MACRO-LINKAGES, OIL PRICES AND DEFLATION WORKSHOP
JANUARY 6–9, 2009

DSGE Modelling at the Banco de Portugal

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Outline

1. DSGE models at the Banco de Portugal
2. Introducing and calibrating PESSOA
   - Households and labour unions
   - Firms
   - Government
   - Rest of the world and market clearing
   - Calibration
3. Increasing competition in the domestic markets
   - Motivation of the paper
   - Simulation design and results
   - Main findings
4. Ongoing research using PESSOA
5. Directions for further research

DSGE models at the Banco de Portugal

DSGE modelling activities started in 2005

Available DSGE models

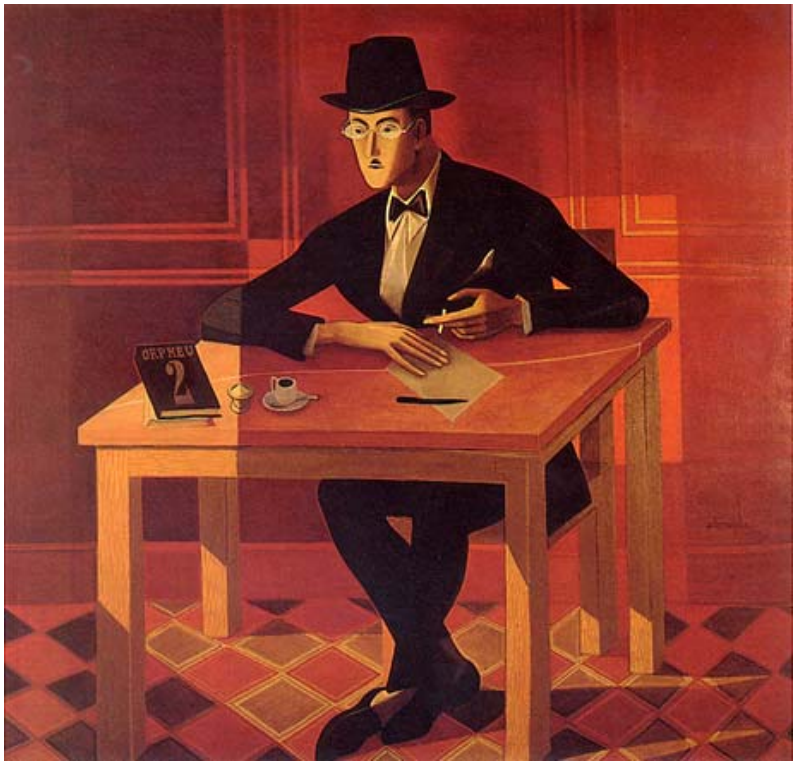
EA-US model Alves, N., S. Gomes and J. Sousa (2007)

PESSOA model Almeida, V., G. Castro and R. Félix (2008)

Ongoing DSGE research projects

- Available models are being used in applied research
- **EAGLE** model: joint project with ECB and Banca d'Italia
- Identification issues in DSGE models
- Credit frictions in DGSE models

Introducing *PESSOA*



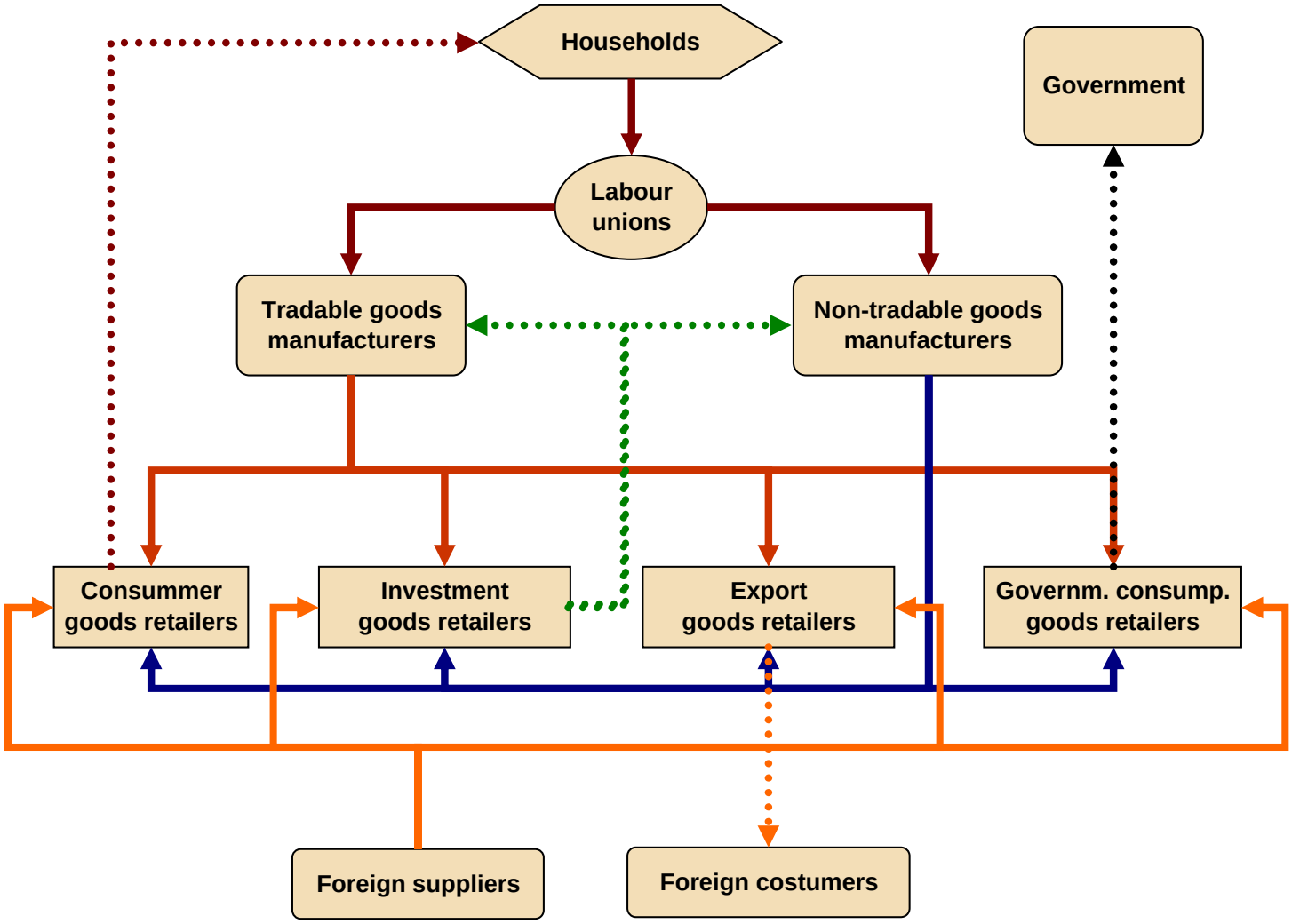
PESSOA

Portuguese
Economy
Structural
Small
Open economy
Analytical model

Almeida, Vanda, Gabriela Castro and Ricardo Mourinho Félix (2008) "Improving competition in the non-tradables goods and labour market" WP 16/2008, Banco de Portugal

Introducing *PESSOA*: the model

Figure 1: Model flowchart



Introducing *PESSOA*: the model

General features

- SOE integrated in a monetary union (=euro area)
- 6 types of agents:
  - Households
  - Labour unions
  - Manufacturers (intermediate goods producers)
  - Distributors (final goods producers)
  - Government
  - Rest of the world (=euro area$\Rightarrow S = 1$)
- Labour and product differentiation
- Competition: monopolistic in output markets, perfect in input markets
- Real and nominal rigidities (quadratic adjustment costs)

Introducing *PESSOA*: the model

PESSOA is largely inspired on GIMF (Kumhof, M. and M. Laxton (2007))

PESSOA

- Small-open economy model
- Exogenous monetary policy
- No role for public investment
- Trade in semi-finished goods
- Heterogeneous import contents

GIMF

- Multi-country model
- Endogenous monetary policy
- Public investment plays a role
- Trade in intermediate and final goods
- Homogeneous import content

Households (I)

General features

- Blanchard-Yaari overlapping generations, declining lifetime productivity
- Liquidity constrained and liquidity unconstrained ($H \in \{LIQ, OLG\}$)
- Consume goods from distributors, supply labour to a union
- Pay taxes on consumption and labour income, receive transfers
- External habit persistence

OLGs' specific features

- Own firms
- Hold domestic and foreign bonds

Households (II)

CRRA utility

$$U^H_{a,t}(h) = \frac{1}{1-\gamma}\left[\left(\frac{C^H_{a,t}(h)}{Hab^H_{a,t}}\right)^{\eta^H}(1-L^H_{a,t}(h))^{1-\eta^H}\right]^{1-\gamma}$$

Budget constraints

- OLG:

$$P_t C^{OLG}_{a,t}(h) + B_{a,t}(h) + B^*_{a,t}(h) = (1-\tau_{L,t})W_t\Phi_a L^{OLG}_{a,t}(h) + \text{Tansfers}^{OLG}_{a,t}(h) +$$
$$+ \frac{1}{\theta}\left[i_{t-1}B_{a-1,t-1}(h) + i^*_{t-1}B^*_{a-1,t-1}(h)\right] + \text{Dividends}_{a,t}(h)$$

- LIQ:

$$P_t C^{LIQ}_{a,t}(h) = (1-\tau_{L,t})W_t\Phi_a L^{LIQ}_{a,t}(h) + \text{Transfers}^{LIQ}_{a,t}(h)$$

where $P_t = P^C_t(1+\tau_{C,t})$ is the numeraire.

Households (III)

Utility maximisation problems

- OLG:

$$\max_{C_{a,t}^{OLG}(h), L_{a,t}^{OLG}(h), B_{a,t}(h), B_{a,t}^{*}(h)} E_t \sum_{s=0}^{\infty} (\beta\theta)^s \, U_{a,t+s}^{OLG}(h)$$

s.t. Intertemporal budget constraint OLG_t

- LIQ:

$$\max_{C_{a,t}^{LIQ}(h), L_{a,t}^{LIQ}(h)} E_t \sum_{s=0}^{\infty} (\beta\theta)^s \, U_{a,t+s}^{LIQ}(h)$$

s.t. Intratemporal budget constraint LIQ_t

Wealth

$hw_t + fw_t =$ human wealth+financial wealth

$\tilde{R}_{t+s} = \Pi_{l=1}^{s} \theta / i_{t+l-1}$ human wealth discount factor

Labour unions

General features

- Hire labour from households, rent it to manufacturers charging a markup
- Pay tax on "dividend" arising from monopolistic competition
- Quadratic wage growth adjustment costs

Dividend

$$D_t^U(h) = \left(1 - \tau_{L,t}\right)\left[\left(V_t(h) - W_t\right) U_t(h) - \text{Adj.costs}_t(h)\right]$$

Dividend maximisation problem

$$\max_{V_t(h)} \quad E_t \sum_{s=0}^{\infty} \tilde{R}_{t+s} D_{t+s}^U(h)$$

s.t. Adj.costs, Type h labour demand

Manufacturers (I)

General features

- Produce tradable and non-tradable goods ($J \in \{T, N\}$), using labour from unions and capital (formed with investment good from distributors)
- Pay social security contributions on wage bill, tax on dividends
- Quadratic price growth and investment adjustment costs

Production function

$$Z_t^J(j) = \left((1-\alpha_U^J)^{\frac{1}{\xi_{ZJ}}} \left(K_t^J(j) \right)^{\frac{\xi_{ZJ}-1}{\xi_{ZJ}}} + (\alpha_U^J)^{\frac{1}{\xi_{ZJ}}} \left(T_t A_t^J U_t^J(j) \right)^{\frac{\xi_{ZJ}-1}{\xi_{ZJ}}} \right)^{\frac{\xi_{ZJ}}{\xi_{ZJ}-1}}$$

Capital accumulation equation

$$K_{t+1}^J(j) = (1-\delta^J) K_t^J(j) + I_t^J(j)$$

Manufacturers (II)

Dividend

$$D_t^J(j) = \left[P_t^J(j)Z_t^J(j) - (1+\tau_{SP,t})V_t U_t^J(j) - P_t^I I_t^J(j) - (\text{Fix.+Adj.costs})_t^J(j)\right] -$$
$$- \tau_{K,t}\left[P_t^J(j)Z_t^J(j) - (1+\tau_{SP,t})V_t U_t^J(j) - P_t^I\left(q_t^J \delta^J K_t^J(j)\right) - (\text{Fix.+Adj.costs})_t^J(j)\right]$$

Dividend maximisation problem

$$\max_{P_t^J(j), I_t^J(j), U_t^J(j), K_{t+1}^J(j)} E_t \sum_{s=0}^{\infty} \tilde{R}_{t+s} D_{t+s}^J(j)$$

s.t. Cap.accum.equation, Prod.function, Adj.costs, Type j intermediate good demand

Distributors (I): General features

Two-stage production technology

1st stage

- Produce composite tradable good using domestic tradables and imported goods
- Quadratic import content adjustment costs

2nd stage

- Produce private and government consumption, investment and export goods ($F \in \{C, I, G, X\}$) using tradable good produced in 1st stage and non-tradable goods from domestic manufacturers
- Pay tax on profits
- Quadratic price growth adjustment costs

Distributors (II): 1st stage

Production function

$$Y_t^{AF}(f) = \left((\alpha_{AF})^{\frac{1}{\xi_{AF}}} \left(Z_t^{TF}(f) \right)^{\frac{\xi_{AF}-1}{\xi_{AF}}} + (1-\alpha_{AF})^{\frac{1}{\xi_{AF}}} \left(M_t^F(f) \left[1 - \Gamma_t^{AF}(f) \right] \right)^{\frac{\xi_{AF}-1}{\xi_{AF}}} \right)^{\frac{\xi_{AF}}{\xi_{AF}-1}}$$

Cost

$$C_t^F(f) = P_t^T Z_t^{TF}(f) + P_t^* M_t^F(f)$$

Cost minimisation problem

$$\min_{Z_t^{TF}(f), M_t^F(f)} C_t^F(f)$$

s.t. Prod.function, Adj.costs

Distributors (III): 2nd stage

Production function

$$Y_t^F(f) = \left((1-\alpha_F)^{\frac{1}{\xi_F}} \left(Y_t^{AF}(f) \right)^{\frac{\xi_F - 1}{\xi_F}} + (\alpha_F)^{\frac{1}{\xi_F}} \left(Z_t^{NF}(f) \right)^{\frac{\xi_F - 1}{\xi_F}} \right)^{\frac{\xi_F}{\xi_F - 1}}$$

Dividend

$$D_t^F(f) = (1-\tau_{D,t}) \left[P_t^F(f) Y_t^F(f) - \Lambda_t^{AF}(f) Y_t^{AF}(f) - P_t^N Z_t^{NF}(f) - (\text{Fix.+Adj.costs})_t^F(f) \right]$$

Dividend maximisation problem

$$\max_{P_t^F(f), Y_t^{AF}(f), Z_t^{NF}(f)} E_t \sum_{s=0}^{\infty} \tilde{R}_{t+s} D_{t+s}^F(f)$$

s.t. Prod.function, Adj.costs, Type f final good demand

Government

General features

- Collects taxes, pay/receives transfers, consumes, issues debt
- Budget constraint

$$SG_t = \text{Taxes}_t - P_t^G G_t + \text{NetTransfers}_t^G$$
$$B_t = B_{t-1} - SG_t - (i_{t-1} - 1) B_{t-1}$$

- Structural budget balance fiscal rule

$$\left(\frac{SG}{GDP}\right)_t = \left(\frac{SG}{GDP}\right)_t^{tar} + d_{tax}\left(\frac{RV_t - RV_t^{ss}}{GDP_t^{ss}}\right) + d_{debt}\left(\frac{B_t}{GDP_t^{ss}} - \left(\frac{B}{GDP}\right)_t^{tar}\right)$$

- Labour income tax rate is set endogenously

Rest of the world and market clearing

Rest of the world = euro area

- Trade linkages: sells goods to distributors, buys export goods from distributors
- Financial linkages: households sell/buy bonds in the RoW

Market clearing

$$\sum_H L_t^H = \sum_J U_t^J$$

$$Z_t^J = \sum_F Z_t^{JF} + \text{Fix.+Adj.costs}_t$$

$$Y_t^C = \sum_H C_t^H + \text{Fix.+Adj.costs}_t; \quad Y_t^I = \sum_J I_t^J + \text{Fix.+Adj.costs}_t$$

$$Y_t^G = G_t + \text{Fix.+Adj.costs}_t; \quad Y_t^X = X_t + \text{Fix.+Adj.costs}_t$$

$$B_t^* = i_{t-1} B_{t-1}^* + P_t^X X_t - P_t^* M_t + \text{NetTransfers}_t^*$$

Calibration

- Productivity growth, inflation rate, interest rate: euro area DSGE models
- Steady-state key ratios: National Accounts data, 1995-2006
- Structural parameters: DSGE literature
- Nominal and real rigidities: Parameters from the literature as initial guesses

Increasing competition in the domestic markets: motivation

The Portuguese economy: 90's versus 2000's

90's A case of success in the European integration process

2000's Slowdown in economic activity, real divergence vs. euro area

What is behind this ?

Most popular stories are:

- FDI was diverted to Eastern European countries
- Integration of emerging economies with low unit labour costs

It can be disputed:

- FDI: $E(r^K) >$ cost of capital
- Non-competitive Portuguese companies were displaced

Increasing competition in the domestic markets: motivation

How to restore competitiveness in the new international environment ?

Increasing competition in domestic markets fosters international competitiveness

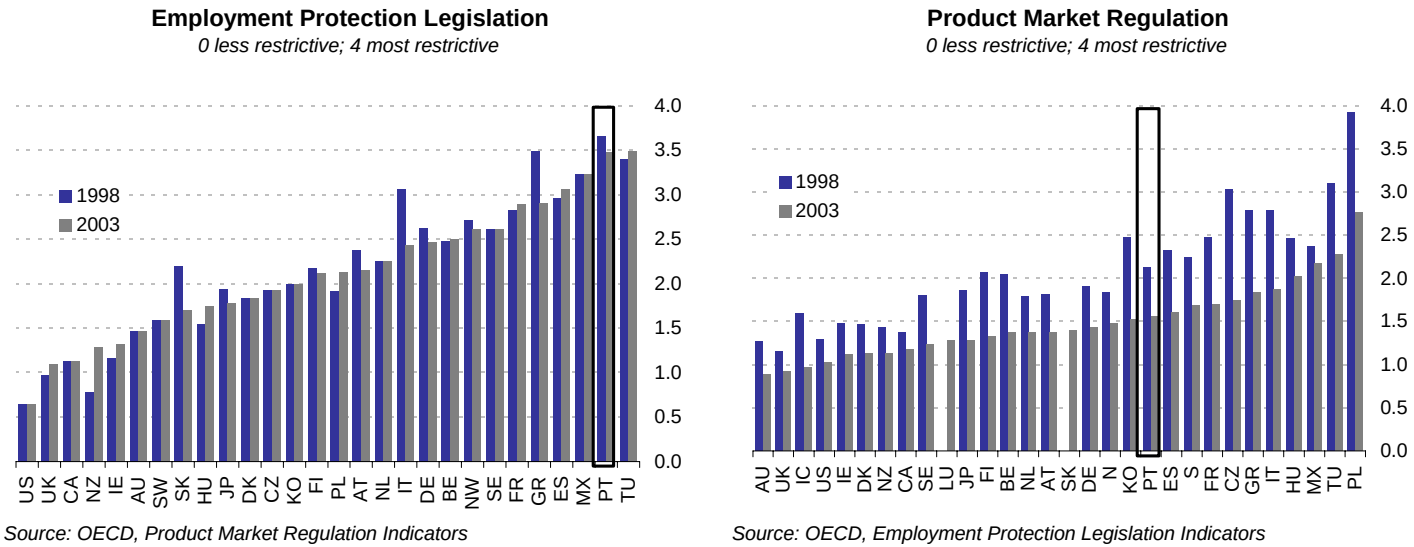
- Improves resource allocation
- Reduces non-tradable costs (knock-on effects)
- Crucial for a sound business environment (FDI inflows)
- Faster adjustment to shocks
- Portugal has still margin to improve competition

References: OECD, EC; Aghion; Høj, Conway, Nicoletti; Laxton and Bayoumi; Blanchard and Giavazzi

Increasing competition in the domestic markets: motivation

How to restore competitiveness in the new international environment ?

Figure 2: Regulation stance in Portugal



Source: OECD, Product Market Regulation Indicators

Source: OECD, Employment Protection Legislation Indicators

Simulation design

Features

- Permanent shocks to non-tradables price and wage markups
- Perfect foresight/information

Design

Non-tradable : Decline of 2 pp. in price markup (from 20% to 18%)

Wage : Decline of 2.5 pp. in wage markup (from 25% to 22.5%)

Pass-through : 80 % of the decline achieved in 2 years

The impact of increasing competition in non-tradables

Table 1: LR impact

	NT
GDP	1.3
Consumption	1.9
GFCF	2.1
Exports	1.5
Imports	0.3
Human wealth	1.2
Real wage (firms)	0.5
Labour inc. tax (pp.)	-2.0
NFA (% GDP)	4.7
Real exch. rate (+ depr.)	1.5
Domestic ToT (+ depr.)	1.7
Price tradables	0.3
Price non-tradables	-1.4
Tradables output	2.0
Non-tradables output	1.4
Tradables hours	1.7
Non-tradables hours	1.2

Source: Own calculations

1. Real exchange rate depreciation
   $(p^N \Downarrow, p^T \uparrow) \Rightarrow \lambda^F \downarrow \Rightarrow (p^X \downarrow, \epsilon \uparrow)$
2. Higher demand for domestic intermediates and final goods
   $(p^X \downarrow, \epsilon \uparrow) \Rightarrow X \uparrow$
   $\epsilon \uparrow \Rightarrow (Z^{TF} \Uparrow, M^F \uparrow)$
3. Increase in the capital intensity of output
   $(p^I/v) \downarrow \Rightarrow (K/L) \uparrow$
4. Households' consumption increases
   $(w \uparrow, \tau_L \downarrow) \Rightarrow hw \uparrow; fw \uparrow \Rightarrow C \uparrow$

The impact of increasing competition in labour market

Table 2: LR impact

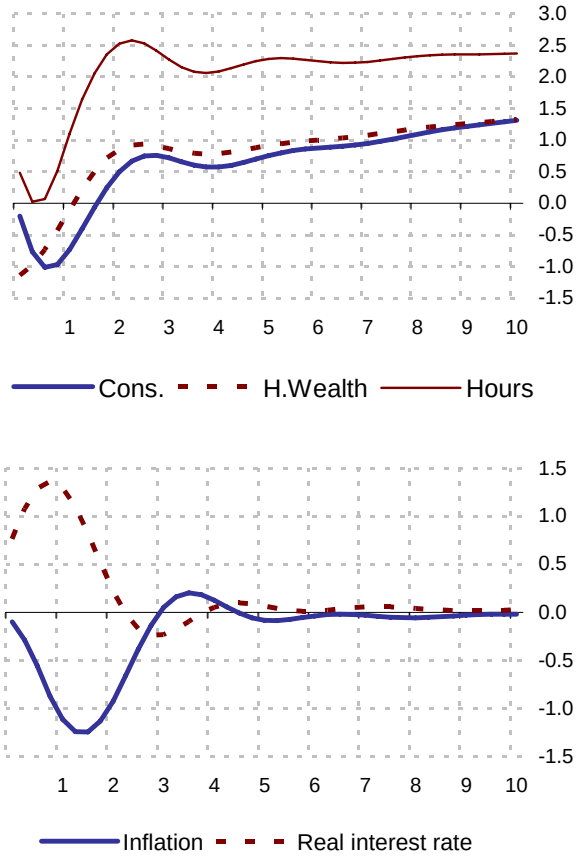
	NT	W	All
GDP	1.3	1.2	2.5
Consumption	1.9	1.7	3.5
GFCF	2.1	0.8	2.9
Exports	1.5	1.1	2.5
Imports	0.3	0.3	0.6
Human wealth	1.2	1.2	2.3
Real wage (firms)	0.5	-0.6	0.0
Labour inc. tax (pp.)	-2.0	-1.2	-3.2
NFA (% GDP)	4.7	4.5	9.2
Real exch. rate (+ depr.)	1.5	0.8	2.2
Domestic ToT (+ depr.)	1.7	0.0	1.7
Price tradables	0.3	-0.3	0.0
Price non-tradables	-1.4	-0.3	-1.7
Tradables output	2.0	1.7	3.7
Non-tradables output	1.4	0.8	2.2
Tradables hours	1.7	2.0	3.7
Non-tradables hours	1.2	1.1	2.2

Source: Own calculations

1. Real exchange rate depreciation
   $(p^N, p^T) \downarrow \Rightarrow \lambda^F \downarrow \Rightarrow (p^X \downarrow, \epsilon \uparrow)$
2. Higher demand for domestic intermediates and final goods
   $(p^X \downarrow, \epsilon \uparrow) \Rightarrow X \uparrow$
   $\epsilon \uparrow \Rightarrow (Z^{TF} \uparrow > M^F \uparrow)$
3. Higher labour intensity
   $(v/p^I) \downarrow \Rightarrow (K/L) \downarrow$
4. Households' consumption increases
   $D^U \downarrow < (w \uparrow, \tau_L \downarrow) \Rightarrow hw \uparrow$
   $; fw \uparrow \Rightarrow C \uparrow$

Implementation issue: SR negative impact on consumption

Figure 3: SR impact



1. Real interest rate increases temporarily $(\pi \downarrow; \bar{i}) \Rightarrow r \uparrow$
2. Households' consumption declines $r \uparrow \Rightarrow hw \downarrow \Rightarrow C \downarrow$
3. Higher demand, hours increase $\pi \downarrow \Rightarrow \epsilon \uparrow \Rightarrow Y \uparrow \Rightarrow L \uparrow$

The impact of increasing competition: main findings

- Increasing competition in domestic markets promotes the real exchange rate adjustment of the Portuguese economy within the EMU
- A cut in non-tradable goods prices and wage markups improves international competitiveness and boost economic activity
- Practical implementation issue: short-run negative impact in consumption and leisure
- Estimated impacts are on the downside: fiercer competition induces productivity gains not considered

The Portuguese economy in the EMU: a story of shocks and frictions (ongoing research!)

Aim of the study

Assess the performance of the Portuguese economy in the EMU through the lens of a DSGE model and draw some policy implications (if there are some!)

Structure of the article

- Empirical evidence and identification of some stylised facts
- Main shocks and the role of frictions
  - S1 Total factor productivity slowdown
  - S2 The fiscal policy imbalance and the fiscal consolidation
  - S3 The aftermath of the sharp interest rate decline
  - S4 Fiercer competition in international goods markets
  - S5 Still low competition in domestic markets
- Policy implications (hopefully some will arise!)

Directions for further research

- Extend the calibrated version of the model to include
  - Macro-financial linkages
  - The role of commodities, in particular oil
  - Search and matching frictions in the labour market
- Estimate a stripped down version of the model using Bayesian techniques
- Phase-in the model in regular projection and simulation activities

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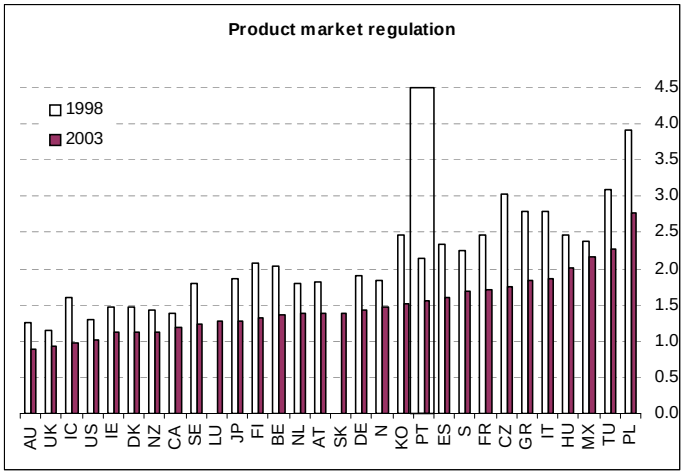
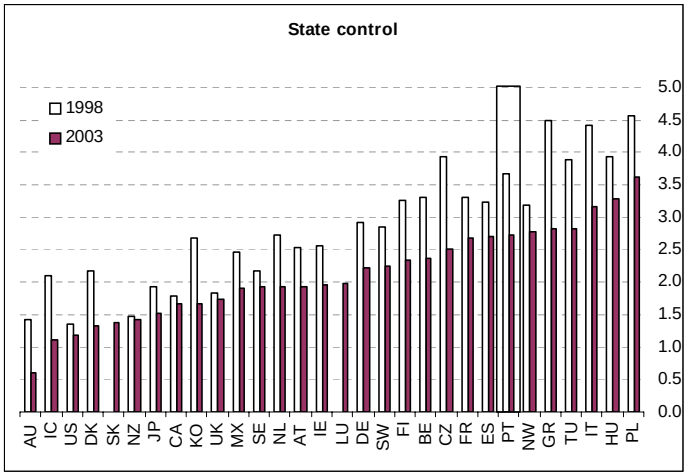
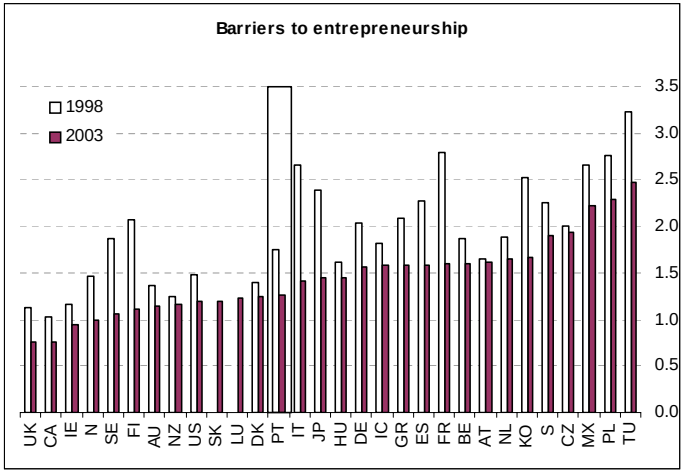
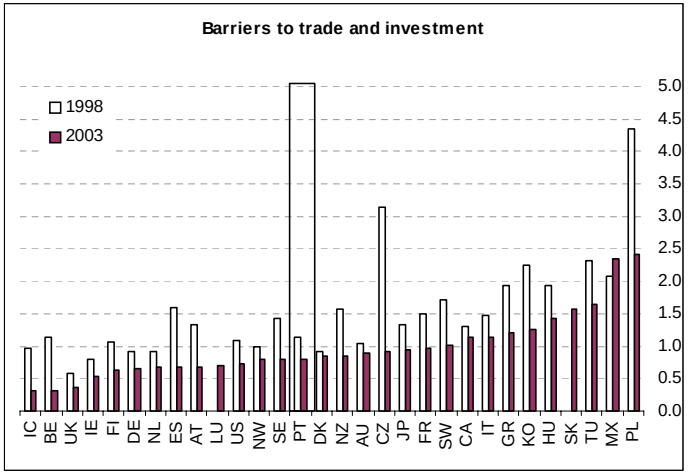
The regulatory stance in Portugal (A1)

Figure 4: PMR indicators



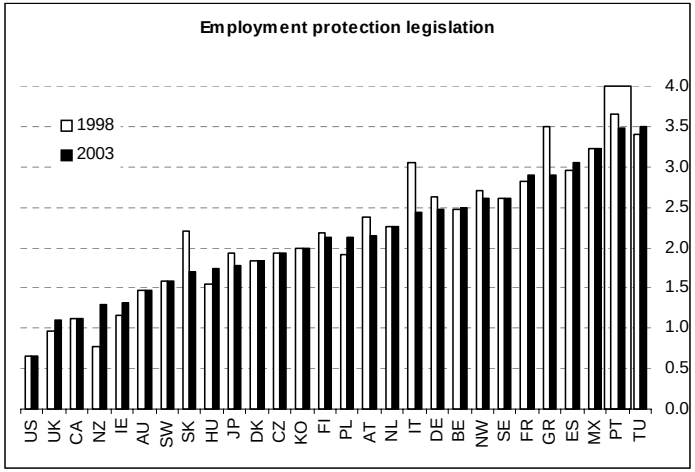


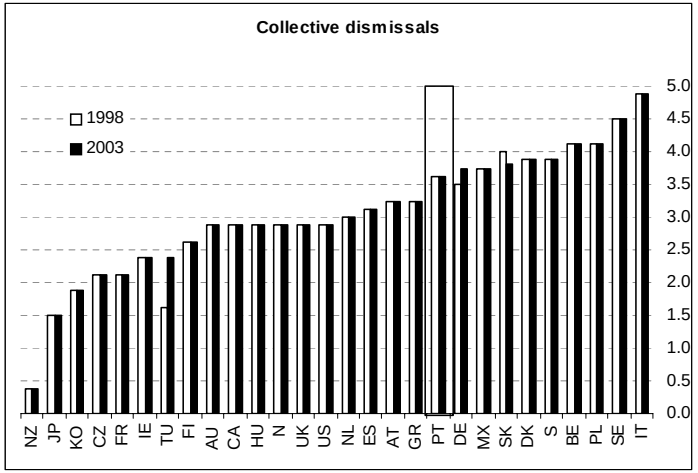


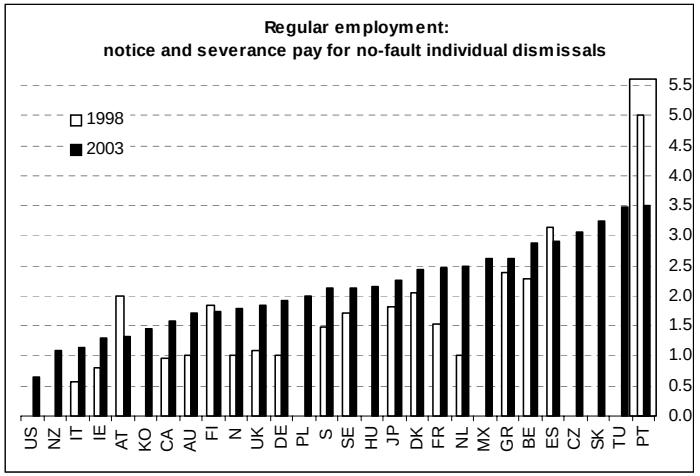


The regulatory stance in Portugal (A2)

Figure 5: EPL indicators

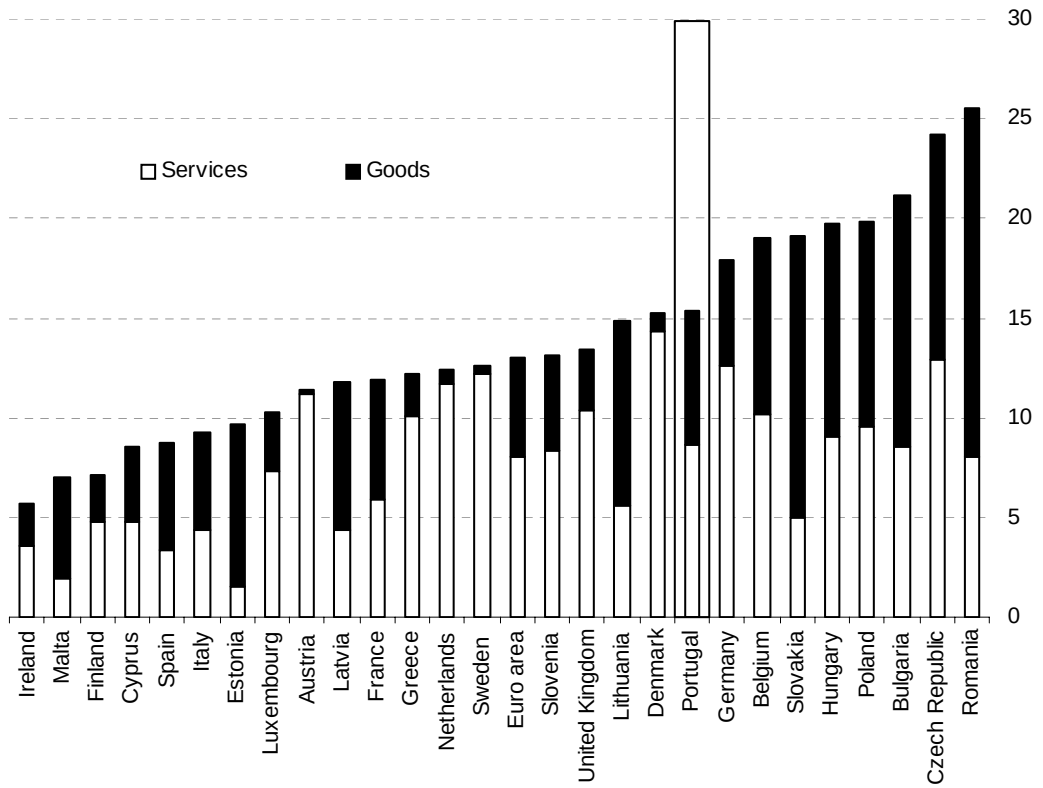






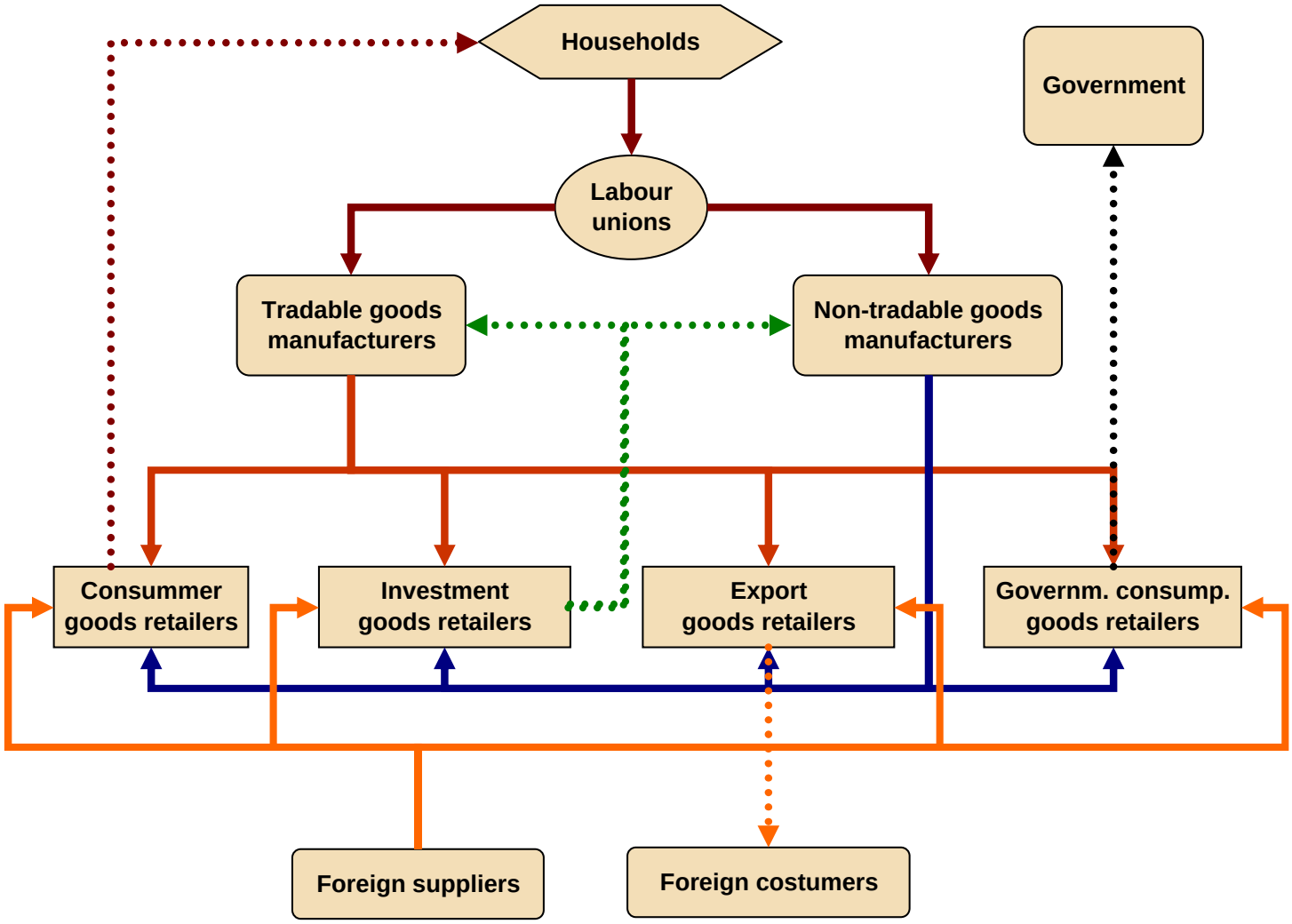
The regulatory stance in Portugal (A3)

Figure 6: Weight of administered prices in HICP



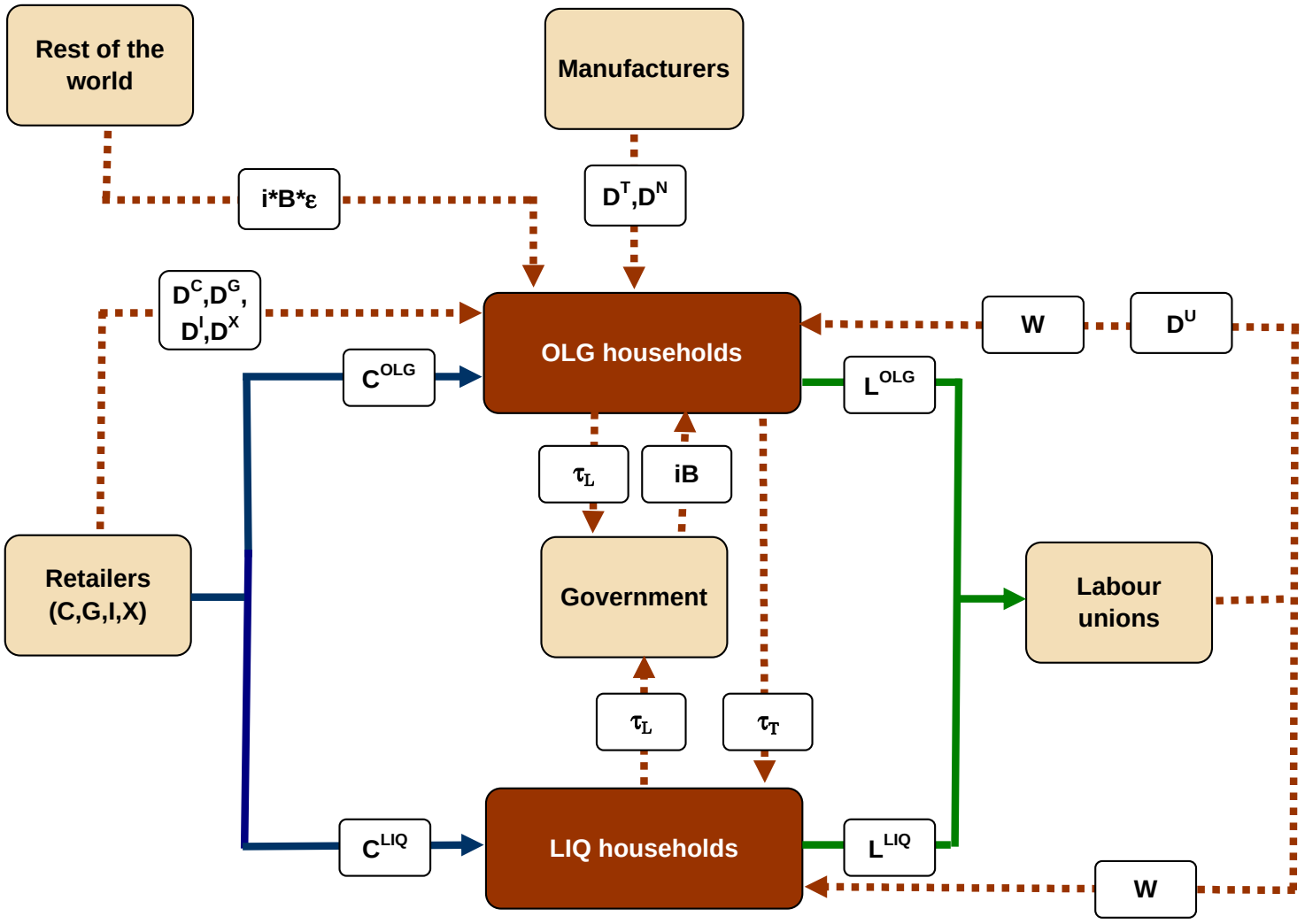
Introducing *PESSOA*

Figure 7: Model flowchart



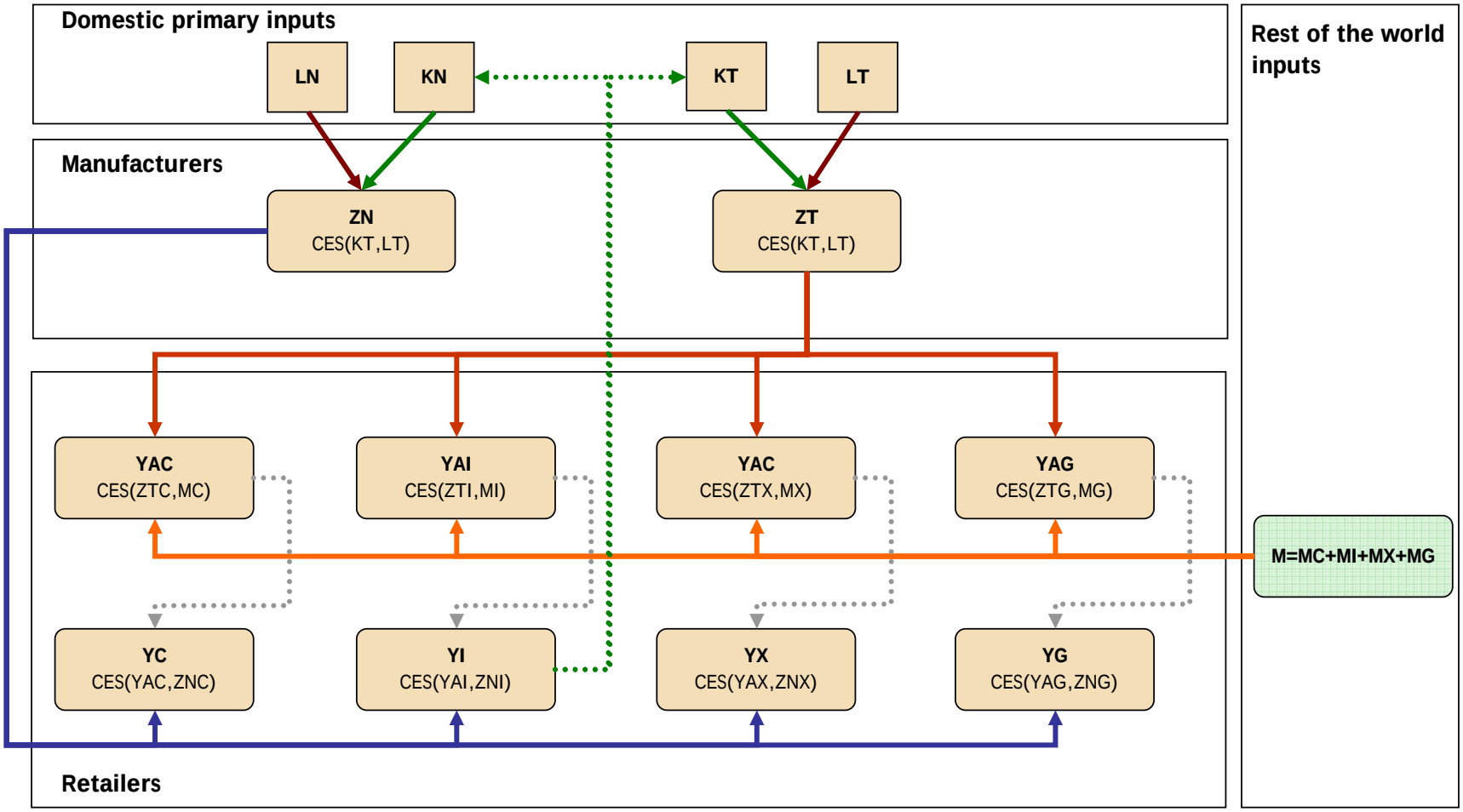
Households

Figure 8: The households' flowchart



Firms

Figure 9: The firms' flowchart



OLG households

Optimal aggregate conditions

$$\frac{C_t^{OLG}}{n(1-\psi) - L_t^{OLG}} = \left(\frac{\eta^{OLG}}{1-\eta^{OLG}}\right)(1-\tau_{L,t})w_t$$

$$i_t = i_t^*$$

$$C_t^{OLG} = mpc_t\left(hw_t^L + hw_t^K + fw_t\right)$$

$$hw_t^L = n(1-\psi)w_t(1-\tau_{L,t}) + \frac{\theta\chi}{r_t}hw_{t+1}^L$$

$$hw_t^K = (1-\iota)\left(d_t^N + d_t^T + d_t^C + d_t^G + d_t^I + d_t^X\right) + (1-\psi)\left(d_t^U + trg_t + trx_t\right) + \frac{\theta}{r_t}hw_{t+1}^K$$

$$fw_t = r_{t-1}\left[b_{t-1} + b_{t-1}^* \cdot \epsilon_{t-1}\right]$$

Labour unions

The equilibrium condition: a wage Phillips curve

$$\frac{\sigma_{U,t}}{\sigma_{U,t}-1}w_t - v_t =$$

$$= \frac{\phi_U T_t}{\sigma_{U,t}-1}\left(\frac{\pi_t^V}{\pi_{t-1}^V}-1\right)\frac{\pi_t^V}{\pi_{t-1}^V} - \left(\frac{1-\tau_{L,t+1}}{1-\tau_{L,t}}\right)\frac{\theta}{r_t}\frac{U_{t+1}T_{t+1}}{U_t}\frac{\phi_U}{\sigma_{U,t}-1}\left(\frac{\pi_{t+1}^V}{\pi_t^V}-1\right)\frac{\pi_{t+1}^V}{\pi_t^V}$$

in steady-state:

$$v = \frac{\sigma_U}{\sigma_U - 1}w$$

Manufacturers

The equilibrium conditions: a Phillips curve

$$\frac{\sigma_{J,t}}{\sigma_{J,t}-1}\frac{\lambda_t^J}{p_t^J}-1=$$
$$\frac{\phi_{PJ}}{\sigma_{J,t}-1}\left(\frac{\pi_t^J}{\pi_{t-1}^J}-1\right)\frac{\pi_t^J}{\pi_{t-1}^J}-\left(\frac{1-\tau_{K,t+1}}{1-\tau_{K,t}}\right)\frac{\theta}{r_t}\frac{\phi_{PJ}}{\sigma_{J,t}-1}\frac{p_{t+1}^J}{p_t^J}\frac{Z_{t+1}^J}{Z_t^J}\left(\frac{\pi_{t+1}^J}{\pi_t^J}-1\right)\frac{\pi_{t+1}^J}{\pi_t^J}$$

in steady-state:

$$p^J=\frac{\sigma_J}{\sigma_J-1}\lambda^J$$

Manufacturers

The equilibrium conditions: desired capital stock level

$$
\begin{aligned}
q_t^J = & \frac{\theta}{r_t}\frac{\pi_{t+1}^I}{\pi_{t+1}}\left[q_{t+1}^J\left(1-\delta^J\right)+\frac{r_{K,t+1}^J}{p_{t+1}^I}-\tau_{K,t+1}\left(\frac{r_{K,t+1}^J}{p_{t+1}^I}-q_{t+1}^J\delta^J\right)\right] \\
& +(1-\tau_{K,t+1})\frac{\theta}{r_t}\frac{\pi_{t+1}^I}{\pi_{t+1}}\frac{I_{t+1}^J}{K_{t+1}^J}\left[\phi_K^J\left(\frac{I_{t+1}^J}{K_{t+1}^J}-\frac{I^J}{K^J}\right)+\phi_I^J\left(\frac{I_{t+1}^J}{K_{t+1}^J}-\frac{I_t^J}{K_t^J}\right)\right] \\
& -(1-\tau_{K,t+1})\frac{\theta}{r_t}\frac{\pi_{t+1}^I}{\pi_{t+1}}\left[\frac{\phi_K^J}{2}\left(\frac{I_{t+1}^J}{K_{t+1}^J}-\frac{I^J}{K^J}\right)^2+\frac{\phi_I^J}{2}\left(\frac{I_{t+1}^J}{K_{t+1}^J}-\frac{I_t^J}{K_t^J}\right)^2\right]
\end{aligned}
$$

In steady-state, after-tax real return on capital equals the certain equivalent real return of government bonds.

$$
\frac{r}{\theta}=1+(1-\tau_k)\left(\frac{r_K^J}{p^I}-\delta^J\right)
$$

Manufacturers

The equilibrium conditions: optimal investment path

Investment path condition depends on investment adjustment cost parameters.

$$q_t^J = 1 + (1 - \tau_{K,t}) \left[\phi_K^J \left(\frac{I_t^J}{K_t^J} - \frac{I^J}{K^J} \right) + \phi_I^J \left(\frac{I_t^J}{K_t^J} - \frac{I_{t-1}^J}{K_{t-1}^J} \right) \right]$$

In steady-state, Tobin's-Q equals unity, market value of installed capital equals replacement cost.

The equilibrium conditions: optimal labour demand

$$(1 + \tau_{SP,t})\, v_t = \lambda_t^J \left(\frac{Z_t^J \alpha_U^J}{T_t A_t^J U_t^J} \right)^{\frac{1}{\xi_{ZJ}}} T_t A_t^J$$

Calibration: steady-state key ratios

Table 3: Steady-state key ratios

	Data	Model
Expenditure (as a % of GDP)		
Private consumption	0.64	0.61
Government consumption and GFCF	0.22	0.21
Private investment	0.21	0.21
Exports	0.29	0.29
Imports	0.37	0.33
Labour income share (as a % of overall income)	0.57	0.56
Tradable goods	0.54	0.54
Non-tradable goods	0.58	0.58
Capital-output ratio (as a % of output)	*NA*	2.34
Tradable goods	*NA*	2.53
Non-tradable goods	*NA*	2.21
Government (as a % of GDP)		
Debt stock	0.57	0.53
Fiscal balance	-0.07	-0.02
Overall revenues	0.38	0.39
Overall expenditure	0.45	0.41
External account (as a % of GDP)		
Net foreign assets	-0.60	-0.60
Current account	-0.06	-0.02
Trade balance	-0.08	-0.04

Calibration: households and labour union parameters

Table 4: Households parameters

Households discount rate (annualised)	β	0.97
Intertemporal elasticity of substitution	$\frac{1}{\gamma}$	0.20
OLG households instant probability of death (annualised)	$1-\theta$	0.04
OLG households habit persistence	ν	0.70
Consumption share - OLG households	η_{OLG}	0.74
Consumption share - LIQ households	η_{LIQ}	0.70
Lifetime productivity decline rate (annualised)	$1-\chi$	0.04
Share of LIQ households	ψ	0.40
Share of dividend transfers from OLG to LIQ households	ι	0.20
Memo items:		
Marginal propensity to consume wealth		*0.05*
Average planning horizon (years)		*25*
Average worklife (years)		*25*

Table 5: Labour union parameters

Wage mark-up	$\frac{\sigma_U}{\sigma_U-1}$	1.25
Wage rigidity - Adjustment cost	ϕ_U	200
Memo items:		
Duration wage contracts (quarters)		*6.4*

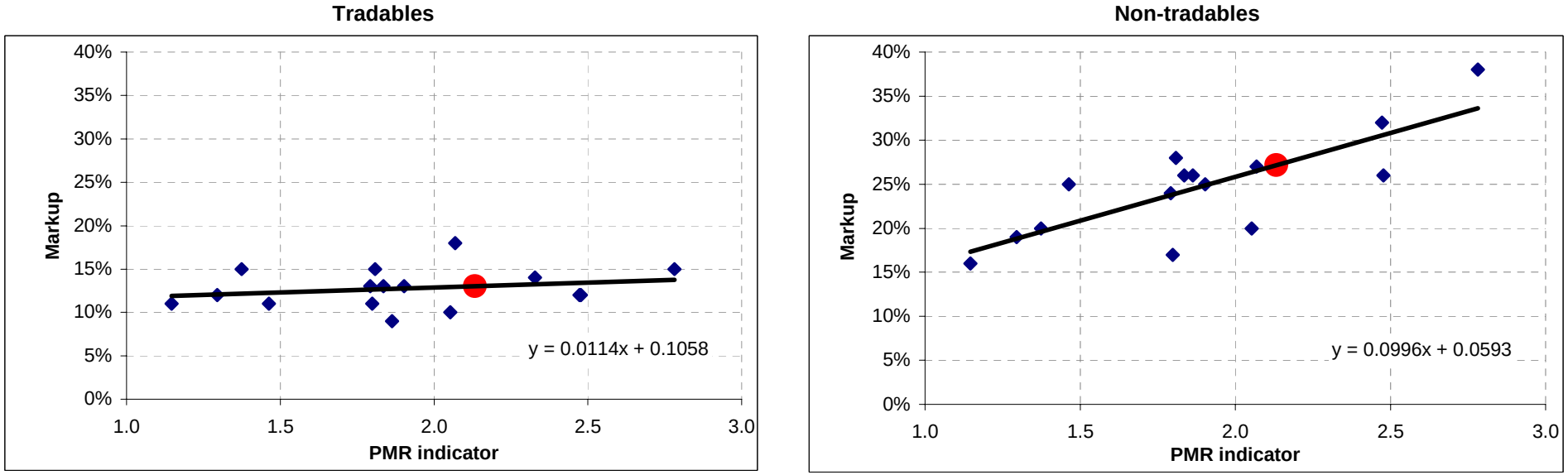
Calibration: manufacturers parameters

Table 6: Manufacturers parameters

		Tradable $J = T$	Non-tradable $J = N$
Depreciation rate (annualised)	δ	0.09	0.09
Labour augmenting prod. growth (annualised)	g	1.02	1.02
EoS between capital and labour	ξ_J	0.99	0.99
Quasi labour income share	α_J	0.60	0.60
Price markup	$\frac{\sigma_J}{\sigma_J - 1}$	1.10	1.20
Capital adjustment cost	ϕ_{KJ}	50	50
Investment adjustment cost	ϕ_{IJ}	100	100
Price adjustment cost	ϕ_{PJ}	200	200
Memo items:			
Duration price contracts (quarters)		*3.9*	*5.7*

Calibration: markups

Figure 10: Markups and PMR indicator



Calibration: distributors parameters

Table 7: Distributors parameters

		Consumer $F = C$	Govt. $F = G$	Invest. $F = I$	Export $F = X$
EoS domestic tradable/imported good	ξ_{AF}	1.50	1.50	1.50	1.50
Assembled good quasi domestic content	α_{AF}	0.12	0.02	0.02	0.19
EoS assembled/non-tradable good	ξ_F	0.50	0.50	0.50	0.50
Non-tradable good (quasi) factor share	α_F	0.71	0.98	0.88	0.15
Price markup	$\frac{\sigma_F}{\sigma_F - 1}$	1.05	1.05	1.05	1.03
Import content adjustment cost	ϕ_{AF}	2	2	2	2
Price adjustment cost	ϕ_{PF}	200	200	200	200
Memo items:					
Implied import content		*0.29*	*0.10*	*0.40*	*0.30*
Implied non-tradable content		*0.38*	*0.88*	*0.53*	*0.05*
Duration price contracts (quarters)		*2.7*	*2.7*	*2.7*	*1.8*

Calibration: government and foreign economy parameters

Table 8: Government parameters

Labour income tax rate	τ_L	0.29
Consumption tax rate	τ_C	0.30
Capital income tax rate	τ_K	0.17
Employers social security contribution rate	τ_{SP}	0.19
Debt to GDP ratio (annualised)	$\frac{b}{gdp}$	0.53
Speed adjustment towards the target debt ratio parameter	d_{debt}	0.10

Table 9: Foreign economy parameters

Foreign interest rate (annualised)	i^*	1.05
Foreign inflation (annualised)	π^*	1.02
EoS between domestic and imported goods	ξ^*	1.50