised version of the Bank of Finland's Discussion Paper 5/2006. The model presented in the paper relies on the Bank of Finland's *Aino* model, which is an outcome of a joint project by Juha Kilponen, Mika Kuismanen (Ministry of Finance), Antti Ripatti and Jouko Vilmunen. We are also indebted to Juha Tarkka for intensive discussions and guidance during the various stages of model development. We are also indebted to participants of the CEPR/ESI 2005 conference and HECER Economics Research Seminar for many useful suggestions. The usual disclaimer applies. Correspondence to firstname.lastname@bof.fi or Bank of Finland, PO Box 160, FIN-00101 Helsinki, FINLAND. The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

1 Introduction

The future challenges in all developed economies are closely connected with fiscal policy and population ageing, which put pressure on both the product and labour markets. This paper studies the response of the Finnish economy, and public finances in particular, to the permanent product and labour market reforms. To study the question we build on the ideas of Blanchard and Giavazzi (2003), where product and labour market (de)regulation are modelled as changes in the elasticity of substitution of different types of goods and labour. In preparing quantitative results, we use the DSGE model of the Finnish economy. A similar exercise for aggregated Europe has been done by Bayoumi et al. (2004a) and applied to the Danish economy by the IMF (2004) using a model variant of Global Economic Model (GEM), build at the International Monetary Fund by Bayoumi et al. (2004b). Jonsson (2007) studies the welfare losses of imperfect competition and its relationship to distortionary taxation. Their results are qualitatively similar to ours. However, significant differences arise from the fact that, unlike the GEM model, our model includes distortionary taxes and households that are essentially non-Ricardian. Moreover, our model depicts the Finnish economy as a small open economy and treats the rest of the world as given, while the GEM can be extended to a multi-country setup, with explicit trade relationships between structurally similar economies. Finally, we interpret the reforms as specific to Finland, so that EMU-wide monetary policy does not respond to these two reforms.

Our model has a non-stochastic balanced growth path at which the economic growth is determined by exogenously given growth of labour saving technology and population. Accumulation of financial assets and physical capital reflect optimal intertemporal decisions of households and firms. Monetary policy follows a fixed-exchange-rate regime, reflecting Finland's small size within the Eurosystem. The model contains exogenously determined markups in the domestic goods markets and labour markets. The first markup, given by the time-varying elasticity of substitution between different product brands, can vary temporarily due both exogenously given variation and Calvo-type price rigidities. A similar structure holds for the labour markets.

A household's lifetime consists of two distinct periods. We label households living in these two different periods as 'workers' and 'retirees', as in Gertler (1999). Workers and retirees differ in terms of their effective planning horisons, marginal propensity to consume, as well as the efficiency of their labour effort. In the model, the public accounts are closed by a labour income tax rule, which responds to the public deficit as well as the deviation of public debt from the exogenously given target. The model is non-Ricardian in three ways: First, the model has distortionary taxation in the form of a labour income tax, indirect taxes (VAT) and corporate (profits) tax. Second, households have finite life. Consequently, they discount government debt at a higher-than-market rate. Finally, in the second stage of life (retirement) households suffer from a reduced ability to work. The age-profile of their productivity decreases stepwise, which affects discounting of labour income.

Reforms that increase competition in both the product and labour markets are welfare enhancing in the long-run. Increasing competition leads to increased consumption, investments, employment and production potential of the economy. However, increasing competition is associated with an initial decline in private consumption and a slight drop in labour effort. This is due to the wealth effect caused by the reduction in profits, as well as a temporary increase in the real interest rate caused by the slowdown of expected domestic inflation. A similar phenomenon is called the intertemporal tradeoff by Blanchard and Giavazzi (2003). This intertemporal tradeoff provides a potential political-economy explanation of why the product market reforms seem to be difficult to implement.

Public sector finances are improved, in the sense that the initial public sector debt-to-GDP ratio can be maintained at a lower labour income tax rate. Our standard simulation suggests that a one per cent reduction in the price and wage markups respectively allows roughly a 1.1 percentage point reduction in the wage income tax rate. The sensitivity analysis shows that the results appear most sensitive to changes the labour supply parameter. It also demostrates that the intertemporal tradeoff may be dampened when combined with activist fiscal policy.

The rest of the paper is organised as follows. Section 2 sets out the model. Section 3 presents the simulation experiment in detail and discusses the results. The final section concludes.

2 Life-cycle model

Following Gertler (1999) a household's finite life-cycle consists of two distinct stages, "active working-age" and "retirement period". Consumption and labour supply decisions are affected by the future prospect of retirement, as well as the fact that labour efficiency is assumed to decline in the retirement stage. In particular, the likelihood that the worker will lose part of his labour income due to retirement, induces her to discount the future income stream at a higher-than-market rate. This reduces consumption and increases saving. In this sense, active working-age population saves for retirement. Retirees discount the future more heavily than active working-age individuals, due to the constant periodic probability of death. Therefore, retirees' propensity to consume out of wealth is greater than that of workers.

In addition to these basic features from Gertler (1999), a few extensions have been made. First, we allow for a set of distortionary taxes: labour income taxes, statutory pension contributions, indirect taxes and corporate taxes. Second, the labour markets are monopolistic, with wage rigidities that arise from Calvo type wage contracts. Third, individuals receive transfers from both the public sector (the state) as well as from (statutory) pension funds. In modelling transfers, we have followed the general features of the transfer system described in the Finnish national accounts. Finally, the model's supply side is based on constant elasticity of substitution (CES) production technology with factor augmentation in the underlying technological progress and monopolistic competition in the goods market. This contrasts with Gertler (1999), which assumes competitive markets and Cobb-Douglas technology.

2.1 Households

Consumers are assumed to be born as active working-age individuals. Conditional on being an active worker in the current period, the probability of remaining one in the next period is ω, while the probability of retiring is $1-\omega$. The transition probability is independent of one's employment tenure, so that the average tenure of active working age is $1/(1-\omega)$. Once an individual has retired she faces a constant periodic probability of death, $1-\gamma$. Also, given that the survival probability γ is assumed to be independent of retirement tenure, the average retirement period is $1/(1-\gamma)$. Regarding population dynamics, in each period $(\hat{N}_t - \omega)N_t$ new active working-age individuals are born, so that the working-age population grows at the gross growth rate of $\hat{N}_t \equiv N_t/N_{t-1}$. Given constant probabilities of retirement and death and that cohorts are large, the retiree population (N_t^r) evolves according to the equation

$$N_{t+1}^r = (1-\omega)N_t + \gamma N_t^r.$$

The ratio of retirees to the whole population, the old-age dependency ratio, evolves according to

$$\varphi_t \equiv \frac{N_t^r}{N_t} = \frac{1-\omega}{\hat{N}_t} + \gamma \frac{\varphi_{t-1}}{\hat{N}_t}. \tag{1}$$

In the steady state, where the population growth is a constant $\hat{N}_t = \hat{N}$, the old-age dependency ratio is $\varphi = (1-\omega)/(\hat{N} - \gamma)$.

In constructing the intertemporal decision problem, Gertler (1999) follows the recursive preferences introduced by Epstein and Zin (1989) and modified by Farmer (1990). The preferences separate intertemporal elasticity of substitution and relative risk aversion. Assuming risk-neutrality, the model solution entails linear decision rules even with idiosyncratic risk to income, asset return and length of life. This class of preferences is applied in the following equation:

$$V_t^i = \left\{ \left[\left(C_t^i\right)^{\nu} (1 - l_t^i)^{1-v} \right]^{\rho_c} + \beta^i [E_t(V_{t+1}|i)]^{\rho_c} \right\}^{\frac{1}{\rho_c}}, \quad i = \{w, r\} \tag{2}$$

where

$$E_t(V_{t+1}|w) = \omega V_{t+1}^w + (1-\omega) V_{t+1}^r, \ \beta^w = \beta \tag{3}$$
$$E_t(V_{t+1}|r) = V_{t+1}^r, \ \beta^r = \beta\gamma.$$

V_t^i denotes an individual's value function, and $i = \{w, r\}$ indicates whether the individual is at active working-age w or retired r. C_t^i is consumption and $1 - l_t^i$ denotes leisure. Thus, l_t^i denotes the fraction of time allocated to work and parameter v is the elasticity of the period utility function with respect to consumption. ρ_c is the curvature parameter, which implies a constant intertemporal elasticity of substitution, $\sigma = 1/(1 - \rho_c)$. The retirees effective discount factor β^r is adjusted to take into account the probability of death, as finite life effectively implies a shorter planning horizon.

A perfect annuities market is assumed in order to eliminate the impact of uncertainty about time of death. An active working age individual, in turn, faces a potential risk of a decline in wage income due to retirement. However, given the individual's preferences, only expected future labour income affects consumption. A worker thus forms a certainty equivalent of his random utility as shown in equation (3).

There are different financial assets available for consumers: a one-period government bond A_t^S, one-period pension fund bond A_t^P, one-period foreign bond A_t^W and shares issued by domestic firms A_t^F. A domestic one-period bond pays a nominal gross return of $R_t = 1 + r_t$, while the gross return on stocks is $R^D \equiv 1 + r_t^D$. Similarly, a foreign bond pays a gross return of $R_t^W \equiv 1 + r_t^W$. Thus, the gross nominal return on asset holdings of population group $i = \{w, r\}$, is

$$R_t A_t^i \equiv (1 + r_t^S)(A_t^{iS} + A_t^{iP}) + (1 + r_t^D)A_t^{iF} + (1 + r_t^W)S_t A_t^{iW}, \quad i = \{w, r\} \tag{4}$$

where S_t isthe nominal exchange rate, r_t^S denotes the one-period bond rate, and r_t^W denotes the corresponding foreign one-period bond rate. Given profits Π_t^D, the gross return is

$$1 + r_t^D = [A_{t+1}^F + (1 - \mathfrak{t}_t^K)\Pi_t^D]/A_t^F,$$

where $\mathfrak{t}_t^K$ denotes corporate tax rate and profits[1] Π_t^D are given by

$$\begin{aligned} \Pi_t^D &= P_t Y_t - W_t^F L_t - R_t K_t \quad \text{(intermediate goods producers)} \\ &+ R_t K_t - P_t^I I_t \quad \text{(capital rental firm).} \end{aligned}$$

2.1.1 Retirees

A periodic budget constraint of a retiree born at time j,retiring at time k, and surviving at least until $t + 1$ is given by

$$A_{t+1}^{rj} = \frac{R_t}{\gamma} A_t^{rj} + W_t(1 - \mathfrak{t}_t^{RS})\xi l_t^{rj} + \mathcal{T}_t^{rjk} - P_t^C C_t^{rj}, \tag{5}$$

where A_t is the set of assets with corresponding gross-return R_t from (4), W_t denotes nominal wage rate, $\mathfrak{t}_t^{RS}$ retirees' labour income tax rate, ξ the relative efficiency of retirees labour effort (in workers' labour units), and $\mathcal{T}_t^{rjk}$ denotes nominal transfers (such as pensions) to an individual born at time j and retiring in period k. The price level of consumption goods are given by P_t^C and the corresponding consumption aggregate is C_t.

A retiree chooses consumption and asset accumulation by maximising (2) subject to (5). Since time and risk aggregators are linear homogeneous, retirees' maximisation problem can be turned into a dynamic programming problem, where the consumption-saving decision is separable from the portfolio optimisation. Furthermore, aggregation can be done by simply

[1] See section 2.4 for details.

summing over the retirees, since the decision rules are linear and there is no heterogeneity among the retirees. It can be shown that the consumption function for retirees is given by

$$P_t^c C_t^r = \epsilon_t \pi_t [R_t A_t^r + \mathcal{H}_t^r + \mathcal{S}_t^r] \tag{6}$$

where $\mathcal{H}_t^r$ and $\mathcal{S}_t^r$ denote discounted after-tax values of labour income and transfers. Their recursive representation is given by

$$\mathcal{H}_t^r = (1 - \mathfrak{t}_t^{RS}) W_t \xi L_t^r + \frac{\mathcal{H}_{t+1}^r}{\hat{N} R_{t+1}/\gamma}, \qquad \mathcal{S}_t^r = \mathcal{T}_t^r + \frac{\mathcal{T}_{t+1}^r}{\hat{N} R_{t+1}/\gamma}.$$

Since the population of pensioners grows at the gross rate $\hat{N}$ and total social security payments are distributed equally among them, $\hat{N}$ enters the discount factor for future social security transfers. Future aggregate labour income is similarly discounted.

The retirees' marginal propensity to consume out of wealth, $\epsilon_t \pi_t$, evolves according to following non-linear difference equation:

$$\epsilon_t \pi_t = 1 - \left(\frac{W_t / P_t^c}{W_{t+1}/P_{t+1}^c} \frac{(1 - \mathfrak{t}_t^{RS})}{(1 - \mathfrak{t}_{t+1}^{RS})} \right)^{\frac{(1-v)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left(\frac{R_{t+1}}{\hat{P}_{t+1}^c} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\epsilon_t \pi_t}{\epsilon_{t+1} \pi_{t+1}} \gamma \tag{7}$$

where $\hat{P}_{t+1}^c \equiv P_{t+1}^c / P_t^c$. The retirees' marginal propensity to consume varies with expected real interest rate $R_{t+1}/\hat{P}_{t+1}^c$ as well as with the expected changes in real net wage income. As in the standard Yaari (1965) and Blanchard (1985) models, the likelihood of death, $(1 - \gamma)$ in (7), raises the retirees' marginal propensity to consume. This can be easily seen by considering a case of logarithmic preferences, where $\sigma \to 1$ (i.e. $\rho_C \to 0$). In this case $\epsilon \pi = 1 - \beta \gamma$.

2.1.2 Workers

As regards to workers, the budget constraint of a household of active working-age (denoted by h) and born at time s is given by

$$A_{t+1}^{whs} = R_t A_t^{whs} + (1 - \mathfrak{t}_t^{WS} - \mathfrak{t}_t^{WP}) W_t L_t^{ws} + \mathcal{T}_t^{ws} - P_t^C C_t^{ws} \tag{8}$$

and where $\mathcal{T}_t^{ws}$denotes net fiscal transfers to workers. As in the case of retirees, we assume that these transfers are independent of workers' age. A worker chooses consumption, labour supply and asset accumulation by maximising (2) subject to (8) and to the constraints that become operative once she retires. Intertemporal maximisation gives rise to a rather complicated Euler equation, but it can be shown that the consumption plan of active working-age individuals can be aggregated as

$$P_t^C C_t^w = \pi_t (R_t A_t^w + \mathcal{H}_t^w + \mathcal{S}_t^w), \tag{9}$$

where π_t is the marginal propensity to consume of an active working-age individual and $\mathcal{H}_t^w$ and $\mathcal{S}_t^w$ denote discounted human and social security wealth.

Marginal propensity to consume out of wealth satisfies the non-linear first order difference equation

$$\pi_t = 1 - \left(\frac{\left(1 - \mathfrak{t}_t^{WS} - \mathfrak{t}_t^{WP}\right) W_t / P_t^C}{W_{t+1}/P_{t+1}^C} \right)^{\frac{(1-\nu)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho}} \left(\frac{\Omega_{t+1} R_{t+1}}{\hat{P}_{t+1}^C} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\pi_t}{\pi_{t+1}}$$

where $\mathfrak{t}_t^{WS}$ is the labour income tax rate and $\mathfrak{t}_t^{WP}$ the pension contribution rate. The factor Ω_{t+1} that weights the gross real return $R_{t+1}/\hat{P}_{t+1}^C$ evolves according to

$$\Omega_{t+1} = \omega \left(\frac{1}{1 - \mathfrak{t}_{t+1}^{WS} - \mathfrak{t}_{t+1}^{WP}} \right)^{1-\upsilon} + (1 - \omega_t) \epsilon_{t+1}^{-\frac{1-\rho_c}{\rho_c}} \left(\frac{1}{\xi \left(1 - \mathfrak{t}_{t+1}^{RS}\right)} \right)^{1-\upsilon}$$

where $\mathfrak{t}_{t+1}^{RS}$ is retirees' labour income tax rate and $\epsilon_{t+1} > 1$ is the ratio of retirees' marginal propensity to consume to that of the active working-age individuals.

$\mathcal{H}_t^w$ in (9) is the discounted sum of the wage bill of active working-age individuals and $\mathcal{S}_t^w$ is the sum across workers alive at t of the capitalized value of social security. Both of these measures take into account corresponding discounted values at the time of retirement. Formally,

$$\begin{aligned} \mathcal{H}_t^w &= \left(1 - \mathfrak{t}_t^{WS} - \mathfrak{t}_t^{WP}\right) W_t L_t^w + \omega \frac{\left(\frac{1}{(1 - \mathfrak{t}_{t+1}^{WS} - \mathfrak{t}_{t+1}^{WP})} \right)^{1-\upsilon} \mathcal{H}_{t+1}^w}{R_{t+1} \Omega_{t+1} \hat{N}} \\ &\quad + (1-\omega) \frac{(\epsilon_{t+1})^{1-\frac{1}{\rho_c}} \left(\frac{1}{\xi(1 - \mathfrak{t}_{t+1}^{RS})} \right)^{1-\upsilon} \varphi^{-1} \mathcal{H}_{t+1}^{r(t+1)}}{R_{t+1} \Omega_{t+1} \hat{N}} \end{aligned} \tag{10}$$

$$\begin{aligned} \mathcal{S}_t^w &= \mathcal{T}_t^w + \omega \frac{\left(\frac{1}{(1 - \mathfrak{t}_{t+1}^{WS} - \mathfrak{t}_{t+1}^{WP})} \right)^{1-\upsilon} \mathcal{S}_{t+1}^w}{R_{t+1} \Omega_{t+1} \hat{N}} \\ &\quad + (1-\omega) \frac{(\epsilon_{t+1})^{1-\frac{1}{\rho_c}} \left(\frac{1}{\xi(1 - \mathfrak{t}_{t+1}^{RS})} \right)^{1-\upsilon} \varphi^{-1} \mathcal{S}_{t+1}^{r(t+1)}}{R_{t+1} \Omega_{t+1} \hat{N}}, \end{aligned} \tag{11}$$

where $\mathcal{H}_{t+1}^{r(t+1)}$ measures the aggregate value of human wealth for a working retiree who retired at time $t+1$ but was still working at time t. Similarly, $\mathcal{S}_{t+1}^{r(t+1)}$ measures the value of total social security for a retiree who retired at time $t+1$ but was still working at time t.

The presence of $\Omega_{t+1} > 1$ in the denominator of (10)–(11) shows how workers discount future income streams at a higher rate than that at which the government can borrow, R_t. This in turn has a tendency to reduce a working-age individual's consumption and increase saving. Ω_{t+1} varies positively with retirees' marginal propensity to consume relative to that of active working-age individuals. It also depends positively on retirement probability and tax rates. This can be seen most easily by looking at the steady state value of Ω in the special case where retirees and active working-age inviduals face the same labour income tax rate $\mathfrak{t}$:

$$\Omega = \left(\frac{1}{\xi(1-\mathfrak{t})}\right)^{1-\upsilon}\left[\omega + (1-\omega)\epsilon^{\frac{1}{1-\sigma}}\right].$$

Moreover, notice that in the special case of logarithmic preferences ($\sigma \to 1$) marginal propensity to consume is constant, and it depends only on discount rate β ($\pi_t = 1-\beta$).

2.1.3 Distribution of wealth and aggregate consumption

working-age persons' and retirees' differing marginal propensities to consume are reflected in the rate at which the two groups accumulate financial assets. As these assets are accumulated at different rates, aggregate consumption depends on how financial assets are distributed among the two groups. In other words, we need a state equation for the distribution of financial wealth among the two groups. Let $\lambda_{t+1}^{f} \equiv A_{t+1}^{r}/A_{t+1}$ be the share of financial assets held by retirees and $1-\lambda_{t+1}^{f} \equiv A_{t+1}^{w}/A_{t+1}$ the share of financial assets held by working-age individuals. It can be shown that retirees' share of financial wealth evolves according to

$$\lambda_{t+1}^{f}/\omega = \frac{\lambda_t^{f}(1-\frac{\epsilon_t\pi_t}{\nu})R_tA_t}{A_{t+1}\omega} + \frac{(1-\tau_t^{RS})\xi W_t N_t^{r} + \mathcal{T}_t^{r} - \frac{\epsilon_t\pi_t}{\nu}(\mathcal{S}_t^{r}+\mathcal{H}_t^{r})}{A_{t+1}} + \frac{(1-\omega)}{\omega}.$$

Finally, aggregate consumption is obtained simply by summing up (6) and (9) and using λ_{t+1}^{f}:

$$C_t = \pi_t \left\{ \left[\left(1 - \lambda_t^f\right) R_t A_t + \mathcal{H}_t^w + \mathcal{S}_t^w \right] + \epsilon_t \left[\lambda_t^f R_t A_t + \mathcal{H}_t^r + \mathcal{S}_t^r \right] \right\}$$

The equation for aggregate consumptions shows that transfers markedly influence the evolution of the distribution of wealth, which in turn affects aggregate consumption. Labour income taxes affect consumption directly via the discounted lifetime human wealth and income transfers, but also indirectly through their effect on labour supply and on the distribution of assets between retirees and active working-age population. Given that the working-age population discounts future income streams at a higher rate than that at which government can borrow, fiscal policy that postpones tax increases into the future boosts consumption in the short-run.

2.2 Aggregate labour markets

In the model, labour supply is determined endogenously via households' optimal decisions on consumption and labour supply. Each individual has one unit of time which he may use to work or to enjoy leisure. Retirees as well as those of active working-age may participate in the labour markets, but retirees are less productive than active working-age individuals. In addition, the labour market is imperfectly competitive due to the wage setting power of workers. Moreover, in the short term, real wages can depart from the desired level, due to the slow adjustment of nominal wages, reflecting the long duration and overlapping nature of wage contracts.

Following Erceg et al. (2000), we assume that there exists a 'labour-aggregator' that uses the following constant-elasticity-of-substitution (CES) production function to aggregate different working-age labour types (j):

$$L_t^w = \left[\int_0^1 L_t^w(j)^{-\rho_t^L} dj \right]^{-\frac{1}{\rho_t^L}} ,$$

where $L_t^w(j)$ denotes the demand for type j workers. Cost minimisation of the labour-aggregator implies that the demand for type j workers depends upon the relative wage and aggregate labour demand index:

$$L_t^w(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\frac{1}{1+\rho_t^L}} L_t^w \tag{12}$$

where $1/(1+\rho_t^L)$ is the elasticity of substitution between differentiated labour inputs. $W_t(j)$ denotes the wage rate of a type j worker and the aggregate wage, W_t, is defined as

$$W_t = \left[\int_0^1 W_t(j)^{\frac{\rho_t^L}{\rho_t^L+1}} dj\right]^{\frac{1+\rho_t^L}{\rho_t^L}}.$$

Following the now standard approach in the literature, it is assumed that only a fraction of ζ^W randomly chosen workers can re-set their wages in each period. For those not able to optimise in period t, the wage is mechanically adjusted using the previous period's growth rate of wages (dynamic indexing). The behaviour of aggregate nominal wages is characterised by the following two equations:[2]

$$W_t^* = \frac{1}{\rho_t^L} \frac{(1-v)\, P_t^c C_t^w / \left(1 - \mathfrak{t}_t^{WS} - \mathfrak{t}_t^{WP}\right)}{v[(1-\varphi)N_t - L_t^w]} \tag{13}$$

$$\Delta^2 \log(W_t) = \beta \, \mathrm{E}_t \, \Delta^2 \log(W_{t+1}) + \frac{(1-\zeta^W)(1-\zeta^W\beta)}{\zeta^W} \left[\log(W_t^*) - \log(W_t)\right] \tag{14}$$

where ρ_t^L is the inverse of the wage markup and N_t is population. The optimal wage rate W_t^* is directly derived from the aggregate version of an active working-age individual's labour supply decision, and taking into account the individual's labour demand constraint (12).

Retirees' labour supply is determined by the corresponding first order condition:

$$L_t^r = \varphi N_t - \frac{\frac{(1-v)}{v} P_t^c C_t^r}{\xi W_t \left(1 - \mathfrak{t}_t^{RS}\right)}.$$

2.3 Public sector, pension fund and fiscal rules

The general government (public sector) is divided into two sectors: *state* (central government) and (statutory) *pension funds.* The state taxes as follows: labour income of workers at the rate $\mathfrak{t}_t^{WS}$retirees' income at $\mathfrak{t}_t^{RS}$, firms' social security contributions at $\mathfrak{t}_t^{FS}$, corporate (profits) at $\mathfrak{t}_t^K$, and indirect taxes at the rate $\mathfrak{t}_t^C$. State consumption C_t^S consists of market goods C_t^{SF}, which are provided by the consumption goods retailer (private sector), and

[2]It is worth noting that we assume that there exist state contingent securities that allow equilibrium consumption and asset holdings to be equal for all workers, despite heterogeneous wages and labour supply. Note also that the second equation is obtained after log-linearization.

non-market goods Y_t^S produced by the public sector itself, using a simple linear production technology $Y_t^S = \Lambda_t^S \xi^G L_t^S$, where Λ_t^S is a technology factor. Public sector employees have different productivity level ξ^G which can differ from that of private sector employees.

State The state also pays taxable and non-taxable income transfers to both working-age and retired individuals. In addition, it issues one-period government bond A_t^S that pay a nominal return r_t. Each period, the following budget constraint holds

$$\begin{aligned}
&-(A_t^S - A_{t-1}^S) \text{ (net lending)} \\
&= \mathfrak{t}_t^{WS} W_t L_t^w + \mathfrak{t}_t^{RS} \xi W_t L_t^r \text{ (income tax revenues)} \\
&+ \mathfrak{t}_t^K \Pi_t \text{ (corporate income tax revenues)} \\
&+ \mathfrak{t}_t^C P_t^C C_t^F \text{ (indirect taxes)} \\
&+ \mathfrak{t}_t^{FS} W_t L_t \text{ (firms' social security contributions)} \\
&- P_t^C C_t^{SF} - P_t^O Y_t^S \text{ (government consumption)} \\
&- P_t^I I_t^S \text{ (government investment)} \\
&- \mathcal{T}_t^w - \mathcal{T}_t^r \text{ (total net transfers)} \\
&- r_t A_{t-1}^S \text{ (interest payments).}
\end{aligned} \tag{15}$$

Public sector revenues must be in harmony with expenditures on public consumption and investment, income transfers and interest expenditure on public debt. This is ensured in the model by the fiscal policy rule

$$\Delta \mathfrak{t}_t^{WS} = \kappa[(A_t^S - A_{t-1}^S)/Y_t - \bar{A}^s(1 - 1/\hat{Y}_t)], \tag{16}$$

where $\hat{Y}_t \equiv Y_t/Y_{t-1}$ denotes the gross growth rate of private production, $(A_t^S - A_{t-1}^S)/Y_t$ is the fiscal deficit expressed as a share of private production, $\bar{A}^s$ is an exogenous target for the central government debt ratio, and κ is the fiscal rule adjustment parameter which controls the speed of adjustment of the labour income tax rate to deviations of public debt from its long-term target. In principle, the higher the value of κ, the more concerned is the state about balancing its budget.[3]

[3] See for instance Railavo (2004) for a discussion of alternative fiscal policy rules and their stability properties.

Statutory pension funds The pension scheme in Finland is a defined benefit scheme in the sense that pension benefits are not directly dependent on workers' contributions to employment pension schemes or on the yields of pension funds. The contribution rates are adjusted in for possible shortfalls in fund balances. Nearly all old age pensions are provided by employment pension institutions or national pension institutions closely controlled by the state. The Finnish statutory pension system is approximately 20 per cent funded. Otherwise, it functions as a decentralised pay-as-you-go (PAYG) system[4].

The fact that the pension scheme is defined benefit and partly funded motivates treatment of pension funds as separate from the central government and modelling them as having their own flow budget constraints and budget balancing rules. Furthermore, we can consider the funded part of the pension system as contractual savings and the PAYG part as a transfer from workers to pensioners.

Accordingly, we assume that the fund collects pension contributions and distributes pensions to retirees $\mathcal{T}_t^{PR}$. Pension fund also accumulates financial assets A_t^P according to the flow budget constraint

$$\begin{aligned}
&-(A_t^P - A_{t-1}^P) \text{ (net lending)} \\
&= \mathfrak{t}_t^{FP} W_t [L_t^F + \xi^G L^G] \text{ (social security contributions of employer)} \\
&+ \mathfrak{t}_t^{WP} [W_t L_t^w] \text{ (social security contributions of workers)} \\
&- \mathcal{T}_t^{PR} \text{ (total transfers paid to retirees)} \\
&- r_t A_{t-1}^P \text{ (interest payments)}
\end{aligned} \tag{17}$$

where $\mathfrak{t}_t^{FP}$ is the employer's pension contribution rate and $\mathcal{T}_t^{SW}$ denotes transfers from the state to workers that are treated as labour income, and finally $\mathcal{T}_t^{PR}$ denotes pensions and other transfers from pension funds to retirees. Furthermore, it is assumed that pension funds have a long-run funding target, expressed as a ratio of financial assets (A^P) to output. This target is eventually achieved by appropriately adjusting the pension contribution rates. This pension contribution rule is similar to the fiscal rule (16).

Monetary policy Monetary policy reflects Finland's small share (1.6 per cent) in the euro area. Consequently, the feedback from Finnish economy to euro area level is very modest.

[4]There is also a national pension scheme covering all citizens, but its role is diminishing. At the same time, voluntary pension schemes and partly tax deductible are becoming increasingly popular.

A reasonable approximation is that the euro area policy rate and the foreign exchange rate are exogenous for the Finnish economy. We also assume that the exchange rate is fixed, i.e. $S_t = S_{t-1}$.

2.4 Firms and technologies

The supply side of the model is essentially based on a single good. This is an intermediate good that is a constant-elasticity-of-substitution (CES) aggregate of a continuum of brands. The domestic intermediate good is combined with the imported good to obtain three different final goods: consumption goods, capital goods and exported goods. These final goods differ with respect to type of imported factor and elasticity of substitution between domestic and imported factors. Domestic producers of intermediate products purchase their capital inputs (capital services) in a competitive capital market (from companies providing capital services) in which capital is freely for sale and transferable for use by other companies. The domestic intermediate goods producers operate in monopolistic product markets due to the imperfect substitutability of their products, and prices are sticky.

2.4.1 Domestic intermediate goods producers

The domestic composite intermediate good, Y_t, is produced according to the following constant elasticity of substitution (CES) production function, which combines individual goods $Y_t(j)$ (Dixit and Stiglitz (1977)):

$$Y_t = \left[\int_0^1 Y_t(j)^{-\rho_t^z}\,\mathrm{d}\,j\right]^{\frac{1}{-\rho_t^z}}$$

The parameter $\rho_t^z \in [-1, \infty)$ determines the elasticity of substitution, $1/(1+\rho_t^z)$. For non-positive values of ρ_t^z the intermediate goods are gross substitutes. Perfect substitutability, and hence perfect competition, is obtained by letting ρ_t^z approach -1, so that in this case the elasticity of substitution approaches infinity. We allow for time variation in the elasticity of substitution.

Cost minimization implies the conditional demand function for the individual good j ($j \in [0, 1]$)

$$Y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\frac{1}{1+\rho_t^z}} Y_t \qquad (18)$$

and the price index for the composite domestic intermediate good

$$P_t = \left[\int_0^1 P_t(j)^{\frac{\rho_t^z}{1+\rho_t^z}} \, \mathrm{d}\, j \right]^{\frac{1+\rho_t^z}{\rho_t^z}} \tag{19}$$

Domestic intermediate goods, $Y_t(j)$, are produced by producers who face monopolistic competition. They take the production technology and factor augmenting technical trends as exogenously given. The production function is of the CES type and takes the specific form of constant-returns-to-scale:[5]

$$Y_t(j) = \left[\delta \left(\Lambda_t^K K_t \right)^{-\rho} + (1-\delta) \left(\Lambda_t^L L_t^F \right)^{-\rho} \right]^{-1/\rho} \tag{20}$$

The factors of production include homogeneous capital services[6], K_t, and homogeneous labour, L_t^F. Λ_t^K and Λ_t^L denote time-varying[7] capital and labour-augmenting technical progress, which are unobservable to the econometrician and are common to all firms. The elasticity of technical substitution is given by $1/(1+\rho)$, where ρ is the substitution parameter in the production function. δ is the share parameter.

Cost minimization implies the following real marginal costs:

$$\frac{MC_t(j)}{P_t(j)} = \left[\delta^{\frac{1}{1+\rho}} \left(\frac{R_t}{\Lambda_t^K P_t(j)} \right)^{\frac{\rho}{1+\rho}} + (1-\delta)^{\frac{1}{1+\rho}} \left(\frac{W_t^F}{\Lambda_t^L P_t(j)} \right)^{\frac{\rho}{1+\rho}} \right]^{\frac{1+\rho}{\rho}}, \tag{21}$$

where R_t denotes the nominal rental price of capital services and $W_t^F = (1 + \mathfrak{t}_t^{FP} + \mathfrak{t}_t^{FS}) W_t$ represents nominal labour costs. Firms' pension and social security contributions are denoted by $\mathfrak{t}_t^{FP}$ and $\mathfrak{t}_t^{FS}$. Price level, $P_t(j) = \Upsilon_t MC_t(j)$, is determined by the markup $\Upsilon_t \equiv -1/\rho_t^z$ over marginal costs. Note, that the markup is not unity in the steady-state case since the steady-state elasticity of substitution[8] between intermediate goods is generally finite.

The first order conditions with respect to labour and capital services are given by the log-linear equations

$$\log \delta - \upsilon_t - \rho \lambda_t^K + (1+\rho)(y_t - k_t) = r_t - p_t \tag{22}$$

$$\log(1-\delta) - \upsilon_t - \rho \lambda_t^L + (1+\rho)(y_t - l_t) = w_t^F - p_t \tag{23}$$

[5]According to Ripatti and Vilmunen (2001) and Jalava et al. (2006) this seems to be a reasonable assumption for the Finnish data.

[6]Capital is rented from capital rental firms, "leasing firms".

[7]We do not specify their stochastic properties at this stage. See Ripatti and Vilmunen (2001) for further discussion of their properties and estimates using aggregate Finnish data.

[8]The elasticity of substitution is $\Upsilon/(\Upsilon - 1)$ in terms of Υ.

where r_t is the log of the nominal rental rate of capital services, $w_t^F = W_t/(1 - \mathfrak{t}_t^{FS} - \mathfrak{t}_t^{FP})$ the log of nominal wages (compensation per employee), and p_t the log of the output price. Due to the monopolistic competition in the market for output, the time-varying slope of the demand curve, $\upsilon_t \equiv \log(\Upsilon_t)$, enters to the first order conditions. Note also that $\lambda_t \equiv \log \Lambda_t$ for each type of λs in the model.

The dynamics of the price level $P_t(j)$ of producer j arises from the assumption that a firm changes its price level when it receives a random 'price-change signal' Calvo (1983). The probability of receiving a price change signal is given by $1 - \zeta$ ($\zeta \in [0, 1]$). Since there is continuum of intermediate producers, $1 - \zeta$ also represents the share of producers that have received such a signal and thus had an opportunity to change their prices. The average time between price changes is given by $1/(1 - \zeta)$. For those firms that do not receive a price-change signal in period t, the price level is mechanically adjusted using the period $t-1$ inflation rate (Altig et al., 2005).

Assuming symmetry of the firms, we obtain the following log-linearized, aggregate pricing equation for the intermediate goods producers:

$$\Delta p_t = M\,\mathrm{E}_t\,\Delta p_{t+1} + \frac{(1-\zeta)(1-\zeta M)}{\zeta}\left[\upsilon_t + mc_t - p_t\right]. \tag{24}$$

Producer price inflation is thus determined by expected producer price inflation and changes in the slope of the demand curve (time-varying markup) and real marginal costs.

2.4.2 Capital rental firms

Capital is a homogeneous factor of production that is owned by a firm that rents capital to producers of domestic intermediate goods. It operates under perfect competition. The capital rental firm may choose between physical capital accumulation K_t^p or a higher utilization rate U_t, with $K_t = U_t K_{t-1}^p$ ($U_t \in [0, 1]$). Physical accumulation generates real adjustment costs in the form of lost capital stock, whereas the capital utilization rate affects the depreciation of the capital stock. Capital accumulation is given by

$$K_t^p + \underbrace{\frac{\gamma_1}{2}\frac{\left(\Delta K_t^p - \gamma_2 \Delta K_{t-1}^p\right)^2}{K_{t-1}^p}}_{\equiv a^K(K_t^p, K_{t-1}^p, K_{t-2}^p)} = K_{t-1}^p\left[1 - \underbrace{\left(\delta_0 + \frac{\delta_1}{1+\delta_2}U_t^{1+\delta_2}\right)}_{\equiv D(U_t)}\right] + I_t \tag{25}$$

where $a^K(\cdot)$ denotes the adjustment costs of the physical capital stock. The depreciation factor $D(U_t)$ ($D(\cdot) \in [0, 1]$) is an increasing function of the capital utilization rate, $D'(U_t) > 0$ (see Baxter and Farr, 2001). The capital rental firm maximizes its expected discounted profits

$$\max_{\{U_t\}\{I_t\}} \mathrm{E}_t \sum_{s=0}^{\infty} M_{t,t+s} \Pi_{t+s}^K$$

subject to the capital accumulation equation (25) and the definition of capital services. The momentary profits are given by

$$\begin{aligned}\Pi_t^K =& R_t K_t - P_t^I I_t \\ =& R_t U_t K_{t-1}^p - P_t^I \{K_t^p + a^K(K_t^p, K_{t-1}^p, K_{t-2}^p) - K_{t-1}^p [1 - D(U_t)]\}\end{aligned}$$

The price index of investment goods is the price index of the domestic investment good retailer, P_t^I. Since the firm is owned by households, the future profits are discounted using the nominal stochastic discount factor (pricing kernel) $M_{t,t+s}$.

The optimal level of capacity utilization is given by the following first order condition w.r.t. U_t:

$$\frac{R_t}{P_t^I} = \delta_1 U_t^{\delta_2} \tag{26}$$

which relates rental price to marginal depreciation of capital stock. The first order condition w.r.t. the capital stock K_t^p is given as

$$\begin{aligned}&- P_t^I \,\mathrm{E}_t \left[1 + \gamma_1 \frac{\Delta K_t^p - \gamma_2 \Delta K_{t-1}^p}{K_{t-1}^p}\right] \\ &+ \mathrm{E}_t \, M_{t,t+1} \left\{ R_{t+1} U_{t+1} - P_{t+1}^I \left[- \gamma_1 (1 + \gamma_2) \frac{\Delta K_{t+1}^p - \gamma_2 \Delta K_t^p}{K_t^p} \right.\right. \\ &\left.\left. - \gamma_1 \frac{(\Delta K_{t+1}^p - \gamma_2 \Delta K_t^p)^2}{2\,(K_t^p)^2} - \left(1 - \delta_0 - \frac{\delta_1}{1 + \delta_2} U_{t+1}^{1+\delta_2}\right)\right]\right\} \\ &\qquad - \mathrm{E}_t \, M_{t,t+2} P_{t+2}^I \gamma_1 \gamma_2 \frac{\Delta K_{t+2}^p - \gamma_2 \Delta K_{t+1}^p}{K_{t+1}^p} = 0.\end{aligned} \tag{27}$$

Due to the end-of-period timing of the physical capital stock, accumulated physical capital is in use in the following period. Hence, it is the expected following period's rental rate that governs the current period investment decision.

2.4.3 Domestic retailers

The economy is inhabited by three retailers, i.e. final goods producers. The first one specializes in consumer goods ($j = C$), the second one in capital goods ($j = I$), and the third one in exported goods ($j = X$). They combine domestic intermediate input — produced by the intermediate goods producers — and sector specific imported goods and services and operate under perfect competition. This means that they do not produce any value-added and can be considered as aggregators that reflect the way consumers or the capital rental firm (and public sector) substitute between domestic and foreign intermediate goods and services. The production structure of retailers is similar in all three cases. What varies is the elasticity of technical substitution and the time-path of factor-augmenting technical changes. The technical changes are assumed to be constant in the balanced-growth-path, but there may be shifts during the transition. Their developments affect the relative prices of final goods. The CES aggregators are

$$j_t = \left[\delta^j \left(\Lambda_t^{jY} Y_t^j\right)^{-\rho^j} + (1-\delta^j)\left(\Lambda_t^{jM} M_t^j\right)^{-\rho^j}\right]^{1/\rho^j}, \quad j = \{C, I, X\}.$$

Conditional factor demands are of the form

$$\begin{aligned} Y_t^j &= \left(\delta^j\right)^{\frac{1}{1+\rho^j}} \left(\Lambda_t^{jY}\right)^{\frac{-\rho^j}{1+\rho^j}} \left(\frac{P_t}{P_t^j}\right)^{\frac{-1}{1+\rho^j}} j_t \\ M_t^j &= \left(1-\delta^j\right)^{\frac{1}{1+\rho^j}} \left(\Lambda_t^{jM}\right)^{\frac{-\rho^j}{1+\rho^j}} \left(\frac{P_t^{Mj}}{P_t^j}\right)^{\frac{-1}{1+\rho^j}} j_t \quad j = \{C, I, X\} \end{aligned}$$

and the price index is given by

$$P_t^j = \left[\left(\delta^j\right)^{\frac{1}{1+\rho^j}} \left(\frac{P_t}{\Lambda_t^{jY}}\right)^{\frac{\rho^j}{1+\rho^j}} + \left(1-\delta^j\right)^{\frac{\rho^j}{1+\rho^j}} \left(\frac{P_t^{Mj}}{\Lambda_t^{jM}}\right)^{\frac{\rho^j}{1+\rho^j}}\right]^{\frac{\rho^j+1}{\rho^j}} . \quad j = \{C, I, X\}$$

According to our estimation, it turns out that in the production of consumption goods and capital goods, the inputs are gross substitutes and in the production of exports, the domestic and foreign inputs are gross complements (the elasticity of substitution is less than unity). Note also that consumption goods form the tax base for indirect taxation. In this case the price index P_t^C in the above formulas should be replaced by the indirect tax rate factor $(1 - \mathfrak{t}_t^C)P_t^C$.

2.4.4 Importing firms

In deriving a model for import prices, we follow the approach derived by Betts and Devereux (1996 and 2000) and applied to Finnish aggregate import data by Freystätter (2003). We assume that a fraction of importers price their product in local (Finnish) currency and the rest in producer (their own) currency. Their pricing contains identical frictions in the form of Calvo (1983), i.e. they may change their price only in the event of a random price-change signal. And their marginal costs are identical. Aggregation of prices over these two types of importers yields an import-price Euler equation where import prices depend on expected future import price inflation and current and expected future changes in foreign exchange rates, and on the real marginal costs of importers.

To model a delayed pass-through of foreign exchange rates, we assume that a fraction ω^j of firms in each final goods sector, $j \in \{C, I, X\}$, price their products in the Finnish currency, the rest price in their own producer currency. Each of these two types of firms have Calvo price rigidities (price change probability $1 - \zeta^j$, $j \in \{C, I, X\}$) with dynamic indexing (see, for example, Altig et al., 2005). The aggregation of the two type of firms leads to the following pricing scheme

$$\begin{aligned}\Delta^2 p_t^{Mj} =& R^\star \operatorname{E}_t \Delta^2 p_{t+1}^{Mj} + \frac{(1-\zeta^j)(1-\zeta^j R^\star)}{\zeta^j}(s_t + mc_t^j - p_t^{Mj}) \\ & + (1-\omega^j)(\Delta^2 s_t - R^\star \operatorname{E}_t \Delta^2 s_{t+1}), \quad j = \{C, I, X\}\end{aligned}$$

where s_t is the nominal foreign exchange rate in domestic currency (e.g. EUR/USD), mc_t^j the marginal cost for importing firms, p_t^{Mj} the import price for sector j. The parameter $R^\star$ denotes the foreign steady state discount factor, and $1 - \zeta^j$ the probability of reoptimising prices.

2.5 Market equilibrium

All markets are in equilibrium at every point of time. The capital goods market is in the equilibrium if the supply of capital services by the capital rental firm equals the demand for capital services by intermediate goods producers. Similarly the demand of labour equals its supply. There is an extra complication because labour supply and labour demand are measured in different efficiency units, the former (L_t^{LW}) in terms of working-age population and the latter (L_t^{LF}) in terms of private sector employment:

$$L_t^{LW} = L_t^W + \xi L_t^R \tag{28}$$

$$L_t^{LF} = L_t^F + \xi^G L_t^G. \tag{29}$$

In terms of number of employed, labour supply equals labour demand, i.e. $L_t^S = L_t^D$ as follows:

$$L_t^S = L_t^W + L_t^R = L_t^{LW} + (1-\xi)L_t^R \tag{30}$$

$$L_t^D = L_t^F + L_t^G = L_t^{LF} + (1-\xi_t^G)L_t^G. \tag{31}$$

In the intermediate goods sector, the demand for intermediate goods by retailers and exporters together equals total supply:

$$Y_t^C + Y_t^I + Y_t^X = Y_t. \tag{32}$$

Stock markets clear when the supply of shares equals the demand for shares.

Markets for consumption goods clear when government purchases C_t^{SF} plus private consumption C_t equals the supply of consumption goods C_t^T

$$C_t^{SF} + C_t = C_t^T \tag{33}$$

and the markets for capital goods clear when public I_t^S plus private I_t investments equals to the supply of capital goods I_t^T:

$$I_t^S + I_t = I_t^T. \tag{34}$$

Export demand and supply are given by

$$\left(\frac{P_t^X}{S_t P_t^W}\right)^{-\rho^W} \mathcal{M}_t = X_t, \tag{35}$$

where the left-hand-side of equation (35) represents world demand for exports and $\mathcal{M}_t$ and P_t^W are aggregate rest-of-the-world imports and the unit price in terms of foreign currency. When market clearing conditions (28) – (35) hold workers' and pensioners' budget constraints, (8) and (5), the general government budget constraint (15), and pension fund's budget constraint (17) imply the following accumulation of (net) foreign assets:

$$S_t A_t^W = (1 + r_t^F) S_t A_{t-1}^W + \underbrace{P_t^X X_t - P_t^{MR} M_t^R - P_t^{MC} M_t^C - P_t^{MI} M_t^I}_{\equiv \text{trade balance}} \quad (36)$$

where the lower line defines the trade balance.

To close the model we specify stochastic processes for the exogenously given variables: $\hat{\Lambda}_t^L$, $\hat{N}_t$, Υ_t, Λ_t^K, Λ_t^{CY}, Λ_t^{CM}, Λ_t^{IY}, Λ_t^{IM}, Λ_t^{XY}, Λ_t^{XM}, Λ_t^G, I_t^S, C_t^{SF}, $\mathcal{T}_t^w$, $\mathcal{T}_t^r$, Y_t^S, $\mathfrak{t}_t^K$, $\mathfrak{t}_t^{FP}$, $\mathfrak{t}_t^{FS}$, $\mathfrak{t}_t^C$, $\mathcal{T}_t^{PRT}$, r_t^F, S_t, $\hat{P^W}_t$, $\mathcal{M}_t$. For each variable, we provide a univariate first order autoregressive equation of the form

$$x_t = (1 - \rho^x)\bar{x} + \rho^x x_{t-1} + \varepsilon_t^x, \quad \varepsilon_t^x \sim \text{IID}(0, \sigma_x^2) \quad (37)$$

where x is one of the variables above. An important part of the calibration exercise is calibration of the steady-state values of the exogenous variables.

2.6 Model calibration

The parameters affecting the demographics is calibrated to approximately fit the demographic structure in the near future, where the retirees' share of the whole population, here defined as individuals of age 15–74 years, is roughly 25 %. Table 1 gives the implied probability of retirement and death. Corresponding retirement and active working-age periods are then roughly 13 and 48 years. Annual net growth rate of population is set to 0.16 percent. These demographic assumptions reflect Finland's situation over the next decade, according to official demographic projections.

In order to fit the participation rates close to 1995-2004 averages, we set the relative efficiency, ξ, of 'retirees' at 32% of that of active working-age. The elasticity of periodic utility with respect to consumption, ν, is set at 0.844, and the intertemporal elasticity of substitution, 0.4, is based on the estimate by Viitanen (2002). These parameter values are summarized in table 1.

We calibrate the steady-state product market markup to 1.085. This is low compared to the estimate of Martins et al. (1996), which finds a manufacturing sector markup of 1.24.

Table 1: Parameter values

Parameter	Explanation	Value
υ	Consumption share in utility	0.844
σ	Inter-temporal substitution	0.4
γ	Probability of surviving	0.979836 (12.5 years)
ω	Probability of remaining 'worker'	0.99478 (48 years)
ξ	Relative labour efficiency of retirees	0.32
$\hat{N}$	Population growth rate, p.a.	0.16%
$\bar{M} = R^{\star}$	Discount rate	$1.02^{1/4}$
γ_1	Capital adj. cost (level)	300
γ_2	Capital adj. cost (lag)	0.95
δ_0	'Rust and dust' in depreciation	0.010
δ_1	'Wear and tear' in depreciation	0.03
δ_2	'Wear and tear' curvature	4.5
$1/(1+\rho)$	Subst. in intermediate goods	0.58
δ	corresponding share parameter	0.1
ζ	Calvo parameter in goods market	$1 - 1/6$
ζ^W	Calvo parameter in labour market	$1 - 1/8$
Υ	Steady-state product markup	1.085
$1/\rho^L$	Steady-state wage markup	1.30
$1/(1+\rho^C)$	Subst. in consumption retailer	2.5
δ^C	corresponding share parameter	0.87
$1/(1+\rho^I)$	Subst. in capital retailer	2.2
δ^I	corresponding share parameter	0.67
$1/(1+\rho^X)$	Subst. in exporter	0.45
δ^X	corresponding share parameter	0.51
ζ^C	Calvo, imported consumption	0.88
ω^C	Share of LCP firms in above	0.6
ζ^I	Calvo, imported capital goods	0.95
ω^I	Share of LCP firms in above	0.3
ζ^X	Calvo, imported materials	0.6
ω^X	Share of LCP firms in above	0.9
ρ^W	Export price elasticity	1.24

Their method, however, differs markedly from ours. [9] Kilponen and Santavirta (2004) find that the average price-cost margin in Finnish industry is roughly 8 per cent, based on microdata from annual Industrial Statistics surveys that cover essentially all Finnish manufacturing plants employing at least 20 persons. The labour market markup is calibrated to 1.30, to match the labour share and employment rate in recent Finnish data. This wage markup is roughly the same as that observed in Europe on average.

The elasticity of technical substitution between capital and labour follows the estimate by Jalava et al. (2006), 0.58. The elasticity of substitution between domestic intermediate

[9] Another reason for a relatively small estimate of the steady-state markup results from the model construction: The profit function of the capital rental firm is nonlinear, and it yields positive steady-state profits even in the case of perfect competition. Hence a significant part of the private sector profits are generated by that firm instead of by intermediate goods producers. Therefore our estimate is tentative but consistent with the data and the parameter values in the model.

goods and imported consumption goods is calibrated to 2.5 and is marginally higher than that of the capital goods retailer, 2.2. For exports, the elasticity of substitution is estimated at 0.45.

In order to illustrate how well the model accords with the recent data, we use the data from 1995–2005 and calculate averages of several macro economic variables. The reason for not using a longer time span is that Finland experienced major structural changes during the 1990s recession whereas we want to fit the balanced growth path to the more recent economic environment. Table 2 gives summary statistics of those macro economic variables. The model's implied steady state portrays the expected demographic change in the forthcoming decades and therefore differs somewhat the most recent data. In particular, there is a higher dependency ratio, implying a bigger private consumption share, reflected in a larger import share.

Table 2: Steady state shares and the data

Variable (% of private production)	The data (1995–2005)	Steady-state
Imports	44.8	53.9
Exports	56.0	62.2
Consumption	101.9	101.4
Private	72.0	77.1
Public	29.9	24.3
Investments	26.4	28.1
Private	22.5	25.1
Public	3.9	3.0
Employment rate, %	58.6	59.7
Labour share, %	49.0	55.5
I/K, %	1.8	1.9
Dependency ratio, %	21.8	33.0
Income tax rate, %	31.6	27.2
Pension contributions, %	4.4	4.4

3 Product and labour market reforms

Gersbach (2000)[10] classifies possible mechanisms of labour market reforms into three categories: direct effect of lower markup, stimulation of technical change, and expanded set of product varieties. The seminal article by Blanchard and Giavazzi (2003) studies the political economy of product and labour market reforms in a model that combines the first and the third of the above mechanisms. A novel feature of their model is that the product market markup, which is related to the number of firms, is endogenously determined by an entry

[10]See also Høj and Wise (2004).

condition. The very same feature in their model also creates a link between labour and product markets. In their model "product market deregulation leads to higher real wages, and to lower unemployment in the long run". This result has been challenged by Spector (2004) who, by imposing decreasing returns to labour (production function), shows that real wages may fall even in the long-run. Building on a model with labour market matching model and efficiency wages, Amable and Gatti (2004) demonstrate that product market deregulation may lead to employment losses even in the long run. Ebell and Haefke (2003) also builds on a matching model and, due to hiring externalities, finds that quantitatively the product market deregulation has a small effect.

The relationship between degree of product market competition and technical change has been an important part of the research agenda of Aghion and Howitt[11]. This is quantitatively potentially the most important channel. Their argument gets some empirical support from Nicoletti et al. (2001) and Kilponen et al. (2004). The theoretical linkages of labour and product market reforms, as set out by Blanchard and Giavazzi (2003), also get empirical support from Nicoletti et al. (2001) and Jean and Nicoletti (2002)[12].

Our approach differs from the above in three important dimensions: First, both product and labour market markups are exogenously given. For this reason, there is no link from markup to technical change. Second, in our model, agents optimize intertemporally and due, to nominal and real rigidities, our model is able to analyze dynamics along the transition path. Finally, as emphasized in the previous section, the model is non-Ricardian and so includes a role for fiscal policy[13].

Here, 'product market reform' refers to an increase in the elasticity of substitution of different product brands. The degree of product market competition in the model is determined by the time-varying parameter $\Upsilon_t \equiv -1/\rho_t^z$ in the pricing equation (24). It is the inverse of the substitution parameter in the aggregator of domestic intermediate goods (18). Less than perfect substitutability between goods may capture effects such as competition regulation, horizontal collusion in product markets, public ownership of domestic firms, differences in product standards, etc. The imperfect competition is limited to the intermediate goods sector, since final goods producers, including exporters, operate under perfect competition

[11] See, for example, Aghion and Howitt (1994) Aghion et al. (2005) Aghion and Howitt (2006).

[12] The measure of wage premia in the above-mentioned studies is based on the characteristics of workers, working conditions and firms. Therefore, it does not directly correspond to our labour market markup measure.

[13] Bokan and Hughes Hallett (2006) enrich the Blanchard and Giavazzi (2003) model by with labour income and payroll taxes.

in their product markets.[14] An example of this kind of reform was the change in Finnish legislation in 2003 that forced mobile phone operators (carriers) to set up a system where the client could keep the phone number after switching to another operator. Mobile phone call prices declined substantially after the reform and contributed (together with a decline in handset prices) −0.3 percentage point to the annual inflation rate.[15] (Bank of Finland, 2005) The emergence of net-stores provides another example that can be interpreted as an increase in the elasticity of substitution.

Similarly, we use 'labour market reform' to refer to an increase in the elasticity of substitution of different labour types. The degree of imperfection in the labour markets is given by the process for ρ_t^L in equation (13). $1/\rho_t^L$ determines the premium over the marginal rate of substitution between consumption and leisure, which is the relevant measure of the marginal cost of changing labour by one unit. It captures factors like the bargaining power of labour unions, the unionisation rate, minimum wage legislation, unemployment benefits, hiring and firing costs, immigration policies etc. In this sense, the parameter can be thought of as capturing the essential 'non-competitive' features of the wage setting process.

In the following simulation exercise we assume an *unanticipated instantaneous* decline of the markup process by one per cent. This results to a new steady-state. The persistence of the shock is known by agents. The model is linearized around the terminal ('after-shock') steady-state.[16] Due to this choice of shock structure, the resulting dynamic path portrays intrinsic dynamics of the model.

Høj and Wise (2004) list in detail the possible restrictions to product market competition in Finland. They also provide estimates of the macroeconomic effects of increased competition. According their estimate, based on empirical work by Nicoletti et al. (2001), 'if Finland moved towards best practice for product market liberalisation in the OECD, then the employment rate could increase by another 1/4–1/2 percentage point' (page 36).

3.1 Responses to product and labour market reforms.

We study the responses of the economy to product and labour market markup shocks, both separately and combined. Table 3 reports the new steady-states relative to the initial steady-state reported in table 2, and figure 1 whows the dynamic (first 20 years) responses.

[14] The GEM model of Bayoumi et al. (2004b) allows for imperfect competition in various components of final goods and is able to make this breakdown.

[15] This is surprisingly large number given quantitative inflation responses of our model.

[16] The simulation is carried out with the `forecast` command of Dynare 3.065 (Juillard, 2003) and cross-checked with deterministic simulations (`simul` command) of Dynare 4.

Since the model is close to linear, the responses of combined shocks are close to the sums of individual shocks. In each case the size of a shock is one per cent from the initial steady-state value. This means that the product market markup declines from 1.085 to 1.074 and that of the labour market from 1.30 to 1.287. Consequently, the labour markup shock is marginally larger, in percentage points, than the product markup shock.

The reduction in product market markup results an increase in factor demands that raises the real wages, employment, and capital stock. Due to the decrease in domestic price level and the fixed exchange rate regime, the real exchange rate depreciates. The reduction in price markup raises the marginal product of capital and leads to a higher capital-output ratio. Consequently, the consumption must give room to investments to reach the new capital-output ratio. Household financial wealth will decline due to the reduction in firms' profits and thus in the value of equity. Deceleration of consumer price inflation boosts the real interest rate, further tilting the consumption profile. Increased real wages and employment operate in opposite directions and consumption exceeds its original steady state level after 10 years. Fiscal policy plays an import role in the transmission of the price markup shock. Labour income tax revenues increase due to the increase in employment and real wages. This is, however, not enough to balance the budget, due to the significant decline in indirect and corporate tax revenues. The budget is driven into deficit. The budget closure rule implies an adjustment in the labour income tax that increases tax distortions. Pension scheme financing relies solely on labour income taxes. Therefore, the pension contribution rate monotonically declines. Due to the ultimate reduction in distortions (markup), the permanent response of consumption to product market deregulation is positive. Given this, there is a permanent improvement in the fiscal balance. This gives room for lowering the labour income tax rate and pension contribution rate by 0.5 and 0.4 percentage points respectively.

A one per cent shock to the labour market markup results in responses that are only 1/3 of the magnitude of the product markup shock. Responses also portray substantial differences. As described in section 2.2, working-age persons use their monopoly power in the wage-setting. Their labour supply elasticity is smaller than that of retirees (see discussion in next section). A reduction in the labour market markup shifts the supply of labour downwards, producing a rise in employment and a reduction in real wages (see table 3). Contrary to the product market reform, the wealth effect is small due to the modest increase in the value of the capital stock. Consumption increases. Improved public finances enable an easing of the tax burden by 0.17 and 0.05 percentage points.

Table 3: Long run (steady-state) responses to the product and labour deregulation

	Reform in (market)		
	product	labour	both
Private production, %	1.28	0.35	1.60
Private consumption, %	1.49	0.34	1.81
Private investment, %	1.78	0.31	2.06
Capital stock, %	1.81	0.33	2.08
Employment, %	0.70	0.27	0.96
Real wage, %	1.60	-0.03	1.55
Income tax rate, % pts	-0.51	-0.17	-0.67
Pension contrib. rate, % pts	-0.43	-0.05	-0.47
Real exchange rate, %	0.40	0.18	0.56
Wage markup, %		-1.00	-1.00
Price markup, %	-1.00		-1.00

The responses of the combined reform are almost the sum of the two individual reforms. Ultimately, the fiscal burden is eased by 1.15 percentage points. This is a substantial amount given the small size of the shocks.

Our results confirm some of the results of Blanchard and Giavazzi (2003). In response to product market deregulation, the households ultimately gain more as workers than they loose as investors (owners of the capital stock): both real wages and employment rise in the steady-state. The cost of the reform is in the short-run response, where households loose more as investors than they gain as workers. This implies the existence of short-run political costs in such a reform. In the Blanchard and Giavazzi (2003) model the labour market reforms reduce real wages in the short-run and have no employment effect. Due to an endogenous decrease in the product market markup, the long-run employment response is positive. This is the intertemporal tradeoff in their model. In our case of exogenous markups, the short-run response of employment is also positive and no intertemporal tradeoff exists, in contrast to the product market reform.

3.2 Robustness

General equilibrium models like the one here have a number of deep parameters which critically shape the dynamic and long-run effects. In this section we discuss how the results change when some of the crucial parameters are altered. First, we increase the intertemporal elasticity of substitution from 0.4 to 0.7, thus reducing the income effect of consumption. It turns out that in the long-run the higher intertemporal elasticity of substitution tends to downplay the effects of increasing competition in the product and labour markets on output, consumption and capital stock. For instance, the tax burden is eased by 1 percentage point instead of 1.1 after full adjustment to increasing competition. Only is the long-run response of real wage slightly magnified with the higher intertemporal elasticity of substitution.

Reducing the wage elasticity of labour supply is likely to magnify the effects of increasing competition in both the labour and product markets. We have thus experimented by increasing the share of consumption share in the utility function, ν, from 0.844 to 0.9. In order to attract an increase in labour supply, the real wages need to rise by more than in the baseline case. The responses to reforms are then dampened as households appreciate consumption more than leisure. As a consequence, the fiscal impact is also reduced: the scope for tax reduction shrinks to 0.8 percentage point instead of 1.15. The intertemporal tradeoff is worsened as the consumption response is prolonged.

As a final check of the robustness of our results, we make the fiscal adjustment considerably faster. This is achieved by increasing the value of parameter κ in the fiscal adjustment equation from 0.03 to 0.1. Since the debt target remains the same, the steady-state responses are not changed. As expected, faster fiscal adjustment leads to a more pronounced increase in the income tax rate in the short and medium run. Faster adjustment of the income tax rate, in turn, implies less accumulation of the debt-to-output ratio in the short run. The period of rise in the income tax rate is, however, significantly shorter. The income tax rate returns to the baseline level in about 6 years instead of 10 as in the baseline case. Due to the same reason, the consumption returns to original level sooner than in the baseline case. Therefore, the intertemporal tradeoff is eased. The effect is more pronounced if we increase the cameralism further. This points to the fact that the product and labour market reforms should be combined with an activist fiscal policy in order to dampen the short-run negative effects.

4 Conclusions

Like other Nordic (Scandinavian) countries, the Finnish economy has performed comparatively well during the last decade. Many regulatory reforms have also been carried out to make the Finnish economy more market driven. However, as suggested by Høj and Wise (2004), there is still room to improve the competitive environment of product markets in Finland. Similarly, due to the institutional setup of wage negotiations, the wage determination is essentially non-competitive. Moreover, the Finnish economy will face a dramatic demographic change and resulting fiscal burden in the forthcoming decades. In this paper, we evaluate quantitatively the macroeconomic effects of increased product and labour competition in the Finnish economy. By means of simulations we show that the product and labour market reforms may be an avenue to relief of the fiscal burden along with improved efficiency.

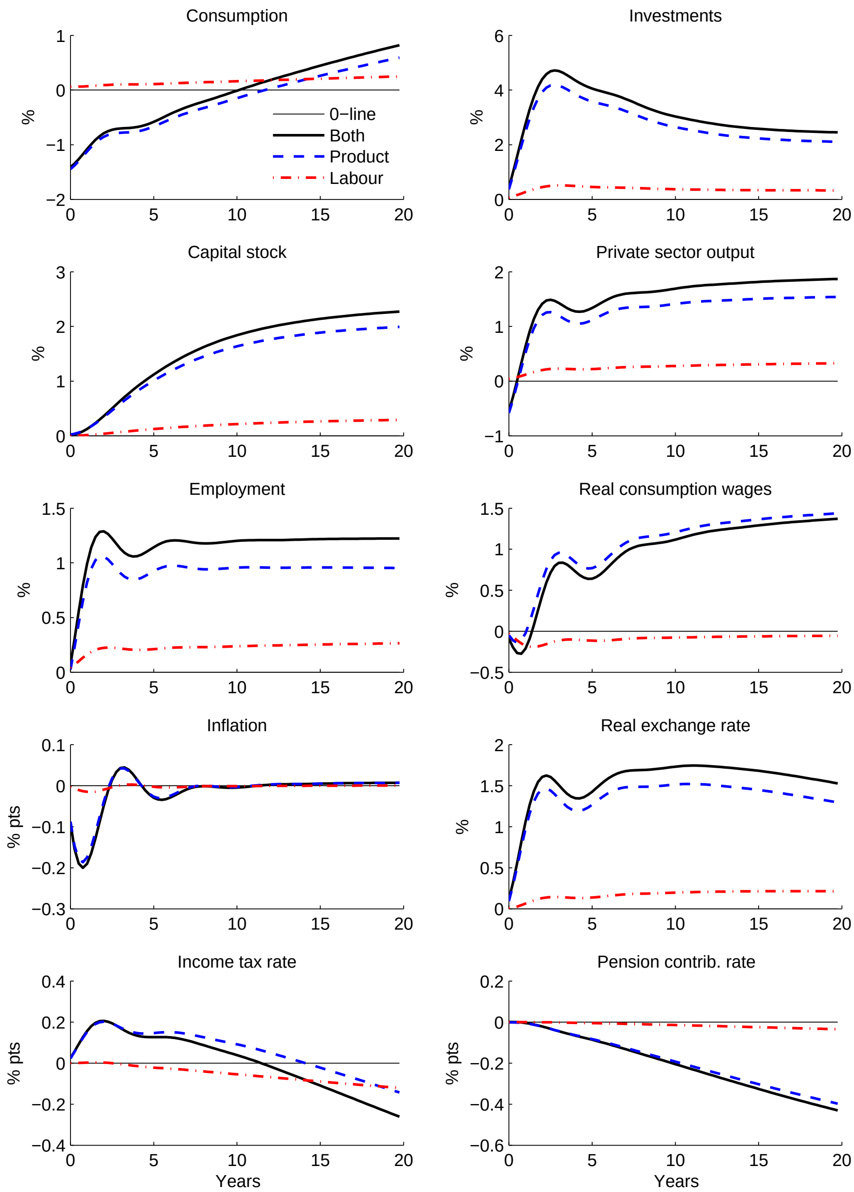
We simulate the response of the model's economy to changes in price and wage markups that are given by the elasticity of substitution in intermediate goods production and labour aggregator. The size of shock is one per cent in both markups, which — according to our estimate — are initially at the level of eight and 30 per cent respectively. The shocks are assumed to be permanent and to show no intrinsic persistence — all that is known by the agents.

Our standard simulation suggests that the increased efficiency enables reductions in the income tax rate and employees' pension contribution rate by 0.7 and 0.5 percentage point respectively, while keeping the long-run public debt-to-GDP ratio in tact. Transition of the economy to a new competitive environment is however costly. There is an initial fall in consumption since it has to give room to investment. This initial fall in consumption generates an intertemporal tradeoff. The short-run costs of deregulation provide incentive for short-sighted politicians to postpone product market reform.

An increase in elasticity of intertemporal substitution, σ, and/or in wage elasticity of labour demand, ν, leads to marginally more modest responses of key macroeconomic variables and fiscal policy in particular. It also turns out that a more activist fiscal policy would dampen the intertemporal tradeoff.

Finally, it should be noted that product market competition and technological change are not necessarily independent, as suggested by Nicoletti et al. (2001). Positive correlation between these would imply even greater positive responses. Since our experiment does not take into account this interdependence our quantitative estimates of the benefits of product and labour market reforms may be on the conservative side.

Figure 1: Dynamic Responses to Labour and Product Market Reforms



References

Aghion, Philippe, and Peter Howitt (1994) 'Growth and unemployment.' *Review of Economic Studies* 61, 477–494

— (2006) 'Appropriate growth policy.' *Journal of the European Economic Association* 4, 269–314

Aghion, Philippe, Nicholas Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt (2005) 'Competition and innovation: An inverted u relationship.' *Quarterly Journal of Economics* 120(2), 701–728

Altig, David, Lawrence J. Christiano, Martin Eichenbaum, and Jesper Lindé (2005) 'Firm-specific capital, nominal rigidities and the business cycle.' Working Paper 11034, National Bureau of Economic Research, January. available at `http://www.faculty.econ.northwestern.edu/faculty/christiano/research`

Amable, Bruno, and Donatella Gatti (2004) 'Product market competition, job security, and aggregate employment.' *Oxford Economic Papers* 56, 667–686

Bank of Finland (2005) 'Economic outlook.' *Bank of Finland Bulletin* 3, 1–82

Baxter, Marianne, and Dorsey D. Farr (2001) 'Variable factor utilization and international business cycles.' Working Paper 8392, NBER

Bayoumi, Tamim, Douglas Laxton, and Paolo Pesenti (2004a) 'Benefits and spillovers of greater competition in Europe: A macroeconomic assessment.' Working Paper 10416, NBER

Bayoumi, Tamim, Douglas Laxton, Hamid Faruqee, Benjamin Hunt, Philippe Karam, Jaewoo Lee, Alessandro Rebucci, and Ivan Tchakarov (2004b) 'GEM: A new international macroeconomic model.' Occasional Paper 239, IMF

Betts, Caroline, and Michael B. Devereux (1996) 'The exchange rate in a model of pricing-to-market.' *European Economic Review* 40, 1007–1021

— (2000) 'Exchange rate dynamics in a model of pricing-to-market.' *Journal of International Economics* 50, 215–244

Blanchard, Olivier, and Francesco Giavazzi (2003) 'Macroeconomic effects of regulation and deregulation in goods and labour markets.' *Quarterly Journal of Economics*

Blanchard, Olivier J. (1985) 'Debt, deficits and finite horizons.' *Journal of Political Economy* 93(2), 223–247

Bokan, Nikola, and Andrew Hughes Hallett (2006) 'Labour and product market reforms in the economy with distortionary taxation.' Discussion Papers 5431, CEPR, January. available at `http://ideas.repec.org/p/cpr/ceprdp/5431.html`

Calvo, Guillermo A. (1983) 'Staggered prices in a utility-maximizing environment.' *Journal of Monetary Economics* 12, 983–998

Dixit, Avinash, and Joseph Stiglitz (1977) 'Monopolistic competition and optimum product diversity.' *American Economic Review* 67, 297–308

Ebell, M., and C. Haefke (2003) 'Product market deregulation and labor market outcomes.' IZA Discussion Paper 957, University of Bonn

Epstein, Larry G., and Stanley E. Zin (1989) 'Substitution, risk aversion, and the temporal behavior of consumption and asset returns: a theoretical framework.' *Econometrica* 57, 937–969

Erceg, Christopher, Dale Henderson, and Andrew Levin (2000) 'Optimal monetary policy with staggered wage and price contracts.' *Journal of Monetary Economics* 46, 281–313

Farmer, Roger E. (1990) 'Rince preferences.' *Quarterly Journal of Economics* 105, 43–60

Freystätter, Hanna (2003) *Price setting behavior in an open economy and the determination of Finnish foreign trade prices* (Helsinki: Suomen Pankki). Bank of Finland Studies, E:25

Gersbach, Hans (2000) 'Promoting product market competition to reduce unemployment in europe: An alternative approach?' *Kyklos* 53, 117–133

Gertler, Mark (1999) 'Government debt and social security in a life-cycle economy.' *Carnegie-Rochester Conference Series of Public Policy* 50(1), 61–110

Høj, Jens, and Michael Wise (2004) 'Product market competition and economic performance in Finland.' Economics Department Working Paper 413, OECD

IMF (2004) 'Denmark: Selected issues.' Country Report 04/241, International Monetary Fund, Washington, D.C.

Jalava, Jukka, Matti Pohjola, Antti Ripatti, and Jouko Vilmunen (2006) 'Biased technical change and capital-labour substitution in Finland, 1902-2003.' *Topics in Macroeconomics* 6, Article 8. available in `http://www.bepress.com/bejm/topics/vol6/iss1/art8`

Jean, Sébastien, and Guiseppe Nicoletti (2002) 'Product market regulation and wage premia in Europe and North America: An empiricial investigation.' Economics Department Working Paper 318, OECD

Jonsson, Magnus (2007) 'The welfare cost of imperfect competition and distortionary taxation.' *Review of Economic Dynamics* 10, 576–594

Juillard, Michel (2003) 'Dynare: A program for solving rational expectation models.' Dynare manual, CEPREMAP and University Paris 8

Kilponen, Juha, and Torsten Santavirta (2004) 'Competition and innovation – microeconometric evidence using finnish data.' Government Institute for Economic Research (VATT) Research Repor No. 113/2004

Kilponen, Juha, Jaakko Kiander, and Jouko Vilmunen (2004) 'Labor taxation, public finance, and wage determination: Evidence from OECD countries.' *European Journal of Political Economy* 20, 983–999

Martins, Joaquim Oliveira, Stefano Scarpetta, and Dirk Pilat (1996) 'Mark-up pricing, market structure and the business cycle.' Economic Studies 27, OECD

Nicoletti, Giuseppe, Andrea Bassanini, Ekkehard Ernst, Sébastien Jean, Paulo Santiago, and Paul Swaim (2001) 'Product and labour markets interactions in OECD countries.' Economics Department Working Paper 312, OECD

Railavo, Jukka (2004) 'Stability consequences of fiscal policy rules.' Bank of Finland Discussion Papers 1/2004

Ripatti, Antti, and Jouko Vilmunen (2001) 'Declining labour share — evidence of a change in the underlying production technology?' Discussion Paper 10/2001, Suomen Pankki — Bank of Finland

Spector, David (2004) 'Competition and the capital-labor conflict.' *European Economic Review* 48, 25–38

Viitanen, Jari (2002) 'Risk aversion and intertemporal subsitution in aggregate consumption: Finland 1975-2001.' University of Joensuu, Business and Economics Discussion Papers, N:o 3.

Yaari, Menahem E. (1965) 'Uncertain lifetime, life insurance and the theory of consumer.' *Review of Economic Studies* 32, 137–150