Lessons from a finitely-lived agents structural model

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Abstract
We aim at identifying differences in the narrative for the Portuguese economy brought about by two estimated structural models, identical in all dimensions except the households structure. In the finitely-lived agents model, households live according to the overlapping-generations scheme. They have have stochastic finite lifetimes, attributing greater economic value to near-term events. The infinitely-lived agents model follows standard practice in the literature. We show that the households structure triggers little quantitative differences in the narrative. When exist, they work mostly through the effects of demand shocks, which play a more prominent role in economic developments in the finitely-lived agents model, and which are alternatively channeled to technological perturbations in the infinitely-lived agents model. These differences do not convey an alternative narrative in qualitative terms and fail to deliver a dramatically different overview for the Portuguese economy over the 1999–2019 period. Two important components in this outcome are the presence of hand-to-mouth households in the infinitely-lived agents model—which creates non-negligible non-Ricardian effects—and the always active fiscal rule—which greatly limits debt financing of public expenditures. (JEL: C11, C13, E20, E32)

Keywords: DSGE models, euro area, small-open economy, Bayesian estimation, OLG, finitely-lived, infinitely-lived.

1. Introduction

In the last two decades (1999–2019), the Portuguese economy depicted a rich set of perturbations, from distinct origins. Economic developments were shaped by several driving forces—external events, financing conditions or discretionary fiscal policy, amongst others—alternating between favorable and unfavorable environments. Two crisis periods stand out in the recent period: the 2009 downturn, after the bankruptcy of Lehman Brothers and the large fall in world trade; and the 2011–2012 collapse, amidst a sovereign debt crisis in the euro area. The built up of significant economic imbalances until then was at the origin of the economic and financial assistance programme that came into force in 2011, which, among other measures, triggered the most severe increase in taxation in recent history.

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Estimated Dynamic Stochastic General Equilibrium (DSGE) models provide a structural interpretation of business cycle fluctuations, and estimation byproducts—of which the most important are historical and variance decompositions and impulse response functions—constitute powerful storytelling devices and instruments of policy analysis.[1] However, the view provided by these models greatly depends on their structure, and different underlying characteristics may lead to competing interpretations of history. One key dimension in which these models may differ is with respect to the household structure, which greatly affects the intrinsic Ricardian features and results in different interpretations of fiscal developments, such as those related with the accumulation of large fiscal imbalances prior to 2011 and those triggered by the financial assistance programme onwards.

This article is related with a long tradition in economics concerning model misspecification, and the DSGE empirical literature places an important focus on shock dynamics.[2] Herein we focus on the narrative produced by two estimated models for Portugal, identical in all dimensions except the households structure. Both are medium-scale models for an economy integrated in a monetary union, embodying imperfect market competition and frictions, as most influential references in the field do (*e.g.* Smets and Wouters 2003; Christiano *et al.* 2005; Adolfson *et al.* 2007). The financial sector is modeled along the lines in Bernanke *et al.* (1999) and Christiano *et al.* (2014).

The infinitely-lived agents model (henceforth *INF model*) follows standard practice in the literature. Households can be of two types: asset holders or hand-to-mouth. The consumption decision of asset holders is to a great extent based on the permanent income hypothesis. They are able in general to smooth out consumption over time, accessing financial markets to buy and sell assets as required. Intrinsic Ricardian features generate an indifference between tax and debt financing of public expenditures, since

1. The implementation and estimation of DSGE models has assumed an important role amongst a number of policy-making institutions, such as the *Riksbank* (Adolfson *et al.* 2008), the *Suomen Pankki* (Kilponen *et al.* 2016), the *Bundesbank* (Gadatsch *et al.* 2015), the European Central Bank (Christoffel *et al.* 2008), the *Banco Central do Brasil* (De Castro *et al.* 2015), or the European Commission (Ratto *et al.* 2009). Several episodes affecting the Portuguese economy have already been identified and analyzed in light of DSGE models. Almeida *et al.* (2009) use a calibrated overlapping-generations model—the PESSOA model—to evaluate, in the European context, the effects of several disturbances on the Portuguese economy. Technical details can be found in Almeida *et al.* 2013a. Castro *et al.* (2015) evaluate the economic environment under which a fiscal consolidation policy may lead to an higher debt in the short run, in percentage of Gross Domestic Product (GDP). Other examples of applications in a calibrated framework include Almeida *et al.* (2010, 2013b) and Castro *et al.* (2013). Júlio and Maria (2017) present an estimated version of the PESSOA model to address the post-2008 period. This version has also been used to identify the main determinants behind GDP projectons of Banco de Portugal over 2020–2022 (Banco de Portugal 2020).

2. For instance, Ireland (2004) admits that the reduced-form equations of a DSGE have measurement errors that follow a VAR; Cúrdia and Reis (2010) consider that the exogenous disturbances may not be independent autoregressive processes of order one; Schmitt-Grohé and Uribe (2011) favor the inclusion of a common stochastic trend in neutral and investment-specific productivity; Justiniano and Preston (2010) claim that correlated cross-country shocks is an adequate step to account for the variability observed in the data. More recently, Den Haan and Drechsel (2020) post severe alerts on the conclusions drawn from estimated models since these can be severely distorted if structural disturbances enter the model in an incorrect way.

the latter instrument is equivalent to future taxes and therefore severely impacts present wealth. Since the level of net foreign assets (NFA) is not pinned down to a particular long-run equilibrium level (Harrison *et al.* 2005), it is common to assume that higher NFA drives a wedge between domestic and foreign interest rates (Schmitt-Grohe and Uribe 2003) in order to pin down the steady state. Admitting that some households do not have asset to financial markets and consume all their income in each period (hand-to-mouth households) introduces some “sand in wheels” in the above-mentioned Ricardian features (Galí *et al.* 2007).

The finitely-lived agents model, on the other hand, has intrinsic non-Ricardian features. Households evolve according to an Overlapping Generations (OLG) scheme, along the lines initially suggested by Blanchard (1985) and Yaari (1965), and are subject to stochastic finite lifetimes and decaying labor productivity. They strongly prefer to finance government expenditure through public debt issuance, since future taxes will be charged largely on yet-to-be born generations or paid later in life, when labor income is lower due to decaying labor productivity. The model should therefore more easily generate realistic private consumption responses to government expenditure shocks (Blanchard 1985; Galí *et al.* 2007). Instead of biological death, the household structure can be interpreted as an indicator of the degree of “myopia,” where the future is a period of lower economic relevance (Bayoumi and Sgherri 2006). Adding hand-to-mouth households in this framework creates another layer of non-Ricardian effects. Finally, NFA is by nature a stationary and endogenously defined variable (Harrison *et al.* 2005).[3]

Our aim is to ascertain whether these two models provide a different interpretation of recent history for the Portuguese economy. Our choice of models is motivated by the large fiscal imbalances accumulated during the first decade of 2000’s, and the fiscal adjustment that followed the 2011-12 sovereign debt crisis. This environment triggers a rich set of fiscal perturbations, which each model may address differently. Specifically, the shorter planning horizon of the overlapping-generations model may induce stronger wealth effects in the aftermath of fiscal developments when compared with the infinitely-lived agents model, as deficits will be supported by future taxes that may possibly be paid by yet-to-be-born generations. This could trigger larger contributions of fiscal developments to GDP fluctuations in the former model, which the latter one could attribute to alternative mechanisms, such as demand or technology perturbations.

Both models are estimated using Bayesian methods and quarterly observations for twenty four observable time series, over the 1999:1–2019:4 period. These include real, nominal and financial variables. The stochastic behavior is driven by twenty four structural shocks, grouped into six distinct categories: demand (public and private), technology, markup, financial, fiscal, and external. We show that the household structure does imply some quantitative differences in the narrative, particularly in the technology

3. Examples of models featuring stochastic finite lifetimes include Smets and Wouters (2002) or Kumhof *et al.* (2010).

and demand categories, but not for fiscal variables. Technology shocks play a more prominent role on GDP developments in the infinitely-lived agents model, with the largest contributions to GDP growth taking place in the downturns of 2009 and 2012. On the opposite direction, demand plays a more important role in the finitely-lived agents model, with the largest contributions taking place during the 2011–2012 downturn and the 2014's recovery. GDP forecast error variance decomposition suggests that technology shocks are a more important source of fluctuations in the infinitely-lived agents model, whereas the demand component plays a greater role in the finitely-lived agents model. Impulse response functions suggest that higher public consumption increases GDP by less in the infinitely-lived agents model, while crowding out private consumption. This contrasts with the finitely-lived agents model, where private consumption increases. Disturbances in technology lead to greater GDP levels in the infinitely-lived agents case, while depicting a jump on impact.

These quantitative differences are small and insufficient to convey a qualitatively different story. The binding fiscal policy rule ensuring debt stability and the presence of hand-to-mouth households, particularly in the infinitely-lived agents model, seems to play a key role in results. The private consumption responses in the face of a public demand disturbance is an important difference, but the effects are small and do not create an alternative economic analysis over the sample period. Furthermore, there are also important quantitative similarities in both models, of which the ability to reproduce the variance of the data and the path depicted by shocks are two examples.

The remainder of the article is organized as follows. The next section provides a short description of both models. We continue by presenting the database and the stochastic content. This is followed by a section highlighting the main differences in terms of narrative between both models. The last section concludes.

2. The infinitely and finitely-lived agents models

The infinitely and finitely-lived agents models estimated and analyzed in this article are as far as possible equivalent.[4] Both are New-Keynesian DSGE models for a monetarily-integrated small open economy, featuring identical multi-sectoral production structures, imperfect market competition, and nominal and real rigidities. In addition, both models embody financial frictions, whereby financial shocks are transmitted and propagated to the real economy. Trade and financial flows are restricted to euro area countries, and the euro area is immune to domestic shocks, a consequence of the small-open economy framework. The law of one price implies that domestic prices are tied down by the euro-area price level in the long run.

The domestic economy is composed of nine types of agents: households, capital goods producers, entrepreneurs, banks, intermediate goods producers (manufacturers),

4. The finitely-lived agents model presented herein is similar to that presented in Júlio and Maria (2017), with the exception of a few details. The infinitely-lived agents model is identical is all aspects except the households structure, which is replaced by a more familiar framework very close to the standard practice in the literature.

final goods producers (distributors), the government, importers, and foreign agents (the remaining euro area). Two household types coexist in the model: asset holders or type-$\mathcal{A}$ households, who are able to smooth consumption over lifetime by trading assets; and hand-to-mouth or type-$\mathcal{B}$ households, who have no access to asset markets and therefore consume all their income in each and every period. Let $\mathcal{H} \in \{\mathcal{A}, \mathcal{B}\}$ denote the household type. The differences between both models arise at the household level, with the finitely-lived OLG structure superimposing powerful non-Ricardian characteristics.

The infinitely-lived agents model follows closely standard practice in the literature. Expected lifetime utility is

$$\mathrm{E}_t \sum_{s=0}^{\infty} \beta^s U_{t+s}^{\mathcal{H}}(C_{t+s}, L_{t+s})$$

where β is the discount factor, $U^{\mathcal{H}}$ is the utility function of the representative agent $\mathcal{H}$, C_t is the aggregate consumption level, and L_t stands for total hours worked.

In the finitely-lived agents model, households $\mathcal{H}$ evolve according to the overlapping generations scheme first proposed in Blanchard (1985) and Yaari (1965). They are subject to stochastic finite lifetimes and face an identical and constant probability of death, independent of age (see Frenkel and Razin 1996; Harrison *et al.* 2005; Bayoumi and Sgherri 2006). Population is constant, implying that in each period the number of newborns equals those who perish. A perfectly competitive life insurance company collects the wealth of those agents who did not survive and distributes it to those that survived, assuring in this way that households do not leave bequests. In this framework asset holders strongly prefer to finance government expenditure through public debt issuance, since future taxes will be charged largely on yet-to-be born generations (Buiter 1988). Non-Ricardian effects are magnified by the life-cycle income profile, which shifts the proneness of agents towards paying taxes later, when labor income is lower. Expected lifetime utility is

$$\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\theta)^s U_{a+s,t+s}^{\mathcal{H}}(C_{a+s,t+s}, L_{a+s,t+s})$$

where θ is the probability os staying alive (independent of time), and therefore the average life expectancy at any time is constant at $(1-\theta)^{-1}$. In this formulation consumption and hours worked are age dependent, and therefore $U_{a+s,t+s}^{\mathcal{H}}$ is the utility function of the representative agent $\mathcal{H}$ of generation $a+s$.[5]

The wage-setting mechanism is also identical in both models. Unions hire labor-specific varieties from households, to be supplied to manufacturers. The resulting

5. Technical details on the aggregation method across generations can be found in Almeida *et al.* (2013a). Instead of biological death, $(1-\theta)$ can also be interpreted as the relevant economic horizon behind agents' decisions, *i.e.* the probability of "economic death" or an indicator of the degree of "myopia." In this case, $(1-\theta)^{-1}$ is interpreted as the "average planning horizon" (Bayoumi and Sgherri 2006), where the present can be seen as a period of higher economic relevance.

equilibrium wage equations are similar, embodying a markup charged to manufacturers which reflects a wedge between the marginal disutility from work and the wage received by households.

Manufacturers combine capital, rented from entrepreneurs, with labor services (which are directly affected by unit-root and stationary technological elements), to produce an intermediate good, which is thereafter sold to distributors. Manufacturers are perfectly competitive in the input market and monopolistically competitive in the output market, and face quadratic adjustment costs on price changes. They pay social security taxes on their payroll and capital income taxes on profits.

The financial accelerator mechanism—whereby financial frictions affect the after-tax return on capital and therefore capital demand—comprises capital goods producers, entrepreneurs, and banks, along the lines of Bernanke *et al.* (1999) and Christiano *et al.* (2014). Capital goods producers are the exclusive producers of capital. Before each production cycle, they buy the undepreciated capital from entrepreneurs and combine it with investment goods bought from distributors to produce new installed capital, which is thereafter sold to entrepreneurs. Capital goods producers face quadratic adjustment costs when changing investment levels and are assumed to operate in a perfectly competitive environment in both input and output markets.

Entrepreneurs' actions have a direct effect on the capital accumulation of the economy. They do not have sufficient funds to finance desired capital purchases, but can cover the funding gap by borrowing from banks.[6] With net worth taken as given, they decide capital holdings—bought from capital goods producers—and concomitantly balance sheet composition and leverage. Entrepreneurs face a risky environment in which idiosyncratic shocks change the value of the capital stock (after the balance sheet composition has been decided). They rent the capital stock to manufacturers for usage in the production process, receiving a rental rate in return, and pay a capital income tax on their profits.

Banks operate in a perfectly competitive environment, and their sole role is to borrow funds from asset holders and lend them to entrepreneurs. If an entrepreneur goes bankrupt, due to an adverse idiosyncratic shock, the bank must hire monitoring services from households. Since capital acquisitions are risky, so are the loans of banks, who therefore charge a spread over the nationwide interest rate to cover for bankruptcy losses. Even though individual loans are risky, aggregate banks' portfolio is risk free since each bank holds a fully diversified portfolio of loans. The contract celebrated between the entrepreneur and the bank features a menu of state contingent interest rates that ensures zero profits for banks in each period and in all possible states of the world. All households loans are therefore secure at all times.

Distributors combine domestic intermediate goods with imported goods to produce final goods. Consumption goods are acquired by households, investment goods by capital goods producers, public consumption goods by the government, and export

6. Dividend distribution prevents net worth accumulation beyond which external finance is no longer required.

goods by foreign distributors. They are perfectly competitive in the input market and monopolistically competitive in the output market, face quadratic adjustment costs on price changes, and pay capital income taxes on profits.

Government spending comprises not only the above-mentioned acquisition of public consumption goods from distributors but also lumpsum transfers to households and interest outlays. These activities are financed through tax levies on wage income, capital income, and households' consumption. The government may issue one-period bonds to finance expenditure, paying an interest rate on public debt. Wage income taxes include the contributions paid by employees (henceforth referred to as labor taxes) and the payroll tax paid by manufacturers. Labor taxes ensure that debt follows a nonexplosive path, although automatic stabilization policies allow for the fiscal balance to temporarily deviate from the pre-determined target level.

The rest of the world corresponds to the rest of the monetary union, and thus the nominal effective exchange rate is irrevocably set to unity. The domestic economy interacts with the foreign one via the goods and financial markets. Domestic interest rates may differ from foreign interest rates due to the existence of a nationwide risk premium. In the goods market, importers buy imported goods from abroad to be used in the production of final goods, paying quadratic adjustment costs on price changes. In the international financial market, asset holders trade assets to smooth out consumption.

3. Shocks and data

The stochastic behavior of the main model is driven by twenty one structural shocks affecting directly the domestic economy and following first-order autoregressive processes. The parameters and additional three shock processes for the rest of the euro area are jointly estimated with those of the small euro area economy. We categorize the twenty four structural shocks into six branches

1. Two demand shocks, on households' consumption (private component), and on public consumption and investment (public component);
2. Four technology shocks, on the unit root (worldwide) labor-augmenting technology, the stationary labor-augmenting technology, imports efficiency, and private investment efficiency;
3. Six markup shocks, on wages, and the prices of consumption, investment, government, export, and import goods;
4. Five fiscal shocks, on household transfers, fiscal rule (or equivalently on labor taxes), and tax rates over consumption, capital, and payroll;
5. Three financial shocks, on borrowers' riskiness, entrepreneurial net worth and the nationwide risk premium; and
6. Four external/foreign shocks, on the export market share, and on euro-area inflation, output, and interest rate.

We estimate the model for the Portuguese economy, using quarterly observations for the 1999:1–2019:4 period for twenty four observable time series. All endogenous variables and their transformation, prior to estimation follow standard practice in the literature (*e.g.* Ratto *et al.* 2009; Christiano *et al.* 2011) and are reported in Table 1. It should be noted that observed data transformations isolate the estimation from exogenous influences not directly accounted by the model's structure. The revenue-to-GDP ratio from payroll taxes and the social benefits-to-GDP ratio are two examples of observed data endowed with in-sample trends that are to a great extent related with a protracted increase in social protection and with aging. The model is not designed to capture these features, which assume a structural nature. To properly take into account their high frequency movement we computed the first (log) difference. We also demean most time series—thus suppressing exogenous trend growth differences or level differences—to favor the business cycle content of observed data and to avoid trending exogenous processes that affect the great ratios. All quarterly observations are seasonally adjusted. Whenever adjusted official series were not available, the transformation was performed using X12 ARIMA. The variance of measurement errors is calibrated at 5 percent of the variance of each data series for real data and 25 percent for nominal and financial data.[7]

We follow common practice in the literature and calibrate several non-identifiable or weakly identified parameters according to related empirical studies or micro evidence, or by matching "great ratios" or any other quantifiable steady-state measure. The remaining parameters are estimated through Bayesian methods. Prior information is combined with the likelihood to obtain the posterior kernel, which is maximized through a numerical optimization routine to obtain an estimate for the posterior mode and the corresponding variance-covariance matrix. This information is used as an input to initialize the Random-Walk Metropolis-Hastings algorithm, yielding a sample from the posterior density of model parameters. We compute 3 parallel chains of 1 million draws each and discard the first 500 thousand as the burn-in phase. Convergence of the simulation is assessed through the diagnostics suggested by Brooks and Gelman (1998). All estimation byproducts are evaluated at the posterior mean. Observed data series used in estimation and smoothed variables without measurement error are, in general, virtually identical, with the exception of noisier variables, such as credit growth and implicit tax rates.

4. Lessons from an OLG-based narrative for the Portuguese economy

In this section we address some key differences in the narrative for the Portuguese economy, brought about by the infinitely and finitely-lived agents models. Our focuses here relies mostly on a comparative perspective. Throughout the section we use several estimation byproduts, all evaluated at the posterior mean and each providing a specific view over the data.[8]

Both models reproduce relatively well actual volatility (see Table 2). This includes the higher volatility of private consumption in comparison with GDP. The nominal side

7. Measurement errors allow for the inclusion of data for all GDP components in addition to GDP itself, while avoiding stochastic singularity in the resource constraint.

8. All results are available from the authors upon request.

Observed variables	Transformation
Real side	
GDP, per capita	First log difference, demeaned
Private consumption, per capita	First log difference, demeaned
Public consumption and investment, per capita	First log difference, demeaned
Private investment, per capita	First log difference, demeaned
Exports, per capita	First log difference, demeaned
Imports, per capita	First log difference, demeaned
Real wages, per capita	First log difference, demeaned
Hours worked, per capita	First log difference, demeaned
Nominal side	
Private consumption deflator	First log difference, demeaned
Public consumption and investment deflator	First log difference, demeaned
Private investment deflator	First log difference, demeaned
Exports deflator	First log difference, demeaned
Imports deflator	First log difference, demeaned
Fiscal policy	
Revenue-to-GDP ratio: indirect taxes	Level, demeaned
Revenue-to-GDP ratio: household income taxes	Level, demeaned
Revenue-to-GDP ratio: corporate taxes	Level, demeaned
Revenue-to-GDP ratio: Payroll taxes	First log difference, demeaned
Expenditure-to-GDP ratio: social benefits	First log difference, demeaned
Financial side	
Real loans to Non-financial corporations, per capita	First log difference, demeaned
Corporate interest rate spread	Level, demeaned
Nationwide risk premium	Level, demeaned
Euro area data	
Real GDP, per capita	First log difference, demeaned
GDP deflator	First log difference, demeaned
3-month EURIBOR	Level, demeaned

TABLE 1. Observed variables.

Source: Statistics Portugal, EUROSTAT and Banco de Portugal.

Notes: *Per capita* aggregates are computed with the overall population. Real wages are deflated by the private consumption deflator. Real loans are deflated by the GDP deflator. The corporate interest rate spread is computed as the difference between the interest rate paid by non-financial corporations on new loans and the 3-month EURIBOR. The nationwide risk premium is measured by the differencial between Portuguese and German short-term Treasury bills (except over 1999–2002, a period where we assumed a nil risk premium, and over 2011–2012, a period where we used the differential between Portuguese and German corporate interest rates).

of the domestic economy is slightly more volatile than that generated by both models, with the exception of consumer price inflation. Measurement errors contribute to this outcome, absorbing some noise present in the data. The highest discrepancy in volatility between data and models is registered in the labor tax revenue-GDP ratio. The fiscal rule is designed to close persistent deficits through an increase in labor taxes. If the data is not compatible with such a path, the estimation procedure compensates deviations from the fiscal rule with exogenous perturbations, reflected into the estimated standard error of the respective innovation and hence in model volatility. In this respect, the infinitely-lived agents model performs worse, yielding a higher volatility in the labor tax revenue-GDP ratio.

Variable	Data	Inf-model	OLG-model
GDP growth	0.76	0.79	0.81
Private consumption growth	0.94	1.05	1.16
Private investment growth	4.53	5.06	5.14
Public cons. & inv. growth	1.43	1.46	1.45
Exports growth	2.61	2.64	2.62
Imports growth	2.58	2.89	3.02
Labor growth	0.87	0.65	0.70
Wage growth	0.74	0.79	0.78
Private consumption inflation	0.48	0.50	0.50
Private investment inflation	2.81	2.37	2.40
Public cons. & inv. Inflation	0.98	0.90	0.91
Exports inflation	1.04	0.72	0.73
Imports inflation	1.72	1.25	1.27
GDP growth, euro area	0.60	0.56	0.54
GDP inflation, euro area	0.11	0.24	0.18
Interest rate	0.43	0.43	0.34
Consumption tax revenue-GDP ratio	0.72	0.53	0.54
Labor tax revenue-GDP ratio	1.14	2.18	1.82
Payroll tax revenue-GDP ratio	0.28	0.22	0.22
Capital tax revenue-GDP ratio	0.51	0.41	0.40
HH transfers-GDP ratio	0.56	0.52	0.51
External finance premium	0.21	0.25	0.26
Corporate loans growth	1.60	1.59	1.62
Nationwide risk premium	0.13	0.09	0.10

TABLE 2. Standard deviation of actual data and those generated by models.

The implied evolution of smoothed shock processes is in most cases relatively close across models, and different impacts on endogenous variables potentially arise from distinct mechanisms within the model rather than from important differences in the size of perturbations. One of the most important shock processes driving economic developments in the past two decades is the technological growth rate, shared by both Portugal and the euro area, and which triggers region-specific cycles (Figure 1). Results show a high degree of similarity across both models, implying identical trend-cycle extractions. The economic environment that characterizes the 2009–2017 period is for instance interpreted as including a persistent technological effect. The resulting trend is relatively smooth and delivers meaningful cycles under both models, positive before the turmoil and featuring a double dip recession afterwards. The cycle becomes positive again towards the end of the sample, a period influenced by more resilient trend growth.

The similarities across models extends to other smoothed shocks as well (Figure 2). Labor and consumption tax processes are virtually identical over the entire sample period. Government consumption levels are also very close, particularly after 2008, whereas household transfers have a slight upward shift in the infinitely-lived agents

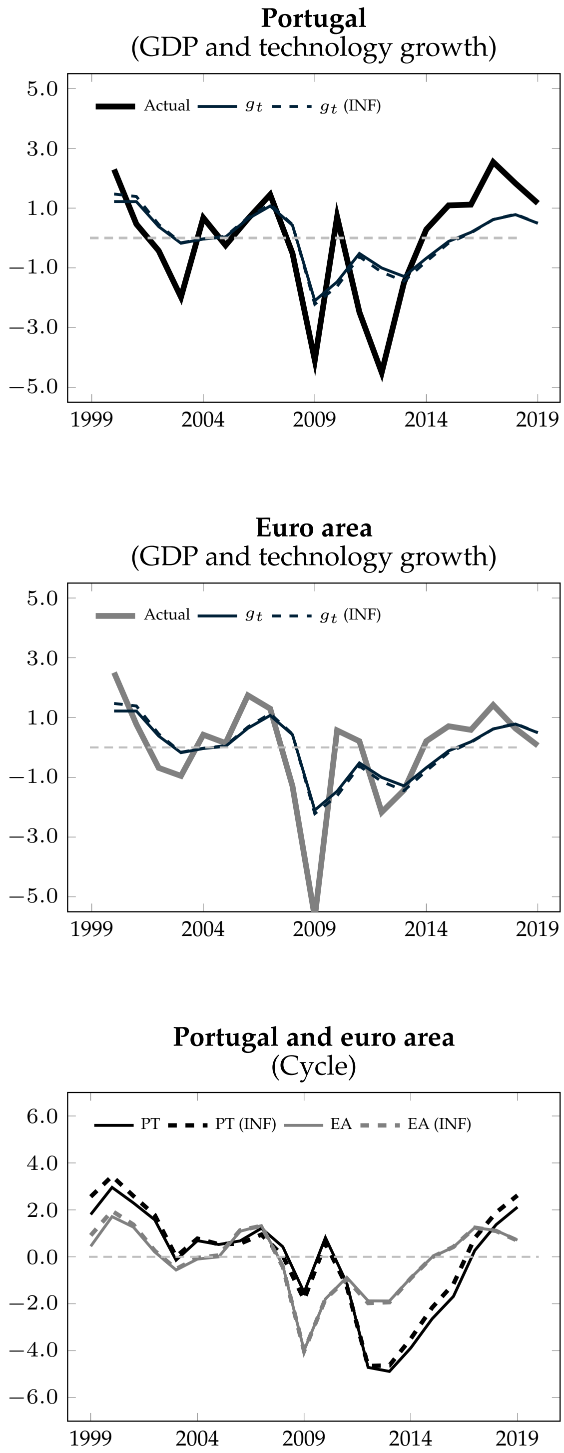


FIGURE 1: GDP and technology.

Notes: The technology growth rate is identified with g_t, which is the (logarythmic) change of the labor-augmenting technology level shared by both Portugal and the euro area. Identifier "INF" refers to the infinitely-lived agents model and "OLG" to the overlapping-generations (finitely-lived agents) model. Portugal and the euro area are identified with "PT" and "EA." All cycles are measured in percentage against steady-state levels. All data is demeaned.

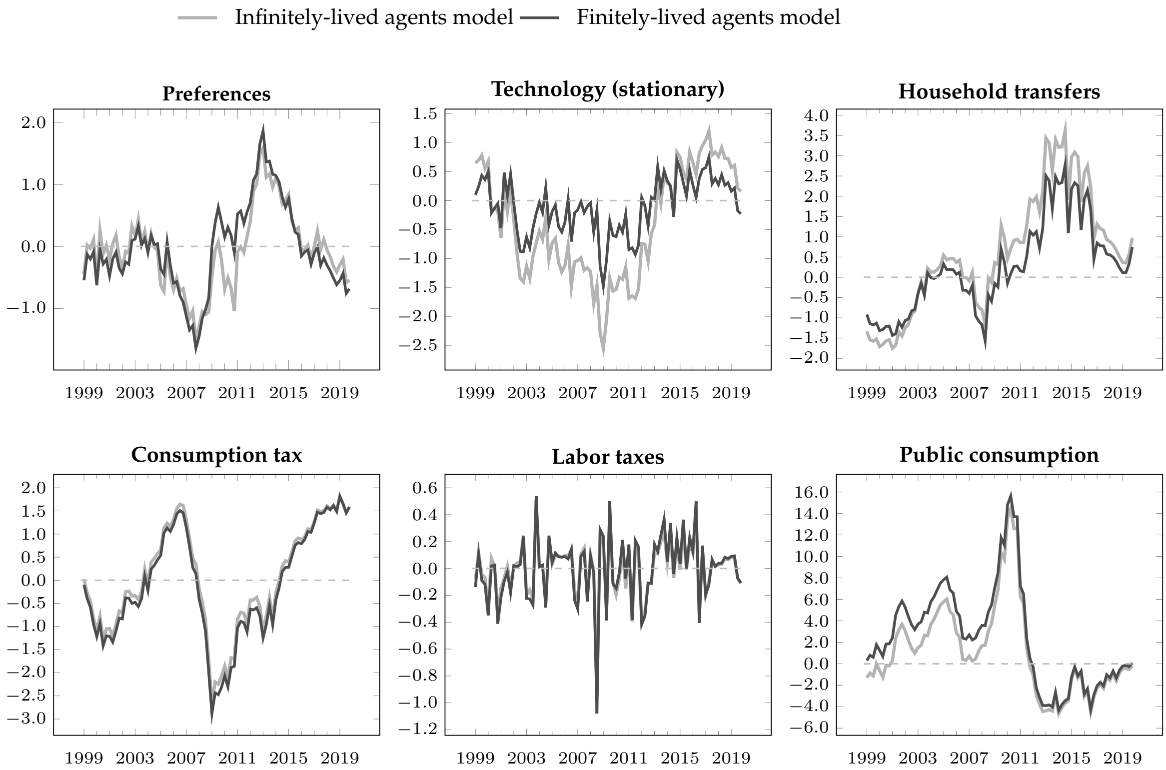


FIGURE 2: Selected smoothed shock processes.

Notes: All shocks are in scaled deviations from steady state levels. "Technology (stationary)" identifies shocks with temporary effects on the domestic labour-augmenting technology level. "Consumption taxes" and "labour taxes" are implicit tax rates. Household transfers are in percentage of GDP.

model. Models are using measurement errors in order to improve the fit to the data, and different mechanisms within each model lead to distinct noise-extraction outcomes. This contributes to different smoothed shock processes across models, even when these are highly related with observables, as it is the case of transfers or public consumption. Note that the government/fiscal response to the 2008 turmoil was swift, with increases in public consumption and declines in taxes over consumption and labor. On the opposite direction, the 2011–2013 sovereign debt crisis implied corrective government/fiscal measures which radiated nearly till the end of the sample period. Public consumption and household transfers were pushed downwards, whereas taxes on consumption and labor faced historically large increases. The collapse in euro area GDP—a proxy for world demand in the model's export equation—reflects the business-cycle spillover effect of the worldwide crisis on the domestic environment.

The labor-augmenting stationary technology component is one important exception. The finitely-lived agents model brings forward a less volatile and slightly less persistent smoothed shock than the infinitely-lived agents model. Although both models feature a large fall during 2008–2009 period, the latter takes place from substantially lower levels. The decaying labor productivity built in the OLG framework, by affecting the consumption-labor choice, may contribute decisively towards this result.

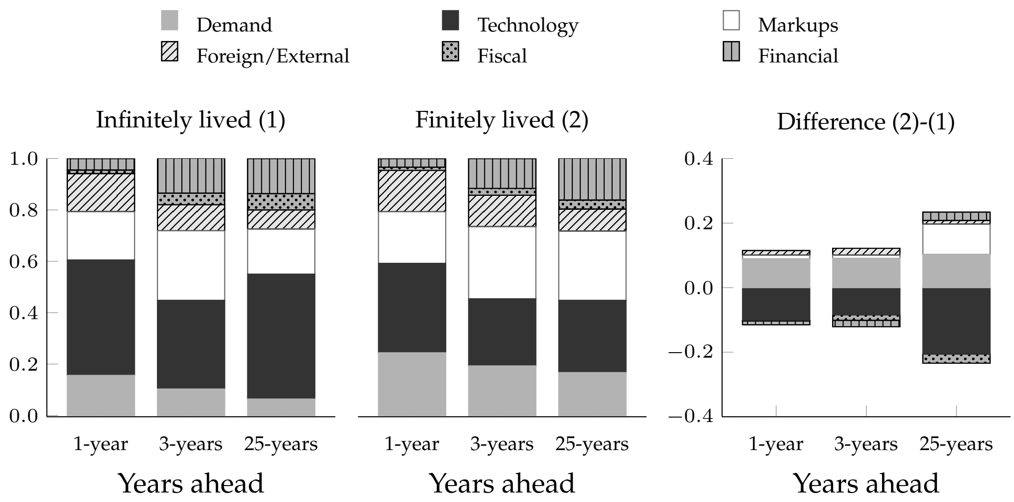
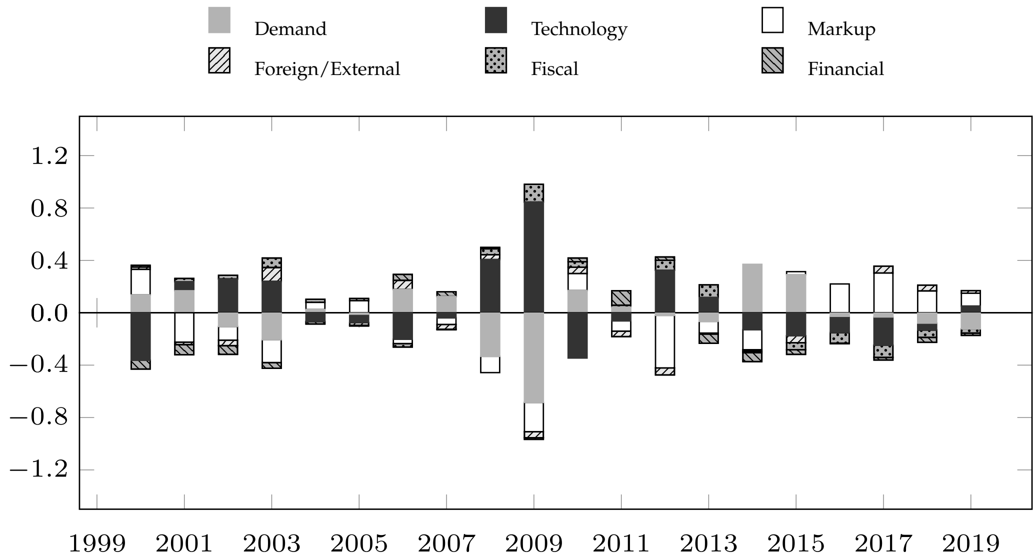


FIGURE 3: GDP forecast error variance decomposition.

Differences in the endogenous transmission mechanisms may result not only in slightly different smoothed shocks, but also in possibly distinct interpretations of recent history. These conclusions splash onto the GDP variance decomposition, with the demand category gaining a higher importance in explaining GDP fluctuations in the finitely-lived agents model *vis-à-vis* the infinitely-lived framework (Figure 3). Differences are persistent across different horizons. On the opposite direction, the technology category is downplayed by the finitely-lived agents model, and the contribution is systematically below that of the infinitely-lived agents model. The less volatile labor-augmenting technology smoothed shock in the OLG model finds echo here, delivering a less sizable contribution of technology factors to GDP fluctuations. The model compensates this by attributing a greater role to preference shocks. Differences in the remaining categories are relatively minor.

The historical decomposition of GDP growth confirms the existence of some quantitative differences, particularly in the technology and demand components. However, their magnitude is small, amounting at best to 0.4 percentage points (pp) in absolute terms (Figure 4). The only exception is the 2009 crisis, when the differential between both models reaches 0.8 pp in the technology aggregate and 0.7 pp in the demand aggregate, the former in favor of the infinitely-lived agents model and the latter in favor of the finitely-lived agents one. A similar conclusion emerges on the crises of 2003 and 2012, but to a lesser extent.

When we juxtapose the contributions of each model, the narrative in qualitative terms is broadly similar (Figure 5). The contributions from technology are indeed larger in the infinitely-lived agents model, but they are also important and with the same sign in the finitely-lived agents model. The same conclusion is valid for the demand shocks, as well as for the remaining categories. When we decompose demand (Figure 6), the divergence emerges from preference shocks, and not from the public component, despite the presence of crowding out/in effects on consumption in the infinite/finite lived



(A) GDP growth, difference between infinite and finitely lived models.

FIGURE 4: Historical decomposition.

Notes: A positive bar means that the contribution of shocks to GDP growth in the corresponding category in the infinitely-lived agents model outweighs that depicted by the finitely-lived agents model, and *vice-versa*.

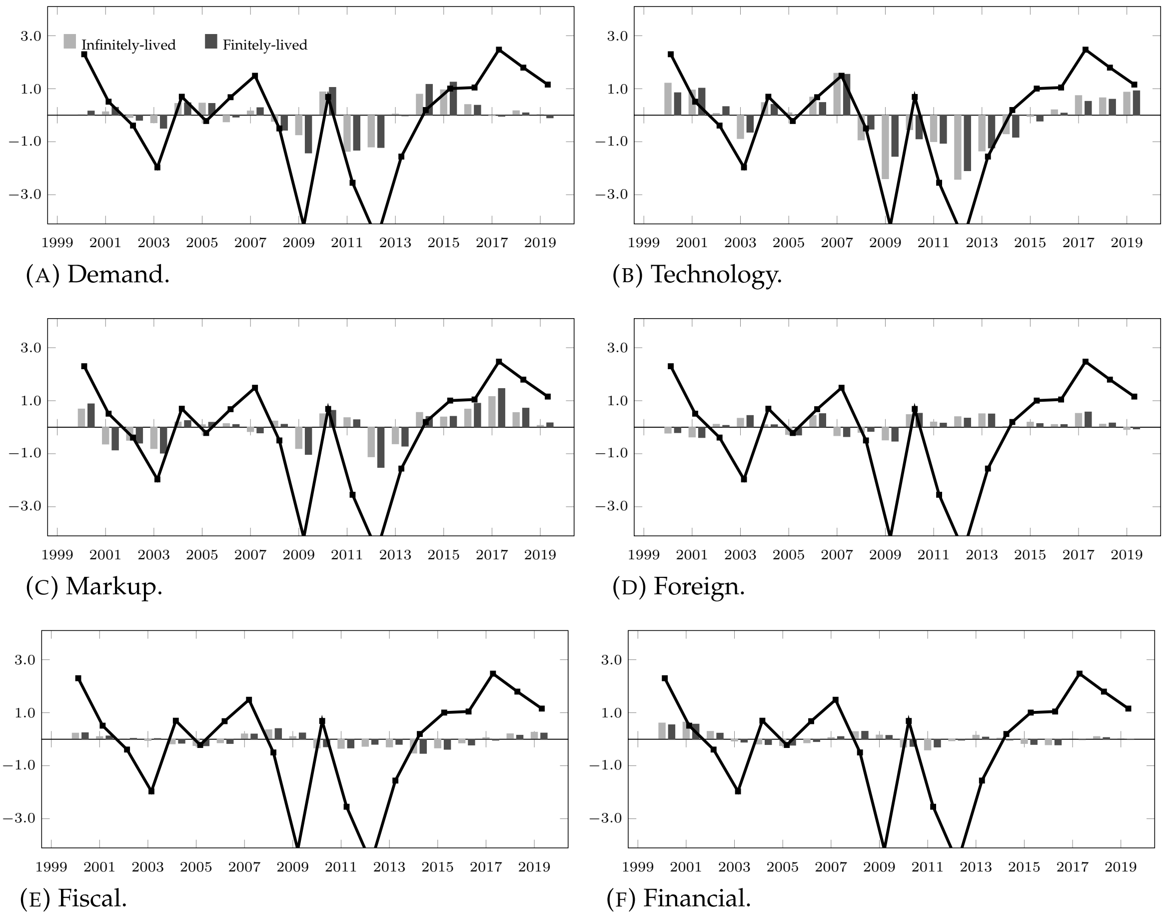
agents models. An important component for this results lies in the presence of hand-to-mouth households in the infinitely-lived agents model, which creates non-negligible non-Ricardian effects.

These differences are also reflected in impulse responses, important tools of policy analysis and simulation (Figure 7). The OLG structure tends to generate more powerful short-run effects when in the presence of stronger wealth impacts superimposed by the non-Ricardian framework. This is noticeable in government consumption shocks, where we detect a crowding-in effect on private consumption—in contrast with the crowding-out efect in the infinitely-lived agents model.

The growth shock triggers a more marked increase in technology and concomitantly a more powerful long-run impact of all non-stationary variables in the infinitely-lived agents model. The shorter planning horizon associated with finitely-lived agents augments wealth impacts, and therefore the estimation process attributes less persistence to growth shocks, as compared with the infinitely-lived agents model. We failed to find important divergences in the remaining responses worth highlighting.

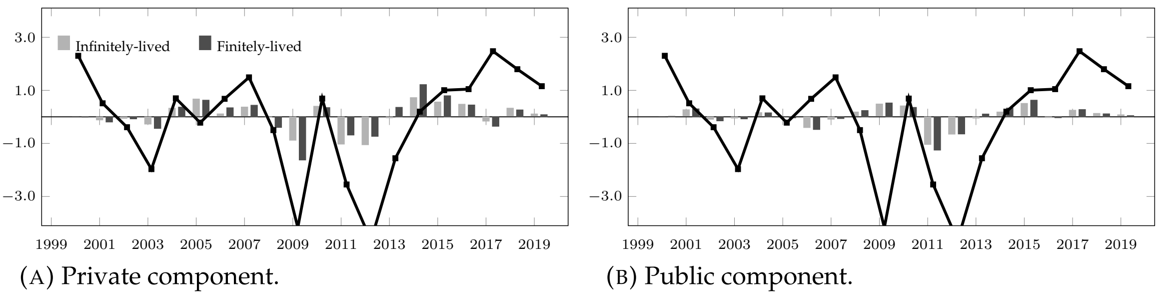
5. Concluding remarks

This article shows how different are the narratives produced by two estimated medium-scale small-open Dynamic Stochastic General Equilibrium models, identical in all respects except the household structure. Both models are estimated for the Portuguese economy, for the 1999-2019 period. The infinitely-lived agents model follows closely standard practice in the literature, whereas in the finitely-lived agents model households



(A) Demand.
(B) Technology.
(C) Markup.
(D) Foreign.
(E) Fiscal.
(F) Financial.

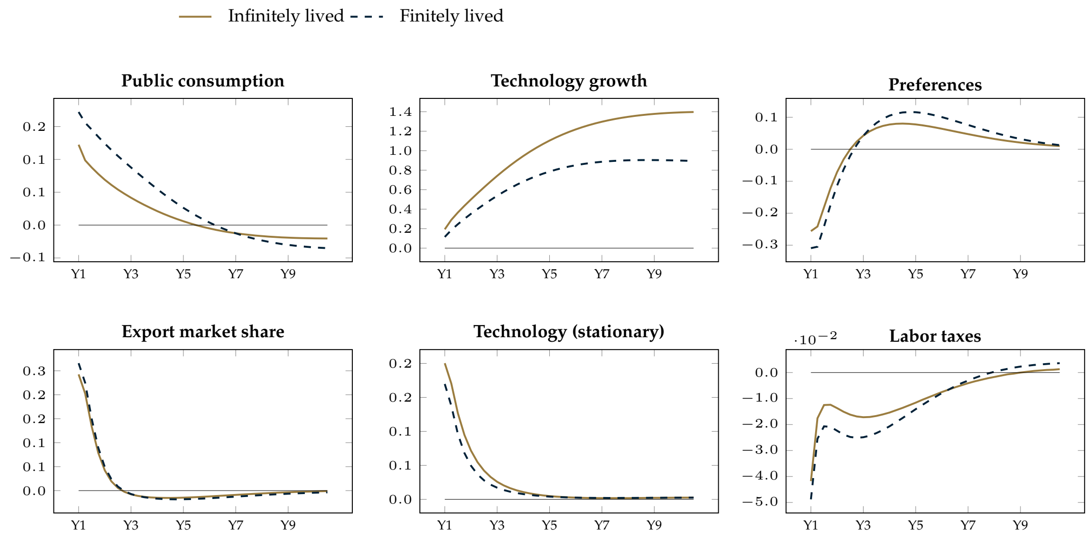
FIGURE 5: Historical decomposition of the Portuguese GDP growth.
Notes: GDP growth rates in percentage (black line), and contributions of components in percentage points.



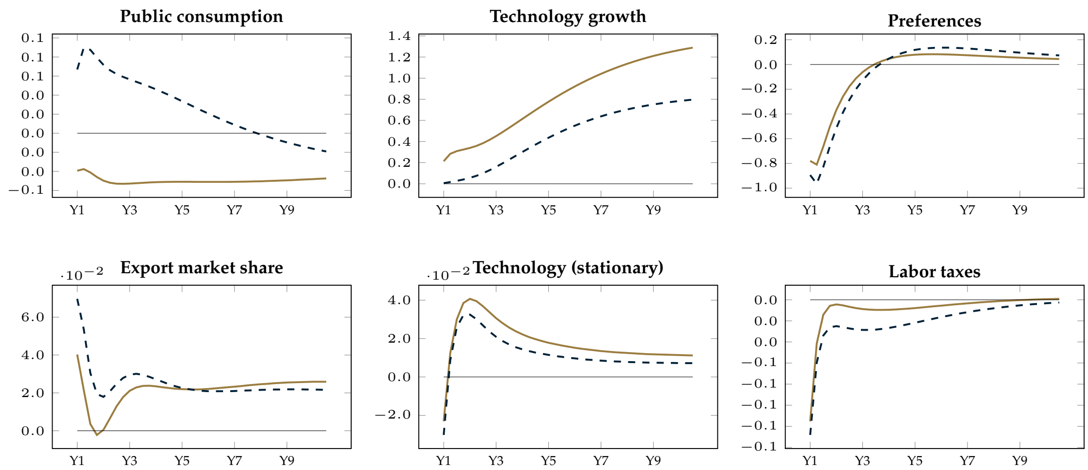
(A) Private component.
(B) Public component.

FIGURE 6: Historical decomposition of the Portuguese GDP growth: the demand component.
Notes: GDP growth rates in percentage (black line), and contributions of components in percentage points.

are subject to stochastic finite lifetimes and face decaying labor productivity. Both models feature hand-to-mouth households, to which the estimation process attributes a greater role in the infinitely-lived world, and which creates an important non-Ricardian source in that model.



(A) GDP



(B) Private Consumption

FIGURE 7: Impulse response functions.

Notes: All impacts are in deviations from steady state.

Our findings suggest that both models filter the data in identical ways, producing in general very similar smoothed shock processes. The differences, when exist, jointly with distinct mechanics within models, imply a slightly different narrative for the Portuguese economy over the 1999-2019 period, but fail to deliver a dramatically different overview. The non-Ricardian features embodied in the finitely-lived agents model deliver more powerful demand-side impacts—effects which are alternatively channeled towards technology-side perturbations in the infinitely-lived agents model. This affects mostly historical and variance decompositions, though the effects are not sufficiently different in quantitative terms to convey an alternative interpretation of history. The impulse response functions to a public consumption perturbation are also affected, with the infinitely-lived agents model depicting crowding-out and the finitely-lived agents model crowding-in effects in private consumption. The former model also depicts more persistent growth effects. In many other dimensions analyzed herein, such as moment comparison, trend-cycle decomposition, and other impulse responses, we fail to find divergences worth highlighting.

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