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## Labour and product market competition in a small open economy – Simulation results using a DGE model of the Finnish economy

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Juha Kilponen – Antti Ripatti

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Juha Kilponen – Antti Ripatti



## **Labour and product market competition in a small open economy – Simulation results using a DGE model of the Finnish economy**

The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

Aino model is a result of joint project by Juha Kilponen, Mika Kuismanen (ECB), Antti Ripatti and Jouko Vilmunen. We are also indebted to Juha Tarkka for plentiful of intensive discussions and guidance during the various stages of the model development project. We are also indebted to CEPR/ESI 2005 conference participants for many useful suggestions. The usual disclaimer applies. Correspondence to [firstname.lastname@bof.fi](mailto:firstname.lastname@bof.fi) or Bank of Finland, P.O. Box 160, FIN-00101 Helsinki, FINLAND.

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# Labour and product market competition in a small open economy – Simulation results using a DGE model of the Finnish economy

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## Abstract

Using the DGE model of the Finnish Economy (the ‘Aino’ model), we study the response of the economy to reforms in both labour and product markets. The reforms are two-fold. We assume that the wage mark-up, ie the monopoly power of wage-setters is gradually reduced by 5 percentage points. At the same time, the degree of competition is increased, ie price margins are exogenously reduced by 2 percentage points. These reforms imply a very favourable outcome of the economy. Both consumption and employment increases permanently and the reforms are welfare enhancing. Public balances improve giving room for 1.5 percentage point cut in income taxes. Our simulation exercises clearly demonstrate that such reforms may help in financing the future fiscal burden of an ageing population.

Key words: competition, dynamic general equilibrium, public finance

JEL classification numbers: E60, C68

# Työ- ja hyödykemarkkinakilpailun kiristymisen kokonaistaloudelliset vaikutukset pienessä avotaloudessa: simulointituloksia Suomen talouteen sovitetusta dynaamisesta yleisen tasapainon mallista

Suomen Pankin tutkimus  
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Juha Kilponen – Antti Ripatti  
Rahapolitiikka- ja tutkimusosasto

## Tiivistelmä

Tässä tutkimuksessa tarkastellaan Suomen talouden analysointiin rakennetun dynaamisen yleisen tasapainon mallin (Aino-mallin) avulla, miten kilpailun lisääntyminen työ- ja hyödykemarkkinoilla vaikuttaa talouteen ja erityisesti julkisen talouden tasapainoon. Tutkimuksessa oletetaan, että palkkamarginaalit supistuvat vähitellen 5 prosenttiyksikköä ja että hintamarginaalit kutistuvat 2 prosenttiyksikköä. Tämä johtaa taloudenpitäjien hyvinvoinnin kannalta suotuisaan lopputulokseen: sekä kulutus, reaali-palkat että työllisyys kasvavat. Julkisen talouden tasapaino paranee siten, että tuloveroa ja eläkemaksuja voidaan pienentää yhteensä noin 1,5 prosenttiyksikköä. Tutkimus osoittaa, että talouden kilpailullisuutta tukevat rakenteelliset reformit helpottaisivat osaltaan väestön ikääntymisen aiheuttamaa lisääntyvää julkisen talouden rasiitetta.

Avainsanat: kilpailu, dynaamiset yleisen tasapainon mallit, finanssipolitiikka

JEL-luokittelu: E60, C68

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# 1 Introduction

The future challenges in the Finnish economy are closely connected with fiscal policy, demographic ageing, changes in production technology, as well as globalisation which puts pressure both on the product and labour markets. In this paper, we concentrate on analysing product and labour market reforms and their simulated effects on the aggregate behavior of the Finnish economy. In particular, we examine how an increase in competition in the two markets affects various macroeconomic variables and public finances when the full general equilibrium features are accounted for. In preparing quantitative results we use the recently build DGE model of the Finnish economy called *Aino*. Similar exercise for aggregated Europe has been done by Bayoumi, Laxton and Pesenti (2004a) and applied to Danish economy by IMF (2004) using a model variant of Global Economic Model (GEM), build at the International Monetary Fund (Bayoumi, Laxton, Faruqee, Hunt, Karam, Lee, Rebucci and Tchakarov 2004b). Their results are qualitatively similar to ours. However, some differences arise from the fact that unlike the GEM model, the *Aino* model has distortionary taxes and consumers are essentially non-Ricardian. Moreover, *Aino* 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 each structurally similar economies. Finally, we interpret the reforms as specific to Finland so that the monetary policy reactions of the two reforms are not considered.

*Aino* depicts the Finnish economy as a dynamically optimizing small open economy which trades with rest of the world and has internationally given real interest rate. The 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. The model contains exogenously determined mark-up in the domestic goods markets as well as labour markets. The first mark-up is given by the time-varying elasticity of substitution of different product brands and it can vary temporarily due to Calvo-type price rigidities. Similar structure holds for the labour markets as well.

Households' saving decisions, and thus accumulation of financial assets, are influenced by households' desire to smooth consumption over time. Individuals are expected to have finite lives which consist of two distinct periods. We label the households living in these two different periods as 'workers' and 'retirees', as in Gertler (1999). Workers and retirees differ essentially in terms of their effective planning horizons, marginal propensity to consume, as well as in terms of marginal productivity of labour. There are inter-generational transfers between workers and retirees, which are however kept constant throughout the simulations in this paper. The same applies to all other public transfers in the model. Finally, the public deficit is closed by an income tax rule, which reacts to public deficit as well as deviation of public debt from some prespecified target.

Simulation results suggest that reforms that increase competition both in the product and labour markets are welfare enhancing, as increasing competition leads to increased consumption, investments, employment and production potential of the economy in the long-run. However, increasing competition is associated with initial decline in private consumption and a slight drop in labour effort. This is due to the wealth effect caused by the temporary reduction in profits, as well as temporary

increase in the real interest rate caused by the slow down of expected domestic inflation. Public sector finances are also improved, in the sense that the public sector balance is now reached at lower tax rate. Our standard simulation suggest that two and five percentage point decline in the price and wage mark-up respectively allows roughly a 1.5 percentage point drop in the wage income tax rate. The sensitivity analysis shows that the results appear most sensitive to changes in elasticity of substitution between consumption and leisure. This is the critical parameter affecting the (Frisch) elasticity of labour supply.

Rest of the paper is organised as follows. Sections 2–7 set up the model. Section 8.1 presents the simulation experiment in detail and discusses the results. The final section concludes.

## 2 Consumers

### 2.1 General features

In Aino, in the spirit of general equilibrium theory, consumers make optimal decisions on consumption and labour supply. The theory does not describe any particular household, but only what happens on average. As is typical in modern macroeconomic models, consumers in Aino model seek to hold their life-cycle consumption as stable as possible. Consumers are viewed as being free from periodic credit constraints, and so households can smooth consumption against stochastic sources of risk. Consumption decisions depend on household's discounted wealth over the lifespan, ie, in addition to financial assets, on the expected present value of future labour income and income transfers. This permanent income feature of households' consumption behaviour loosens the relationship between consumption and current income. Transitory changes in income will have only a small effect on their current consumption, whereas more persistent and, in the limit, permanent changes in income will change current consumption by a sizable amount.

Individuals' finite life-cycles consist of two distinct periods, "active working age" and "retirement period", as in Gertler (1999). Consumption and labour supply decision of individuals are affected by the future prospect of their retirement, as well as the fact that labour efficiency is assumed to fall in retirement. In particular, the likelihood that the worker may lose part of his labour income due to retirement, induces her to discount the future income stream at higher rate than otherwise. This reduces consumption and increases saving. In this sense, active working age population saves for retirement. Similarly, finite expected lifetime makes the worker value the future less relative to present, as compared to infinite horizon representative agent case. Retirees, on the other hand, discount future more heavily than active working age individuals due to the constant periodic probability of death. Therefore, in the model, pensioners' propensity to consume out of wealth is greater than that of the active working-age population.

Under these assumptions, increased public consumption, financed *eg* by central government debt, will stimulate the economy in the short term. Consumers will take into account the higher future taxes that will result from increased public consumption by increasing their savings in the medium term. The short-term expansionary effect of an increase in public expenditure depends critically on households' saving propensity. The stronger household saving responds to changes in real interest rates,

the weaker will the expansionary effect of fiscal policy be.

Moreover, higher income transfers to retirees boosts consumer demand, because the retired are more ready to consume than the working-age population. However, this has direct implications for labour supply, particularly when increases in social security expenditure are financed by higher taxes. Increasing social security expenditure makes pensioners better off, but the long-term effect is to slow capital formation and hence weaken the economy's production potential.

In addition to these basic features of Gertler's (1999) model few extensions have been made. First, we allow for distortionary taxes. Second, the labour markets are monopolistic and there are nominal rigidities that arise from Calvo type wage contracts. Third, individuals receive transfers from both the public sector (the state) as well as from pension funds. In modelling transfers, we have followed the general features of the transfers system in national accounts. Finally, Aino model's supply side is rich and based on CES-production technology with factor augmentation in the underlying technological progress. In Gertler (1999), the model is closed assuming competitive markets and Cobb-Douglas technology.

## 2.2 Population dynamics

Consumers are assumed to be borne 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  $\omega$ , while the probability of retiring is  $1 - \omega$ . These transition probabilities are independent on individuals' employment tenure, so that the average tenure of active working age is  $\frac{1}{1-\omega}$ . Once individual has retired she is facing a constant periodic probability of death ( $1-\gamma$ ). Also, given that the survival probability ( $\gamma$ ) is assumed to be independent of retirement tenure, the average retirement period is  $\frac{1}{1-\gamma}$ . Regarding population dynamics, it is assumed that in each period  $(\hat{N}_t - \omega)N_t$  new active working age individuals are born, so that working age population grows at the rate gross growth rate of  $\hat{N}_t$ . Given constant probabilities of retirement and death and that cohorts are large, retiree population ( $N_t^r$ ) then evolves according to

$$N_{t+1}^r = (1 - \omega)N_t + \gamma N_t^r \quad (2.1)$$

Ater some manipulations, it can be shown that ratio of retirees to whole population evolves according to

$$\varphi_t \equiv \frac{N_t^r}{N_t} = \frac{1 - \omega}{\hat{N}_t} + \gamma \frac{\varphi_{t-1}}{\hat{N}_t}, \quad (2.2)$$

where  $\hat{N}_t \equiv N_t/N_{t-1}$ . In the steady state, where  $\hat{N}_t = \hat{N}$ , and  $\varphi_t = \varphi$ , this ratio becomes

$$\varphi = \frac{1 - \omega}{\hat{N} - \gamma}. \quad (2.3)$$

In the steady state, active working age population and the retirees grow at the aggregate population growth rate  $\hat{N}$ . Although we can allow for time-varying demographic structure in general, we keep demographic structure unchanged in the following simulations. Thus, in what follows, we assume that  $\hat{N}_t = \hat{N}$  and therefore  $\varphi_t = \varphi$ .

## 2.3 Preferences

Stochastic intertemporal decision problems are often solved recursively by constructing a sequence of value functions and decision rules. In order to obtain closed form decision rules, one needs to restrict attention to linear forms of value functions and specific type of uncertainty. Perhaps the most exploited case is the one where the agents face random interest rates (multiplicative uncertainty) but no uncertainty regarding endowments (additive uncertainty). Under these assumptions, agents preferences admit non-linearity across time and states of nature. In many situations, however, agents not only face uncertainty regarding, say, interest rate fluctuations, but also regarding endowments. In the framework of Von-Neumann and Morgenstern (VNM) utility theory, the general case of random interest rates with random endowments does not admit a closed-form solution, unless the agents preferences are linear across the states of nature as well as through time. However, relaxing VNM axiom that agents are indifferent to the timing of the resolution of uncertainty, a much broader class of intertemporal stochastic decision rules can be obtained.<sup>1</sup>

One interesting class of preferences is called recursive preferences, originally introduced by Epstein and Zin (1989). This class of preferences allows intertemporal elasticity of substitution and relative of risk aversion to be represented by two different parameters<sup>2</sup>. In the conventional time-additive and time-separable von Neuman Morgensterns expected utility preferences, coefficient of relative risk aversion is the reciprocal of the elasticity of intertemporal substitution. Risk aversion describes, say, consumers reluctance to substitute consumption across states of the world, where as the elasticity of intertemporal substitution describes consumers willingness to substitute consumption across time. There is no particular reason why these two should be connected to each other (see for instance Hall (1988)).

One popular parametric example of recursive preferences consists of a constant elasticity aggregator<sup>3</sup>:

$$V_t = [\{u(C_t, \cdot)\}^{\rho_c} + \beta \{E_t(V_{t+1})^\mu\}^{\frac{\rho_c}{\mu}}]^{\frac{1}{\rho_c}} \quad (2.4)$$

$u(C_t, \cdot)$  denotes instant utility over consumption (and possibly over leisure),  $V_t$  is the value function and  $\beta$  gives subjective time preference. The parameter  $\rho_c < 1$  captures intertemporal substitution and parameter  $\mu \leq 1$  the decision maker's attitude toward risk. Commonly  $1 - \mu$  is referred to as the coefficient of relative risk aversion. This parameter determines how the decision maker divides her current wealth across available financial assets at any point of time. The special case of  $\mu = 1$  corresponds to a type of risk neutrality, where the agents are indifferent regarding risk, but still maintaining a non-trivial preference for the time at which consumption occurs (cf. Farmer (1990)).<sup>4</sup> This special case is analytically tractable, since it generates linear decision rules even with (idiosyncratic) risk to income, asset return and length of life. This is what we now assume.

<sup>1</sup>For details, see for instance Kreps and Porteus (1978)

<sup>2</sup>In general, recursive preferences are defined in the nonstochastic environment by the assumption that, say, consumption ranking over future decisions is independent of the ranking over consumption bundles. These preferences can also capture the behavior where individuals prefer either early, or late resolution of uncertainty (for details, see for instance Weil (1990) and Farmer (1990)).

<sup>3</sup>Vitonen (2002) has estimated the parameters of relative risk aversion and elasticity of intertemporal substitution using this type of utility functions for Finland.

<sup>4</sup>Since  $\rho_c$  is bounded above by 1, it follows that the risk-neutral decision maker prefer late resolution of uncertainty (for details see Kreps and Porteus (1978)).

As a result, special class of recursive preferences applied in the *Aino* model can be summarised as follows:

$$V_t^z = \left\{ [(C_t^z)^v (1 - l_t^z)^{1-v}]^{\rho_c} + \beta^z [E_t(V_{t+1}|i)]^{\rho_c} \right\}^{\frac{1}{\rho_c}} \quad (2.5)$$

where

$$E_t(V_{t+1}|w) = \omega V_{t+1}^w + (1 - \omega) V_{t+1}^r, \quad \beta^w = \beta \quad (2.6)$$

$$E_t(V_{t+1}|r) = V_{t+1}^r, \quad \beta^r = \beta\gamma. \quad (2.7)$$

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

In the current setup of the model, perfect annuities market are introduced in order to eliminate the impact of uncertainty about time of death: Remaining wealth that retirees hold at the time of death are invested in a mutual fund which in turn invests them in available financial assets at each period of time. Those surviving to the following period receive a return that is proportional to their contribution to the fund. For instance, if  $R_t$  is the gross return per unit invested by the fund, the gross return for a surviving retirees is  $R_t/\gamma$  at time  $t$ . An active working age individual, in turn, faces a potential risk of a decline in wage income. However, given individual's preferences only expected future income, affects consumption. A worker thus forms a certainty equivalent of his random utility as shown in equation (2.6).

## 2.4 Consumption

Both retirees and active working age individuals consume and save out of income derived from financial assets, labour and transfers received from the public sector. Given specific assumptions regarding preferences, population dynamics and constant per period probabilities of retirement and death, there is no need to keep track how assets and consumption are distributed among the retirees and active working age population. Yet, since marginal propensities to consume out of wealth differ between the two groups, we must keep track of the asset distribution between retirees and active working age population. Aggregate private consumption, which is the sum of consumption of active working age individuals and retirees will depend on the evolution of this distribution.

### 2.4.1 Assets

There are different financial assets available for consumers : domestic bonds ( $A_t^S$  and  $A_t^P$ ), issued by the public sector, foreign bonds  $A_t^W$  and stocks issued by the domestic firms  $A_t^F$ . The domestic one period bonds pay a nominal gross return  $1 + r_t$ , while the gross return on stocks is determined according to the profits of the firms in the model<sup>5</sup>. Foreign bonds pay a gross return of  $1 + r_t^F$ . There is an exogenously

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<sup>5</sup>See section 6 for details.

determined risk-premium between domestic bonds and stocks issued by the domestic firms. Thus, the gross nominal return on asset holdings of population group  $Z$ ,  $Z = w, r$ , is defined as

$$(1 + r_t) A_t^Z \equiv (1 + (1 - \mathbf{t}_t^S) r_t^{SR})(A_t^{ZS} + A_t^{ZP}) + (1 + r_t^D) A_t^{ZF} + (1 + r_t^F) S_t A_t^{ZW} \quad (2.8)$$

where  $S_t$  is nominal exchange rate,  $r_t^S$  denotes short-term nominal interest rate and  $r_t^F$  denotes corresponding foreign short term interest rate.  $\mathbf{t}_t^S$  denotes tax rate at source. The share price is the nominal price (ex-dividend) of a unit of equity in period  $t$ . The factor defining the gross return of stocks is the profits of the firms  $\Pi_t^D$  in the model. This gross return is determined as follows

$$1 + r_t^D = [A_{t+1}^F + (1 - \mathbf{t}_t^K) \Pi_t^D] / A_t^F \quad (2.9)$$

where  $\mathbf{t}_t^K$  denotes corporate tax rate.

Profits, in turn are given as

$$\begin{aligned} \Pi_t^D &= P_t Y_t - W_t^F L_t - R_t K_t \text{ (intermediate goods producers)} \\ &+ R_t K_t - P_t^I I_t \text{ (capital rental firm)} \\ &+ P_t^X X_t - P_t^{MR} M_t^R - P_t^X Y_t^X \text{ (exporter)} \\ &+ (1 - \mathbf{t}_t^C) P_t^C C_t^T - P_t^{MC} M_t^C - P_t Y_t^C \text{ (consumption goods retailer)} \\ &+ P_t^I I_t^T - P_t^{MI} M_t^I - P_t Y_t^I \text{ (Capital goods retailer)} \end{aligned} \quad (2.10)$$

This generates an important wealth channel in the model, making consumption and labour supply react directly to changes in the firms profits and profit margins.

#### 2.4.2 Consumption of retirees

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

$$\begin{aligned} &A_{t+1}^{rSj} + A_{t+1}^{rPj} + S_{t+1} A_{t+1}^{rWj} + A_{t+2}^{rFj} \\ &= [R_t^S (A_t^{rSj} + A_t^{rPj}) + R_t^F S_{t+1} A_t^{rWj} + R_t^D A_{t+1}^{rFj}] / \gamma \\ &+ W_t (1 - \mathbf{t}_t^{RS}) \xi l_t^{rj} + \mathcal{T}_t^{rjk} - P_t^C C_t^{rj} \end{aligned} \quad (2.11)$$

where  $R_t^h$  denotes after tax gross rate of return of corresponding asset:

$$\begin{aligned} R_t^S &\equiv 1 + (1 - \mathbf{t}_t^S) r_t^S \\ R_t^F &= (1 + r_t^F) \\ R_t^D &= 1 + r_t^D \end{aligned} \quad (2.12)$$

A retiree chooses consumption and asset accumulation by maximising (2.5) subject to (2.11).  $\mathcal{T}_t^{rjk}$  denotes nominal transfers (such as pensions) of an individual born at time  $j$  who retired in period  $k$ .<sup>6</sup> In the current setup of the model these transfers are independent of retirees' age or income ie  $\mathcal{T}_t^{rjk} = \mathcal{T}^{rk}$ . Finally,  $\xi$  measures efficiency of retirees relative to workers, common to all retirees. The retirees maximisation

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<sup>6</sup>Effectively in the model we separate between taxable and non taxable transfers. Moreover transfers are distributed by the government or by the pension funds.

problem can be turned into dynamic programming problem, where consumption-saving decision is separable from the portfolio optimisation<sup>7</sup>. Consequently, in order to find optimal consumption path, we re-express the budget constraint as

$$A_{t+1}^{rhjk} = (R_t/\gamma) A_t^{rhjk} + (1 - \tau_t^{RS}) W_t \xi L_t^{rjk} + \mathcal{T}_t^{rk} - P_t^C C_t^{rjk} \quad (2.13)$$

where

$$R_t = \sum_{h=1}^J w_{h,t-1}^{rjk} R_t^h, \quad \sum_{h=1}^J w_{h,t-1}^{rjk} = 1, \quad h = P, F, W$$

The weights of single assets  $w_{h,t-1}^{rjk}$  are chosen optimally before the realisation of the state of the nature at period  $t$ . The underlying households' maximisation problem then yields fairly standard first order conditions for consumption, labour and asset demands. Furthermore, aggregation can be done simply summing over the retirees since the decision rules are linear and there is no heterogeneity among the retirees.

First, under the assumption of perfect annuity markets and above constraints it can be shown that the consumption function for retirees is given by

$$P_t^C C_t^r = \epsilon_t \pi_t [R_t A_t^r + \mathcal{H}_t^r + \mathcal{S}_t^r] \quad (2.14)$$

where  $\mathcal{H}_t^r$  and  $\mathcal{S}_t^r$  denote discounted after tax values of labour income and transfers:

$$\mathcal{H}_t^r = (1 - \tau_t^{RS}) W_t \xi L_t^r + \frac{\mathcal{H}_{t+1}^r}{\hat{N} R_{t+1} / \gamma} \quad (2.15)$$

$$\mathcal{S}_t^r = \mathcal{T}_t^r + \frac{\mathcal{T}_{t+1}^r}{\hat{N} R_{t+1} / \gamma}. \quad (2.16)$$

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 labour income is similarly discounted.

$\epsilon_t \pi_t$  in (2.14) is the retirees' marginal propensity to consume out of wealth and it evolves according to following non-linear difference equation:

$$\epsilon_t \pi_t = 1 - \left( \frac{W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \frac{(1 - \tau_t^{RS})}{(1 - \tau_{t+1}^{RS})} \right)^{\frac{(1-v)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho_c}} \left( \frac{R_{t+1}}{\hat{P}_{t+1}^c} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\epsilon_t \pi_t \gamma}{\epsilon_{t+1} \pi_{t+1}} \quad (2.17)$$

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 expected changes in real net wage income. As in standard Yaari (1965) and Blanchard (1985) models, likelihood of death  $(1 - \gamma)$  in (2.17) raises the retirees' marginal propensity to consume. This can be seen easily by considering a case of logarithmic preferences, where  $\sigma \rightarrow 1$ . In this case

$$\epsilon \pi = 1 - \beta \gamma \quad (2.18)$$

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<sup>7</sup>This is due to the fact that time and risk aggregators are linear homogenous.



Optimal consumption plan given by equations 2.14–2.17, can then be combined with optimisation of the portfolio weights  $w_{h,t-1}$ . Taking the first order conditions of the corresponding Euler equations with respect to portfolio weights gives us

$$\left( \frac{W_t/P_t^c}{W_{t+1}/P_{t+1}^c} \frac{(1 - \mathfrak{t}_t^{RS})}{(1 - \mathfrak{t}_{t+1}^{RS})} \right)^{\frac{(1-\nu)\rho_c}{1-\rho_c}} \left( \frac{R_{t+1}}{\hat{P}_{t+1}^c} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{R_{t+1}^h}{\hat{P}_{t+1}^c} \frac{C_{t+1}^r}{C_t^r} = \phi \quad (h = 1, \dots, J) \quad (2.19)$$

where  $\phi$  is the Lagrange multiplier for the sum of the portfolio weights. In the deterministic version of the model, eq (2.19) implies that

$$r_t = \frac{r_t^D}{(1 - \tau_t^S)} \quad (2.20)$$

$$1 + r_t^S = (1 + r_t^F) \frac{S_{t+1}}{S_t} \quad (2.21)$$

where the latter is the standard UIP condition.

### 2.4.3 Consumption of workers

As regards to workers, a budget constraint of active working age population, born at time  $s$ , is given by

$$A_{t+1}^{whs} = R_t A_t^{whs} + (1 - \mathfrak{t}_t^{WS} - \mathfrak{t}_t^{WP}) W_t L_t^{ws} + \mathcal{T}_t^{ws} - P_t^C C_t^{ws} \quad (2.22)$$

and where  $\mathcal{T}_t^{ws}$  denotes net financial transfers to the workers. As in the case of retirees, we assume that these transfers are independent on workers age. A worker chooses consumption, labour supply and asset accumulation by maximising (2.5) subject to (2.22) 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 the the consumption plan of active working age individuals can be aggregated into

$$P_t^C C_t^w = \pi_t (R_t A_t^w + \mathcal{H}_t^w + \mathcal{S}_t^w) \quad (2.23)$$

$\pi_t$  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 correspondingly.

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

$$\pi_t = 1 - \left( \frac{(1 - \mathfrak{t}_t^{WS} - \mathfrak{t}_t^{WP}) W_t / P_t^c}{W_{t+1} / P_{t+1}^c} \right)^{\frac{(1-\nu)\rho_c}{1-\rho_c}} \beta^{\frac{1}{1-\rho}} \left( \frac{\Omega_{t+1} R_{t+1}}{\hat{P}_{t+1}^c} \right)^{\frac{\rho_c}{1-\rho_c}} \frac{\pi_t}{\pi_{t+1}} \quad (2.24)$$

where  $\mathfrak{t}_t^{WS}$  is the statutory tax rate on wage income,  $\mathfrak{t}_t^{WP}$  the pension contribution rate and the factor  $\Omega_{t+1}$  that weights the gross real return  $R_{t+1} / \hat{P}_{t+1}^c$ . It evolves according to

$$\Omega_{t+1} = \omega \left( \frac{1}{(1 - \mathfrak{t}_{t+1}^{WS} - \mathfrak{t}_{t+1}^{WP})} \right)^{1-\nu} + (1 - \omega_t) \epsilon_{t+1}^{-\frac{1-\rho_c}{\rho_c}} \left( \frac{1}{\xi (1 - \mathfrak{t}_{t+1}^{RS})} \right)^{1-\nu} \quad (2.25)$$

where  $\mathfrak{t}_{t+1}^{RS}$  is statutory tax rate paid by the retirees and  $\epsilon_{t+1} > 1$  is the ratio of marginal propensity to consume of the retirees to that of the active working age individuals.

$\mathcal{H}_t^w$  in (2.23) 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 capitalised value of social security. Both of these measures take into account corresponding discounted values at the time of retirement. Formally,

$$\mathcal{H}_t^w = \frac{\omega \left( \frac{1}{(1-\mathfrak{t}_{t+1}^{WS}-\mathfrak{t}_{t+1}^{WP})} \right)^{1-v} \mathcal{H}_{t+1}^w}{R_{t+1}\Omega_{t+1}\hat{N}} + \frac{(1-\omega)(\epsilon_{t+1})^{1-\frac{1}{\rho_c}} \left( \frac{1}{\xi(1-\mathfrak{t}_{t+1}^{RS})} \right)^{1-v} \varphi^{-1} \mathcal{H}_{t+1}^{r(t+1)}}{R_{t+1}\Omega_{t+1}\hat{N}} + (1-\mathfrak{t}_t^{WS}-\mathfrak{t}_t^{WP})W_tL_t^w \quad (2.26)$$

$$\mathcal{S}_t^w = \mathcal{T}_t^w + \frac{\omega \left( \frac{1}{(1-\mathfrak{t}_{t+1}^{WS}-\mathfrak{t}_{t+1}^{WP})} \right)^{1-v} \mathcal{S}_{t+1}^w}{R_{t+1}\Omega_{t+1}\hat{N}} + \frac{(1-\omega)(\epsilon_{t+1})^{1-\frac{1}{\rho_c}} \left( \frac{1}{\xi(1-\mathfrak{t}_{t+1}^{RS})} \right)^{1-v} \varphi^{-1} \mathcal{S}_{t+1}^{r(t+1)}}{R_{t+1}\Omega_{t+1}\hat{N}} \quad (2.27)$$

$\mathcal{H}_{t+1}^{r(t+1)}$  measures the aggregate value of human wealth for the working retiree who retired at time  $t+1$ , but was still working at time  $t$ . Similarly,  $\mathcal{S}_{t+1}^{r(t+1)}$  measures a value of total social security for the 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 (2.26)–(2.27) shows how workers discount future income streams at a higher rate than at which the government can borrow,  $R_t$ . This in turn has a tendency to reduce working age individual's consumption and increase saving.  $\Omega_{t+1}$  varies positively with the marginal propensity to consume of retirees relative to active working age individuals. It depends positively also on the retirement probability and tax rates. This can be seen most easily by looking at the steady state value of  $\Omega$  in the special case where retirees and active working age individuals face the same tax rate  $\mathfrak{t}$ . Then,

$$\Omega = \left( \frac{1}{\xi(1-\mathfrak{t})} \right)^{1-v} [\omega + (1-\omega)\epsilon^{\frac{1}{1-\sigma}}] \quad (2.28)$$

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

$$\pi_t = 1 - \beta \quad (2.29)$$

#### 2.4.4 Distribution of wealth and aggregate consumption

Working age and retirees different marginal propensities to consume are reflected in the rate at which the two groups accumulate financial assets. As these assets are accumulated in 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  $\lambda_{t+1}^f \equiv \frac{A_{t+1}^r}{A_{t+1}^w}$  be

the share of financial assets held by the retirees and  $1 - \lambda_{t+1}^f \equiv \frac{A_{t+1}^w}{A_{t+1}}$  be the share of financial assets held by the working age individuals. After some tedious algebra it can be shown that the retirees' share of financial wealth evolves according to<sup>8</sup>

$$\begin{aligned} \lambda_{t+1}^f / \omega &= \lambda_t^f \left(1 - \frac{\epsilon_t \pi_t}{\nu}\right) R_t A_t / A_{t+1} \\ &+ \frac{(1 - \tau_t^{RS}) \xi W_t N_t^r + \mathcal{T}_t^r - \frac{\epsilon_t \pi_t}{\nu} (\mathcal{S}_t^r + \mathcal{H}_t^r)}{A_{t+1}} + \frac{(1 - \omega)}{\omega} \end{aligned} \quad (2.33)$$

Finally, aggregate consumption is obtained simply by summing up (2.14) and (2.23), using  $\lambda_{t+1}^f \equiv \frac{A_{t+1}^r}{A_{t+1}}$  and remembering that all the assets are eventually held by the domestic consumers:

$$C_t = \pi_t \left( \left[ (1 - \lambda_t^f) R_t A_t + \mathcal{H}_t^w + \mathcal{S}_t^w \right] + \epsilon_t [\lambda_t^f R_t A_t + \mathcal{H}_t^r + \mathcal{S}_t^r] \right) \quad (2.34)$$

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

### 3 Aggregate labour markets

In Aino, 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 at active working age may participate in the labour markets, yet retirees are less productive than active working age individuals. In addition, the labour market is imperfectly competitive due to the wage setting power of the active working age population<sup>9</sup>. Workers' pricing power in the labour markets mean that real wages will settle in the long-run at a

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<sup>8</sup>To see this, notice that retirees total assets evolve according to

$$A_{t+1}^r = R_t A_t^r + (1 - \tau_t^{RS}) W_t \xi L_t^r + \mathcal{T}_t^r - P_t^c C_t^r + (1 - \omega) A_{t+1|t}^w \quad (2.30)$$

where  $A_{t+1|t}^w$  denotes financial wealth accumulated by period  $t$  workers for period  $t + 1$ :

$$A_{t+1|t}^w \equiv R_t A_t^w + (1 - \tau_t^{WS} - \tau_t^{WP}) W_t L_t^w + \mathcal{T}_t^W - P_t^c C_t^w \quad (2.31)$$

A fraction of  $(1 - \omega)$  of this accumulated wealth qualifies as retirees' wealth, since this is a fraction of active working age population that retires at the end of period  $t$ . The rest,  $\omega$  of this financial wealth is held by the young workers from period  $t$  to  $t + 1$ . Consequently, total financial assets of active working age individuals evolve according to

$$A_{t+1}^w = \omega [R_t A_t^w + (1 - \tau_t^{WS} - \tau_t^{WP}) W_t L_t^w + \mathcal{T}_t^W - P_t^c C_t^w] \quad (2.32)$$

<sup>9</sup>We assume that workers supply differentiated types of labour to the production sites, but their decisions are independent on specific labour and wage conditions at different locations.

level above the competitive equilibrium. Moreover, in the short term, real wages can depart from optimal level, due to the slow adjustment of nominal wages, reflecting the long duration and over-lapping nature of wage contracts. Following the now standard approach in the literature it is assumed that only a fraction of randomly chosen workers can re-set their wages in each period. This fraction is determined by exogenously given probability  $q$  of being able to re-optimize the wage in each period. For those not being able to optimize in period  $t$ , the wage is mechanically adjusted using the steady state growth rate of wages. This steady state growth rate is denoted by  $w\bar{g}$ .

More formally, the behavior of aggregate nominal wages is characterised by the following two equations<sup>10</sup>

$$W_t^* = \frac{(1-v)P_t^c C_t^w / (1 - \tau_t^{WS} - \tau_t^{WP})}{v\rho_L[(1-\varphi)N_t - L_t^w]} \quad (3.1)$$

$$W_t = \frac{(1-q)\beta w\bar{g}}{(1+\beta(1-q)^2 w\bar{g}^2)} E_t W_{t+1} + \frac{(1-q)w\bar{g}}{(1+\beta(1-q)^2 w\bar{g}^2)} W_{t-1} \quad (3.2)$$

$$+ \frac{q(1-(1-q)\beta w\bar{g}^2)}{(1+\beta(1-q)^2 w\bar{g}^2)} W_t^* \quad (3.3)$$

where  $C_t^w$  is consumption of active working age population and  $P_t^c$  is consumer price index, to be determined later on,  $\rho_L$  is inverse of wage mark-up,  $N_t$  is population and  $L_t^w$  denotes labour demand for active working age individuals.  $\tau_t^{WS}$  denotes labour income tax rate of the working age population and  $\tau_t^{WP}$  denotes the pension contribution rate.  $W_t^*$  denotes the optimal wage rate for the workers. Optimal wage  $W_t^*$  is directly derived from the aggregate version of an active working-age individual's labour supply decision, and taking into account individual labour demand constraint (3.6).

Given that active working age individuals and retirees have different marginal productivities, we define aggregate effective labour supply index  $L_t$  as

$$L_t = L_t^w + \xi L_t^r \quad (3.4)$$

Here  $\xi \in (0, 1)$  denotes the relative efficiency of a unit of retirees' labour. Labour demand for active working age population  $L_t^w$  is derived from (3.4) by assuming that retirees are always on their labour supply curve at prevailing wage ( $W$ ), and that the domestic intermediate goods producer<sup>11</sup> is always on its labour demand curve<sup>12</sup>.

<sup>10</sup>It is worth noticing that we assume that there exists state contingent securities that allow equilibrium consumption and asset holdings be equal among workers, despite of heterogenous wages and labour supply.

<sup>11</sup>See section 6 for details.

<sup>12</sup>Each intermediate goods firm uses CES combination of differentiated types of labour. Aggregate demand for young workers is given by

$$L_t^w = \left[ \int_0^A L_t^w(j)^{-\rho_L} dj \right]^{-\frac{1}{\rho_L}} \quad (3.5)$$

where  $L_t^w(j)$  denotes the demand of type  $j$  worker. Cost minimisation in the intermediate goods producing sector implies that the demand of worker type  $j$  depends upon relative wage and aggregate labour demand index as follows:

$$L_t^w(j) = \left( \frac{W_t(j)}{W_t} \right)^{-\eta} L_t^w \quad (3.6)$$

Retirees labour supply is determined by corresponding first order condition, written as

$$L_t^r = \varphi N_t - \frac{\frac{(1-v)}{v} P_t^c C_t^r}{\xi W_t (1 - \tau_t^{RS})} \quad (3.7)$$

$C_t^r$  denotes retirees' consumption and  $\varphi$  is the (constant) fraction of retired population as in (2.2). In solving the steady state version of the model, the labour demand/supply indices presented above are made stationary by scaling them with  $N_t$ , while wages are scaled by labour augmenting technical change  $\Lambda_t^L$  and *numeraire* price level  $P_t$ , to be determined later on.

## 4 Public sector, pension fund and fiscal rules

The general government (public sector) is divided into two sectors, state (central government) and pension funds. The state collects taxes from labour income at rate  $\tau_t^{WS}$ ,  $\tau_t^{RS}$ , capital gains at rate  $\tau_t^{FS}$  and consumption at rate  $\tau_t^C$ . State consumption  $C_t^S$  has two components, market goods  $C_t^{SF}$  which are provided by the consumption goods retailer, and non-market goods  $Y_t^S$  which, on the other hand, are produced by the public sector itself, using a simple linear production technology

$$Y_t^S = \Lambda_t^S L_t^S \quad (4.1)$$

where  $\Lambda_t^S$  is technology factor.

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

$$\begin{aligned} & - (A_t^S - A_{t-1}^S) \text{ (net lending)} \\ & = \tau_t^{WS} W_t L_t^w + \tau_t^{RS} \xi W_t L_t^r \text{ (income tax revenues)} \\ & + \tau_t^S r_t (A_{t-1}^S + A_{t-1}^P) \text{ (tax at source)} \\ & + \tau_t^K \Pi_t \text{ (corporate income tax revenues)} \\ & + \tau_t^C P_t^C C_t^F \text{ (indirect taxes)} \\ & + \tau_t^{FS} W_t L_t \text{ (firms' social security contributions)} \\ & + P_t^O Y_t^G - W_t^F \xi_t^S L_t^S \text{ (profits from the public sector company)} \\ & - P_t^C C_t^{SF} - P_t^O Y_t^S \text{ (government consumption)} \\ & - P_t^I I_t^S \text{ (government investment)} \\ & - \mathcal{T}_t \text{ (total net transfers)} \\ & - r_t A_{t-1}^S \text{ (interest payments)} \end{aligned} \quad (4.2)$$

Public sector revenues must be in harmony with expenditure from public consumption and investment, income transfers and interest expenditure on public debt. This is

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where  $\eta = 1/(1 + \rho_L)$  is elasticity of substitution among differentiated labour inputs.  $W_t(j)$  denotes wage paid to worker type  $j$  and the wage index  $W$  is defined as

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

ensured in the model by the use of a fiscal policy rule. This sets the labour income tax rate so as to ensure that the long-term budget constraint is satisfied. The fiscal policy rule largely determines how quickly and how strongly, tax rates respond to changes in public sector deficits and indebtedness. Thus adjustment is typically assumed to be slow. Formally the fiscal policy rule is written in the following format:

$$\Delta \mathbf{t}_t^{WS} = \kappa[(A_t^S - A_{t-1}^S)/Y_t - \bar{A}^s(1 - 1/\hat{Y}_t)] \quad (4.3)$$

where  $\hat{Y}_t \equiv \frac{Y_t}{Y_{t-1}}$  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 and  $\bar{A}^s$  is an exogenous target for the central government debt ratio,  $\kappa$  is the fiscal rule adjustment parameter which controls the size of the adjustment of the labour income tax rate to deviations of public debt from its long-term target. In principle, the higher the value of  $\kappa$ , the more concerned the state is on balancing its budget<sup>13</sup>.

## 4.1 Statutory pension funds

The pension scheme in Finland is defined benefit in the sense that pensions paid are not directly dependent on contributions workers have made to employment pension schemes or/and the yield of pension funds. The contribution rates have been adjusted in response to possible shortfalls in the pension fund's balance. Nearly all old age pensions are provided by employment pension institutions or national pension institutions closely controlled by the state. Approximately 20 per cent of the Finnish statutory pension system is funded. Otherwise it functions as a decentralised pay-as-you-go (PAYG) system<sup>14</sup>.

The fact that the pension scheme is defined benefit and partly funded, motives to consider the pension funds separately from the central government and model 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 thus assume that the fund collects pension contributions from the private sector – from companies and employees, consumes  $C_t^P$  and invests  $I_t^P$  in each period, as well as distributes pensions to the retirees  $\mathcal{T}_t^{PR}$ . It also receives small transfers  $\mathcal{T}_t^{SP}$  from the state. Each pension fund also accumulates its financial assets  $A_t^P$  that are assumed to be held by the private sector. Each period, therefore, the following flow budget constraint holds for a pension fund:

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<sup>13</sup>See for instance Railavo (2004) for the discussion on alternative fiscal policy rules and their stability properties.

<sup>14</sup>There is also a national pension scheme covering all citizens, but its role is diminishing. At the same time, non-statutory pension schemes that are partly tax deductible are becoming increasingly popular.

$$\begin{aligned}
& - (A_t^P - A_{t-1}^P) \text{ (net lending)} \\
& = \tau_t^{FP} W_t [L_t^F + \xi^G L_t^G] \text{ (social security contributions of employer)} \\
& + \tau_t^{WP} [W_t L_t^w + \mathcal{T}_t^{SW}] \text{ (social security contributions of employee)} \\
& + \mathcal{T}_t^{SP} \text{ (transfers from the state)} \\
& - \mathcal{T}_t^{PR} \text{ (total transfers paid to retirees)} \\
& - P_t^O C_t^P - P_t^I I_t^P \text{ (consumption and investments)} \\
& - r_t A_{t-1}^P \text{ (interest payments)}
\end{aligned} \tag{4.4}$$

where  $\tau_t^{FP}$  is the employer's pension contribution rate  $\mathcal{T}_t^{SW}$  denotes those transfers from the state to workers that are treated as labour income,  $\mathcal{T}_t^{SP}$  are transfers from the state to pension funds and finally  $\mathcal{T}_t^{PR}$  denote pensions and other transfers from pension funds to retirees. The particular way income transfers are treated here is due to the fact that we want to mimic at least partly the actual transfers observed and accounted in the national accounts system. Furthermore, it is assumed that pension funds have some long-run funding target, expressed as a share of financial assets ( $A^P$ ) to output. This target is eventually achieved by adjusting the pension contribution rates accordingly. In the current version of the model, this 'pension contribution rule' follows the same logic as the fiscal rule.

## 5 Calibration of demand side

Until the very recent applications of Bayesian estimation techniques to large-scale DSGE models<sup>15</sup>, many structural parameters in the micro-founded models like Aino used to be calibrated or estimated by using traditional GMM techniques. In the current version of Aino, many parameters in the supply side have indeed been estimated using the GMM and cointegration techniques, while the demand side parameters have been largely calibrated. This is clearly somewhat unsatisfactory, given the rapid development and availability of Bayesian estimation techniques.

Nevertheless, in the current version of the model, parameters affecting demographics has been calibrated such as 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 12 and 48 years. Annual net growth rate of population has been set to 0.16%. These demographic assumptions reflect roughly the situation Finland is facing during the following decade.

In order to fit the participation rates observed we have set the relative efficiency,  $\xi$ , of 'retirees' to be 33% of that of active working age, while wage mark-up has been set to 25%. This wage mark-up is somewhat lower than the ones observed in Europe on average (30%). Given the difficulty of obtaining reliable estimates for the wage mark-up, we have calibrated the wage mark-up such as to produce reasonable participation rates.

The elasticity of the periodic utility,  $v$ , has been set to 0.855 and intertemporal elasticity of substitution has been set as high as 0.5. Both of these are on a high side,

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<sup>15</sup>See for instance Smets and Wouters (2003a, 2003b).

but are necessary in order to obtain reasonable calibration of the steady state values of the model.

Table 1. **Calibration of Demand Side**

Parameter	Explanation	Value	Method
$v$	Elasticity of utility	0.855	Calibrated
$\sigma$	Inter-temporal substitution	0.5	Calibrated
$\gamma$	probability of surviving	0.979836	Calibrated
$\omega$	probability of remaining in active workforce	0.99478	Calibrated
$\xi$	relative labour efficiency of retirees	0.32	Calibrated
$1/\rho_L$	wage mark-up	25%	Calibrated
$\hat{N}$	population growth rate, p.a.	0.16%	Calibrated

In order to illustrate how the current version of Aino model meets the recent data, we use the data from 1995–2004 and calculate annual averages of several macro economic variables. The reason for not using longer time span is that Finland experienced major structural changes during the 1990s recession and we thus want to fit the balanced growth path of Aino to the more recent economic environment.

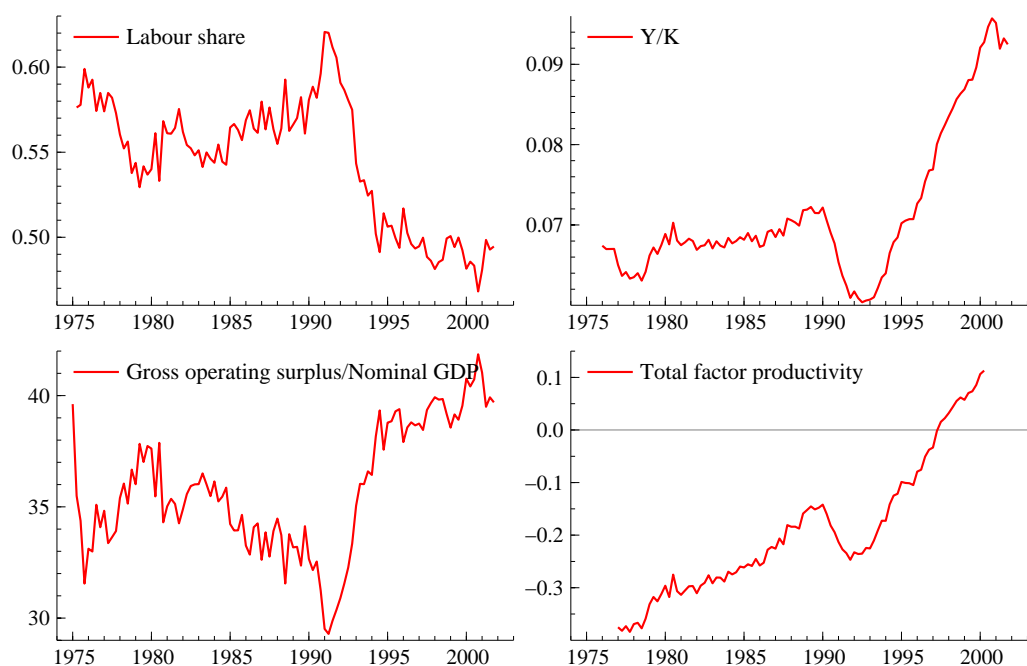
Table (2) summarises some relevant macro economic variables expressed either as a percentage share of the private production or in the case of labour market and demographic variables, as a percentage share of the whole population. The model's initial steady state reflects partially an expected demographic change in the near future. In particular, there is a higher private consumption share, which shows up also in a higher import share. In addition, statutory pension contribution rate is higher than in the data, reflecting the underlying assumption of higher pensions during the following decade. High import's rate reflect the fact that in the data we observe a trend in imports share of private production.

Table 2. **Steady state shares and the data**

Variable	Code	The data (1995–2004)	Steady- state
Private production(in efficiency units)	$Y$	0.19	0.22
Imports (% of priv.prod.)	$M$	44.6	67.1
Exports (% of priv.prod.)	$X$	55.6	64.0
Total consumption (% of priv.prod.)	$C$	103.6	105.5
Private consumption	$C^H$	72.4	86.2
Public consumption	$C^G$	31.3	29.3
Investment (% of priv.prod.)	$I$	27.5	29.4
Private investment	$I^S$	23.3	25.4
Public investment	$I^G$	4.0	3.8
Employment rate	$L/N$	58.2	57.8
Capital share in efficiency units	$K$	2.57	2.7
Retirees (% share of tot. pop.)	$\varphi$	0.18	0.25
Income tax rate, %	$t^{WS}$	32.0	32.0
Pension contribution rate, %	$t^{WP}$	4.4	6.6



Figure 1. **Technological change in the Finnish economy**




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All variables are in logs. Means and ranges are adjusted in graphs with two lines.

## 6 Firms and technologies

The particular challenge for the supply side of Aino is to describe the major changes in the structure of the economy that occurred in the 1990s: the dramatic decline in the labour share, the rapid improvement in average capital productivity and the growth in price mark-up (see figure 1). Being a growth model, Aino has been built around the conventional assumption that in the balanced growth path real economic growth depends on the efficiency and volume of labour input.<sup>16</sup>

In Aino, temporary sources of growth and slump can be of many different types. Capital-augmenting technological advances are important in explaining the 1990s phenomenon whereby, despite rapid growth in output, investment recovery was, historically speaking, slow. According to Aino, this was because considerably more output was extracted from the existing capital stock. The structure of Aino also makes it possible to take into account temporary changes in consumer preferences. Such changes can be seen in, for example, growing demand for domestic products relative to imported goods irrespective of similar movements in relative prices.

The supply side of Aino 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 one to obtain three different final goods: consumption goods, capital goods and exported goods. These final goods differentiate with respect to the type of imported factor and to the elasticity of substitution between domestic and imported factors.

Each brand of a domestic intermediate good is produced using the CES produc-

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<sup>16</sup>Technically speaking, long-term economic growth depends on the pace of development in labour-augmenting technology and the pace of growth in labour input.

tion function with capital services and labour as inputs. The domestic intermediate goods producers operate in monopolistic product markets. Thus, they have pricing power in relation to their products. Such power is a consequence of the products' imperfect substitutability that is exogenously determined. The model assumes that only a constant fraction of firms are able to reset their prices at the corresponding optimal level (Calvo pricing). Therefore, some prices are sticky and do not immediately adjust to the underlying flex price optima.

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. An alternative to changes in the physical capital stock is to change the capacity utilisation rate. The cost here is that more intensive capital utilisation also speeds up capital depreciation. Building up new capital generates cost – adjustment costs – in the form of lost capital stock. Because it takes resources to build up the physical capital stock, when deciding on an investment companies must take into account what the economic operating environment will be like by the time the investment has matured into functioning production capacity. The optimal investment decisions described above together with the pricing feature make firms' behaviour forward-looking. In this respect, Aino emphasises, in line with modern macroeconomic theory, the importance of expectations in the behaviour of economic agents.

Domestic intermediate products are used in the production of final products. Companies producing consumer goods and services combine domestic and foreign intermediate product inputs. Capital goods and services producers and producers of goods and services for export also operate in a similar way. All three types of final producers operate in competitive product markets in which they take the market price for their products as given in their own decision-making. Thus, they only decide their own output volumes and the intermediate products they will use within the limits set by their production technology. Because of this, total imports depend on consumption, investment, exports and the relative prices of imports.

In Aino, the impact of relative prices is estimated to be fairly strong. This means eg that if the prices of imported intermediate products (import prices) rise strongly relative to the price of the domestic intermediate product, the final producer will to a large degree substitute the imported input with domestic input. An exception to this is that in the manufacture of goods for export the domestic and foreign intermediate product inputs are gross complement.

Nominal import prices are assumed to be sticky in the manner corresponding to domestic prices, ie Calvo pricing is applied here as well. It is also assumed that, in the short term, exchange rate pass-through to import prices is incomplete. This is due to the fact that a fixed fraction of importing companies price their products in accordance with demand in the specific market area.

The remaining of this section is organised as follows. We first introduce an aggregator that generates demand function for each intermediate goods producer and the time-varying degree of competition, ie mark-up. The key firm, domestic intermediate goods producer is introduced in the subsequent section. Capital markets are studied in the subsection that follows. Retailers, ie final goods producers are studied in subsections 6.3–6.4. Subsection 6.5 describes the behaviour of importers. Final section discusses the parameter values of the supply side.

## 6.1 Domestic intermediate goods producer

The domestic composite intermediate good,  $Y_t$ , is produced by the following constant elasticity of substitution (CES) production function that combine individual goods  $Y_t(j)$  (Dixit and Stiglitz 1977)

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

The parameter  $\rho_t^z \in [-1, \infty)$  determines the elasticity of substitution  $1/(1 + \rho_t^z)$ . For non-positive values of  $\rho_t^z$  the intermediate goods are gross substitutes. Perfect substitutability, and, consequently, perfect competition, is obtained by letting  $\rho_t^z$  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 following conditional demand function for the individual good  $j$  ( $j \in [0, 1]$ )

$$Y_t(j) = \left( \frac{P_t(j)}{P_t} \right)^{-\frac{1}{1+\rho_t^z}} Y_t \quad (6.1)$$

and the price index for the composite domestic intermediate good

$$P_t = \left[ \int_0^1 P_t(j)^{\frac{\rho_t^z}{1+\rho_t^z}} dj \right]^{\frac{1+\rho_t^z}{\rho_t^z}} \quad (6.2)$$

Domestic intermediate goods,  $Y_t(j)$ , are produced by producers who face monopolistic competition. They take the production technology and the factor augmenting technical trends as exogenously given. The production function is of the CES type and take the specific form of constant-returns-to-scale<sup>17</sup>.

$$Y_t(j) = \left[ \delta (\Lambda_t^K K_t)^{-\rho} + (1 - \delta) (\Lambda_t^L L_t^F)^{-\rho} \right]^{-1/\rho} \quad (6.3)$$

The factors of production include homogenous capital services<sup>18</sup>,  $K_t$ , and homogenous labour,  $L_t^F$ .  $\Lambda_t^K$  and  $\Lambda_t^L$  denote, respectively, time-varying<sup>19</sup> capital and labour-augmenting technical progress, which are unobservable to the econometrician. They are common to all firms. The elasticity of technical substitution is given by  $1/(1 + \rho)$ , where  $\rho$  is the substitution parameter in the production function.  $\delta$  refers to the share parameter.

Cost minimization implies the following real marginal costs

$$\frac{MC_t(j)}{P_t(j)} = \left[ \delta^{\frac{1}{1+\rho}} \left( \frac{R_t}{\Lambda_t^K P_t(j)} \right)^{\frac{\rho}{1+\rho}} + (1 - \delta)^{\frac{1}{1+\rho}} \left( \frac{W_t^F}{\Lambda_t^L P_t(j)} \right)^{\frac{\rho}{1+\rho}} \right]^{\frac{1+\rho}{\rho}} \quad (6.4)$$

where  $R_t$  denotes the nominal rental price of capital services and  $W_t^F = (1 + \mathbf{t}_t^{FP} + \mathbf{t}_t^{FS})W_t$  represents nominal labour costs<sup>20</sup>. In the steady-state<sup>21</sup>, prices,  $P(j)$ , are

<sup>17</sup>According to Ripatti and Vilmunen (2001) this seems to be reasonable assumption for post 1980 data.

<sup>18</sup>Capital is rented from capital rental firms, "leasing firms".

<sup>19</sup>We do not specify their stochastic properties at this stage. See Ripatti and Vilmunen (2001) for further discussion about their properties and estimates using aggregate Finnish data.

<sup>20</sup> $\mathbf{t}_t^{FP}$  and  $\mathbf{t}_t^{FS}$  denote firms pension and social security contributions respectively

<sup>21</sup>The symbols without time subscript denote the steady state values.

determined by mark-up,  $\Upsilon$  over marginal costs

$$P(j) = \Upsilon MC(j)$$

where mark-up is given by

$$\Upsilon = -\frac{1}{\rho^z} \quad (6.5)$$

Note, that the mark-up is not unity in the steady-state case since the steady-state elasticity of substitution<sup>22</sup> between the intermediate goods is generally finite.

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

$$\log \delta - v_t - \rho \lambda_t^K + (1 + \rho)(y_t - k_t) = r_t - p_t \quad (6.6)$$

$$\log(1 - \delta) - v_t - \rho \lambda_t^L + (1 + \rho)(y_t - l_t) = w_t^F - p_t \quad (6.7)$$

where  $r_t$  is the log of the nominal rental rate of capital services,  $w_t^F$  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,  $v_t \equiv \log(\Upsilon_t)$ , enters to the first order conditions. Note also that  $\lambda_t \equiv \log \Lambda_t$  for each type of  $\lambda_s$  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). Probability of receiving a price change signal is given by  $1 - \zeta$  ( $\zeta \in [0, 1]$ ). It is constant. Since there is continuum of intermediate producers,  $1 - \zeta$  also represents the share of producers that have received such a signal and, consequently, got an opportunity to change their prices. The average time between price changes is given by  $1/(1 - \zeta)$ . Let  $\bar{P}_t(j)$  denote the price level set by those intermediate goods producers that received the ‘price-change signal’ in period  $t$ . With probability  $\zeta^s$  the price  $\bar{P}_t(j)$  is still in effect at date  $t + s$  ( $s \geq 0$ ). The producer’s problem is the following

$$\max_{\{\bar{P}_t(j)\}} E_t \sum_{s=0}^{\infty} \zeta^s M_{t,t+s} \Pi_{t+s} [\bar{P}_t(j)] \quad (6.8)$$

where  $M_{t,t+s}$  is the nominal stochastic discount factor and where momentary profits are given by

$$\Pi_{t+s} [\bar{P}_t(j)] = [\bar{P}_t(j) - MC_{t+s}(j)] Y_{t+s}(j) = [\bar{P}_t(j) - MC_{t+s}(j)] \left[ \frac{\bar{P}_t(j)}{P_{t+s}} \right]^{-\frac{1}{1+\rho_t^z}} Y_{t+s} \quad (6.9)$$

The first order condition is given by

$$\bar{P}_t(j) = \Upsilon_t \frac{E_t \sum_{s=0}^{\infty} \zeta^s M_{t,t+s} P_{t+s}^{\frac{1}{1+\rho_t^z}} Y_{t+s} MC_{t+s}(j)}{E_t \sum_{s=0}^{\infty} \zeta^s M_{t,t+s} P_{t+s}^{\frac{1}{1+\rho_t^z}} Y_{t+s}} \quad (6.10)$$

<sup>22</sup>The elasticity of substitution is  $\Upsilon/(\Upsilon - 1)$  in terms of  $\Upsilon$ .

Following the formulation (6.2) of the price index of intermediate goods, the aggregate price level evolves according to the following equation of motion

$$P_t = \left[ \zeta P_{t-1}^{\frac{\rho_t^z}{1+\rho_t^z}} + (1-\zeta) \bar{P}_t(j)^{\frac{\rho_t^z}{1+\rho_t^z}} \right]^{\frac{1+\rho_t^z}{\rho_t^z}} \quad (6.11)$$

The first term on the right hand side reflects the prices set by the those firms that have *not* received a ‘price-change signal’, ie prices inherited from the previous period. The second term is the price level set by those firms that have received a ‘price-change signal’. It is determined by equation (6.10).

### Linearization

We linearize the pricing equations (6.10) and (6.11) in the standard way. Note however, that we need to allow for the time-varying mark-up. Assuming symmetry of the firms we obtain the following aggregate pricing equation for the intermediate goods producers

$$\Delta p_t = M E_t \Delta p_{t+1} + \frac{(1-\zeta)(1-\zeta M)}{\zeta} [v_t + mc_t - p_t] \quad (6.12)$$

Producer price inflation is thus determined by expected producer price inflation and changes in the slope of the demand curve and the real marginal costs.

## 6.2 Capital rental firms

Capital is a homogenous 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

$$K_t^p + a^K(K_t^p, K_{t-1}^p, K_{t-2}^p) = K_{t-1}^p [1 - D(U_t)] + I_t \quad (6.13)$$

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,  $D'(U_t) > 0$ . The capital rental firm maximizes its expected discounted profits

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

subject to capital accumulation equation (6.13) and the definition of capital services. The momentary profits are given by

$$\begin{aligned} \Pi_t^K &= R_t K_t - P_t^I I_t \\ &= R_t U_t K_{t-1}^p - P_t^I \{K_t^p + a^K(K_t^p, K_{t-1}^p, K_{t-2}^p) - K_{t-1}^p [1 - D(U_t)]\} \end{aligned} \quad (6.14)$$

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)  $M_{t,t+s} = \beta^s U'(C_{t+s}) P_t^C / [U'(C_t) P_{t+s}^C]$  ( $P_t^C$  refers to price index of composite consumer goods).

Optimal level of capacity utilization is given by the following first order condition wrt  $U_t$

$$R_t = P_t^I D'(U_t) \quad (6.15)$$

which relates the rental price to the marginal depreciation of the capital stock. The first order condition wrt the capital stock  $K_t^p$  is given as follows

$$\begin{aligned} & - P_t^I E_t [1 + a_1^K(K_t^p, K_{t-1}^p, K_{t-2}^p)] \\ & + E_t M_{t,t+1} \{ R_{t+1} U_{t+1} - P_{t+1}^I [a_2^K(K_{t+1}^p, K_t^p, K_{t-1}^p) - (1 - D(U_{t+1}))] \} \\ & - E_t M_{t,t+2} [P_{t+2}^I a_3^K(K_{t+2}^p, K_{t+1}^p, K_t^p)] = 0 \end{aligned} \quad (6.16)$$

Due to the end-of-period timing of the physical capital stock<sup>23</sup>, 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.

### Parametrics

We define the adjustment cost function as follows

$$a^K(K_t^p, K_{t-1}^p, K_{t-2}^p) = \frac{\gamma_1 (\Delta K_t^p - \gamma_2 \Delta K_{t-1}^p)^2}{2 K_{t-1}^p}$$

This formulation of adjustment costs allow for hump-shaped responses of investments to various shocks. The depreciation factor is parameterised as follows (see Baxter and Farr (2001))

$$D(U_t) = \delta_0 + \frac{\delta_1}{1 + \delta_2} U_t^{1+\delta_2}$$

It has the rust-and-dust part,  $\delta_0$ , whereas the second term on the right-hand-side is the wear-and-tear part.

The parametric version of (6.16) is as follows:

$$\begin{aligned} & - P_t^I E_t \left[ 1 + \gamma_1 \frac{\Delta K_t^p - \gamma_2 \Delta K_{t-1}^p}{K_{t-1}^p} \right] \\ & + E_t M_{t,t+1} \left\{ R_{t+1} U_{t+1} - P_{t+1}^I \left[ - \gamma_1 (1 + \gamma_2) \frac{\Delta K_{t+1}^p - \gamma_2 \Delta K_t^p}{K_t^p} \right. \right. \\ & \left. \left. - \gamma_1 \frac{(\Delta K_{t+1}^p - \gamma_2 \Delta K_t^p)^2}{2 (K_t^p)^2} - \left( 1 - \delta_0 - \frac{\delta_1}{1 + \delta_2} U_{t+1}^{1+\delta_2} \right) \right] \right\} \\ & - E_t M_{t,t+2} P_{t+2}^I \gamma_1 \gamma_2 \frac{\Delta K_{t+2}^p - \gamma_2 \Delta K_{t+1}^p}{K_{t+1}^p} = 0 \end{aligned} \quad (6.17)$$

<sup>23</sup>This is a usual way to measure the capital stock in the national accounts.

and, that of the (6.15)

$$\frac{R_t}{P_t^I} = \delta_1 U_t^{\delta_2} \quad (6.18)$$

The usual ‘investment equation’ can be obtained by substituting (6.6) and (6.18) into (6.17). Consider the case that this substitution is done and the resulting equation is linearised. The resulting equation contains the ‘fundament’ part corresponding to (6.6) and the dynamic part that contains leads and lags of  $\Delta k_t$ . The parameters  $\gamma_1$  and  $\gamma_2$  – related to adjustment cost function – determine the coefficients of leads and lags of  $\Delta k_t$ . The coefficient of the ‘fundament’ part is essentially determined by the parameters in depreciation function,  $\delta_1$  and  $\delta_2$ , and the elasticity of technical substitution  $\rho$ .

### 6.3 Domestic retailers

The economy is inhabited by two retailers. The first one is specialized for consumer goods and the other one for capital goods. They combine domestic intermediate input – produced by the intermediate goods producers – and 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, which represent how consumers or capital rental firm (and public sector) substitute between domestic and foreign intermediate goods and services. The domestic intermediate goods used in the production of consumption and investment goods are labelled as  $Y_t^C$  and  $Y_t^I$  respectively. The imported goods we label as  $M_t^C$  and  $M_t^I$ . We allow for time-varying factor augmenting technical progress,  $\Lambda_t^{CY}$ ,  $\Lambda_t^{CM}$  and  $\Lambda_t^{IY}$ ,  $\Lambda_t^{IM}$  to reflect the changes in the preferences related to the consumption or investments of tradables and non-tradables. Their role is to model the changes in factor demands that cannot be explained by relative price changes. Since the technology is of the CES type, we introduce substitution parameters  $\rho^C$  and  $\rho^I$ .<sup>24</sup>

The retailers sell their products both to the private sector and to the general government. The output of the consumption goods retailer consist of the private consumption, and public purchases<sup>25</sup>,  $C_t^T \equiv C_t^H + C_t^{SF}$ . Same holds for the investment goods retailer,  $I_t^T \equiv I_t + I_t^G$ . Since general government is divided into pension funds and other general government<sup>26</sup>, we disaggregate public investments as follows:  $I_t^G = I^P + I^S$ . The price indices of the retailers are in market prices, ie prices faced by consumers and firms.

The consumption goods retailer pays indirect taxes<sup>27</sup>, measured as a share of the nominal output,  $t^C$ . The profits of the consumption goods retailer are

$$(1 - t^C)P_t^C C_t^T - P_t Y_t^C - P_t^{MC} M_t^C \quad (6.19)$$

<sup>24</sup>The elasticities of substitution are given by  $1/(1 + \rho^C)$  and  $1/(1 + \rho^I)$  respectively.

<sup>25</sup>Public purchases here means general government consumption in national accounts from which the public value added, ie mainly salaries, is subtracted.

<sup>26</sup>In the national accounts standard (ESA95), this other general government includes central government, municipalities and social security funds.

<sup>27</sup>We use national accounts measure of indirect taxes less subsidies. In the Finnish economy, the most important indirect tax is VAT. Alcohol, tobacco, gasoline and car taxes make also a very significant contribution here.

The technologies – or, rather, aggregators – of the retailers are given as follows

$$C_t^T = \left[ \delta^C (\Lambda_t^{CY} Y_t^C)^{-\rho^C} + (1 - \delta^C) (\Lambda_t^{CM} M_t^C)^{-\rho^C} \right]^{-1/\rho^C} \quad (6.20)$$

$$I_t^T = \left[ \delta^I (\Lambda_t^{IY} Y_t^I)^{-\rho^I} + (1 - \delta^I) (\Lambda_t^{IM} M_t^I)^{-\rho^I} \right]^{-1/\rho^I} \quad (6.21)$$

Cost minimization implies the following price indices  $P_t^C$  and  $P_t^I$

$$P_t^C = (1 - \mathfrak{t}_t^C)^{-1} \left[ (\delta^C)^{\frac{1}{1+\rho^C}} \left( \frac{P_t}{\Lambda_t^{CY}} \right)^{\frac{\rho^C}{1+\rho^C}} + (1 - \delta^C)^{\frac{1}{1+\rho^C}} \left( \frac{P_t^{MC}}{\Lambda_t^{CM}} \right)^{\frac{\rho^C}{1+\rho^C}} \right]^{\frac{\rho^C+1}{\rho^C}} \quad (6.22)$$

$$P_t^I = \left[ (\delta^I)^{\frac{1}{1+\rho^I}} \left( \frac{P_t}{\Lambda_t^{IY}} \right)^{\frac{\rho^I}{1+\rho^I}} + (1 - \delta^I)^{\frac{1}{1+\rho^I}} \left( \frac{P_t^{MI}}{\Lambda_t^{IM}} \right)^{\frac{\rho^I}{1+\rho^I}} \right]^{\frac{\rho^I+1}{\rho^I}} \quad (6.23)$$

and the conditional factor demands

$$Y_t^C = \delta^{C(1+\rho^C)} (\Lambda_t^{CY})^{\frac{-\rho^C}{1+\rho^C}} \left( \frac{P_t}{(1 - \mathfrak{t}_t^C) P_t^C} \right)^{\frac{-1}{1+\rho^C}} C_t^T \quad (6.24)$$

$$Y_t^I = \delta^{I(1+\rho^I)} (\Lambda_t^{IY})^{\frac{-\rho^I}{1+\rho^I}} \left( \frac{P_t}{P_t^I} \right)^{\frac{-1}{1+\rho^I}} I_t^T \quad (6.25)$$

$$M_t^C = (1 - \delta^C)^{1+\rho^C} (\Lambda_t^{CM})^{\frac{\rho^C}{1+\rho^C}} \left( \frac{P_t^{MC}}{(1 - \mathfrak{t}_t^C) P_t^C} \right)^{\frac{-1}{1+\rho^C}} C_t^T \quad (6.26)$$

$$M_t^I = (1 - \delta^I)^{1+\rho^I} (\Lambda_t^{IM})^{\frac{-\rho^I}{1+\rho^I}} \left( \frac{P_t^{MI}}{P_t^I} \right)^{\frac{-1}{1+\rho^I}} I_t^T \quad (6.27)$$

In the estimation of the elasticity of substitution between imported consumption goods and domestic intermediate products we rely on the first order condition with respect to imported goods. Its log-linear version may be written as follows

$$\log(1 - \delta^C) + \rho^C (c_t^T - m_t^C - \lambda_t^{CM}) = p_t^M + m_t^C - p_t^C - c_t - \log(1 - \mathfrak{t}_t^C) \quad (6.28)$$

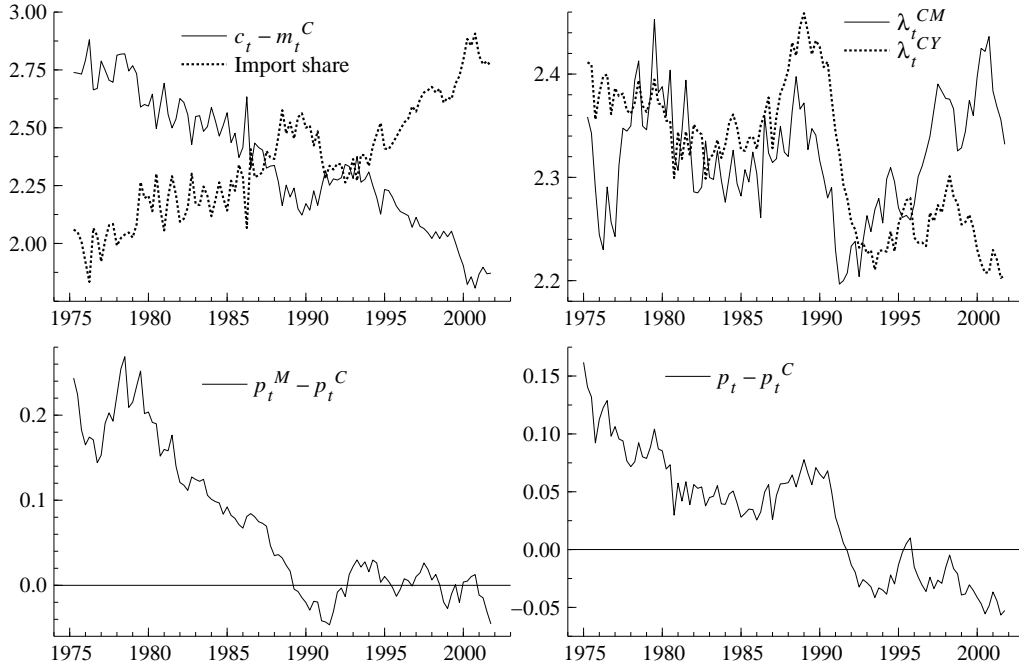
Note that the right-hand-side of the above equation is the share of imports in the value of consumption. For positive values of  $\rho^C$  the inputs are gross-complements and for negative values gross-substitutes. This form is particularly useful in the graphical investigation.

We rely on the cointegration techniques in the estimation of the elasticity of substitution  $1/(1 + \rho^C)$ . This requires an assumption that (6.28) forms a stationary linear combination and that  $\lambda_t^C$  is stationary. Our point estimate for the parameter  $\rho^C$  is -0.7731 (with standard error 0.049) that implies elasticity of substitution 4.4. This implies that the elasticity of substitution deviates significantly from zero and from the unity<sup>28</sup>. Figure 2 depicts relative factor prices and the estimated technical trends. Note that, here as in the case of intermediate goods producers, we are not able to identify the share parameter  $\delta^C$ . This is due to the fact that it cannot be distinguished from the constant term in the technical trends. We calibrate this parameter to correspond the intermediate good's factor share. It is 0.87.

<sup>28</sup>Unit elasticity of substitution corresponds the Cobb-Douglas aggregator.



Figure 2. **Relative price of imported consumption goods and the technical trend**



All variables are in logs. Means and ranges are adjusted in graphs with two lines.

The estimation of the elasticity of substitution between imported investment goods and domestic intermediate goods relies on the similar first order condition as (6.28). The estimated elasticity of substitution is smaller in the case of investment goods. Our estimate is 2.2, which is given by the estimate of  $\rho^I = -0.538$  with the standard error of 0.183. This means that the factors are gross-substitutes. The calibrated value of the share parameter  $\delta^I$  is 0.67

## 6.4 Exporter

Exporter is a firm that combines domestic intermediate input,  $Y_t^F$ , and imported materials<sup>29</sup>,  $M_t^R$  to produce for export,  $X_t$ , in competitive markets. We allow for time-varying factor-augmenting technical progresses,  $\Lambda_t^{XY}$  and  $\Lambda_t^{XM}$  to reflect the increase in the efficiency of factor usage. Since the technology is of the CES type, we introduce a substitution parameter  $\rho^X$ . Consequently, the technology – or the export aggregator – is given as follows

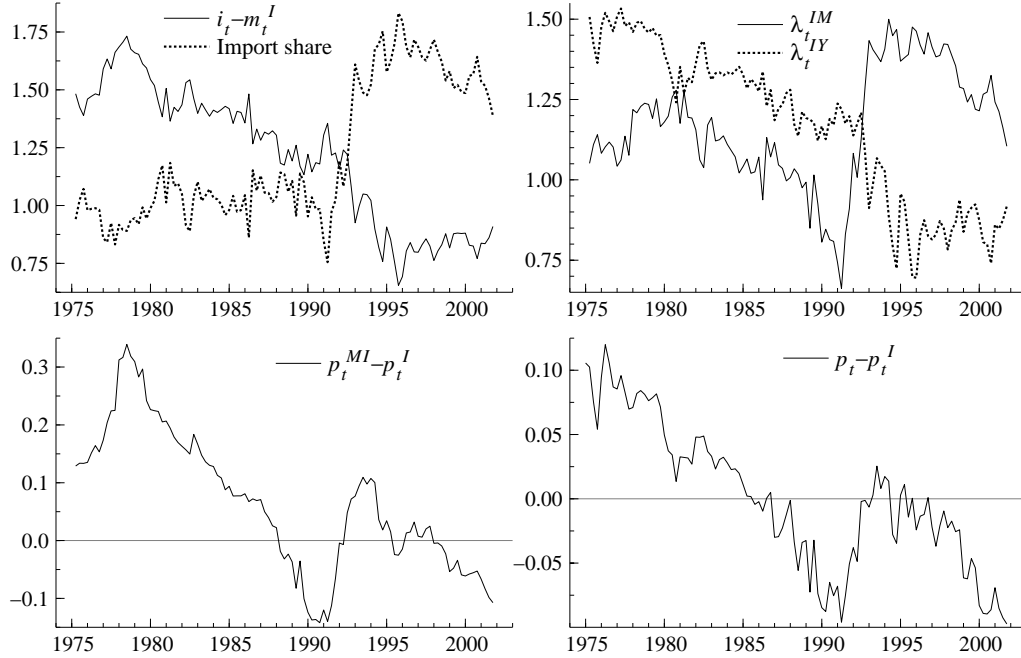
$$X_t = \left[ \delta^X (\Lambda_t^{XY} Y_t^F)^{-\rho^X} + (1 - \delta^X) (\Lambda_t^{XM} M_t^R)^{-\rho^X} \right]^{-1/\rho^X} \quad (6.29)$$

Cost minimization implies the following price index  $P_t^X$

$$P_t^X = \left[ (\delta^X)^{\frac{1}{1+\rho^X}} \left( \frac{P_t}{\Lambda_t^{XY}} \right)^{\frac{\rho^X}{1+\rho^X}} + (1 - \delta^X)^{\frac{1}{1+\rho^X}} \left( \frac{P_t^R}{\Lambda_t^{XM}} \right)^{\frac{\rho^X}{1+\rho^X}} \right]^{\frac{\rho^X+1}{\rho^X}} \quad (6.30)$$

<sup>29</sup>This includes energy, other raw materials, and industrial intermediate inputs.

Figure 3. **Relative price of imported investment goods and the technical trend**



All variables are in logs. Means and ranges are adjusted in graphs with two lines.

and the conditional demand functions for inputs

$$Y_t^X = \delta^{X1+\rho^X} (\Lambda_t^{XY})^{\frac{-\rho^X}{1+\rho^X}} \left( \frac{P_t}{P_t^X} \right)^{\frac{-1}{1+\rho^X}} X_t, \quad (6.31)$$

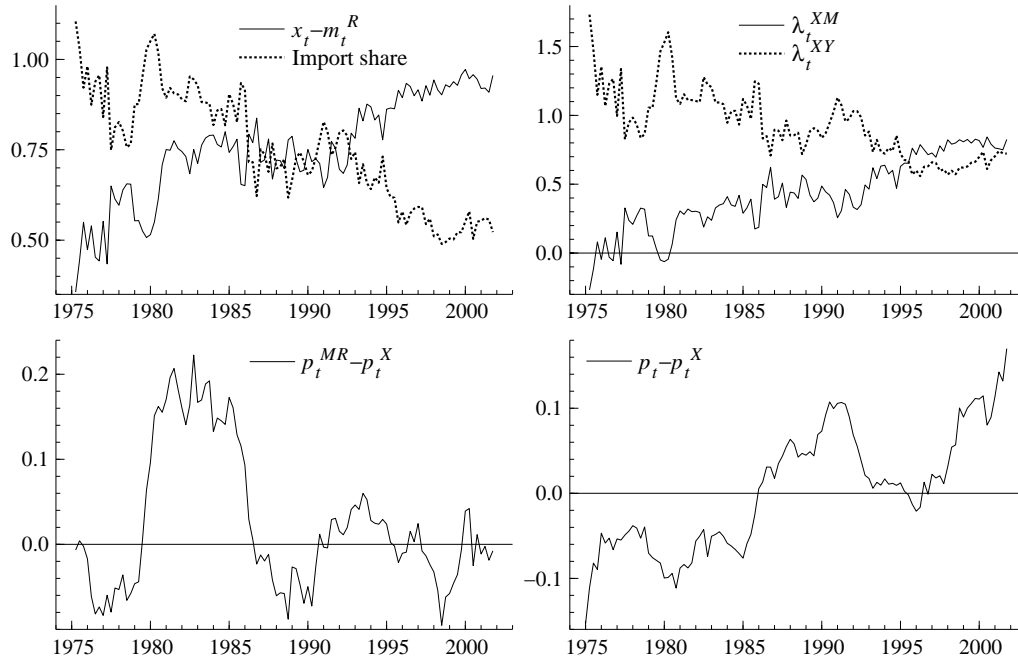
$$M_t^R = (1 - \delta^X)^{1+\rho^X} (\Lambda_t^{XM})^{\frac{-\rho^X}{1+\rho^X}} \left( \frac{P_t^{MR}}{P_t^X} \right)^{\frac{-1}{1+\rho^X}} X_t. \quad (6.32)$$

In the estimation of the elasticity of substitution between domestic intermediate input and imported raw materials, we rely on the same approach as in the case of domestic retailers. We assume that the imported-input-augmenting technical change may contain a deterministic linear time trend. This trend captures structural changes in the input usage of exports. Its positive slope means that the share of imported raw materials in the production of exports has steadily decreased. This is simply a local approximation since this share cannot decrease forever. Our estimate for the elasticity of substitution is 0.45. The implied estimate of  $\rho^X$  is 1.217 with a standard error of 0.378. Not surprisingly, the point estimate suggest that the imported raw materials and the domestic intermediate input are gross-complements in the production of exported goods and services. The calibrated value of the share parameter  $\delta^X$  is 0.51.

## 6.5 Importing firms

This subsection relies on Ripatti and Viertola (2004). Imported goods and services are used by the retailers and the exporter in the *Aino* economy. They combine imported and domestically produced intermediate goods to produce final consumption,

Figure 4. **Relative price of imported raw materials and the technical trend in exports**



All variables are in logs. Means and ranges are adjusted in graphs with two lines.

capital and exported goods. The consumer goods and services (including 5 per cent of imported energy) are used by the consumption goods retailer, capital goods and services are used by the capital goods retailer, and the exporter uses energy and intermediate goods in producing exported goods. Each of these retailers operates under perfect competition in their output markets.

We derive a model for import prices of imports by main use, ie for the retailer sector. 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 rest of importers in producer (in their own) currency. Their pricing contains identical frictions in the form of Calvo (1983), ie they may change their price only in the case of receiving a random price-change-signal. Their marginal costs are identical too. Aggregation of the prices over these two types of importers yields an import price Euler equation where import prices depend on expected future import price inflation, current and expected future changes in foreign exchange rates and on the real marginal costs of the importers.

For each group of import products we introduce three sets of firms: an importer (aggregator), foreign importers pricing their products in the Finnish currency (FCP firms), and foreign importers pricing their products in their own currency (PCP firms). We introduce the following notation,  $M$  is the aggregate imported good with an aggregate price level  $P$ , the prices related to FCP firms are denoted by  $P^F$  and to PCP firms by  $P^P$ . Quantities are  $M^F$  and  $M^P$  respectively. In the log-linearization, small letters denote log-deviations of the variables from the steady-state, ie  $x_t = \log X_t - \log X$ , where letter without a time subscript denotes the

steady-state value. In static equations we ignore the time subscripts. The foreign discount factor between periods  $t$  and  $t + k$  is denoted by  $R_{t,t+k}^*$ .

### 6.5.1 Aggregator

An importing firm aggregates the products of the foreign importing firms (FCP and PCP firms). The goods are produced in a number of varieties or *brands* defined over a continuum of unit mass. Brands of goods by FCP firms are indexed by  $j \in [0, \omega]$  and those of PCP firms by  $j \in [\omega, 1]$ . Aggregate imports,  $M$ , is then defined as

$$M = \left[ \int_0^\omega M^F(j)^{-\rho} dj + \int_\omega^1 M^P(j)^{-\rho} dj \right]^{-1/\rho} \quad (6.33)$$

The aggregate import price index is then defined as follows

$$P = \left\{ \int_0^\omega P^F(j)^{\frac{\rho}{1+\rho}} dj + \int_\omega^1 [SP^P(j)]^{\frac{\rho}{1+\rho}} dj \right\}^{\frac{1+\rho}{\rho}} \quad (6.34)$$

where  $S$  is the foreign exchange rate measured as domestic price of foreign currency, eg EUR/USD. Assuming symmetric equilibria and log-linearising the price equation (6.34) around the steady-state yields

$$p_t = \omega p_t^F + (1 - \omega) p_t^P + (1 - \omega) s_t \quad (6.35)$$

One may give  $\omega$  an interpretation as the share of the firms that price their products in local (Finnish) currency. These are firms that do not have the opportunity to immediately adjust their prices when foreign exchange rates move.

Cost-minimization implies the following conditional demand functions

$$M^F(j) = \left[ \frac{P^F(j)}{P} \right]^{-\frac{1}{1+\rho}} M \quad (6.36)$$

$$M^P(j) = \left[ \frac{SP^P(j)}{P} \right]^{-\frac{1}{1+\rho}} M \quad (6.37)$$

It does not matter whether the importer operates inside or outside the Finnish borders, since it does not produce any value-added. Therefore, it does not influence to the accounting system of the whole *Aino* model.

### 6.5.2 Foreign importers

Foreign importers operate outside Finnish borders. They face imperfect competition in their output markets. This means that they take into account the demand functions (6.36) and (6.37) in their pricing decisions. We assume that all FCP and PCP firms share the same cost function  $C(j)$ , which is assumed to be homogenous of degree one in output. They also mutually share the same stochastic discount factor  $R_{t,t+k}^*$ . According to international consumption smoothing this cannot permanently deviate from the domestic one.

The dynamics of the price level  $P_t(j)$  of importer  $j$  arises from the assumption that a firm changes its price level when it receives a random “price-change signal”

(see Calvo 1983). Probability of receiving a price change signal is given by  $1 - \zeta$  ( $\zeta \in [0, 1]$ ). It is a constant and identical to all (both FCP and PCP) firms. Since there is continuum of firms,  $1 - \zeta$  also represents the share of firms that has received such a signal and, consequently, got an opportunity to change their prices. The average time between price changes is given by  $1/(1 - \zeta)$ . Let  $\bar{P}_t^i(j)$   $i = F, P$  denote the price level set by those firms that received the “price-change signal” in period  $t$ . With probability  $\zeta^k$  the price  $\bar{P}_t^i(j)$  is still in effect at date  $t + k$  ( $k \geq 0$ ). Firms’s problem is the following

$$\max_{\{\bar{P}_t^i(j)\}} \text{E}_t \sum_{k=0}^{\infty} \zeta^s R_{t,t+k}^* \Pi_{t+k}^i [\bar{P}_t^i(j)], \quad i = F, P \quad (6.38)$$

where  $\Pi_{t+k}^i [\bar{P}_t^i(j)]$   $i = F, P$  denotes momentary profits of a firm type  $i$ .

### FCP firms

Given the momentary profits of a FCP firm

$$\begin{aligned} \Pi_{t+k}^F [\bar{P}_t^F(j)] &= \bar{P}_t^F(j) M_{t+k}^F(j) - S_{t+k} C_{t+k}(j) M_{t+k}^F(j) \\ &= [\bar{P}_t^F(j) - S_{t+k} C_{t+k}(j)] \left[ \frac{\bar{P}_t^F(j)}{P_{t+k}} \right]^{-\frac{1}{1+\rho}} M_{t+k} \end{aligned}$$

the first-order-condition of the profit maximization problem (6.38) is given by

$$\bar{P}_t^F(j) = -\frac{1}{\rho} \frac{\text{E}_t \sum_{k=0}^{\infty} \zeta^s R_{t,t+k}^* P_{t+k}^{\frac{1}{1+\rho}} M_{t+k} S_{t+k} M C_{t+k}(j)}{\text{E}_t \sum_{k=0}^{\infty} \zeta^s R_{t,t+k}^* P_{t+k}^{\frac{1}{1+\rho}} M_{t+k}} \quad (6.39)$$

where  $MC(j) = C'(j)$ .

The aggregate price level  $P_t^F$  evolves according to the following equation of motion

$$P_t^F = \left\{ \zeta (P_{t-1}^F)^{\frac{\rho}{1+\rho}} + (1 - \zeta) [\bar{P}_t^F(j)]^{\frac{\rho}{1+\rho}} \right\}^{\frac{1+\rho}{\rho}} \quad (6.40)$$

Assuming a symmetric equilibrium and log-linearising equations (6.39) and (6.40) gives the Euler equation for FCP firms

$$\Delta p_t^F = R^* \text{E}_t \Delta p_{t+1}^F + \frac{(1 - \zeta)(1 - \zeta R^*)}{\zeta} (s_t + m c_t - p_t^F) \quad (6.41)$$

### PCP firms

Given the following momentary profits of PCP firm

$$\begin{aligned} \Pi_{t+k}^P [\bar{P}_t^P(j)] &= S_{t+k} \bar{P}_t^P(j) M_{t+k}^P(j) - S_{t+k} C_{t+k}(j) M_{t+k}^P(j) \\ &= [\bar{P}_t^P(j) - S_{t+k} C_{t+k}(j)] S_{t+k} \left[ \frac{S_{t+k} \bar{P}_t^P(j)}{P_{t+k}} \right]^{-\frac{1}{1+\rho}} M_{t+k} \end{aligned}$$

the first-order-condition of the profit maximization problem (6.38) is given by

$$\bar{P}_t^P(j) = -\frac{1}{\rho} \frac{\text{E}_t \sum_{k=0}^{\infty} \zeta^s R_{t,t+k}^* S_{t+k} P_{t+k}^{\frac{1}{1+\rho}} M_{t+k} M C_{t+k}(j)}{\text{E}_t \sum_{k=0}^{\infty} \zeta^s R_{t,t+k}^* S_{t+k} P_{t+k}^{\frac{1}{1+\rho}} M_{t+k}} \quad (6.42)$$

where  $MC(j) = C'(j)$ .

The aggregate price level  $P_t^F$  evolves according to the following equation of motion

$$S_t P_t^P = \left\{ \zeta (S_t P_{t-1}^P)^{\frac{\rho}{1+\rho}} + (1 - \zeta) [S_t \bar{P}_t^P(j)]^{\frac{\rho}{1+\rho}} \right\}^{\frac{1+\rho}{\rho}} \quad (6.43)$$

Assuming symmetric equilibrium and log-linearising equations (6.42) and (6.43) gives the Euler equation for PCP firms

$$\Delta p_t^P = R^* E_t \Delta p_{t+1}^P + \frac{(1 - \zeta)(1 - \zeta R^*)}{\zeta} (mc_t - p_t^P) \quad (6.44)$$

### Aggregation

Using the aggregator (6.35) and Euler equations (6.41) and (6.44), we obtain an equation for the aggregate import price inflation

$$\begin{aligned} \Delta p_t = & R^* E_t \Delta p_{t+1} + \frac{(1 - \zeta)(1 - \zeta R^*)}{\zeta} (s_t + mc_t - p_t) \\ & + (1 - \omega)(\Delta s_t - R^* E_t \Delta s_{t+1}) \end{aligned} \quad (6.45)$$

This is the theoretical equation we base our calibration on. Parameters of interest are  $\zeta$ ,  $R^*$  and  $\omega$ .

## 6.6 Estimation of parameter values

The parameter estimates are given in table 3. We estimate the parameters of the production functions using cointegration methods (Johansen 1995). The parameters related to the capital stock's adjustment costs, depreciation function and import prices are estimated using GMM. For detailed description of estimation strategies, see Ripatti and Vilmunen (2004). Generally, cointegration methods work reasonably well in most cases. The deep recession in early 1990s makes it difficult to estimate the elasticity of technical substitution between capital and labour and the elasticity of substitution in consumption goods retailer's production function.

## 7 Market equilibrium

All the markets are in equilibrium at each point of time. The capital goods market is in the equilibrium if the supply of capital services by the capital rental firm equals to the demand for capital services by intermediate goods producers. Similarly the demand of labour equals its supply. There is an extra complication due to the fact that we measure the labour supply ( $L_t^{LW}$ ) and labour demand ( $L_t^{LF}$ ) are measured in different efficiency units, the former in terms of young workers and the latter in terms of private sector employment

$$L_t^{LW} = L_t^W + \xi L_t^R \quad (7.1)$$

$$L_t^{LF} = L_t^F + \xi^G L_t^G \quad (7.2)$$

Table 3.

**Parameters of the Supply Side**

Parameter	Value	Std.err.	Method
$\nu_\tau$	-19.37		Calibrated
$\bar{M}$	0.978		Calibrated
$\gamma_1$	79		Calibrated
$\gamma_2$	0.45		Calibrated
$\delta_2$	13.29		Calibrated
$\delta_\tau$	-0.25		Calibrated
$\gamma_\tau$	7.80		Calibrated
$\tau_\tau$	0.75		Calibrated
$\bar{\delta}$	0.0125		Derived <sup>a</sup>
$\delta_0$	0.010		Derived
$\delta_1$	0.034		Derived
$\delta_2$	4.5		Calibrated
$\rho$	0.724		Historical data
$1/(1 + \rho)$	0.58		Derived
$\delta$	0.1		Calibrated
$\rho^C$	-0.5		Calibrated
$1/(1 + \rho^C)$	2		Derived
$\delta^C$	0.87		Calibrated
$\rho^I$	-0.538	0.183	Cointegration
$1/(1 + \rho^I)$	2.2		Derived
$\delta^I$	0.67		Calibrated
$\rho^X$	1.22	0.38	Cointegration
$1/(1 + \rho^X)$	0.45		Derived
$\delta^X$	0.51		Calibrated
$R^C$	$= R^I = R^R = M$		Calibrated <sup>b</sup>
$\zeta^C$	0.88		Calibrated <sup>c</sup>
$\omega^C$	0.6		Calibrated <sup>c</sup>
$\zeta^I$	0.95		Calibrated <sup>c</sup>
$\omega^I$	0.3		Calibrated <sup>c</sup>
$\zeta^X$	0.6		Calibrated <sup>c</sup>
$\omega^X$	0.9		Calibrated <sup>c</sup>
$\rho^W$	1.24		Cointegration

<sup>a</sup>The steady-state depreciation coefficient is estimated as the average of depreciation coefficient from the capital accumulation equation.

<sup>b</sup>Preliminary estimates exist.

Since these are measured in different units they need not be equal in equilibrium. In terms of the number of employed, labour supply equals labour demand, ie  $L_t^S = L_t^D$  as follows:

$$L_t^S = L_t^W + L_t^R = L_t^{LW} + (1 - \xi)L_t^R \quad (7.3)$$

$$L_t^D = L_t^F + L_t^G = L_t^{LF} + (1 - \xi^G)L_t^G \quad (7.4)$$

In the intermediate goods sector demand for intermediate goods by the retailers and exporter equals total supply:

$$Y_t^C + Y_t^I + Y_t^X = Y_t \quad (7.5)$$

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

$$\delta_t^D = 1 \quad (7.6)$$

Markets for final goods clear when

$$C_t^{SF} + C_t = C_t^T \quad (7.7)$$

$$I_t^G + I_t = I_t^T \quad (7.8)$$

$$\left( \frac{P_t^X}{S_t P_t^W} \right)^{-\rho^W} \mathcal{M}_t = X_t \quad (7.9)$$

where the L.H.S. of equation (7.9) represents world demand for our exports and where  $\mathcal{M}_t$  and  $P_t^W$  are, respectively, aggregate R-O-W imports and its unit price in terms of foreign currency. Markets for non-market goods clear when the supply of non-market goods,  $Y_t^G$  equals pension funds' consumption,  $C_t^P$ , and other general government's consumption of non-market goods,  $Y_t^S$ :

$$C_t^P + Y_t^S = Y_t^G \quad (7.10)$$

When market clearing conditions (7.1) – (7.10) hold, then the workers' and pensioners' budget constraints (2.22), (2.11), the general government budget constraint (4.2) and pension fund's budget constraint (4.4) imply the following accumulation of (net) foreign assets

$$S_t A_t^W = (1 + r_t^F) S_t A_{t-1}^W + \mathcal{T}_t^{SEU} + \underbrace{P_t^X X_t - P_t^{MR} M_t^R - P_t^{MC} M_t^C - P_t^{MI} M_t^I}_{\equiv \text{trade balance}} \quad (7.11)$$

where the lower line defines trade balance. The current account is given by  $S_t(A_t^W - A_{t-1}^W)$ , the factor income account by  $r_t^F S_t A_{t-1}^W$  and the transfers account by  $\mathcal{T}_t^{SEU}$ .

### Monetary policy

Monetary policy reflects Finland's small share in euro area. According to capital key of the ECB, the share of Finnish economy is approximately 1.5 percent that of the euro area. Consequently, the feedback from the Finnish economy to euro area level is very modest. A reasonable approximation is that the euro area policy rate and the foreign exchange rate<sup>30</sup> are exogenous for the Finnish economy. We furthermore assume that the exchange rate is fixed. Therefore, the model assumes that  $S_t = S_{t-1}$ .

<sup>30</sup>In the data we approximate the currency basket  $S_t$  according to export weights of the following countries: Germany, Italy, UK, USA, Sweden and Japan. See Ripatti and Viertola (2004) for details.



## 8 Product and labour market reforms

### 8.1 Background

An increase in competition implies a fall in the mark-up. It reduces the ability of intermediate goods producers and workers to exploit their market power by restricting the supply of intermediate goods and labour effort. Therefore, in the *Aino* model, it directly scales up supply of intermediate goods and labour supply. Increased competition also boosts – within the limits of elasticity of substitution – factor demands, ie employment, capital and consumption. Nominal price and wage levels directly decline.

Høj and Wise (2004) discuss possible channels through which measures to increase competition may operate:

- Reduction of price margins.
- Reduction of the slack in the use of input factors.
- Competitive environment stimulates productivity growth.

Since technological change in the *Aino* model is exogenously given, we can only take into account the first and last channel. Therefore, our estimates of the potential benefits of increased competition lie on the conservative side. Nicoletti, Bassanini, Ernst, Jean, Santiago and Swaim (2001) and Kilponen, Kiander and Vilmunen (2004) model the interlinkages in regulations and technological growth. Hence, a possible future extension of our work involves modelling the linkage between the price mark-up and labour-augmenting technological change.

Martins, Scarpetta and Pilat (1996) estimate product mark-ups for various OECD countries and industries. In manufacturing, the mark-up in Finland is among highest (1.24) in OECD countries whereas in some other industries it is at or below the average level (1.19–1.36). The manufacturing industry consists mainly of large exporting firms that are large in their output markets. Consequently, they probably have market power and display pricing-to-market behaviour in particular in their domestic markets that are fairly small relative to their level of production.

Høj and Wise (2004) list in a very detailed manner possible restrictions to product market competition in Finland. They also provide estimates of the macroeconomic effects of increased competition. According their estimate, based on the 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). This quantitative estimate is in the same range as the outcome in the scenario in Bank of Finland (2004), where the product market mark-up is assumed to decline 1/2 percentage point in the long-run. The resulting long-run employment growth is estimated to be 0.2 percent in the long-run. However, although similar a direct comparison of these estimates may not be warranted, because the assumption of a fall in the mark-up does not necessarily correspond to the approach by Høj and Wise (2004) to measuring increases in product market competition.

Nicoletti et al. (2001) and Jean and Nicoletti (2002) argue that the lack of competition in product markets typically correlates with the lack of competition in labour

markets.<sup>31</sup> The existence of mark-ups in product markets gives rise to economic rents. That may induce rent seeking behaviour by labour unions leading to mark-ups in labour markets. Therefore these are generally not independent.

## 8.2 Estimation of mark-ups

The degree of product market competition in the *Aino* model collapses to the time-varying parameter  $\Upsilon_t \equiv -1/\rho_t^z$  in the pricing equation (6.12). It is the inverse of the substitution parameter in the aggregator of domestic intermediate goods. 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 model setup has the drawback that imperfect competition is limited to intermediate goods sector only. Final good producers operate under perfect competition in their product markets. Consequently, we cannot, for example, limit the mark-up changes to domestic markets only. The export markets is influenced too.<sup>32</sup> This create some difficulties in interpreting the simulation results as the positive mark-up in exports market generally increases domestic welfare but reduces foreign welfare due to higher profits of exporting firms.

Estimation of the product mark-up,  $\Upsilon_t$ , in the pricing equation (6.12) is based on the approach developed by Ripatti and Vilmunen (2001) and applied in the context of the *Aino* model by Ripatti and Vilmunen (2004). It relies on the factor demands and pricing equations of the intermediate goods producers, *ie* equation (6.6), (6.7), and (6.12) respectively, and on the capital adjustment costs and depreciation function, (6.17) and (6.18). If the parameters of those equations were known, the unobserved capital-augmenting technical change  $\Lambda_t^K$ , labour-augmenting technical change  $\Lambda_t^L$  and price mark-up  $\Upsilon_t$  could be computed using these equations.

As an estimate of the elasticity of technical substitution,  $1/(1 + \rho)$ , between capital and labour, we use the value 0.58 which is close to estimate by Jalava, Pohjola, Ripatti and Vilmunen (2006) for the post-war period. The rest of the parameters are as reported in table 3. We have computed the estimates of  $\Lambda_t^L$ ,  $\Lambda_t^K$  and  $\Upsilon_t$  based on the perfect foresight assumption. This assumption and measurement errors result in very volatile estimates of these unobservables. In our exercise we rely on the smoothed<sup>33</sup> versions of these measures.

Figure 5 depicts various measures of private sector firms' profits. Profits and  $\Upsilon_t$  are model based measures, whereas gross-operating surplus is a national accounts measure. All of them share similar level shift, although the timing of the shift varies. A possible explanation of this level shift is the structural change in manufacturing after the deep recession and the rise of the ICT industries. It may also reflect changes in corporate governance, since the financial system in Finland during 1990s moved from bank-centred to more market based. At the same time the degree of foreign ownership in major exporting firms increased substantially. This may have influenced the required return of investments. Despite of the fact that the model is silent on the underlying reasons, all of this creates some confidence to our estimate of  $\Upsilon_t$ . In

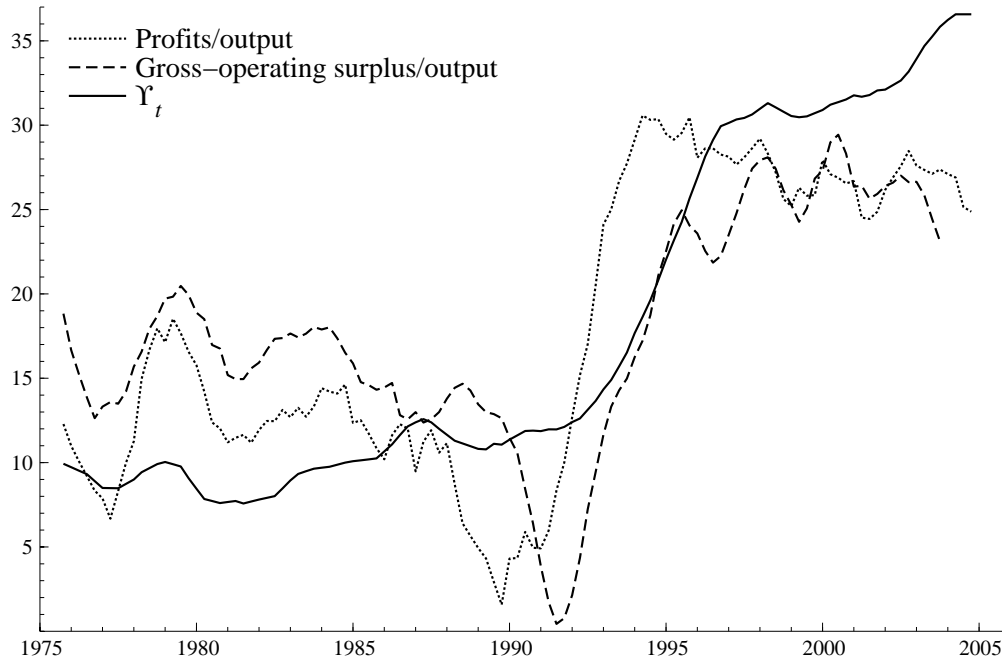
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<sup>31</sup>The measure of wage premia in the above-mentioned studies is based on the characteristics of the workers, working conditions and firms. Therefore, it does not directly correspond our labour market mark-up measure.

<sup>32</sup>The GEM model (Bayoumi et al. 2004b) allows for imperfect competition in various components of final goods and is able to make this breakdown.

<sup>33</sup>We use unobserved stochastic components model to smooth the time series.

Figure 5. **Private sector profit measures and  $\Upsilon_t$**



Means and ranges are adjusted. Left scale corresponds Profits/output line. Profits is the model's profit measure,  $\Pi_t/Y_t$ , gross-operating surplus is obtained from the national accounts and  $\Upsilon_t$  is based on our own calculations.

recent years the smoothed values of  $\Upsilon_t$  have varied around the level 1.08. This is a fairly small value compared to, for example, estimates by Martins et al. (1996) which suggest a value of 1.24 for manufacturing. The actual level of  $\Upsilon_t$  depends, in particular, on the choice of exogenously given risk premia in stock returns. As described above, the parameters of the production, pricing functions and adjustment costs in investments also play a crucial role here. Therefore our estimate is tentative but consistent with data and other parameters in the model. One may also defend this estimate in the light of new microeconomic evidence. Kilponen and Santavirta (2004) find that the average price-cost margin in Finnish industry is roughly 8%, when using microdata from annual Industrial Statistics surveys. This data covers essentially all the Finnish manufacturing plants employing at least 5 persons, up to year 1994, and from 1995 onwards, plants owned by the firms that employ no less than 20 persons.

The rate and the size of the decline in mark-up is more important than the level estimate of  $\Upsilon_t$  itself. In our simulation experiment we assume that  $\Upsilon_t$  declines from 1.078 to 1.06. In relative terms this is fairly substantial increase in the level of competition. We also assume that there is persistence in the transition to lower mark-up. We try to mimic the goals of Lisbon Agenda so that 80 per cent of the decline is achieved in 5 years.

The degree of imperfection in the labour markets is given by the parameter  $\rho_L$  in equation (3.1).  $1/\rho_L$  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, this parameter can be thought of as capturing essential ‘non-competitive’ features of the wage setting process in Finland.

Given the calibrated level of product market mark-up,  $\Upsilon_t = 1.078$ , we calibrate rest of the model parameters to produce a steady state that is relatively close to the average data between 1995–2004. This implies that the labour market mark-up is at the level of 25 percent, ie  $\rho_L = 0.8$ . In the following simulations we assume that this mark-up declines 5 percentage points ( $\rho_L = 0.833$ ). We assume that this process is gradual as in the case of price markup. Whether the size of the assumed decline in the mark-ups is big or small is difficult to judge. Cross-country comparisons using the same methodology and model structure would possibly support our choices.

### 8.3 Labour market reforms — simulation results

In an imperfect competition model, like *Aino*, the decline in the market power of the workers shows up – by construction – in an increasing supply of labour and lower wages. Lower wages translates into lower producer price level through reduced marginal costs. Booming investments will restore the original relative factor price array. Increased price competitiveness boosts aggregate demand (exports, consumption and investments). Given the current parameter values, the income effect dominates the substitution effect in imports and aggregate import is expanded as well.

The above channel is counter-balanced by the fact that the real interest rate will temporarily rise. This is due to the fixed nominal interest rate and falling prices. The rise in real rates impinges negatively on current consumption and investments. The size of the effect is, naturally, conditional on the magnitude of intertemporal elasticity of substitution.

The elasticity of substitution between consumption and leisure determines the labour supply response. The response is amplified by the income tax rule for closing the public sector accounts. Income taxes create a distorting wedge between production prices and consumption prices, and, consequently, between consumption-leisure marginal rate of substitution and the marginal product of labour. In the current simulation this wedge narrows down due to the reduction of public deficit.

Dynamic responses are driven by the nominal rigidities, ie wage and price rigidities, real rigidities, like capital adjustment costs and the capacity utilization, and the sensitivity of fiscal policy to the public debt to output ratio. Intertemporal elasticity of substitution is also a key determinant of the dynamic responses. Distortionary income taxes play an important role in the dynamic responses. The speed of fiscal adjustment is controlled by the parameter  $\kappa$  in equation (4.3).

In order to assess the magnitudes of these various effects, table (4) shows how an anticipated gradual decline in the wage mark-up translates into deviations of several macroeconomic variables from the baseline. Table (4) also shows the share of the total effect that is achieved in 5 years.

In general, the model simulations suggest small, but fairly reasonable effects on the macroeconomic equilibrium. Private production increases in the long run by 1.2% with the associated increase in private investment, private consumption and employment. Real exchange rate depreciation is relatively modest in comparison to the increase in consumption and investments. Yet, there is a moderate improvement

Table 4. **Aino estimates of the increasing labour market competition in the Finnish economy**

	After, years			Long run	% of total effect after 5 years
	2	5	10		
Private production, %	0.21	0.51	0.78	1.24	41.0
Private consumption, %	-0.01	0.11	0.27	1.23	8.7
Private investment, %	0.47	0.83	1.02	1.08	76.5
Capital stock, %	0.04	0.16	0.39	1.08	15.3
Employment, %	0.25	0.55	0.76	0.98	55.7
Real wage, %	-0.24	-0.45	-0.48	-0.24	184.77
Income tax rate, % pts	0.0	0.0	-0.08	-0.7	12.0
Pension contrib. rate, % pts	0.0	-0.01	-0.03	-0.18	16.7
Real exchange rate, %	0.20	0.45	0.66	0.65	.44
Debt to output ratio, % pts	-0.4	-2.6	-7.4	0	-
Wage mark-up, %	-1.8	-3.2	-3.9	-4.0	80.0
Export to import ratio, % pts	0.20	0.47	0.71	0.33	22.3
Welfare, %	-	-	-	0.47	-

in export to import ratio in the long-run. Fiscal adjustment shows up in a very modest short and medium term decline in income tax rate, and comparatively larger adjustment of the debt to GDP ratio. Once the economy has reached a new equilibrium, however, considerably lower income tax rate is required for maintaining the budget balance. Similarly, the required pension contribution rate settles to a  $-0.2$  percentage points lower value. Finally, there is an improvement in the *Aino* model's consumer welfare of about 0.5%.

Looking at the short- and medium run adjustment, it is evident from the table that increasing competition in the labour markets translates relatively rapidly into investment hike, while consumption responds with a considerable delay. Moreover, there is a hump-shaped response of real wages, such that in the medium term real wages over-react to the declining market power of the wage setters. This is reflected also in private consumption which shows a modest decline during the first 2 years of the simulation. Faster initial reaction in real wages also implies that increases in employment contribute more to the increase in private production than does the increase in the capital stock. The sluggish increase in the capital stock reflects also the real adjustment costs of capital. Similarly the slow consumption response reflects relatively low intertemporal substitution of the *Aino* model's consumers.

#### 8.4 Product and labour market reforms combined — simulation results

In many situation, regulatory reforms in the product markets can be associated with reforms in the labour markets. Consequently, in the next simulation we combine gradually declining wage mark-up with gradually declining price mark-up. As in the previous simulation, we assume that roughly 80% of the 2 percentage point decline in the price mark up is achieved in 5 years. The results are reported in table (5) as deviations from the baseline.

Decline in the price mark-up reduces monopoly power of domestic intermediate

Table 5. **Aino estimates of the increasing product and labour market competition in the Finnish economy**

	After, years			Long run	% of total effect after 5 years
	2	5	10		
Private production,%	0.51	1.35	1.98	2.92	46.3
Private consumption,%	-0.67	-.23	0.22	2.47	-27.3
Private investment,%	2.78	3.82	3.99	3.65	104.8
Capital stock,%	0.26	0.86	1.74	3.65	23.5
Employment,%	0.54	1.14	1.44	1.71	67.0
Real wage,%	0.39	1.05	1.73	2.77	37.8
Income tax rate,% points	0.1	0.2	0.2	-0.7	-27.2
Pension contr. rate, % points	0.0	0.0	-0.16	-0.7	6.4
Real exchange rate,%	.59	1.22	1.73	1.59	77.0
Debt to GDP ratio, % points	2.18	1.03	-2.4	0.0	-
Wage mark-up, %	-1.8	-3.2	-3.9	-4.0	80.0
Price mark-up, %	-0.82	-1.47	-1.78	-1.85	80.0
Export to import ratio,% points	0.58	1.16	1.74	0.86	102.5
Welfare, %	-	-	-	1.22	-

goods producers. Output rises and production prices decline. There is also substantial increase in factor demands. Once this is combined with the decline in the wage mark-up, there is a considerable efficiency gain for the economy, once the adjustment process is completed. There is roughly a 3 percent increase in private production. Demand for capital stock increases up to 3.7 percent. Declining price mark up also results in an increasing real wage of 2.8 percent in the long-run. Increasing real wage encourages labour supply, thus increasing employment of about 1.7% in the new balanced growth path. Regarding consumption, we observe a small initial and fairly prolonged decline in the consumption level. This is due to the wealth effect as the discounted value of firms' profits are driven down. Moreover, since the nominal interest rate remains constant, and the economy's rate of inflation is temporally driven down, there is a temporary increase in the real interest rate. Higher real interest rate contributes to the initial decline in consumption. In the long run, however, as the increasing real wage and economy's capital stock translate into higher accumulated human and financial wealth, consumers consumption possibilities eventually improve of about 1.7 percent relative to the baseline. This is also translated into a considerable welfare increase of about 1.2 percent when measured in consumption units.

In the long-run fiscal balances improve, leading to a 0.7 percentage point decline in the income tax rate. Similarly, there is a 0.7 percentage point decline in the pension contribution rate. Lower income tax rates improve the efficiency of the economy together with declining mark-ups, as distortions to intra-temporal margins are reduced. Finally, export to import ratio improves along with the depreciating real exchange rate and improved price competitiveness of the domestic products.

Short-run and medium run dynamics reveal how the economy adjust to the new equilibrium. One interesting feature arises from fiscal adjustment. Namely, in the short-run income tax rates are driven up, as well as debt to output ratio. This is mainly due to the fact that initial drop in consumption drives down indirect tax revenues. In order to finance government consumption, transfers and investments, there is a need

to compensate these lost revenues by increasing tax revenues from wages, hence temporarily increasing the income tax rate and borrowing from the households.

## 8.5 Sensitivity analysis

General equilibrium models like *Aino*, has a number of deep parameters which critically shape the dynamic and long-run effects. In this section we discuss how the results would change if some of these crucial parameters are altered. First, we change the intertemporal elasticity of substitution from 0.5 to 0.7 thus reducing the income effect of consumption<sup>34</sup>. This change in parameter has more significant effects in the short-and medium run than in the long-run. It turns out that in the long-run higher intertemporal elasticity of substitution tends to downplay the effects of increasing competition in the product and labour markets to output, consumption and capital stock. For instance, level of consumption is now 2.25% higher, instead of 2.47% after adjustment to increasing competition has been completed. Only the long-run response of real wage is slightly magnified with higher intertemporal elasticity of substitution.

Lowering the elasticity of substitution between labor and capital from 0.72 to 0.62 has relatively minor effects on simulation results. Increasing competition results slightly smaller effects on output, consumption and capital stock. For instance, as a result of increasing competition in the labor and product markets, the level of the capital stock goes up by 3.5% in comparison to 3.7% in the baseline simulation.

In the *Aino* model, the Frisch elasticities of labour supply for workers and pensioners are 0.15 and 0.31 in the standard calibration of the model in the long-run<sup>35</sup>. The value for workers is at the bottom range of international microeconomic studies, which report the values from 0.15–0.32.<sup>36</sup> Kuismanen (2005a, 2005b) has estimated compensated labour supply elasticities using Finnish Labor Force survey data. Depending on the data sample and the methods used, his estimates range from 0.08 to 0.30.

Increasing Frisch elasticity of labour supply is likely to magnify the effects of increasing competition both in the labour and the product markets. We have thus experimented by decreasing the value of the elasticity of utility w.r.t. consumption,  $\nu$ , from 0.855 to 0.8. This requires re-calibration of the pensioners labour efficiency parameter to 0.6 in order to keep pensioners labour supply within the observed range. As a result of this re-calibration, workers' Frisch elasticity of labour supply increases to value 0.23, while pensioners Frisch labour supply elasticity remains at roughly 0.3. With these new values of elasticities we find that the effects of increasing competi-

<sup>34</sup>Higher intertemporal elasticity of substitution reduces the labour supply of pensioners. Consequently we have re-calibrated the labour efficiency of pensioner to 0.375.

<sup>35</sup>Given Cobb-Douglas form of intratemporal utility the steady state values of Frisch elasticities of labour supply for workers and retirees can be calculated as

$$\bar{\nu}_F^W = \frac{1 - v}{\nu[\bar{W}(1 - \bar{t}^{WS} - \bar{t}^{WP})/\bar{C}^W - 1]}$$

$$\bar{\nu}_F^R = \frac{1 - v}{\nu[\xi\bar{W}(1 - \bar{t}^{RS})/\bar{C}^R - 1]}$$

<sup>36</sup>However, in comparison to typical calibrations in the Real Business Cycle literature the workers' labour supply elasticity is on the low side. For instance Bayomi, Laxton and Pesenti (2004) use the value 0.33 in their benchmark calibration of the GEM to the Euro area.

Table 6. **Increasing product and labour market competition in the Finnish economy with faster fiscal adjustment**

	After, years			Long run	% of total effect after 5 years
	2	5	10		
Private production,%	0.44	1.28	1.98	2.92	43.8
Private consumption,%	-0.78	-.31	0.25	2.47	-12.6
Employment,%	0.47	1.06	1.43	1.71	62.0
Real wage,%	0.45	1.13	1.74	2.77	40.7
Income tax rate,% points	.41	.48	.18	-.7	-27.2
Debt to GDP ratio, % points	1.54	-2.4	-8.2	0	-
Wage mark-up, %	-1.8	-3.2	-3.9	-4.0	80.0
Price mark-up, %	-.82	-1.47	-1.78	-1.85	80.0

tion are now roughly 30% higher than in the standard simulation (see table 5). For instance output and private consumption increase in the long-run by 4% and 3.5% respectively. Similarly, employment increases now by 2.5% in comparison to 1.7% in the standard simulation. Finally, these larger effects also show up in markedly higher increase in utility. Utility increase measured in units of consumption is 1.7% in the long-run.

As a final check of the robustness of our results, we make fiscal adjustment considerably faster. This is achieved by increasing the value of  $\kappa$  parameter in the fiscal adjustment equation from 0.02 to 0.1. 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 pronounced increase in debt to output ratio in the short run. Faster fiscal adjustment results slightly more pronounced decline in consumption in the short-run when compared to the case with slow fiscal adjustment. This is associated with somewhat less pronounced increase in employment but more pronounced increase in the real wage. Finally, faster fiscal adjustment has only very minor effects on private investment and capital stock (not reported). The table 6 summarises some of the results with faster fiscal adjustment. Finally, figure 6 compares the dynamic adjustment paths under standard simulation (dashed line) and under faster fiscal adjustment (solid line).

## 9 Conclusions

In terms of economic performance the Finnish economy has performed comparatively well during the last decade when assessed. Many regulatory reforms have also been made 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 the product markets in Finland. Similarly, the Finnish labour markets share many features that make the wage determination essentially non-competitive. Moreover, the Finnish economy will face a dramatic demographic change in the forthcoming decades leading to substantial rise in old-age dependency ratio and deteriorating fiscal balance. The product and labour market reforms may form a possible avenue to relief this burden along improved efficiency. In this paper, we have used the recently developed dynamic general equilibrium model called *Aino* to evaluate quantitatively the macroeconomic effects of increased product and labour competition in



the Finnish economy.

We have simulated the response of the model's economy to changes in the price and wage mark-ups. Our estimate for the baseline level of product market mark-up was 8 per cent and for the labour market mark-up 25 per cent. We simulated the effects of a 2 percentage points decline in the price mark-up and 5 percentage points decline in the wage mark-up. The decline was assumed to be gradual so that 80 percent of it was passed in 5 years. We tested the robustness of our simulation results to changes in some key parameters of the model. These included parameters such as fiscal adjustment and labour supply elasticity.

Our standard simulation suggests that increasing competition in the product and labour markets will eventually lead considerable welfare improvement, supported by increased consumption, investments, employment and production potential of the economy. The increased efficiency gives room to a reduction in the income tax rate and employees' pension contribution rate by 0.7 percentage points each, yet keeping the long-run public debt to GDP ratio intact. Transition of the economy to new competitive environment is costly however. There is an initial fall in consumption due to the wealth effect from lower profits and a rise in the real interest rate<sup>37</sup>. Overall, however, the quantitative effects clearly suggest that continuation of the regulatory reforms is crucial, not least because they would ease the future fiscal burden of the aging population.

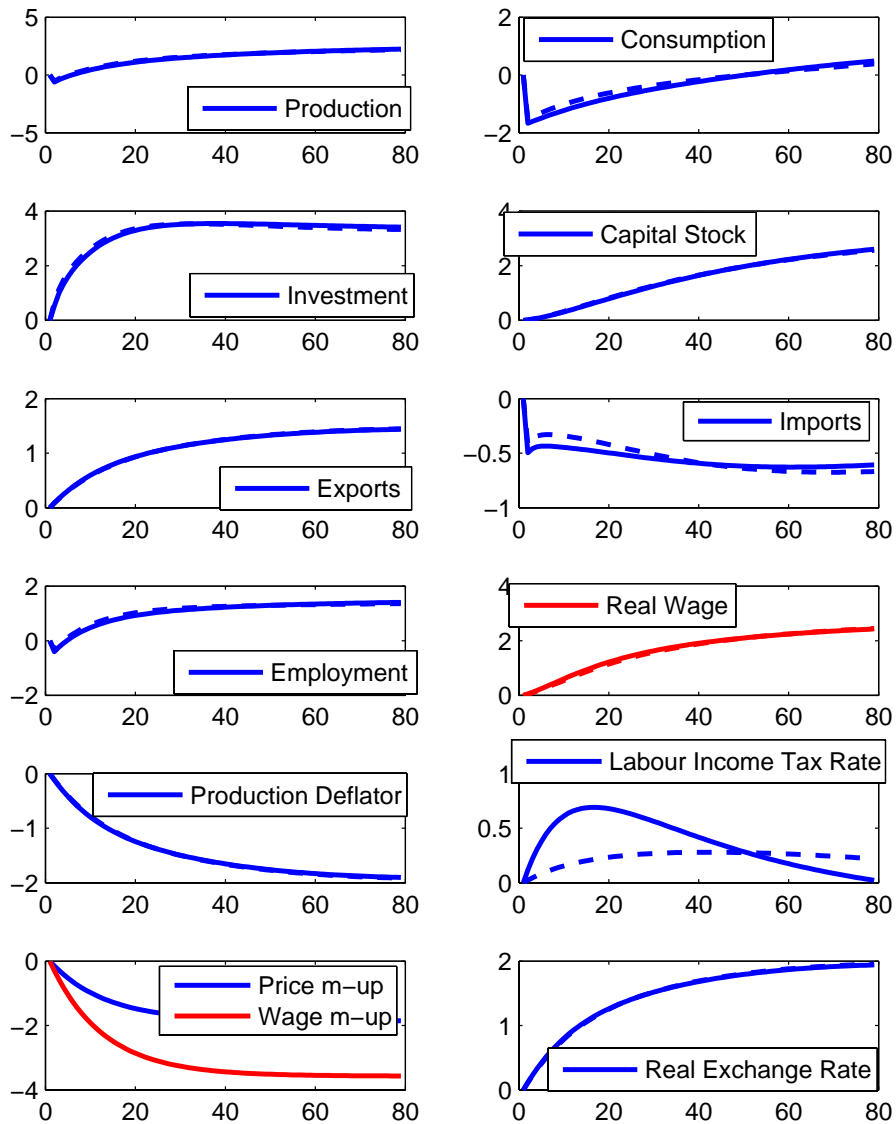
Finally, it should be noted that product market competition and technological changes are not necessarily independent as suggested by Nicoletti et al (2001). Positive correlation between these would imply even greater positive responses. Since our experiment does not take into account this interdependence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

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<sup>37</sup>Such short-run effects could potentially be alleviated by designing optimal fiscal and monetary policies along the transition path.

Figure 6.

**Labour and product market reforms: dynamic solution paths under alternative assumptions about fiscal adjustment**



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