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Working Papers

16 | 2008

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Vanda Almeida
Gabriela Castro
Ricardo Mourinho Félix

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Please address correspondence to
Ricardo Mourinho Félix
Economics and Research Department
Banco de Portugal, Av. Almirante Reis no. 71, 1150-012 Lisboa, Portugal;
Tel.: 351 21 313 0321 , Email: rfelix@bportugal.pt

BANCO DE PORTUGAL

Economics and Research Department
Av. Almirante Reis, 71-6th floor
1150-012 Lisboa
www.bportugal.pt

Printed and distributed by
Administrative Services Department
Av. Almirante Reis, 71-2nd floor
1150-012 Lisboa

Number of copies printed
170 issues

Legal Deposit no. 3664/83
ISSN 0870-0117
ISBN 978-989-8061-52-2

Improving competition in the non-tradable goods and labour markets: the Portuguese case*

Vanda Almeida Gabriela Castro

Ricardo Mourinho Félix

Economics and Research Department, Banco de Portugal†

October 21, 2008

Abstract

This study assesses the macroeconomic impacts of increasing competition in the non-tradable goods and labour markets in Portugal. We lean on evidence that the maintenance of low competition in these markets may have contributed to the recent poor performance of the Portuguese economy. The analysis is performed using *PESSOA*, a dynamic general equilibrium model for a small-open economy integrated in a monetary union, featuring Blanchard-Yaari households, a multi-sectoral production structure and a number of nominal and real rigidities. We conclude that measures aimed at increasing competition in the Portuguese non-tradable goods and labour markets could induce important international competitiveness gains and be valuable instruments in promoting necessary adjustments within the monetary union framework. However, in the short run, real interest rates are likely to increase temporarily, driving consumption and output temporarily downwards.

Keywords: competition; competitiveness; DSGE; small-open economy; Portugal.

JEL classification numbers: E2, E60, F16, F41

*We would like to thank all the support provided by Douglas Laxton, Michael Kumhof and Antti Rippati. This paper also benefited from the comments and suggestions of António Antunes, João Amador, Isabel Horta Correia and participants at the 4th Dynare Conference and Banco de Portugal Research Department seminar. The views expressed in this paper are those of the authors and do not necessarily reflect the views of Banco de Portugal. Any errors and mistakes are ours.

†Address for correspondence: Banco de Portugal, Departamento de Estudos Económicos, Rua Francisco Ribeiro, 2, 1150-165 Lisboa. E-mail addresses: vralmeida@bportugal.pt, ggcastro@bportugal.pt or rfelix@bportugal.pt

1 Introduction and motivation

In this study, we use *PESSOA*[1], a dynamic general equilibrium model for a small-open economy integrated in a monetary union, to assess the macroeconomic impact of reforms aimed at increasing competition in the Portuguese labour and non-tradable goods markets.

In the last 20 years, Portugal has been a case study for both good and bad reasons. During the 90s, it was frequently pointed out as a successful example of the European integration process. However, since the beginning of the current decade, the situation has changed significantly. In a context of a rapidly changing international environment, the Portuguese economy's structural fragilities have become evident. The country ceased to be an attractive destination for foreign direct investment, total factor productivity decelerated sharply and capital deepening went into a halt, leading to a slowdown of economic activity, to growth rates well below those of the euro area.

Two types of reasons are frequently put forward to explain the loss of competitiveness of the Portuguese economy. Firstly, the accession to the EU of Eastern Europe economies with lower wages, higher productivity levels, a more competitive tax system and sizeable EU transfers has diverted foreign direct investment away from Portugal. Secondly, the integration in international trade of emerging economies with very low unit labour costs and an export pattern similar to the Portuguese (mainly China), has led to significant market share losses, in particular in the textiles and clothing industry.[2] However, this reasoning can be disputed from at least two standpoints. Firstly, foreign direct investment, like every type of investment, flies to where it can yield expected returns higher than the cost of capital. One can thus hardly justify the decline of foreign direct investment inflows in Portugal using the fact that Eastern European countries benefited from it instead. More likely, the issue is that Portugal ceased to be a profitable destination for many industries in the current international context. Secondly, the EU as a whole largely benefited from the impact of opening its borders to exports from economies with low production costs, since this promoted a more efficient allocation of resources and expanded the consumption possibility frontier of the representative European household. The dual of this result is that inefficient Portuguese firms, previously sheltered from international competition, turned out to be unviable in the new international context. In our perspective, the fundamental issue is then: how to restore the competitiveness of Portuguese firms in the new international pattern of comparative advantages?

Blanchard and Giavazzi (2003) and Aghion, Askenazy, Bouelès, Cette and Dromel (2007) suggest that the level of product and labour market competition is an important factor behind the health of the business environment, which in turn determines to a large extent foreign direct investment inflows. Moreover, increasing competition is also a means to allow for better resource

[1] *PESSOA* is the acronym for **P**ortuguese **E**conomy **S**tructural **S**mall **O**pen economy **A**nalytical model.

[2] It is worth mentioning that the last stage of the multi-fiber agreement, which opened EU borders to textile imports from low labour cost economies, notably China, determined significant market share losses in European countries with an export pattern heavily dependent on these products, like Portugal and Italy.

allocation, promoting higher efficiency levels. In addition, as referred in Bayoumi, Laxton and Pesenti (2004) and in the European Commission (2008), higher competition promotes faster adjustment in the event of shocks, avoiding prolonged periods of anemic growth like the one the Portuguese economy has been experiencing since 2000. The available evidence (e.g. Conway and Nicoletti (2006), Høj, Jimenez, Maher, Nicoletti and Wise (2007), OECD (2006) and OECD (2008)) suggests that Portugal has a substantial margin to improve competition in its labour and non-tradable goods markets through the implementation of better regulation practices and a more active enforcement of the existing competition law. Leaning on these considerations and evidence, we suggest that increasing competition in the labour and non-tradable goods markets is a way to promote real exchange rate adjustment capable of addressing the current situation of Portugal within the EMU framework.

The use of a dynamic general equilibrium model to perform the analysis is crucial, since most of the impact of increasing competition in the non-tradable goods and labour markets is achieved through an increase in international competitiveness due to general equilibrium effects on tradable goods prices and on the real exchange rate. Moreover, dynamic general equilibrium models are currently the state of the art for simulation and policy analysis not only in academia, but also in policy-making institutions. Some interesting examples are: the use of the IMF's model, GIMF, presented in Kumhof and Laxton (2007*b*), for the analysis of the effects of fiscal policy in the US economy; the role played by the Sveriges Riksbank model, described in Adolfson, Laseén, Lindé and Villani (2005), in the context of policy analysis and forecasting; the extensive use of the AINO model, developed at the Bank of Finland, in the analysis of ageing and demographics in Kilponen, Kinnunen and Ripatti (2006*a*) and Kilponen, Kinnunen and Ripatti (2006*b*); and the New Area Model developed at the ECB and presented in Coenen, McAdam and Straub (2007).

The rest of the paper is structured as follows: section 2 surveys the empirical literature on product and labour market competition and positions Portugal in the context of the OECD economies; section 3 describes *PESSOA*; section 4 discusses its calibration; section 5 presents and discusses the simulation results; and finally, section 6 concludes and points some directions for further research.

2 The product and labour markets regulatory framework in Portugal

In the last years, several studies have addressed the macroeconomic impact of improving labour and product market competition. Bayoumi et al. (2004), using a general equilibrium model, found that significant impacts in output and employment may result from improving competition in the euro area, using a general equilibrium model. Kilponen and Ripatti (2006) found similar

results for Finland, and Forni, Gerali and Pisano (2008) also provide the same assessment for Italy. European Commission (2005) assessed labour and product market regulatory framework in the EU and suggested that reforms aimed at increasing competition may substantially increase income and employment levels in the euro area.

According to product and labour market competition indicators available in OECD (2006) and OECD (2008) the Portuguese economy's relative position did not change much in the context of OECD countries, despite the important progress made between 1998 and 2003. These surveys suggest that reforms aimed at promoting greater competition in these markets would enhance the adjustment of the Portuguese economy to a new and more competitive international environment. On the product market front, it is suggested that the business sector environment can benefit a great deal from a reduction in the regulatory and administrative burden, which may lead to the entry of innovative firms, higher foreign direct investment inflows and more efficient resource allocation. Moreover, it is pointed out that the non-tradable goods sector, including network industries (e.g. electricity, gas and telecommunications) and retail distribution, requires pro-competition regulation to increase efficiency and promote a decline of prices to levels closer to the marginal cost, since the market power of incumbents sharply limits competition.[3] Furthermore, high non-tradable goods prices have significant knock-on effects in tradable goods costs, hindering international competitiveness. On the labour market front, the evidence suggests a potentially dysfunctional labour market, exhibiting a steady increase in long-term unemployment and declining real wage flexibility. Labour demand is likely to be hindered by costs imposed by high employment protection legislation, while real wage adjustments turn out to be particularly difficult in a context of low inflation and low job creation. [4] Moreover, it is pointed out that unemployment benefits are extremely generous, implying higher reservation wages and contributing to longer unemployment spells. In this context, there is scope for measures aimed at promoting higher labour mobility and job creation and a tightening of unemployment benefits. These measures seem appropriate to improve competition in the labour market and introduce higher wage flexibility conditions.

The above-mentioned surveys are in line with Høj et al. (2007) stock-taking of product market regulation indicators for OECD countries.[5] As far as the Portuguese economy is concerned, this study refers to the fact that competition in services and, in particular, in network industries is hampered by state control on private business activities through special voting rights; in addition, the scope of administered prices in services is larger than in most OECD countries. This study

[3]The information published in these surveys reveals that domestic and industrial electricity and gas pre-tax prices in Portugal are among the highest in OECD countries, despite some improvement in market liberalisation in the context of the Iberian Electricity Market. In the telecommunications sector, telephone charges declined towards OECD average in the mobile-phone sector, but fixed line charges for business remain high.

[4]The available evidence suggests that the sensitivity of real wages to business cycle conditions is higher for newly hired workers than for workers that stay in the firm.

[5]Conway, Janod and Nicoletti (2005) presents an updated set of product market regulation indicators for the whole economy and compares the 2003 situation of OECD countries with the 1998 situation.

also suggests that Portugal is likely to have significant price markups due to low competition in non-tradable goods as a result of weak antitrust indicators and a weak competition policy and law enforcement. Moreover, the tight planning regulations for large stores and restrictions in opening hours imply weak competition in the retail distribution sector.

Conway and Nicoletti (2006) measures cross-country differences in the regulatory framework of the non-tradable goods sector. The study stresses the importance of the non-tradable goods sector due to its weight in the economy and to the impact it has on consumers' welfare. Even more important is the fact that non-tradable goods prices exert a significant impact in tradable goods' marginal costs, not only because they are used as intermediate inputs, but also because of the impact they have in the price of investment goods and wages. The evidence found for Portugal indicates that the Portuguese regulatory framework in network industries (notably energy and telecommunications), retail distribution and professional services has room for improvement, since it is substantially restrictive in comparison with other OECD countries.

Høj (2007) takes stock of competition policy and law enforcement indicators and concludes that these vary substantially between countries. Portugal is pointed out as a case of weak competition policy and weak law enforcement, reflecting government special voting rights in private companies, restrictive entry regulations in network industries and low accountability of competition authorities.

Nicoletti and Scarpetta (2005) details evidence of the impact of product market reforms on employment and finds that product and labour market reforms may be complementary. Moreover, the authors find that restrictive product market regulations limit job creation, a point also noted in Blanchard and Giavazzi (2003), and that restrictive product regulations may interact with labour market settings that increase the bargaining power of the insiders, depressing employment further. The main policy implications are that large employment gains can be obtained by promoting higher product market competition in economies where this market is overly regulated and that the impacts on employment are likely to be more important in economies with more rigid labour markets.

Jean and Nicoletti (2002) uses cross-country data on industry-specific product market regulation and finds that it has a significant positive impact on wage premia due to the strategic interaction between management and workers in the sharing of monopolistic competition rents. Measures aimed at increasing competition in the product market therefore tend to reduce not only the goods price markup, but also the wage markup.

To sum up, the available evidence unambiguously suggests that Portugal can gather substantial benefits from implementing reforms aimed at improving labour and product market competition. These include enhanced flexibility, improved competition policies and better competition law enforcement. In the product market, this seems to be particularly true for the non-tradable goods sector. These reforms seem to be a powerful way to increase employment and income levels and

promote a leap forward in the real convergence of the Portuguese economy within the euro area.

3 Introducing *PESSOA*

PESSOA is a model for a small open economy integrated in a fully-fledged monetary union. It features six types of economic agents: households, labour unions, manufacturers, distributors, the government and the rest of the world.

Households follow the Blanchard-Yaari overlapping generations model, which allows for non-Ricardian features of fiscal policy. [6] In addition, two types of households are considered, those which have perfect access to financial markets and those which are liquidity constrained. The first perform inter-temporal optimisation, are the sole owners of domestic firms and public debt stock (full home bias in asset detention is assumed) and are able to borrow from abroad, possibly at the cost of paying an exogenous risk premium on the monetary union interest rate.[7] The second can only perform intra-temporal optimisation, since they cannot save for the next period. This is a commonly adopted strategy to break the Ricardian equivalence in general equilibrium models and it is considered to be useful in obtaining realistic short-run responses to a fiscal policy rule adjustment. Since these households are not able to smooth consumption by adjusting portfolio, any shock affecting their budget constraint affects their consumption decisions immediately, ensuring that fiscal policy has immediate effects on output. Note that these households are not purely "rule-of-thumb" agents, since they have an optimisation plan, just like any other agent. All households consume and supply differentiated labour services.

Labour unions buy labour services from households and sell them to manufacturers at a higher price, exploiting the market power created by the fact that labour services are differentiated. The rents generated by this behaviour are then fully transferred to households, in the form of dividends. These are very particular dividends, since they simply correspond to the share of each household in the wedge generated by monopolistic competition in the labour market. This is a widely used modeling strategy to generate monopoly power and sticky wages in general equilibrium models, implying that households are rewarded in excess of their marginal disutility of labour.

Turning to the supply side, there are two types of firms: manufacturers, who produce two kinds of differentiated intermediate goods (tradables and non-tradables); and distributors, who produce four kinds of differentiated final goods (private consumption, government consumption, investment and export goods). All firms operate in monopolistic competition in their output markets and in perfect competition in their input markets. Manufacturers' technology features a deterministic

[6] See original works from Blanchard (1985) and Yaari (1965). For a detailed discussion of this type of model see Blanchard and Fischer (1989) and Frenkel and Razin (1996). For applications to fiscal policy see Harrison, Nikolov, Quinn, Ramsay, Scott and Thomas (2005), Kilponen and Ripatti (2006) and Kumhof and Laxton (2007*b*)

[7] In practice this allows the domestic interest rate to depart from the monetary union's interest rate.

labour-augmenting productivity trend, which is the only source of growth in the model.

The government has two main activities: consume and perform transfers across households through taxes and subsidies. To finance its activities, the government levies taxes on labour income, firm dividends and household consumption, and benefits from non-tax revenues stemming from EU transfers. Furthermore, it sells one-period government bonds to households, paying an interest rate on the stock of bonds held from one period to the next. To prevent an explosive debt path, a fiscal rule is imposed, according to which the labour income tax rate adjusts endogenously to ensure that the fiscal surplus-to-GDP ratio converges to a specified target value.

The rest of the world is assumed to correspond to the members of the monetary union (excluding the domestic economy), implying that the nominal effective exchange rate is irrevocably set to unity and that all flows are recorded in the same unit. Furthermore, since the domestic economy is small enough, domestic shocks are assumed to have no impact in the foreign economy. The two economies interact through both trade and financial flows. Where trade is concerned, this is done exclusively with distributors, to whom the rest of the world sells tradable intermediate goods and from whom it buys export goods. As for financial flows, since the home economy is small, changes in its net foreign position do not affect the foreign real interest rate.

The model includes wage and intermediate goods price markup shocks and a number of nominal and real frictions, such as price and wage rigidities, external habit formation, and investment and import content adjustment costs, which allow for smoother and more realistic short-term adjustment.

Some of conventions adopted in this study should be made clear from the outset. Firstly, $p_t^X = \frac{P_t^X}{P_t}$ is the relative price of good X in terms of the numeraire price, which corresponds to the after-tax final consumption good price. Secondly, interest rates, inflation rates and risk premium are expressed as gross rates. Thirdly, the symbol $*$ indicates a foreign variable, that is, a euro area variable in the context of this model. Finally, we suppress the expectation operator for the sake of notation simplicity, $x_{t+1} = E_t x_{t+1}, \forall t$.[8]

3.1 Households

There are two types of overlapping generations optimising households (indexed by $H \in \{OLG, LIQ\}$): OLG households, which have full access to financial markets; and LIQ households, which do not have access to financial markets, being thus forced to consume their after tax income in each period. There is a continuum of households (indexed by $h \in (0, 1)$), with each one supplying a different variety of labour.

[8]The model exhibits a balanced growth path, therefore to render it stationary all model conditions must be divided by the determinist trend T_t. The model in the stationary form will be made available by the authors in a technical appendix.

In each period, a new generation of households is born. Each household faces an instant probability of death $1-\theta$, which is constant throughout life, irrespectively of age, and equal for all households. The probability of a household dying after t periods of life is then equal to $(1-\theta)\theta^{t-1}$, implying that its expected life horizon at any time is $\frac{1}{1-\theta}$.[9] Each generation is large enough so that $1-\theta$ is also the decline rate of the generation's size over time. Thus, although each household is uncertain about the time of death, the size of a cohort declines deterministically through time, meaning that there is uncertainty for each individual household, but no aggregate uncertainty in this aspect. A convenient normalisation is that the size of a new generation of OLG and LIQ households is $n(1-\psi)(1-\theta)$ and $n\psi(1-\theta)$, respectively, where ψ corresponds to the share of LIQ households in overall population. This implies that the number of households born in each period is $n(1-\theta)$ and that the total number of households in each period is constant and equal to n.[10] Although this may seem a strong assumption, it is not completely at odds with the situation in many European countries, including Portugal.

A representative household h of type H with age a, derives utility from consumption, $C^H_{a,t}(h)$, relative to a consumption habit, $Hab^H_{a,t}$, and from leisure, $1-L^H_{a,t}(h)$, assuming no bequest motive. The consumption habit is external, being a function of the lagged aggregate per capita consumption, C^H_{t-1}, which is unaffected by the household's h decisions, and is formulated as follows:

$$Hab^{OLG}_{a,t} = \left(\frac{C^{OLG}_{t-1}}{n(1-\psi)}\right)^{v} \quad \text{and} \quad Hab^{LIQ}_{a,t} = \left(\frac{C^{LIQ}_{t-1}}{n\psi}\right)^{v} \tag{1}$$

where $0 \leq v \leq 1$ parameterises the degree of habit persistence.

The expected lifetime utility of each household at time t is given by:[11]

$$E_t \sum_{s=0}^{\infty} (\beta\theta)^s \frac{1}{1-\gamma} \left[\left(\frac{C^H_{a+s,t+s}(h)}{Hab^H_{a+s,t+s}} \right)^{\eta^H} (1 - L^H_{a+s,t+s}(h))^{1-\eta^H} \right]^{1-\gamma} \tag{2}$$

where $\gamma > 0$ is the coefficient of risk aversion ($\frac{1}{\gamma}$ is the intertemporal elasticity of substitution), $0 \leq \eta^H \leq 1$ is the consumption share parameter and $0 \leq \beta \leq 1$ stands for the time discount factor. Note that each period's utility is discounted not only by the usual time discount factor, β, but also by θ. This reflects the fact that households take into account that lifetime is a stochastic variable, since they know they will die, but do not know exactly when. Because of this, they attach an extra value to utility flows closer in time and therefore discount future utility more than implied by β.[12]

[9] The expected life horizon can be obtained from the fact that $\sum_{t=1}^{\infty} t(1-\theta)\theta^{t-1} = \frac{1}{(1-\theta)}$.

[10] Note that $n(1-\theta) + n(1-\theta)\theta + n(1-\theta)\theta^2 + ... = n(1-\theta)\sum_{s=1}^{\infty}\theta^{s-1} = n$.

[11] We consider the cashless limit economy advocated in Woodford (2003), and therefore, money demand is not included in the utility function.

[12] This feature is known in the literature as over-discounting. For further details on this issue see Blanchard (1985), Frenkel and Razin (1996) and Harrison et al. (2005).

An important consequence of this is that it breaks the Ricardian equivalence, since households are not indifferent as to increases in government spending financed through current taxes or debt issuance (which implies future taxation). They strongly prefer debt, since they attach a positive probability to the event of not being alive by the time higher future tax payments are due.

The model features a life-cycle pattern following Blanchard (1985). Labour productivity of a household with age a, $\Phi_{a,t}$, is assumed to decline at a constant rate over lifetime, in order to generate a declining real wage pattern, in line with the formulation in Blanchard (1985):

$$\Phi_{a,t} = \Phi_a = k\chi^a, \quad \forall t \tag{3}$$

where $0 \leq \chi \leq 1$ determines the labour productivity rate of decay. Note that this feature amplifies the non-Ricardian behaviour, since households prefer to be taxed tomorrow (when they are less productive and consequently their labour income is smaller) than today (when they are more productive, having a higher real wage). In addition, it should be mentioned that the formulation adopted is a very crude approximation to life-cycle behaviour, since in practice the labour income profile tends to be hump-shaped during working life and to collapse to zero at retirement age. However, in the context of the OLG Blanchard-Yaari model, analytical tractability concerning aggregation over the different generations is difficult to ensure with more sophisticated formulations. Furthermore, without loss of generality, the overall population's average productivity is normalised to unit, implying that the aggregate labour productivity of OLG and LIQ households is respectively $n(1-\psi)$ and $n\psi$.[13]

3.1.1 OLG households

OLG households are distinguishable from LIQ households by the fact that they have access to financial markets and therefore can perform active consumption smoothing over time, minimising the impact of shocks to the economy on their consumption pattern.

An OLG household h with age a rents labour services to a union, receiving a wage for its services, $W_t\Phi_a$ (reflecting its productivity level), and pays a labour income tax to the government at the tax rate $\tau_{L,t}$. Household h invests in financial assets, composed of domestic government bonds, $B_{a,t}(h)$, and foreign bonds, $B^*_{a,t}(h)$, which yield gross nominal interest rates i_t and i^*_t, respectively, on bonds held from period t to period $t+1$. By convention, we assume that interest is paid at the

[13] In order to ensure unit average productivity for OLG and LIQ households, we impose:

$$\frac{n(1-\psi)(1-\theta)\sum_{a=0}^{\infty}\theta^a\Phi_{a,t}}{n(1-\psi)} = 1 \Leftrightarrow n(1-\psi)(1-\theta)\sum_{a=0}^{\infty}\theta^a\Phi_{a,t} = n(1-\psi)$$

$$\frac{n\psi(1-\theta)\sum_{a=0}^{\infty}\theta^a\Phi_{a,t}}{n\psi} = 1 \Leftrightarrow n\psi(1-\theta)\sum_{a=0}^{\infty}\theta^a\Phi_{a,t} = n\psi$$

implying $k = \frac{1-\theta\chi}{1-\theta}$.

beginning of period $t+1$. A risk premium wedge can be demanded for holding domestic assets, Ψ, reflecting the fact that domestic bonds may be riskier than foreign bonds. Furthermore, OLG households receive dividends from firms (indexed by $D \in \{N, T, C, G, I, X\}$ i.e. non-tradable and tradable goods manufacturers and distributors of private consumption, government consumption, investment and export goods) and from unions. Since there is a continuum of firms (indexed by $d \in (0,1)$) and unions (indexed by $h \in (0,1)$) in the economy, we denote the after-tax nominal dividends received from firm d of type D by $D_t^D(d,h)$ and the after-tax nominal dividends received from union h by $D_t^U(h)$. In addition, the representative OLG household also receives lump-sum transfers from the government, $TRG_t^{OLG}(h)$, and from abroad, $TRX_t^{OLG}(h)$, and pays a lump-sum tax to the government, $TRH_t(h)$, which in turn redistributes it to LIQ households. This last type of transfer is a way of allowing LIQ households to benefit in some way from the existence of firm dividends without explicitly owning them, operating closely to an income insurance scheme.

Following the original work in Yaari (1965), the model features a life insurance company that operates under a zero-profit condition.[14] In a stochastic lifetime framework, in the absence of a life insurance company, households may die either as creditors, leaving unintended positive bequests, or as debtors, leaving unintended negative bequests. The insurance company solves the issue of unintended bequest by taking advantage of the fact that there is individual uncertainty but no aggregate uncertainty. All households sign a contract with the life insurance company, stating that they will receive a premium of $\frac{1-\theta}{\theta}$ on each unit of their financial wealth for each period they survive, in exchange for their estates in the event of death.

The OLG household's budget constraint in nominal terms is then given by:

$$\begin{aligned} &P_t C_{a,t}^{OLG}(h) + B_{a,t}(h) + B_{a,t}^*(h) = \frac{1}{\theta}\left[i_{t-1}B_{a-1,t-1}(h) + i_{t-1}^*\Psi B_{a-1,t-1}^*(h)\right] + \\ &+ W_t \Phi_a L_{a,t}^{OLG}(h)(1-\tau_{L,t}) + \sum_{D=N,T,C,G,I,X}\int_0^1 D_{a,t}^D(h,d)dd + D_{a,t}^U(h) - \\ &- TRH_{a,t}(h) + TRG_{a,t}^{OLG}(h) + TRX_{a,t}^{OLG}(h) \end{aligned} \tag{4}$$

The OLG household's optimisation problem is to choose consumption, labour supply, domestic bond holdings, and foreign bond holdings that maximise the present discounted value (PDV) of its future utility stream subject to the constraints imposed by (1), (3) and (4). The solution of this problem is a set of FOCs that express the optimal policy functions of the representative household of generation a. Since all OLG households within cohort a are identical, one can impose symmetric equilibrium, which implies that optimal conditions are identical for all households within cohort a, and therefore we can suppress from them the household's identifier h. From the combination of the

[14] The zero-profit condition means that the insurer's receipts equal the payouts at each point in time, implying a large enough turnover of the population.

FOCs for consumption and labour supply, we obtain the consumption/leisure optimal allocation for households of generation a. This must be aggregated across the different age groups to obtain an aggregate consumption/leisure decision rule. For this, we need to aggregate consumption and labour, taking into account the size of each cohort at the time of birth, $n(1-\psi)(1-\theta)$, and the size of each of the remaining generations, $n(1-\psi)(1-\theta)\theta^a$:

$$C_t^{OLG} = n(1-\psi)(1-\theta)\sum_{a=0}^{\infty}\theta^a C_{a,t}^{OLG} \tag{5}$$

$$L_t^{OLG} = n(1-\psi)(1-\theta)\sum_{a=0}^{\infty}\theta^a (L_{a,t}^{OLG}\Phi_{a,t}) \tag{6}$$

where C_t^{OLG} and L_t^{OLG} are respectively the aggregate level of consumption and labour supply of OLG households.

Applying this to the consumption/labour supply equation of cohort a and using the fact that aggregate productivity of OLG households is $n(1-\psi)$, we get the following expression defining the aggregate consumption/labour supply decision rule of OLG households:

$$\frac{C_t^{OLG}}{n(1-\psi)-L_t^{OLG}} = \frac{\eta^{OLG}}{1-\eta^{OLG}} w_t(1-\tau_{L,t}) \tag{7}$$

Combining the FOCs for domestic and foreign bonds, we obtain the optimal portfolio allocation, which yields the following interest rate parity condition:

$$i_t = i_t^*\Psi \tag{8}$$

which implies that the domestic interest rate is simply the risk-adjusted monetary union rate.

Finally, using the FOCs for consumption and domestic bonds, we obtain the following consumption Euler equation for a specific cohort of age a:

$$C_{a+1,t+1}^{OLG} = \left(\frac{C_t^{OLG}}{C_{t-1}^{OLG}}\right)^{\upsilon\eta^{OLG}(1-\frac{1}{\gamma})} \left(\frac{w_{t+1}\chi(1-\tau_{L,t+1})}{w_t(1-\tau_{L,t})}\right)^{(1-\eta^{OLG})(1-\frac{1}{\gamma})} (r_t\beta)^{\frac{1}{\gamma}} C_{a,t}^{OLG} \tag{9}$$

where $r_t = \frac{i_t}{\pi_{t+1}}$ is the real interest rate and $\pi_{t+1} = \frac{P_{t+1}}{P_t}$ stands for consumer price inflation rate.

Another fundamental equation is the consumption function, which relates the household's consumption to its wealth, through the marginal propensity to consume out of wealth (mpc_t). To derive this function, we must impose a transversality condition on the household's optimisation problem, to ensure that expected asset holding at the time of death is nil:

$$lim_{s\to+\infty}\tilde{R}_{t,s}[B_{a+s,t+s} + B_{a+s,t+s}^*] = 0 \tag{10}$$

where $\tilde{R}_{t,s}$ is a subjective discount factor applied by the household to its income streams, which incorporates the probability of survival, implying overdiscounting of events further apart in time. This is defined as:

$$\tilde{R}_{t,s} = \begin{cases} 1 \quad \text{for} \quad s = 0 \\ \\ \prod_{l=1}^{s} \frac{\theta}{i_{t+l-1}} \quad \text{for} \quad s > 0 \end{cases} \tag{11}$$

Secondly, we write current consumption of cohort a, in nominal terms, as a function of financial and human wealth:

$$P_t C_{a,t}^{OLG} \Theta_t = HW_{a,t} + FW_{a,t} \tag{12}$$

where Θ_t is the inverse of mpc_t, and is given by:

$$\Theta_t = \frac{1}{\eta^{OLG}} + \frac{\theta \left(\frac{C_t^{OLG}}{C_{t-1}^{OLG}}\right)^{v\eta^{OLG}(1-\frac{1}{\gamma})} \left(\frac{w_{t+1}\chi(1-\tau_{L,t+1})}{w_t(1-\tau_{L,t})}\right)^{(1-\eta^{OLG})(1-\frac{1}{\gamma})} (r_t\beta)^{\frac{1}{\gamma}}}{r_t} \Theta_{t+1} \tag{13}$$

and $HW_{a,t}$ corresponds to cohort a's households' nominal human wealth, defined as the expected PDV of their labour supply endowments, $HW_{a,t}^L$, plus the expected PDV of their capital and dividend income net of lump-sum transfers/payments to the government, $HW_{a,t}^K$. Aggregating these variables across cohorts, we obtain:

$$hw_t = hw_t^L + hw_t^K \tag{14}$$

$$hw_t^L = n(1-\psi)w_t(1-\tau_{L,t}) + \frac{\theta\chi}{r_t} hw_{t+1}^L \tag{15}$$

$$hw_t^K = (1-\iota) \sum_{D=N,T,C,G,I,X} d_t^D + (1-\psi)\left(d_t^U + trg_t + trx_t\right) + \frac{\theta}{r_t} hw_{t+1}^K \tag{16}$$

where all variables are at their aggregate, real levels and ι is the fraction of firms' dividends that are transferred from OLG to LIQ households.

$FW_{a,t}$, in turn, is the financial wealth stock, composed of households' domestic and foreign current liabilities. Aggregating across cohorts we obtain:

$$fw_t = r_{t-1}\left[b_{t-1} + b_{t-1}^* \epsilon_{t-1}\right] \tag{17}$$

where again all variables are expressed in their aggregate, real levels and $\epsilon_t = \frac{P_t^*}{P_t} = p_t^*$ is the real exchange rate. It should be noted that we have adopted the convention that each nominal asset

is deflated by the consumption based price index of the issuer, so that real domestic bonds are $b_t = \frac{B_t}{P_t}$ and real foreign bonds are $b_t^* = \frac{B_t^*}{P_t^*}$.

Finally, aggregating equation (12) over the different cohorts, the relation between consumption and wealth can then be written as:

$$C_t^{OLG} = \frac{1}{\Theta_t}\left(hw_t + fw_t\right) \tag{18}$$

The above equation highlights an important feature of OLG households. The government services its liabilities through different forms of taxation. These future taxes affect different components of the human wealth as well as the marginal propensity to consume out of wealth. But unlike the government, which is infinitely lived, households take into account that they may not live enough to be responsible for higher future tax payments. Hence, each household discounts future tax liabilities by a rate of at least $\frac{r_t}{\theta}$, which is higher than the market's real interest rate r_t, as reflected in the discount factors in (13), (15) and (16). The household's discount rate for the labour income component of human wealth is even higher, $\frac{r_t}{\theta\chi}$, due to the role played by the decline of labour income over the household's life cycle. The implication from the household's point of view is that government debt is in fact net wealth, to the extent that households attach a positive probability to the event of not being responsible for paying the taxes necessary to service that debt. The higher the instant death rate, the greater the portion of outstanding government debt households will consider to be net wealth.

3.1.2 LIQ households

Analogously to the OLG case, a LIQ household h with age a rents labour services to a union, receiving $W_t\Phi_a$, and pays a labour income tax to the government at the tax rate $\tau_{L,t}$. Furthermore, it also receives transfers from the government, $TRH_{a,t} + TRG_{a,t}^{LIQ}$, from abroad, $TRX_{a,t}^{LIQ}$, and a share in labour union dividends, corresponding to the wage wedge created by the fact that its labour service is differentiated.

The LIQ household's budget constraint in nominal terms is thus given by:

$$P_t C_{a,t}^{LIQ}(h) = W_t \Phi_{a,t} L_{a,t}^{LIQ}(h)(1-\tau_{L,t}) + TRH_{a,t}(h) + TRG_{a,t}^{LIQ}(h) + TRX_{a,t}^{LIQ}(h) \tag{19}$$

The LIQ household's optimisation problem is then reduced to the choice of consumption and labour supply that maximise the PDV of her future utility stream, subject to the constraints imposed by (1), (3) and (19). Analogously to OLG households we obtain the following expression

for the aggregate consumption/leisure optimal allocation:

$$\frac{C_t^{LIQ}}{n\psi - L_t^{LIQ}} = \frac{\eta^{LIQ}}{1-\eta^{LIQ}} w_t(1-\tau_{L,t}) \tag{20}$$

Furthermore, aggregating the budget constraint, we get the following expression for the real aggregate consumption of LIQ households:

$$C_t^{LIQ} = w_t L_t^{LIQ}(1-\tau_{L,t}) + \iota\left(d_t^N + d_t^T + d_t^C + d_t^G + d_t^I + d_t^X\right) + \psi\left(d_t^U + trg_t + trx_t\right) \tag{21}$$

3.2 Labour unions

Labour unions hire the differentiated labour services from households and rent it to manufacturers at a higher wage than the one they pay. This way, they explore the market power stemming from labour differentiation, by creating a wedge between the wage received by households and the wage paid by manufacturers. The resulting monopoly rents are then distributed to households in the form of dividends, so that in practice they are the ones who benefit from the labour market power. Each union represents a particular variety of labour attached to a particular household, being therefore identified by the households' index h.

Each manufacturer j demands a homogeneous labour service, $U_t(j)$, composed of different varieties of labour, $U_t(h,j)$, which are bundled up using the following CES technology:

$$U_t(j) = \left(\int_0^1 U_t(h,j)^{\frac{\sigma_{U,t}-1}{\sigma_{U,t}}} dh\right)^{\frac{\sigma_{U,t}}{\sigma_{U,t}-1}} \tag{22}$$

where $0 \leq \sigma_{U,t} \leq \infty$ is the elasticity of substitution across different varieties of labour, modelled as a shock.[15]

Manufacturers minimise the cost of obtaining the different varieties of labour, subject to the quantity of homogeneous labour services they demand, given in (22), which produces the following demand for each variety h, by a representative manufacturer j:

$$U_t(h,j) = \left(\frac{V_t(h)}{V_t}\right)^{-\sigma_{U,t}} U_t(j) \tag{23}$$

where $V_t(h)$ is the wage charged by union h and V_t is the aggregate wage level.

[15] In the context of the current study $\sigma_{U,t}$ plays a prominent role, since it uniquely determines the degree of monopoly in the labour market. In practice, the fiercer the competition, the higher the elasticity of substitution and the lower the labour unions' marker power.

Integrating (23) across manufacturers, we get the following aggregate demand for variety h:

$$U_t(h) = \left(\frac{V_t(h)}{V_t}\right)^{-\sigma_{U,t}} U_t \tag{24}$$

where U_t stands for the aggregate demand for labour services by manufacturers.

Using (23) and (22) it is straightforward to get the aggregate wage as a function of the wages charged for each variety of labour and the elasticity of substitution:

$$V_t = \left(\int_0^1 V_t(h)^{1-\sigma_{U,t}} dh\right)^{\frac{1}{1-\sigma_{U,t}}} \tag{25}$$

In order to feature sticky wage growth, we have imposed quadratic adjustment costs following Kim (2000) and Laxton and Pesenti (2003). The choice of quadratic wage growth adjustment costs instead of staggered wage adjustment suggested by Erceg, Henderson and Levin (2000) with indexation, was mainly due to the higher analytical tractability of the first, in the context of OLG models. Moreover, Rotemberg (1987) has shown that in practice the two schemes yield similar reduced form Phillips curves and therefore are not empirically distinguishable in aggregate terms. Wage growth adjustment costs are then given by:

$$\Gamma_t^U(h) = \frac{\phi_U}{2} T_t U_t \left(\frac{\frac{V_t(h)}{V_{t-1}(h)}}{\frac{V_{t-1}}{V_{t-2}}} - 1\right)^2 \tag{26}$$

where ϕ_U determines how costly it is to adjust wage growth rate.

The expected future dividend stream of labour union h is given by:

$$E_t \sum_{s=0}^{\infty} \tilde{R}_{t+s}(1-\tau_{L,t}) \left[V_t(h)U_t(h) - W_t U_t(h) - P_t \Gamma_t^U(h)\right] \tag{27}$$

The dividend in each period corresponds to the (after tax) union's surplus from selling labour services for a higher price than it paid, $V_t(h)U_t(h) - W_t U_t(h)$, minus the costs paid for adjusting wages, $P_t\Gamma_t^U(h)$. We considered that labour union's dividends are subject to the same tax rate as wage income, to ensure that households are indifferent between wages or labour union dividends. The intertemporal discount rate applied to each period's dividend is $\tilde{R}_{t+s}$ so as to equate the discount factor of labour unions with the subjective discount factor for income streams of their owners, the households.

The labour union will operate like a firm, deciding on the optimal wage to charge to manufacturers, $V_t(h)$, so as to maximise the PDV of its future dividend stream, subject to (24) and (26). The FOC of this problem yields the wage Phillips curve and, as in the case of households, there can be assumed a symmetric equilibrium in which all unions will behave alike and, thus, household

indexes h can be suppressed:

$$\frac{\sigma_{U,t}}{\sigma_{U,t}-1}w_t - v_t = \frac{\phi_U}{\sigma_{U,t}-1}\left[T_t\left(\frac{\pi_t^V}{\pi_{t-1}^V}-1\right)\frac{\pi_t^V}{\pi_{t-1}^V} - \frac{1-\tau_{L,t+1}}{1-\tau_{L,t}}\frac{\theta}{r_t}\frac{U_{t+1}T_{t+1}}{U_t}\left(\frac{\pi_{t+1}^V}{\pi_t^V}-1\right)\frac{\pi_{t+1}^V}{\pi_t^V}\right] \quad (28)$$

where $\pi_t^V = \frac{V_{t+1}}{V_t}$ stands for wage inflation. In the steady-state this Phillips curve simply states that the wage charged to manufacturers is a constant markup on the households' wage rate.

The wage markup, which is in the core of this study, reflects the ability of labour unions to explore the market power arising from labour differentiation. Being differentiated, labour services are not easily substitutable and therefore manufacturers will be willing to pay a higher wage than they would if labour was homogeneous. In practice, this implies that workers will receive more than their marginal disutility of working and can therefore choose to work a bit less and still receive the wage income that they would if they worked harder and were strictly compensated by their disutility of working. This is a friction, in the sense that it limits the quantity of labour supplied, yielding an outcome which is suboptimal from a social point of view. Therefore, reforms aimed at increasing competition in the labour market, and in this way reducing the markup wedge, are likely to promote higher employment levels and stimulate the economy as a whole.

3.3 Firms

Firms are of two types: manufacturers and distributors. Manufacturers produce differentiated tradable and non-tradable intermediate goods, using capital and labour services as inputs. Intermediate goods are then sold to distributors who combine them with imported goods to produce four types of differentiated final goods: private consumption, investment, government consumption and export goods.

All firms in the economy operate in monopolistic competition in their output markets, charging a markup over their marginal cost, and in perfect competition in their input markets, rewarding production factors at their marginal productivity level.

To obtain realistic impulse responses, in particular a reasonable short-run behaviour, a number of nominal and real rigidities are featured in the model, namely in investment, prices and imports.

3.3.1 Manufacturers

Manufacturers (indexed by $J \in \{T, N\}$) produce intermediate goods of two types: tradable (T) and non-tradable (N) goods. For each type of intermediate good, there is a continuum of manufacturing firms (indexed by $j \in (0, 1)$), each one producing a different variety of the good.

Each distributor f demands a homogeneous intermediate good of type J, $Z_t^J(f)$, composed of a certain amount of each variety of intermediate goods of type J, $Z_t^J(j, f)$, which are bundled up using a CES technology. Analysing this distributor-manufacturer relationship in a perfectly

analogous way as we did with the manufacturer-labour union one, we obtain the following aggregate demand for variety j of type J intermediate good:

$$Z_t^J(j) = \left(\frac{P_t^J(j)}{P_t^J}\right)^{-\sigma_{J,t}} Z_t^J \tag{29}$$

where Z_t^J stands for the aggregate demand for intermediate good of type J, $P_t^J(j)$ is the price charged for variety j, P_t^J is the price index of type J good and $0 \leq \sigma_{J,t} \leq \infty$ is the elasticity of substitution between type J good varieties, modelled as a shock.

Furthermore, we obtain an expression for the aggregate price of intermediate good of type J as a function of the prices of all its varieties and the elasticity of substitution:

$$P_t^J = \left(\int_0^1 P_t^J(j)^{1-\sigma_{J,t}} dj\right)^{\frac{1}{1-\sigma_{J,t}}} \tag{30}$$

To produce its good, each firm uses a CES technology, combining labour services, $U_t^J(j)$, with capital stock, $K_t^J(j)$:

$$Z_t^J(j) = \left((1-\alpha_U^J)^{\frac{1}{\xi_{ZJ}}} \left(K_t^J(j)\right)^{\frac{\xi_{ZJ}-1}{\xi_{ZJ}}} + (\alpha_U^J)^{\frac{1}{\xi_{ZJ}}} \left(T_t A^J U_t^J(j)\right)^{\frac{\xi_{ZJ}-1}{\xi_{ZJ}}}\right)^{\frac{\xi_{ZJ}}{\xi_{ZJ}-1}} \tag{31}$$

where $0 \leq \xi_{ZJ} \leq \infty$ is the sector-specific elasticity of substitution between capital and labour and $0 \leq \alpha_U^J \leq 1$ is the CES distribution parameter. T_t is a labour-augmenting technical progress trend, while A^J is a sector-specific technology scaling factor. It should be noted that T_t is the only source of real growth in the steady-state. In practice, we consider that T_t evolves in a purely deterministic fashion such that $T_t = gT_{t-1}$, where $g \geq 1$ is the steady-state quarterly growth rate.

As already mentioned, nominal and real adjustment costs are featured. These are assumed to be quadratic, following the same reasoning presented in the wages case. On the nominal side, price growth adjustment costs, which ensure reasonable price dynamics, are given by:

$$\Gamma_t^{PJ}(j) = \frac{\phi_{P^J}}{2} Z_t^J \left(\frac{\frac{P_t^J(j)}{P_{t-1}^J(j)}}{\frac{P_{t-1}^J}{P_{t-2}^J}} - 1\right)^2 \tag{32}$$

where ϕ_{P^J} is the sector-specific cost adjustment parameter.

On the real side, investment adjustment costs, which ensure a smooth response of capital/investment to changes in the desired capital stock, are given by:

$$\Gamma_t^{IJ}(j) = \frac{\phi_{K^J}}{2} K_t^J(j) \left(\frac{I_t^J(j)}{K_t^J(j)} - \frac{I^J}{K^J}\right)^2 + \frac{\phi_{I^J}}{2} K_t^J(j) \left(\frac{I_t^J(j)}{K_t^J(j)} - \frac{I_{t-1}^J}{K_{t-1}^J}\right)^2 \tag{33}$$

where ϕ_{K^J} and ϕ_{I^J} are sector-specific investment adjustment costs, $\frac{I_t^J(j)}{K_t^J(j)}$ is the sector-specific investment-to-capital ratio in period t and $\frac{I^J}{K^J}$ is the corresponding steady-state level.

A fixed cost term, $T_t\omega^J$, is also assumed to ensure that economic profits arising from monopolistic competition are depleted in the steady-state and that, therefore, there are no firms entering or leaving the market.[16]

As usual, the capital stock results from the accumulation of investment goods, $I_t^J(j)$, with the capital accumulation rule being given by:

$$K_{t+1}^J(j) = (1-\delta^J)K_t^J(j) + I_t^J(j) \tag{34}$$

where $0 \leq \delta^J \leq 1$ stands for the sector-specific capital depreciation rate.

The expected dividend stream of manufacturer j in sector J, $D_t^J(j)$, is defined as follows:

$$E_t \sum_{s=0}^{\infty} \tilde{R}_{t+s} \left\{ P_t^J(j)Z_t^J(j) - (1+\tau_{SP})V_tU_t^J(j) - P_t^I \left(I_t^J(j) + \Gamma_t^{IJ}(j)\right) - P_t^J \left(\Gamma_t^{PJ}(j) + T_t\omega^J\right) - \right.$$
$$\left. -\tau_K \left[P_t^J(j)Z_t^J(j) - (1+\tau_{SP})V_tU_t^J(j) - P_t^I \left(q_t^J\delta^J K_t^J(j) + \Gamma_t^{IJ}(j)\right) - P_t^J \left(\Gamma_t^{PJ}(j) + T_t\omega^J\right)\right]\right\} \tag{35}$$

The dividend in each period corresponds to the operational cashflow of the firm, less the capital income taxes paid to the government. As already explained in the unions' case, the discount rate applied to each period's dividend is $\tilde{R}_{t+s}$. The operational cashflow corresponds to overall revenue, $P_t^J(j)Z_t^J(j)$, minus overall expenditure, which includes the wage bill and social security contributions, $(1+\tau_{SP})V_tU_t^J(j)$, investment expenditure, $P_t^I I_t^J(j)$, and adjustment and fixed cost expenditures, $P_t^I\Gamma_t^{IJ}(j)+P_t^J\Gamma_t^{PJ}(j)+P_t^J T_t\omega^J$. The capital income tax is applied only to operational net profits $P_t^J(j)Z_t^J(j)-(1+\tau_{SP})V_tU_t^J(j)-P_t^I q_t^J\delta^J K_t^J(j)-P_t^I\Gamma_t^{IJ}(j)-P_t^J\Gamma_t^{PJ}(j)-P_t^J T_t\omega^J$, where q_t^J is Tobin's-Q, the shadow price of a unit of installed capital in terms of current investment goods, which enables a correct valuation of the capital stock at each point in time.[17]

The optimal plan of manufacturer j consists in setting labour demand, capital stock, investment and price, in such a way as to maximise the PDV of its future dividend stream subject to (31), (32), (33), (34) and (29). This yields FOCs for the intermediate good's price, labour demand, capital stock level and investment path. As in the households and unions' case, all manufacturing firms operate symmetrically, and therefore the aggregation is straightforward and the individual indexes j can be dropped from the optimality conditions. The optimal price-setting condition yields the

[16] The fixed cost term is defined as a constant share of output, ensuring that it does not vanish along the balanced growth path of the economy as in Kumhof and Laxton (2007*b*).

[17] For fiscal purposes, the relevant concept is net operational profits and not operational cashflow. While the cashflow records all expenditures on capital goods, profits only record the economic depreciation of the installed capital stock. This means, for instance, that an increase in investment implies a lower dividend but does not affect the tax due on operational profits.

following Phillips curve for the inflation rate of type J intermediate good, $\pi_t^J = \frac{P_t^J}{P_{t-1}^J}$:

$$\frac{\sigma_{J,t}}{\sigma_{J,t}-1}\frac{\lambda_t^J}{p_t^J} - 1 = \frac{\phi_{P^J}}{\sigma_{J,t}-1}\left[\left(\frac{\pi_t^J}{\pi_{t-1}^J}-1\right)\frac{\pi_t^J}{\pi_{t-1}^J} - \frac{\theta}{r_t}\frac{p_{t+1}^J}{p_t^J}\frac{Z_{t+1}^J}{Z_t^J}\left(\frac{\pi_{t+1}^J}{\pi_t^J}-1\right)\frac{\pi_{t+1}^J}{\pi_t^J}\right] \tag{36}$$

where λ_t^J stands for the real marginal cost of type J intermediate good. In the steady-state, this Phillips curve collapses to a standard markup condition, implying that the price of intermediate good of type J is simply a markup over its marginal cost. As in the case of labour unions, the markup over the marginal cost charged by the manufacturer of type J good depends solely on $\sigma_{J,t}$, which is the degree of differentiation between varieties of the intermediate good at stake and reflects, among other factors, the institutional framework in the product market. Following the same reasoning as applied in the wages case, any reforms aimed at increasing competition level in the goods market are likely to decrease the price markup and to induce a higher level of output, thus affecting international competitiveness and income levels in non-negligible magnitudes.

The optimal labour demand condition is quite standard and equates the marginal productivity of labour to its (real) marginal cost, which includes employers' social contributions, besides the hourly wage charged by labour union, as follows:

$$(1+\tau_{SP})\frac{v_t}{\lambda_t^J} = \left(\frac{Z_t^J \alpha_U^J}{T_t A^J U_t^J}\right)^{\frac{1}{\xi_{ZJ}}} T_t A^J \tag{37}$$

The optimal capital condition is given by:

$$\begin{aligned}\frac{1}{1-\tau_K}\left(q_t^J \frac{r_t}{\theta}\frac{\pi_{t+1}}{\pi_{t+1}^I} - q_{t+1}^J\right) &= \frac{I_{t+1}^J}{K_{t+1}^J}\left[\phi_K^J\left(\frac{I_{t+1}^J}{K_{t+1}^J} - \frac{I^J}{K^J}\right) + \phi_I^J\left(\frac{I_{t+1}^J}{K_{t+1}^J} - \frac{I_t^J}{K_t^J}\right)\right] - \\ &- \left[\frac{\phi_K^J}{2}\left(\frac{I_{t+1}^J}{K_{t+1}^J} - \frac{I^J}{K^J}\right)^2 + \frac{\phi_I^J}{2}\left(\frac{I_{t+1}^J}{K_{t+1}^J} - \frac{I_t^J}{K_t^J}\right)^2\right] + \frac{r_{K,t+1}^J}{p_{t+1}^I} - q_{t+1}^J \delta^J\end{aligned} \tag{38}$$

The above equation is quite cumbersome and it involves all the elements related with the cost of capital (the depreciation rate, the real interest rate, Tobin's-Q and the price of capital goods), the real rate of return on capital, $r_{K,t+1}^J$, and the adjustment costs associated to investment. In the steady-state, this equation states that the capital stock must be such that the after-tax real return of investing in capital and adjusting for depreciation and capital goods' market value must equal the certain equivalent real return of investing in government bonds.

The investment demand equation relates Tobin's-Q with investment adjustment costs and the capital income tax:

$$q_t^J = 1 + (1-\tau_K)\left[\phi_K^J\left(\frac{I_t^J}{K_t^J} - \frac{I^J}{K^J}\right) + \phi_I^J\left(\frac{I_t^J}{K_t^J} - \frac{I_{t-1}^J}{K_{t-1}^J}\right)\right] \tag{39}$$

The above condition basically implies that the furthest the Tobin's-Q is from unity, the more prone the investor is to incur in investment adjustment costs. Since Tobin's-Q is the shadow value of a unit of installed capital in terms of the market value of capital goods, then a value above (below) unity means that the market value of capital goods is relatively cheaper (more expensive) and thus capital stock must rise (decline), implying that investment to capital ratio must temporarily increase (decrease). In the steady-state, Tobin's-Q is equal to one, meaning that the shadow value of installed capital equals its market value, exhausting arbitrage opportunities.

3.3.2 Distributors

Distributors (indexed by $F \in \{C, G, I, X\}$) produce four types of final goods: consumption goods (C), investment goods (I), government consumption goods (G) and export goods (X). For each type of final good, there is a continuum of distributors (indexed by $f \in (0, 1)$), each one producing a different variety of the good. The four types of distributors use a similar technology, which involves a two stage production process described further on in this section. Similarly to manufacturers, final goods distributors operate in perfect competition in their input markets and in monopolistic competition in their output markets, taking advantage of the monopoly power created by final goods differentiation, charging a markup on marginal costs.

Each type of final good is demanded by a unique type of costumer: private consumption goods are demanded by households, government consumption goods are demanded by the government, capital goods are demanded by manufacturing firms and export goods are demanded by foreign agents. For each type of costumer (indexed by $E \in \{C, G, I, X\}$) there is a continuum of agents (indexed by $e \in (0, 1)$), who demand a certain amount of final good of type F, $Y_t^F(e)$, obtained by bundling up the different varieties of final good, $Y_t^F(f, e)$. This costumer-distributer relation is perfectly analogous to what has been presented for labour unions and manufacturers, and produces the following demand for variety f of type F intermediate good:

$$Y_t^F(f) = \left(\frac{P_t^F(f)}{P_t^F} \right)^{-\sigma_F} Y_t^F \tag{40}$$

where Y_t^F stands for the aggregate demand for type F final good, and $P_t^F(f)$ is the price charged by the distributor for variety f, P_t^F is the aggregate price index of type F good and $0 \leq \sigma_F \leq \infty$ is the elasticity of substitution between different varieties of type F good.

We also obtain the following expression for the aggregate price index of type F final good:

$$P_t^F = \left(\int_0^1 P_t^F(f)^{1-\sigma_F} df \right)^{\frac{1}{1-\sigma_F}} \tag{41}$$

The two stages of the distribution production process, named the assemblage stage and the

distribution stage, will now be described.

Stage 1: the assemblage stage

In this stage, the distributor combines the domestic tradable good, $Z_t^{TF}(f)$, with the imported good, $M_t^F(f)$, through a CES technology, to obtain a composite differentiated good, $Y_t^{AF}(f)$, henceforth called the assembled good.

To obtain a realistic behaviour of the import contents, whenever the economy is hit by shocks that imply significant real exchange rate fluctuations, we consider import content adjustment costs with the following specification:

$$\Gamma_t^{AF}(f) = \frac{\phi_{AF}}{2} \frac{\left(\mathcal{A}_t^{AF}(f) - 1\right)^2}{1 + \left(\mathcal{A}_t^{AF}(f) - 1\right)^2} \quad \text{with} \quad \mathcal{A}_t^{AF}(f) = \frac{M_t^F(f)/Y_t^{AF}(f)}{M_{t-1}^F/Y_{t-1}^{AF}} \tag{42}$$

where ϕ_{AF} is the sector-specific parameter determining the adjustment cost of the assembled good import content.

The production function for variety f of the assembled good of type F is then given by:

$$Y_t^{AF}(f) = \left((\alpha_{AF})^{\frac{1}{\xi_{AF}}} \left(Z_t^{TF}(f)\right)^{\frac{\xi_{AF}-1}{\xi_{AF}}} + (1-\alpha_{AF})^{\frac{1}{\xi_{AF}}} \left(M_t^F(f)\left[1-\Gamma_t^{AF}(f)\right]\right)^{\frac{\xi_{AF}-1}{\xi_{AF}}} \right)^{\frac{\xi_{AF}}{\xi_{AF}-1}} \tag{43}$$

where $0 \leq \xi_{AF} \leq \infty$ is the elasticity of substitution between domestic tradable good and the imported good and $0 \leq \alpha_{AF} \leq 1$ is the home bias parameter.

The optimisation problem of a distributor of variety f of type F final good at this stage consists in setting the demand for both the tradable domestic good and the imported good so as to minimise the cost of producing the desired quantity of assembled good, subject to (43) and (42). The FOCs of this problem set optimal demand for production factors. Since all distributors of type F final good solve the same cost minimisation problem under the same conditions, we can assume a symmetric equilibrium and drop the individual identifier f. The demand for domestic tradable good by type F final good distributors is then given by:

$$Z_t^{TF} = \alpha_{AF} \left(\frac{p_t^T}{\lambda_t^{AF}} \right)^{-\xi_{AF}} Y_t^{AF} \tag{44}$$

where λ_t^{AF} stands for the marginal cost of production of the type F assembled good. This demand function simply states that the desired quantity of tradable good depends on the amount of type F assembled good being produced, its domestic tradable goods content, its price in terms of the firm's marginal cost $\frac{p_t^T}{\lambda_t^{AF}}$ and on the elasticity of substitution between domestic tradable and imported goods.

The demand for imported good by type F final good distributors is in turn given by:

$$M_t^F = (1-\alpha_{AF}) \left(\frac{p_t^*}{\chi_t^{AF} \lambda_t^{AF}} \right)^{-\xi_{AF}} \frac{Y_t^{AF}}{1-\Gamma_t^{AF}} \quad \text{with} \quad \chi_t^{AF} = 1 - \Gamma_t^{AF} - \phi_{FT} \frac{\left(\mathcal{A}_t^{AF}-1\right)\mathcal{A}_t^{AF}}{\left(1+\left(\mathcal{A}_t^{AF}-1\right)^2\right)^2} \quad (45)$$

where P_t^* stands for the price of the imported good, which is in any case set in euros, since the euro area plays the role of the foreign economy. This equation is very similar to equation (44) and its interpretation is identical in the steady-state, when $\chi_t^{AF} = 1$ and $\Gamma_t^{AF} = 0$. However, in the short run, when import contents are changing, adjustment costs arise with $\chi_t^{AF} > 1$ and $\Gamma_t^{AF} > 0$, implying that *ceteris paribus* more imported good needs to be used to obtain the same amount of assembled final good, due to the inefficiencies in the adjustment of the import content.

Using (43), (44) and (45), λ_t^{AF} can easily be derived:

$$\lambda_t^{AF} = \left[\alpha_{AF} (p_t^T)^{1-\xi_{AF}} + (1-\alpha_{AF}) \left(\frac{p_t^*}{\chi_t^{AF}} \right)^{1-\xi_{AF}} \right]^{\frac{1}{1-\xi_{AF}}} \quad (46)$$

Stage 2: the distribution stage

In this stage, the distributor combines the assembled good previously produced, $Y_t^{AF}(f)$, with the domestic non-tradable good, $Z_t^{NF}(f)$, to obtain the final output, $Y_t^F(f)$. This is achieved through the following CES technology:

$$Y_t^F(f) = \left((1-\alpha_F)^{\frac{1}{\xi_F}} \left(Y_t^{AF}(f) \right)^{\frac{\xi_F - 1}{\xi_F}} + (\alpha_F)^{\frac{1}{\xi_F}} \left(Z_t^{NF}(f) \right)^{\frac{\xi_F - 1}{\xi_F}} \right)^{\frac{\xi_F}{\xi_F - 1}} \quad (47)$$

where $0 \leq \xi_F \leq \infty$ is the elasticity of substitution between the assembled good and the non-tradable good and $0 \leq \alpha_F \leq 1$ is the non-tradable good distribution parameter.

At this stage, distributors are subject to price growth adjustment costs, which follow a quadratic form identical to the one assumed for manufacturers:

$$\Gamma_t^{PF}(f) = \frac{\phi_{PF}}{2} Y_t^F \left(\frac{P_t^F(f)/P_{t-1}^F(f)}{P_{t-1}^F/P_{t-2}^F} - 1 \right)^2 \quad (48)$$

where ϕ_{PF} is the sector-specific price adjustment cost parameter for firms operating in sector F and $P_t^F(f)$ is the price charged by the distributor for their output.

Analogously to manufacturers, a fixed cost is assumed, $T_t \omega^F$, which assures that economic profits arising from monopolistic competition are depleted in the steady-state.

The expected dividend income stream for distributor f of type F good can be represented as:

$$E_t \sum_{s=0}^{\infty} \tilde{R}_{t+s} (1-\tau_D) \left[P_t^F(f) \left(Y_t^F(f) - \Gamma_t^{PF}(f) - T_t \omega^F \right) - \Lambda_t^{AF}(f) Y_t^{AF}(f) - P_t^N Z_t^{NF}(f) \right] \quad (49)$$

which corresponds to the after-tax difference between revenue, $P_t^F(f)Y_t^F(f)$, and expenditure, which includes intermediate consumption costs, $\Lambda_t^{AF}(f)Y_t^{AF}(f)+P_t^N Z_t^{NF}(f)$, and the inefficiencies imposed by adjustment and fixed costs, $P_t^F(f)\left(\Gamma_t^{PF}(f)+T_t\omega^F\right)$. As in the case of labour unions and manufacturing firms, the intertemporal discount rate applied to each period's dividend is $\tilde{R}_{t+s}$.

The optimal plan of distributor f of type F consists in setting the demand for assembled good and non-tradable good, and the price of final good output so as to maximise the PDV of future dividend stream, subject to constraints imposed by (47), (48) and (40). The solution of this problem is a set of optimality conditions for input demand and price setting. Again, since all distributors are similar, symmetric equilibrium can be imposed and aggregate conditions can be obtained and f can be suppressed. The demand for assembled final good of type F, is given by:

$$Y_t^{AF} = (1-\alpha_F)\left(\frac{\lambda_t^{AF}}{\lambda_t^F}\right)^{-\xi_F} Y_t^F \tag{50}$$

and, similarly, the demand condition for non-tradable good is given by:

$$Z_t^{NF} = \alpha_F\left(\frac{p_t^N}{\lambda_t^F}\right)^{-\xi_F} Y_t^F \tag{51}$$

Using (50) and (51) in (47), λ_t^F can easily be derived:

$$\lambda_t^F = \left[(1-\alpha_F)(\lambda_t^{AF})^{1-\xi_F}+\alpha_F(p_t^N)^{1-\xi_F}\right]^{\frac{1}{1-\xi_F}} \tag{52}$$

The optimal price-setting condition yields the following Phillips curve for the inflation rate of type F final good, $\pi_t^F = \frac{P_t^F}{P_{t-1}^F}$:

$$\frac{\sigma_F}{\sigma_F-1}\frac{\lambda_t^F}{p_t^F}-1 = \frac{\phi_{PF}}{\sigma_F-1}\left[\left(\frac{\pi_t^F}{\pi_{t-1}^F}-1\right)\frac{\pi_t^F}{\pi_{t-1}^F}-\frac{\theta}{r_t}\frac{p_{t+1}^F}{p_t^F}\frac{Y_{t+1}^F}{Y_t^F}\left(\frac{\pi_{t+1}^F}{\pi_t^F}-1\right)\frac{\pi_{t+1}^F}{\pi_t^F}\right] \tag{53}$$

In the steady-state, this condition has the usual Phillips curve interpretation.

3.4 Government

In this model, the government has two main activities: consuming and performing transfers across households through taxes and subsidies. To finance its activities, the government levies taxes on labour income, firms' dividends and households' consumption, and benefits from non-tax revenues stemming from EU transfers. Government consumption operates as a pure distortion. Nobody benefits from it, since it does not enter in households' utility and has no impact on technology. In fact, the only thing it does is generate demand for a particular type of final good, which is extremely intensive in non-tradable intermediate goods and has a low import content. One must

admit that this is a tremendous simplification of the government's role in the economy, since it fully neglects its role as an employer and investor and the impact of public services on households' utility. In addition, the model does not feature unemployment benefits, since it is assumed that all markets clear in each and every period, including the labour market. However, these simplifications are crucial to keep the model tractable from an analytical perspective.

In view of these simplifying assumptions, government consumption, G_t, and lump-sum government transfers to households, TRG_t, are fully exogenous and follow the exogenous real and nominal trends.[18] Besides these transfers, the government also performs transfers to LIQ households, TRH_t. These are fully funded within each period by lump-sum transfers charged to OLG households, and therefore do not affect per-period government budget constraint, being irrelevant from a fiscal perspective. The point of these transfers is simply to perform some redistribution from OLG to LIQ households so as to compensate the latter for not receiving dividend income.

On the revenue side, taxes are the most important source of revenue. Among them, *ad-valorem* consumption tax is crucial not only due to the share of its receipts in overall revenue, but also due to the distortion it generates, by creating a wedge between the price relevant to the consumption goods' distributor, P_t^C, and the price charged to households P_t. The revenue that accrues to the government from this form of taxation is:

$$RV_{C,t} = \tau_C P_t^C C_t \tag{54}$$

Labour income is taxed at the firm level, since manufacturers pay social security contributions to the government on their payroll, and at the household level, as households pay their labour income taxes. The revenue generated by taxes on labour income is then given by:

$$RV_{SP,t} + RV_{L,t} = \tau_{SP} V_t U_t + \tau_{L,t} \left(V_t U_t - P_t \Gamma_t^U \right) \tag{55}$$

The revenues from dividend income taxes paid by manufacturers and distributors can be represented similarly as a function of an average tax rate on operational profits as follows:

$$RV_{K,t} = \sum_{J=T,N} \tau_K \left[P_t^J \left(Z_t^J - \Gamma_t^{PJ} - T_t \omega^J \right) - (1+\tau_{SP}) V_t U_t^J - P_t^I \left(q_t^J \delta^J K_t^J - \Gamma_t^{IJ} \right) \right] \tag{56}$$

$$RV_{D,t} = \sum_{F=C,I,G,X} \tau_D \left[P_t^F \left(Y_t^F - \Gamma_t^{PF} - T_t \omega^F \right) - P_t^T Z_t^{TF} - P_t^* M_t^F - P_t^N Z_t^{NF} \right] \tag{57}$$

In general, all tax rates but labour income tax are assumed to be exogenous. EU transfers, TRE_t, are also exogenously set and follow a nominal growth trend.

[18] In practice, it corresponds to assume an exogenous government consumption to real output ratio and an exogenous transfers to private consumption ratio along the economy's balance growth path.

To finance its fiscal deficit, the government issues one-period government bonds, B_t. The government pays an interest rate, i_{t-1}, at the beginning of period t on the stock of government bonds held from period $t-1$. For the sake of simplicity, full home bias in domestic government bond holding it assumed, meaning that foreigners do not hold this type of bond in their portfolios. This, however, is not a very stringent assumption, since OLG households may borrow from abroad to buy domestic government bonds. The government budget constraint can be represented as follows:

$$B_t = i_{t-1}B_{t-1} - \sum_{A=C,L,SP,K,D} RV_{A,t} - TRE_t + P_t^G G_t + TRG_t \tag{58}$$

To prevent an explosive debt path, a fiscal rule is imposed. The rule implies that at least one fiscal instrument (a variable fully controlled by the government) must adjust endogenously, ensuring that the fiscal surplus-to-GDP ratio, $\left(\frac{SG}{GDP}\right)_t$, converges to its target value, $\left(\frac{SG}{GDP}\right)_t^{target}$, which is univocally related to the steady-state debt-to-GDP ratio, $\left(\frac{B}{GDP}\right)_t^{target}$. As in Harrison et al. (2005), Kumhof and Laxton (2007*b*), Kumhof and Laxton (2007*a*) and Kilponen and Ripatti (2006), we consider that the government uses the labour income tax as the only fiscal instrument. We consider the structural balance fiscal rule proposed in Kumhof and Laxton (2008):

$$\left(\frac{SG}{GDP}\right)_t = \left(\frac{SG}{GDP}\right)_t^{target} + d_{tax}\left(\frac{RV_t - RV_t^{ss}}{GDP_t^{ss}}\right) + d_{debt}\left(\frac{B_t}{GDP_t^{ss}} - \left(\frac{B}{GDP}\right)_t^{target}\right) \tag{59}$$

where RV_t^{ss} is the tax revenue evaluated in the steady-state, that is the current average tax rates multiplied by tax bases at their respective steady-state levels and GDP_t and GDP_t^{ss} are observed and steady-state levels of nominal GDP, which will be defined below.

The fiscal policy rule adopted takes into consideration not only government debt stabilisation, but also business cycle smoothing. In terms of debt stabilisation, the rule adjusts automatically the labour income tax rate in order to generate sufficient revenue, preventing an explosive debt path. Since in the steady state $RV_t = RV_t^{ss}$ and $\frac{B_t}{GDP_t^{ss}} = \left(\frac{B}{GDP}\right)_t^{target}$, the rule implies that $\left(\frac{SG}{GDP}\right)_t$ converges to $\left(\frac{SG}{GDP}\right)_t^{target}$. As for business cycle smoothing, the rule implies a response of fiscal surplus-to-GDP ratio in each period that clearly depends on the nature of the shock affecting the economy. For instance, for $d_{tax} = 1$, the rule becomes a purely structural balance fiscal rule, the automatic stabilisers will operate at full extent, since realised fiscal surplus will rise with cyclical excess tax revenue. During a boom, for example, when the tax revenue is above its steady-state level, the government will pay off government debt with the extra funds, increasing fiscal surplus above its steady-state level. This structural fiscal balance rule minimises the variability of the labour tax rate and reduces the variability of output and inflation throughout the cycle relative to a balanced budget rule, obtained with $d_{tax} = 0$. A $d_{tax} > 1$ implies a counter-cyclical fiscal policy

rule. Finally, the d_{debt} parameter reflects the degree of government's aversion to deviations of the debt-to-GDP ratio from its target value.

3.5 Rest of the world

The rest of the world (RW) is assumed to correspond to the members of the monetary union (excluding the domestic economy), which enables a simplification of the model, with the nominal effective exchange rate being irrevocably set to unity and all flows recorded in the same currency. The RW affects the home economy through trade and financial flows.

Regarding financial flows, since the home economy is small, changes in its net foreign assets do not affect the foreign interest rate.

As for as trade is concerned, we have already modelled imports' demand by domestic distributors and since we assume foreign prices to be exogenous, imports are fully determined. As for exports, while in a multi-country model these are endogenously determined, depending on comparative advantages among countries, in a single country small open economy model, their modelling is always an issue since the RW is not explicitly modelled. We follow the strategy used in Adolfson et al. (2005), with the home economy being assumed to be sufficiently small in relation to the RW economy, such that the impact of domestic shocks in the foreign economy is marginal enough to be fully neglected.

In this context, we derive the demand for domestic exports assuming that foreign distributors (indexed by $f^* \in (0,1)$) demand an assembled good, $Y_t^{A*}(f^*)$, which results from an assembling of the domestic exported good, $X_t(f^*)$, with an intermediate tradable good, $Z_t^{T*}(f^*)$ produced by foreign tradable goods manufacturers using the following CES technology:

$$Y_t^{A*}(f^*) = \left((1-\alpha^*)^{\frac{1}{\xi^*}} \left(Z_t^{T*}(f^*) \right)^{\frac{\xi^*-1}{\xi^*}} + (\alpha^*)^{\frac{1}{\xi^*}} \left(X_t(f^*) \right)^{\frac{\xi^*-1}{\xi^*}} \right)^{\frac{\xi^*}{\xi^*-1}} \tag{60}$$

where ξ^* is the elasticity of substitution between foreign tradable goods and home exports and α^* is the foreign economy bias parameter.

Each foreign distributor will set the demand for home country exports and tradable goods that minimise the cost of producing the desired quantity of assembled good, subject to the technology constraint imposed by (60). Since all foreign distributors solve the same cost minimisation problem under the same conditions, their optimal decisions will be identical and therefore we can assume symmetric equilibrium, dropping the f^* indexes. The demand for home exports is then given by the following standard demand curve equation:

$$X_t = \alpha^* \left(\frac{p_t^X}{p_t^{T*}} \right)^{-\xi^*} Y_t^{A*} \tag{61}$$

3.6 Market clearing conditions, final output and GDP

The model is closed by a set of market clearing conditions, which ensure that all markets clear in each and every period. In terms of the labour market, imposing that that overall labour supply by OLG and LIQ households must equal overall labour demand by manufacturers as follows:

$$L_t^{OLG} + L_t^{LIQ} = U_t^T + U_t^N \tag{62}$$

In the intermediate goods' market, the output produced by manufacturers in both sectors must meet demand by distributors and cover price adjustment costs and fixed costs as follows:

$$Z_t^T = Z_t^{TC} + Z_t^{TI} + Z_t^{TG} + Z_t^{TX} + \Gamma_t^{PT} + T_t\omega^T \tag{63}$$

$$Z_t^N = Z_t^{NC} + Z_t^{NI} + Z_t^{NG} + Z_t^{NX} + \Gamma_t^{PN} + T_t\omega^N \tag{64}$$

As for the final goods' market, the output supplied by each type of distributor must meet demand, adjustment costs and fixed costs, as follows:

$$Y_t^C = C_t^{OLG} + C_t^{LIQ} + \Gamma_t^{PC} + T_t\omega^C \tag{65}$$

$$Y_t^I = I_t^T + I_t^N + \Gamma_t^{TI} + \Gamma_t^{NI} + \Gamma_t^{PI} + T_t\omega^I \tag{66}$$

$$Y_t^G = G_t + \Gamma_t^{PG} + T_t\omega^G \tag{67}$$

$$Y_t^X = X_t + \Gamma_t^{PX} + T_t\omega^X \tag{68}$$

Finally, the net foreign asset accumulation closes the external block of the model, imposing that domestic savings must equal the change in foreign bond holdings:

$$B_t^* = i_{t-1}B_{t-1}^* + P_t^X X_t - P_t^* M_t + TRE_t + TRX_t \tag{69}$$

In addition, at this stage, it is useful to define GDP (at market prices) in line with the National Accounts (NA) and to distinguish it from final output (at market prices). Final output can be defined as the aggregate nominal value of the final goods made available by distributors:

$$P_t Y_t = P_t Y_t^C + P_t^I Y_t^I + P_t^G Y_t^G + P_t^X Y_t^X \tag{70}$$

This definition does not correspond to the NA definition of final demand, since it includes distributors' price adjustment and fixed costs. The NA nominal GDP is defined as the sum of the final expenditure of all agents in the economy, which corresponds to final demand, excluding the

final expenditure that falls on imported goods, $P_t^* M_t$:

$$GDP_t = P_t C_t + P_t^G G_t + P_t^I I_t + P_t^X X_t - P_t^* M_t \tag{71}$$

where overall imports, M_t, correspond to the sum of imports demand by all distributors, $M_t^C + M_t^I + M_t^G + M_t^X$. To compute chain-linked real GDP, one would have to calculate GDP at the previous year average price level and then derive the implied volume and deflator. However, in the context of this model, the relevant definition of real GDP is simply nominal GDP expressed in terms of the numeraire price.

3.7 Shocks

There are three shocks in the model: one wage markup shock and two sector specific intermediate goods prices' markup shocks. These shocks follows a first order auto-regressive process with zero mean *iid* innovations and unconditional mean equal to their steady-state value.

$$\xi_t = \rho_\xi \xi_{t-1} + \eta_{\xi,t} \qquad \eta_{\xi,t} \sim N(0, \sigma_\xi^2) \tag{72}$$

where $\xi = \{\sigma_T, \sigma_{NT}, \sigma_U\}$.

4 Calibrating *PESSOA* for the Portuguese economy

The calibration relied on data from the Portuguese economy and on other studies in the field. The data was taken from the Annual NA dataset available from the Portuguese statistics office and was mainly used to fix the steady-state parameters. The remaining parameters were calibrated using standard values in the DSGE literature and estimates for Portugal, whenever they are available.

The calibration figures for the model's main parameters are presented in Table 1. Being a small open economy in the euro area, Portugal's steady-state real GDP growth and inflation rate were assumed to be identical to those prevailing in the rest of the euro area, to ensure the existence of a balanced growth path. Therefore, labour-augmenting productivity's annual growth rate was set to 2%, which is consistent with the estimates for the euro area's potential output growth presented in Musso and Westermann (2005) and Proietti and Musso (2007) and also seems a plausible estimate for Portugal in view of the results of Almeida and Félix (2006). Following Coenen et al. (2007), the euro area nominal interest rate in the steady-state was set to 4.5%, whereas inflation was set to 2% in line with the ECB price stability definition. The elasticity of substitution between foreign tradables and Portuguese exports was set to 1.5, broadly in line with the estimate of Coenen et al. (2007), and the Portuguese goods content of foreign goods was calibrated to match the Portuguese

economy's average exports-to-GDP ratio in the recent past, while foreign transfers to households were calibrated to broadly match the private transfers-to-GDP ratio in the balance of payments statistics (close to 2%).

The calibration of households' parameters took into consideration that the model comprehends Blanchard-Yaari overlapping generations, while most DSGE models consider the infinitely lived agents framework. These parameters were therefore largely based on Fagan, Gaspar and Pereira (2004), Harrison et al. (2005), Kumhof and Laxton (2007*a*) and Kumhof and Laxton (2007*b*). η_{OLG} and η_{LIQ} were calibrated so as to ensure that the elasticity of labour supply to real wage is 0.5, a value commonly found in the literature. Since the Blanchard-Yaari overlapping generations households framework allows for an endogenous determination of the net foreign asset position, the discount rate was calibrated to ensure a net foreign debt position of 60% in the steady-state. The coefficient of relative risk aversion was set to calibrate the intertemporal elasticity of substitution to 0.2, which might seem a low figure in comparison with the values typically used in infinitely lived agents models, but it is in the range of the values regularly used in models featuring Blanchard-Yaari households. The share of liquidity constrained households was set to 40%, broadly in line with the estimates for Portugal presented in Castro (2006).

In terms of labour unions' parameters, we considered a 25% wage markup, which is at the upper limit of the values usually found in the literature. Note, however, that since the labour market in Portugal is strongly regulated, one may argue that the markup could be even higher than the figures usually found in the DSGE literature. Nominal wage rigidity was calibrated to ensure that wages adjust to the new equilibrium in 6 quarters, a value slightly above euro area estimates published in Coenen et al. (2007), but still in the range usually found in the literature.

Turning to manufacturers, the depreciation rate was assumed to be identical across firms and was calibrated to get the investment-to-GDP ratio in line with the NA data. As regards the production function, a standard Cobb-Douglas function between capital and labour was assumed and the distribution parameters were calibrated to match the labour income share in the NA data. The price markup of tradable and non-tradable goods' manufacturers was calibrated using OECD product market regulation indicators and the correlation between tradable and non-tradable goods markups and product market regulation indicators found in Høj et al. (2007). In particular, the non-tradable goods markup was set to 20%, which is at the upper bound of the range of values commonly found in the literature, but consistent with the evidence pointing to low competition in the Portuguese non-tradable goods market that is at the core of the motivation for this study (see Section 2). As for real rigidities, capital adjustment costs were calibrated so as to ensure plausible impulse responses in terms of investment volatility. Regarding nominal rigidities, price growth adjustment costs were calibrated to match average adjustment time spans, in line with what is suggested in the literature. In particular, we impose that the adjustment of prices in the

non-tradable goods' sector is slightly slower than in the tradable goods' sector, reflecting the fact that fiercer competition and lower markups imply lower price stickiness.

We now consider distributors' parameters. In the assemblage stage, the elasticity of substitution between domestic tradable goods and imports was taken to be identical across distributors and set above unity, as in most of the literature on open economy DSGE models (see for instance Coenen et al. (2007), Harrison et al. (2005), Erceg et al. (2000) or Kumhof and Laxton (2007*b*)); on the other hand, in the distribution stage, assembled goods (which are basically a composite tradable good) and non-tradable goods were assumed to feature a low substitutability as in Mendoza (2005) and Kumhof and Laxton (2007*b*). The distribution parameters of the production function in each stage were calibrated to match the NA import content and non-tradable goods' content of each type of final good. The degree of monopolistic competition among distributors was assumed to be lower than among manufacturers, with the markup being set to 5%, except in the case of exporters, where fiercer competition is likely to determine a lower markup. In terms of price stickiness, an average duration of price contracts of 2 quarters was assumed for all distributors except for exporters, whose prices are assumed to adjust slightly faster. Real rigidities related to the import content adjustment costs were set to ensure a smooth adjustment of import contents to real exchange rate fluctuations.

Government's average tax rates were calibrated to match the share of revenue-to-GDP ratio in the data. The same applies to EU transfers and to expenditure components (government consumption and investment and government transfers). The parameters of the fiscal policy rule were calibrated to impose a structural budget balance rule (unit fiscal policy stance parameter) and to ensure a smooth labour income tax rate adjustment. The target debt-to-GDP ratio was set to 53%, implying a fiscal balance-to-GDP ratio of -2.1% in the steady-state.[19]

As presented in Table 2, the steady-state calibration is, in general, able to match fairly reasonably the key ratios of the Portuguese economy and deliver a capital-to-GDP ratio that seems plausible by industry standards.[20] The most important aspect that arises is that the evolution of the Portuguese economy in the recent past is not fully consistent with a sustainable path, featuring a debt-to-GDP ratio below 60% and a reasonable net foreign debt-to-GDP ratio.

[19]The values assumed for the debt-to-GDP target and the implied fiscal balance can be questioned in view of the medium term objective that has been set by the European Commission for Portugal (a structural budget balance of -0.5%, implying a debt-to-GDP ratio of close to 12%). However, since in the historical period that was used to calibrate the model the debt-to-GDP ratio averaged 57%, it does not seem reasonable to calibrate it to match something substantially different from historical figures.

[20]Unfortunately, the Portuguese NA does not include figures for capital stock.

Table 1: Main parameters

	Parameter	Value
Monetary union parameters		
Euro area interest rate (annualised)	i^*	1.05
Euro area labour-augmenting prod. growth (annualised)	g	1.02
Euro area inflation target (annualised)	π^*	1.02
Euro area EoS between domestic and imported goods	ξ^*	1.50
Households and Unions		
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}	0.73
Consumption share - LIQ households	η_{LIQ}	0.70
Lifetime productivity decline rate (annualised)	$1-\chi$	0.04
Share of LIQ households	ψ	0.30
Share of dividend transfers from OLG to LIQ households	ι	0.15
Wage mark-up	$\frac{\sigma_U}{\sigma_U-1}$	1.25
Wage rigidity - Adjustment cost	ϕ_U	200
Manufacturers		
Depreciation rate (annualised)	δ	0.09
EoS between capital and labour	ξ_J	0.99
Price markup - tradables	$\frac{\sigma_T}{\sigma_T-1}$	1.10
Price markup - non-tradables	$\frac{\sigma_N}{\sigma_N-1}$	1.20
Capital adjustment cost	ϕ_{KJ}	50
Investment adjustment cost	ϕ_{IJ}	100
Price adjustment cost	ϕ_{PJ}	200
Quasi labour income share - tradables	α_T	0.21
Quasi labour income share - non-tradables	α_N	0.24
Distributors		
EoS domestic tradable/imported good	ξ_{AF}	1.50
EoS assembled/non-tradable good	ξ_F	0.50
Price markup (domestic distributors)	$\frac{\sigma_F}{\sigma_F-1}, F \neq X$	1.05
Price markup (exporters)	$\frac{\sigma_X}{\sigma_X-1}$	1.03
Import content adjustment cost	ϕ_{AF}	2
Price adjustment cost	ϕ_{PF}	200
Government		
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
Fiscal stance parameter	d_{damp}	1.00
Speed adjustment towards the target debt ratio parameter	d_{debt}	0.10

Table 2: 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

5 The macroeconomic impacts of increasing competition in the product and labour markets

In this section we illustrate the impact of reforms aimed at increasing competition in the non-tradable goods and labour markets. The impact of specific reforms affecting markups is hardly measurable on a broad basis, implying a detailed assessment of the reforms at issue. International comparisons are not very helpful, since the impact of specific reforms depends crucially on the design and enforcement of the reform, on the existing legal framework, on the structure of the goods and labour markets and on the degree of openness of the economy. Since the assessment of the impact of specific reforms in wage and price markups is beyond the scope of this study, we assess the impact on the macroeconomic scenario of an increase in competition in the domestic markets by simulating shocks in non-tradable goods price and wage markups. We start by illustrating the impact of a decline in the non-tradable goods price markup, then we do the same for the wage markup and, finally we implement both shocks together. It should be highlighted, as already mentioned in Section 2, that there is evidence pointing to a positive correlation between non-tradable goods price markups and wage markups, though in our model these are assumed to be fully exogenous and, therefore, uncorrelated.

A number of aspects should be made clear from the outset. Firstly, all simulations are performed in a context of perfect foresight and perfect information, implying that the transition path is known with certainty by all agents from the outset.[21] These assumptions may affect the short-run dynamics fastening the adjustment, but they are not likely to affect significantly the long-run impacts. A second important aspect which must be kept in mind is that the government follows a labour income tax based fiscal rule. The choice of the labour income tax rate as the endogenous policy tool is arbitrary and the long-run impact of the simulations depends on that assumption.

The macroeconomic impact of increasing competition in the non-tradable goods market is assessed through the simulation of a permanent decline of 10% in the markup over the marginal costs (corresponding to a decline of the markup from 20% to 18%). Since the non-tradable goods markup is fully determined by the elasticity of substitution between varieties of the non-tradable good, $\sigma_{N,t}$, and given that the shock follows an autoregressive process, the impact gradually feeds through the economy. The persistence parameter implies that roughly 80% of the decline is achieved in two years. The results are reported in the first column of Table 3, as percentage deviations from the baseline level unless otherwise indicated.

Ceteris paribus the permanent decline in the non-tradable goods markup translates into: (i) a decline in final goods prices, including exports, and a real exchange rate depreciation; (ii) a decline

[21] The model is simulated in Portable TROLL and is solved using the Newton-based perfect foresight simulation algorithm proposed in Juillard, Laxton, McAdam and Pioro (1998).

in the capital component of human wealth, reflecting lower dividends from non-tradable goods' manufacturers; (iii) a decline in the relative price of non-tradable goods with respect to tradable, implying a change in factor intensities of final goods. However, in a dynamic general equilibrium model the impact of the shock goes well beyond mechanical impacts, reflecting spillover effects and the adjustment dynamics implied by nominal and real rigidities. Moreover, the income tax based fiscal policy rule may significantly affect the dynamics of households' behaviour through the consumption/leisure choice.

The decline in the non-tradable goods markup has important spillovers to sectors that use this good as an intermediate input. The marginal costs of production of final goods decline across the board, implying among other effects a real exchange rate depreciation and an increase in international competitiveness of Portuguese production. The real exchange rate depreciation drives export demand upwards and fosters the substitution of imports by domestic tradable goods, implying a higher demand for intermediate goods.

The increase in demand for intermediate goods boosts demand for capital and labour services. To provide a higher labour supply, households demand higher labour income, implying an increase in households' real wage or a decline in the labour income tax. The simulation results show that real households' wages are driven upwards, since the decline in the labour income tax does not shift labour supply enough. Investment goods become cheaper as costs related to the non-tradable goods component decline. Therefore, in the new steady-state hours worked are higher and the same applies to the capital stock; however, firms substitute labour for capital services as much as their technological constraint allows them to, since capital is cheaper in relative terms, implying that intermediate goods production technology becomes more capital intensive.

In the new steady-state, consumption is significantly higher mainly as a result of the impact on households' wealth of a higher wage rate and a lower labour income tax rate. In addition, financial wealth also increases due to enhanced competitiveness conditions, which improve the trade balance and the net foreign debt position. All in all, the negative mechanical impact in wealth, stemming from the decline in dividends, is more than offset by higher after-tax wage income and improved net foreign position implying a positive long-run impact on households' consumption.

An apparently puzzling fact is that the decline in the non-tradable goods price markup boosts demand for tradable goods more than for non-tradable goods, when the opposite might seem more intuitive. There are mainly three reasons for this: (i) the increase in non-tradable goods intensity of final goods, in a context where non-tradable goods get relatively cheaper, is limited by the low elasticity of substitution of assembled good for non-tradables; (ii) in a small open economy integrated in a monetary union, the real exchange rate tends to be crucial in terms of adjustment, with a direct effect on exports, which are tradable goods intensive, and import contents, implying a strong substitution of imports for domestic tradable goods; and (iii) the most intensive final good

in non-tradable goods is government consumption, where the assumption is that demand remains unchanged.

Similarly to non-tradable goods, the increase in labour market competition is assessed through the simulation of a permanent decline of 10% in the steady-state wage markup, which amounts to a cut in the wage premia over the marginal rate of substitution of consumption for labour by 2.5 percentage points (from 25% to 22.5%). As in the previous case, the persistence parameter of the shock implies that roughly 80% of the markup decline is achieved in two years. The results are reported in the second column of Table 3.

The permanent decline in the wage markup translates *ceteris paribus* into: (i) a decline in the relative price of labour services with respect to capital from the manufacturers' point of view; (ii) a decline in labour income, due to lower labour union dividends, from the households' perspective; and (iii) lower marginal costs, favouring a decline in intermediate and final goods prices and a real exchange rate depreciation.

The increase in competition in the labour market lowers the relative price of labour with respect to capital, inducing firms to adopt more labour intensive technologies, and driving labour demand upwards. As previously mentioned, the increased labour demand can only be matched by a higher labour supply at the cost of a higher households real wage income.[22] Since the impact of lower labour income tax does not shift labour supply enough, households' real wage will increase.

Turning to the evolution of prices and competitiveness conditions of the economy, the decline in the wage markup implies lower firm wage rate and lower marginal cost for manufacturers. In a context of exogenous steady-state price markups, all declines in marginal costs are fully passed on to costumers, implying that distributors will benefit from the decline in wage markups. Since the labour content of tradable and non-tradable goods is not very different, the impact on prices is similar and, therefore, the differentiated impact in final goods mainly reflects different import contents. As in the non-tradables case, the real exchange rate depreciation implied by lower domestic costs has a significant impact on competitiveness conditions, implying not only permanent market share gains in the export market, but also a substitution of imports for domestic tradable goods, implying an improvement in the current account and net foreign debt position of the economy.

The increase in labour market competition is also likely to be beneficial for households, since it yields higher consumption levels. Households' consumption increases substantially in the new steady-state, reflecting the positive impact of the shock both in the households' human and financial wealth. The negative impact of the shock in households' labour income that might be suggested *ceteris paribus* is fully misleading, since general equilibrium effects imply that the decline in labour

[22] It should be mentioned that the decrease in wage markup *per se* does not affect labour supply since the after-tax households' real wage income does not include labour union dividends.

unions' dividends is more than compensated by higher households' real wage and lower labour income taxes as mentioned above, determining a higher human wealth. In addition, as in the non-tradables case, the improvement in the economy's net foreign debt position affects financial wealth positively.

The impact of a package to increase competition in the domestic markets, i.e. a simultaneous increase in non-tradable goods and labour market competition, raises a number of issues on the timing and implementation of this type of reforms. The results are reported in the third column of Table 3.

The first issue is that the impact of the shock is additive, meaning that the joint impact of decreasing the markup in non-tradable goods prices and wages can be reasonably captured as the sum of the impact of the individual reforms. The policy implication seems to be that from a purely economic point of view there are no big gains or losses from implementing both reform packages simultaneously. However, it should be kept in mind that we have assumed that product and labour market reforms are fully independent, and this, according to Jean and Nicoletti (2002), may not be very realistic, since the wage premia may reflect a share of monopoly rents generated by lack of competition in the goods market and, therefore, higher competition in goods market may induce by itself a decline in the wage markups.

A second issue is related with the transition path of these reforms. The short-run impact of higher competition in product and labour markets translates into a negative effect in households' consumption (see Figure 1). This impact reflects, on the one hand, the real interest rate profile, which is a particular feature of the adjustment of a small open economy integrated in a monetary union, and, on the other hand, the impact of lower dividend income arising from the decline in non-tradable goods markup. With respect to the profile of real interest rate, it should be noted that the reduction in markups implies that the economy goes through a temporary period of inflation below the baseline level. Since a small open economy integrated in a monetary union does not affect monetary policy decisions, it implies a temporary increase in the real interest rate, which translates into a decline in human wealth and in the marginal propensity to consume out of wealth (in the transition path real interest rates induce OLG households to postpone consumption expenditures, since they get a higher real reward for saving in the current period). However, it should be clear that, on the one hand, the negative impact on consumption is a short-run effect, since real interest rates are not permanently affected by this shock, and, on the other hand, as consumers are forward looking they know that in the future these reforms will have a positive impact on their consumption. Therefore, this temporary negative effect should not be a severe political obstacle hindering the implementation of these reforms. Nevertheless, the policy implication one may derive is that the implementation of these reforms in the peak of the business cycle when inflation, consumption and economic activity stand well above the steady-state level, will not only yield the long-run beneficial

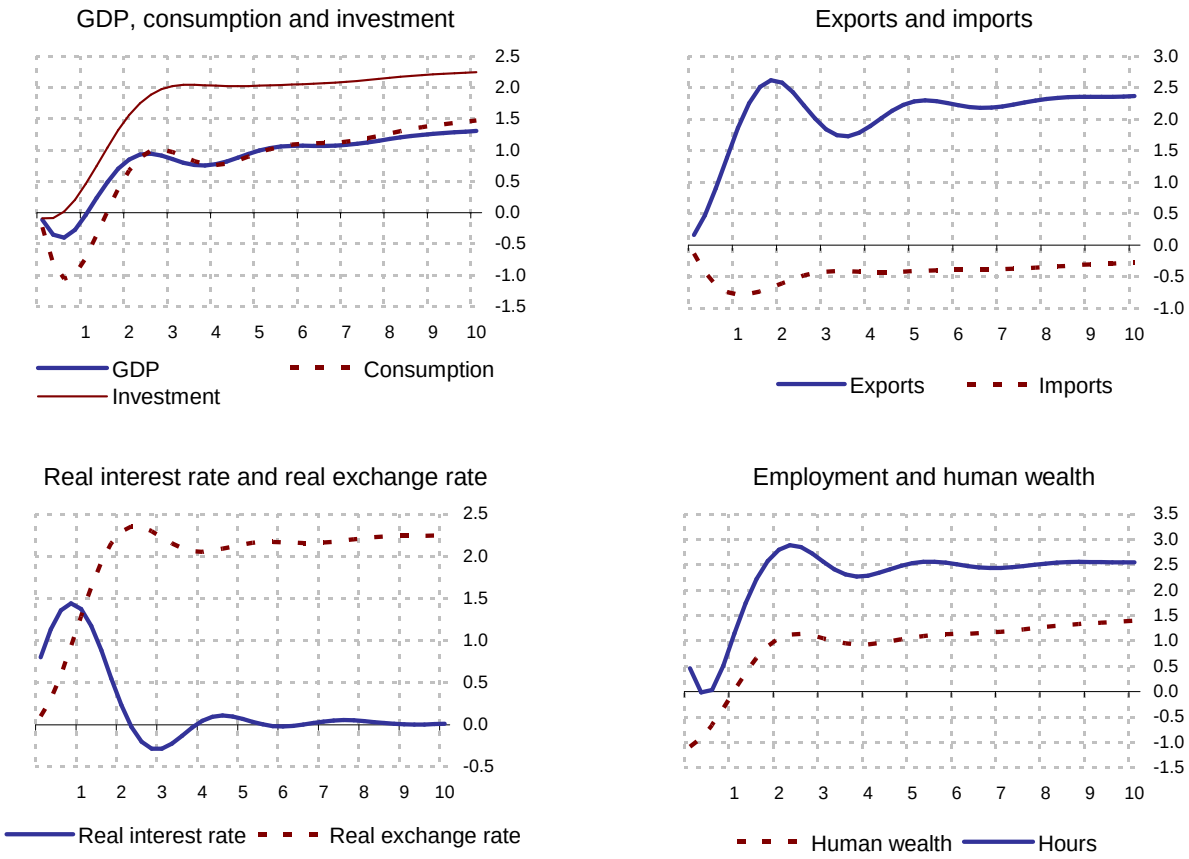
Table 3: Impact of an increase in competition in the domestic market

	NT	W	NT + W
Expenditure			
GDP	1.33	1.16	2.45
Private consumption	1.90	1.68	3.52
Investment	2.08	0.82	2.88
Exports	1.47	1.09	2.51
Imports	0.31	0.30	0.61
Wages and real exchange rate			
Real wage rate (firms)	0.54	-0.59	-0.02
Labour income tax (pp.)	-2.01	-1.24	-3.16
Real exchange rate (depreciation(+)/appreciation(-))	1.53	0.75	2.25
Wealth and bond stocks			
Total human wealth	1.23	1.17	2.33
Government bonds (as a % of GDP)	0.02	0.01	0.03
Foreign bonds (as a % of GDP)	4.70	4.48	9.19
Supply and labour market conditions			
Tradable goods sector			
Output	1.99	1.73	3.66
Hours worked	1.72	2.04	3.67
Price	0.26	-0.28	-0.01
Non-tradable goods sector			
Output	1.44	0.81	2.23
Hours worked	1.20	1.08	2.24
Price	-1.38	-0.31	-1.67

impacts already mentioned but will also contribute to dampen business cycle fluctuation.

Finally, and more importantly, the simulation results suggests that increasing competition in domestic markets clearly fosters economic growth prospects, by improving exports' competitiveness, increasing employment and promoting a more efficient allocation of resources. Furthermore, the macroeconomic impact presented in this study tends to be on the low side, since reforms aimed at increasing competition are also likely to induce important productivity gains, stemming from the fact that fiercer competition tends to lead to the shutdown of the less efficient production units, to a more efficient organisation of the remaining ones and to the installation of new and more productive units, for example through foreign direct investment inflows, and to higher R&D efforts, in line with Blanchard and Giavazzi (2003), Aghion et al. (2007) and OECD (2008).

Figure 1: Impact of an increase in competition in the domestic market (percentage changes from baseline levels except real interest rate)



6 Conclusions and directions for further research

In this study we assess the macroeconomic impact of reforms aimed at increasing product and labour market competition in Portugal, using a multi-sectoral dynamic general equilibrium model. We find that these reforms can be valuable instruments to promote necessary adjustments in the Portuguese economy, within the monetary union framework, mainly through important international competitiveness gains generated by a real exchange rate adjustment, though in a less dramatic way than the sharp nominal wage rate cut suggested in Blanchard (2007).

Specifically, our results suggest that a 10% decrease in non-tradable goods prices and wage markups has non-negligible positive impacts on economic activity, households' consumption and hours worked, reflecting improved international competitiveness conditions. One should highlight that these impacts are likely to be underestimated, since a number of relevant aspects are not featured in the model. In particular, as pointed out in Blanchard and Giavazzi (2003), Aghion et al. (2007) and in OECD (2008), the suggested reforms tend to induce foreign direct investment inflows and higher R&D effort, which typically lead to an increase in total factor productivity that is not being accounted for.

Our results also suggest that the deflationary short-run impact of the reforms under consideration temporarily drives the real interest rate upwards, implying a negative impact on households' consumption and on economic activity. This impact results from the fact that euro area monetary policy decisions are not affected by small country specific shocks. However, it should be clear that this is a temporary effect, which should not be a severe political obstacle for the implementation of these type of reforms. Nevertheless, the policy implication one may recover is that the implementation of these reforms at the peak of the business cycle will not only yield long-run beneficial impacts but will also contribute to dampen business cycle fluctuation.

The results obtained leave a number of directions for further research not only with respect to the issue of domestic competition, but also on the development of *PESSOA*. In terms of the issue of domestic competition, it would be important to develop the implementation of shocks in a way that allows for an appropriate capturing of the correlation between reforms in product and labour market and productivity gains. As far as *PESSOA* is concerned, the brand new general equilibrium model calibrated for the Portuguese economy, we plan to use it, in the near future, to assess the macroeconomic impact of shocks that have hit the Portuguese economy since the beginning of the euro and draw some policy implications, similarly to what has been done here for the issue of competition in the domestic markets. A more ambitious project would be to estimate a streamlined version of the model using Bayesian techniques and use it to perform forecasts for the Portuguese economy.

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