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Towards a quantitative theory of automatic stabilizers: the role of demographics[☆]

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Abstract

Employment volatility is larger for young and old workers than for the prime aged. At the same time, in countries with high tax rates, the share of total hours supplied by young/old workers is lower. These two observations imply a negative correlation between government size and business cycle volatility. This paper assesses in a heterogeneous agent OLG model the quantitative importance of these two facts to account for the empirical relation between government size and macroeconomic stability.

Keywords: Automatic Stabilizers, Distortionary Taxes, Demographics.

JEL codes: E32, E62, H30, J10, J21.

1. Introduction

2 The motivation for this paper consists of two observations. The first is the
3 substantial evidence that countries or regions with large governments display less
4 volatile business cycles, as shown in Galí (1994) and Fatás and Mihov (2001).
5 The second observation, documented by Clark and Summers (1981), Ríos-Rull
6 (1996) and Gomme et al. (2005), is that fluctuations in hours of market work

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7 over the business cycle vary quite dramatically across different demographic
8 groups of the population, with the young experiencing much greater volatility
9 of employment and total hours worked than the prime-aged. Moreover, in a
10 recent paper Jaimovich and Siu (2009) find that changes in the age composition
11 of the work-force account for a significant fraction of the variation in cycli-
12 cal volatility observed in G7 countries. Hence, this article poses the following
13 question: can the relationship between government size and macroeconomic sta-
14 bility be explained by changes in the demographic composition of the workforce
15 resulting from distortionary taxation?

16 The hypothesis we put forward is that large governments stabilize the econ-
17 omy because the share of total market hours supplied by young and old workers
18 is smaller in countries with high tax rates, implying a lower *aggregate* labor
19 supply elasticity. Thus, in the tax-distorted economy we analyze, a relationship
20 emerges between government size (measured by the share of taxes in GDP) and
21 aggregate volatility, consistent with the notion of automatic stabilizers.¹

22 The suggestion that time devoted to market work is affected by changes
23 in tax and transfer policies has received considerable attention. Recent work
24 by Prescott (2004), Rogerson (2008) and Ohanian et al. (2008) argues that these
25 changes account for a large share of the difference in the amount of hours spent
26 working in Europe and in the US. Rogerson and Wallenius (2009) document that
27 the differences in employment rates between Europe and the US are due almost
28 exclusively to differences among young and old workers. This observation offers
29 further motivation for our paper.

30 We examine the strength of automatic stabilizers using a heterogeneous
31 agent OLG model along the lines of Ríos-Rull (1996), and based on the link
32 between the tax system and the aggregate labor supply elasticity.² The model
33 includes heterogeneous preferences and, in particular, labor supply elasticities
34 that change over the life-cycle. These changes are calibrated to match differ-
35 ences in the relative cyclical volatility of employment over the life-cycle and
36 differences in employment rates in high and low tax countries.

37 To be sure, several factors explain why different age groups experience differ-
38 ent labor market fluctuations over the business cycle (Choi et al., 2014). These

¹So-called ‘built-in stabilizers’ are features of the tax structure that make tax liabilities automatically respond to current economic conditions (for instance, distortionary labor and capital income taxes) and reduce aggregate volatility. The stabilizing effect of the income tax is traditionally thought to operate via an assumed sensitivity of consumption demand to changes in current tax liabilities. But this sensitivity is zero according to the Ricardian proposition. Thus, Christiano (1984) concludes that under the Ricardian proposition, the income tax cannot play a role as an automatic stabilizer. Nonetheless, distortionary taxes may affect macroeconomic stability by affecting the aggregate supply and, in particular, the aggregate labor supply elasticity.

²To be sure, our paper is not suitable to study the welfare implications of automatic stabilizers. Optimal taxation must balance distortions versus insurance. But, in our OLG framework, as in Ríos-Rull (1996), markets are sequentially complete. Thus, the insurance gains from automatic stabilizers are negligible. See McKay and Reis (2013) for a detailed study of the insurance role of automatic stabilizers in an incomplete markets DSGE model.

39 factors are related, for example, to family formation, human capital accumu-
40 lation, saving behavior, retirement age and unemployment dynamics, among
41 others. We do not model these elements explicitly and, in particular, abstract
42 from involuntary unemployment. Clearly, differences in employment volatility
43 across demographic groups are partially accounted for by differences in un-
44 employment dynamics. But, we interpret the assumed heterogeneity in labor
45 supply elasticities as a reduced form way to capture all these factors.

46 A related calibration strategy has recently been explored by Dyrda et al.
47 (2012) who, for similar reasons, also generate age differences in the volatility of
48 hours with differences in preferences. They provide a measurement of the ag-
49 gregate labor supply elasticity that, although consistent with micro estimates,
50 yields a much higher macro elasticity. In our paper we establish a similar re-
51 sult in the context of a large OLG economy. The labor supply elasticity of
52 the prime-aged is small, as implied by the meta-analysis of quasi-experimental
53 studies by Chetty et al. (2012) but, given the heterogeneity in preferences, the
54 aggregate labor supply elasticity of the baseline calibration is equal to 0.84, a
55 value recommended by Chetty et al. (2012) to calibrate stand-in agent RBC
56 models.³

57 An important aspect that differentiates this paper from the literature ex-
58 amining the stabilizing role of the government sector is that we conduct a
59 quantitative study, based on a carefully calibrated model.⁴ The baseline cali-
60 bration accounts for about 75% of the strength of automatic stabilizers. This is
61 the result of changes in the workforce demographic composition that affect the
62 aggregate labor supply elasticity.

63 The remainder of the paper is organized as follows. Section 2 documents
64 the empirical motivation. Section 3 presents the model. Section 4 establishes
65 three results on the aggregate labor supply elasticity. Section 5 examines the
66 quantitative performance of the model. Finally, Section 6 concludes.

67 2. Motivating evidence

68 The hypothesis we put forward is that large governments are stabilizing
69 because they lead the demographic groups with high labor supply volatility to
70 work relatively less. Here we document empirical evidence to motivate this
71 mechanism. We start by showing that in all OECD countries, employment
72 volatility exhibits a u-shaped profile over the life-cycle. The employment share

³Mennuni (2013) in the context of an OLG model similar to ours, explores the possibility that changes in the composition of labor affect the evolution of aggregate volatility, but focuses on differences across gender and schooling.

⁴Earlier work focuses on the sign of the relationship. Greenwood and Huffman (1991) and Galí (1994) study if income taxes and government purchases behave as automatic stabilizers in the basic RBC model. Both papers obtain a counterfactual relationship between government size and macroeconomic stability. Andrés et al. (2008) extend the analysis in Galí (1994) and study how models of the business cycle featuring nominal rigidities and costs of capital adjustment can generate a negative correlation between government size and volatility.

73 of the young and old is lower in countries with large governments and these
74 difference affect business cycle volatility.

75 *2.1. The employment volatility profile over the life-cycle*

76 We begin by documenting the relationship between age and employment
77 volatility: the employment volatility of young and old workers is larger than that
78 of prime-age workers. Jaimovich and Siu (2009) show that, in the G7, young
79 and old workers experience much greater business cycle volatility of employment
80 and hours worked than the prime-aged. We show that this empirical regularity
81 is found in all OECD countries. To illustrate this fact, we follow the approach
82 of Gomme et al. (2005) and Jaimovich and Siu (2009), who report cyclical
83 employment volatilities for various age groups.

84 We use annual data on employment by age group from the OECD for an
85 unbalanced panel of 25 countries from 1970 to 2009, and build seven categories:
86 individuals aged between 15 and 19 years old, 20 – 24, 25 – 29, 30 – 39, 40
87 – 49, 50 – 59 and 60 – 64 years old. For each of these categories, we extract
88 the business cycle component of employment by applying the Hodrick-Prescott
89 (HP) filter to the logged series with smoothing parameter equal to 6.25 and we
90 calculate the standard deviation. We report the relative volatility, given by the
91 standard deviation of each age group relative to the standard deviation of the
92 group aged between 40 and 49.

93 [Figure 1 about here]

94 Figure 1 displays the results for a large cross-section of OECD countries.
95 It reveals an ubiquitous u-shaped relationship between age and employment
96 volatility at business cycle frequencies. In all the countries, volatility is the
97 highest either among workers aged 15 to 19, or those aged 60 to 64. The
98 employment volatility of the youngest workers is, on average, nearly five times
99 that of workers aged 40 to 49. The workers aged 60 to 64 also display large
100 employment volatility, on average more than three times that of workers aged
101 40 to 49. Finally, in all the countries the prime-age workers (aged 40 to 49)
102 have the most stable labor supply.⁵

103 *2.2. Demographic composition of employment and government size*

104 The second fact we document concerns the relationship between the work-
105 force's demographic structure and government size. We are interested in the
106 impact of government size on what Jaimovich and Siu (2009) call the *volatile-*
107 *aged* employment share (the ratio of employment of individuals aged 15 to 29
108 and 60 to 64, to that of individuals aged 15 to 64).

109 The first column of Table 1 considers the regression of the *volatile-aged*
110 employment share on government size. Each observation corresponds to an

⁵Although our focus is on employment, the cyclical volatility of unemployment also varies across age groups. For example, Elsby et al. (2010) and Choi et al. (2014) show that the young were the most affected during the Great Recession.

111 OECD country over one of the following periods: 1970 – 1979, 1980 – 1989,
112 1990 – 1999 and 2000 – 2009. The regression reveals a negative and precisely
113 estimated coefficient.

114 [Table 1 about here]

115 Of course, countries with older populations may need large governments.
116 For example, large governments help provide the old with social security and
117 healthcare. At the same time, countries with an older population have a lower
118 share of young workers in aggregate employment. Thus, the negative correlation
119 between the government size and the volatile-aged employment share could be
120 spurious and due to the varying share of old individuals.⁶ To confront this issue,
121 the second column in Table 1 controls for the share of individuals aged 60 or more
122 in the population. The results confirm that countries with older populations
123 have lower volatile-aged employment shares. This implies a weaker independent
124 influence of government size, but still strongly significant. Columns (3) and (4)
125 report the same regressions as in columns (1) and (2), excluding individuals
126 aged 60 to 64 from the volatile-aged employment share. The estimates are very
127 similar.

128 *2.3. Government size and business cycle volatility: role of demographics*

129 Next, we argue that as a result of the negative correlation between the
130 volatile-aged share of employment and government size, business cycles are less
131 volatile in countries with large governments. Column (1) of Table 2 reports
132 the regression of the volatility of aggregate hours on the volatile-aged share
133 of employment. The coefficient is positive and precisely estimated. In turn,
134 countries with larger governments enjoy more stable aggregate hours, as shown
135 in column (2) of Table 2. However, the latter relationship vanishes if we control
136 for the volatile-aged share of employment, as illustrated in column (3) of Table 2.
137 The coefficient falls by 52% and is no longer significant. This suggests that
138 government size affects the volatility of aggregate hours by changing the volatile-
139 aged share of employment.

140 [Table 2 about here]

141 Turning to the volatility of GDP, column (4) of Table 2 shows that higher
142 volatility of aggregate hours implies higher output volatility. Finally, columns
143 (5) to (6) consider the same regressions as in columns (2) to (3), but with the
144 volatility of GDP as the dependent variable, with similar results.

145 *2.4. The intensive margin of adjustment*

146 The evidence discussed so far is about how taxes affect the demographic com-
147 position of employment and how this affects aggregate volatility. But, variation
148 in hours worked in the intensive margin (hours worked by those in employment)

⁶We thank a referee for this comment.

149 was ignored. This component is quantitatively unimportant for the fluctuation
150 of hours worked in the case of the US where most of the variation in total hours
151 is on the extensive margin (Hansen, 1985), but it is more important in more
152 regulated economies such as France (Ohanian and Raffo, 2012).⁷ In Appendix
153 H we show that there is a negative correlation between government size and the
154 relative hours worked by employed young workers, but that the intensive margin
155 contribution to explain the negative correlation between government size and
156 macroeconomic volatility is small.⁸

157 2.5. Summary of the empirical evidence

158 This Section documented the four following facts: i) the employment of
159 young/old individuals fluctuates much more over the business cycle than that
160 of prime-age individuals; ii) across OECD countries, the volatile-aged share of
161 employment declines as the size of the government increases, even after con-
162 trolling for the population’s demographic structure; iii) there exists a negative
163 link between government size and the cyclical volatility of aggregate hours and
164 output, however, controlling for the demographic composition of the workforce
165 attenuates substantially this relationship; iv) this mechanism operates along
166 the extensive margin. Next, we propose a heterogeneous agent OLG model
167 motivated by these four facts.

168 3. The model

169 We present a model with life-cycle changes in the cyclical volatility of hours
170 worked. The framework is that of an OLG economy as in Ríos-Rull (1996), and
171 we model labor supply in the extensive margin by way of a non-linear production
172 function of labor services, as in Prescott et al. (2009). Time is discrete and each
173 date t corresponds to a year. Each year a continuum (measure μ_1) of individuals
174 is born. We denote an individual’s age by $i = 1, \dots, T$. Individuals live at most
175 $T = 70$ periods, but face random lifespans. The conditional probability of
176 surviving from age i to $i + 1$ is ζ_i , with $\zeta_0 = 1$ and $\zeta_T = 0$. Thus, the mass
177 of individuals alive at age i is $\mu_i = \mu_1 \prod_{j=1}^i \zeta_{j-1}$.⁹ All individuals must retire
178 when $i = M = 50$. The other features of the economy are those of the standard
179 RBC model featuring capital adjustment costs and variable utilization.

⁷The data examined in Ohanian and Raffo (2012) is at quarterly frequencies. At the annual frequency, the importance of the extensive margin to explain cyclical variations in total hours is even more predominant. In the US the intensive margin accounts for only about 1/6 of the fluctuations in aggregate hours (Heckman, 1984), and in the majority of OECD countries the annual volatility of employment is at least twice that of hours.

⁸We thank the Associate Editor for suggesting to study this additional channel.

⁹The mass of newborns μ_1 is chosen so that the total population $\sum_{i=1}^T \mu_i$ has unit size.

180 *3.1. Preferences and labor supply*

181 Preferences of an agent aged i are specified over consumption and total hours
182 worked and take the form

$$u(c, n; i) = \frac{1}{1 - \sigma} \left(c - \frac{\lambda_i n^{1+1/\eta_i}}{1 + 1/\eta_i} \right)^{1-\sigma}, \quad (1)$$

183 with $\sigma > 0$ and where c denotes consumption and n the total hours worked
184 in the year.¹⁰ The preference parameters λ_i and η_i are age dependent and, in
185 particular, η_i is the wage-elasticity of labor supply. As in Bils and Cho (1994)
186 and Cho and Cooley (1994), for example, we distinguish between the number of
187 hours worked per unit of time (say a week), denoted $h \in [0, \underline{h}]$, and the number
188 of weeks the individual works in the year, denoted $e \in [0, \underline{e}]$. Hence, total hours
189 worked in a year are $n = eh$.

190 Without loss of generality, we normalize the total “number of weeks” in the
191 year, \underline{e} , to unity and interpret e as the employment rate as in Cho and Cooley
192 (1994). Preferences are specified over total hours worked in the year, but the
193 mapping from hours worked per week and labor services per week is non-linear
194 and workers face a choice between work-week length and the number of work
195 weeks per year. For an individual aged i , the mapping from weekly hours worked
196 to labor services per week obeys

$$\ell_i = g(h; i), \quad (2)$$

197 where the function $g(h; i)$ has the following properties: for each age group i ,
198 $g(h; i)$ is increasing in h ; it is equal to zero at the origin; over the domain
199 $[0, 1]$, $g(h, i)$ is first convex and then becomes concave. This captures two key
200 features: first, that over some domain of hours, a part-time worker is often less
201 productive than a full-time worker; second, that after some point working longer
202 hours leads to fatigue and lower returns to work. The length of the optimally
203 chosen workweek must satisfy the condition

$$\frac{g(\bar{h}_i; i)}{\bar{h}_i} = g'(\bar{h}_i; i), \quad (3)$$

204 with the interpretation that the average productivity in the week is equal to the
205 marginal productivity of an additional hour of work that week. Despite being
206 endogenous, the optimal workweek length does not depend on wealth or the
207 wage rate.

¹⁰If $\sigma = 1$, the utility function specializes to $u(c, n; i) = \ln \left(c - \frac{\lambda_i n^{1+1/\eta_i}}{1+1/\eta_i} \right)$.

208 Individuals maximize their life-time expected utility, given by

$$E_t \left[\sum_{i=1}^T \beta^{i-1} \left(\prod_{j=1}^i \zeta_{j-1} \right) u(c_{i,t+i-1}, n_{i,t+i-1}; i) \right], \quad (4)$$

209 where $c_{i,t} \geq 0$ and $n_{i,t} \in (0, \underline{h} \times \underline{e})$.¹¹

210 3.2. Financial markets

211 As in Ríos-Rull (1996), markets are sequentially complete. In addition,
 212 two outside assets are traded: government bonds and shares in the stand-in
 213 firm.¹² There are also actuarially fair contracts for annuities. These contracts
 214 are arrangements whereby all members of the same cohort sign a contract in
 215 which survivors share the assets (or debts) of the agents that die. Next period's
 216 assets are the current savings divided by the probability of surviving. The
 217 resulting budget constraint faced by an individual aged i is

$$\begin{aligned} (1 + \tau_c) c_{i,t} + p_t s_{i+1,t+1} + d_t b_{i+1,t+1} + \sum_{z \in \mathcal{Z}} q_t^z x_{i+1,t+1}^z \\ = (1 - \tau_h) w_t g(\bar{h}_i; i) e_{i,t} + a_{i,t} + L_t, \end{aligned} \quad (5)$$

218 where τ_c and τ_h are the consumption and labor income tax rates, $x_{i+1,t+1}^z$
 219 constitutes the amount of state-contingent Arrow securities for each event $z \in \mathcal{Z}$,
 220 bought by individuals aged i , at price q_t^z ; $b_{i+1,t+1}$ are the government bonds,
 221 bought at discount price d_t ; $s_{i+1,t+1}$ are the shares in the firm owned by an
 222 individual aged i , bought at the ex-dividend price p_t . The taxable labor income
 223 of an individual aged i is $w_t g(\bar{h}_i; i) e_{i,t}$. Finally, the individual's resources
 224 include lump-sum transfers received from the government L_t and her start of
 225 period wealth, given by

$$a_{i,t} = \frac{(\pi_t + p_t) s_{i,t} + b_{i,t} + x_{i,t}}{\zeta_{i-1}}, \quad (6)$$

226 where $x_{i,t}$ and $b_{i,t}$ are the payments from the Arrow securities and from the
 227 government bonds, and π_t is the after-tax profits distributed to shareholders.

228 3.3. Firms

229 The production function of the representative firm is

$$Y_t = \exp(\epsilon_t^1) ((u_t/\bar{u}) K_t)^\alpha H_t^{1-\alpha}, \quad (7)$$

¹¹See the Appendix B.1 for a detailed derivation of the optimality conditions.

¹²The volume of outstanding equity shares is normalized to unity.

230 where the capital services are the product of the stock of capital K_t and the
 231 rate of capital utilization, (u_t/\bar{u}) , and where

$$H_t \equiv \sum_{i=1}^M \mu_i g(\bar{h}_i; i) e_{it}, \quad (8)$$

232 are the efficiency units of labor services. Shocks to productivity, ϵ_t^1 , follow an
 233 exogenous Markov process. Raising the capital utilization rate is costly because
 234 it implies a faster capital depreciation; the depreciation function is

$$\delta(u_t) = \delta_0 + \delta_1 (u_t/\bar{u})^{1+\varsigma}, \quad (9)$$

235 with $\varsigma > 0$ and $\bar{\delta} \equiv \delta_0 + \delta_1 \in (0, 1)$ the steady state depreciation rate. The firm
 236 faces adjustment costs in investment, so that

$$K_{t+1} - K_t = \Phi(I_t/K_t) K_t - \delta(u_t) K_t. \quad (10)$$

237 with $\Phi(\bullet)$ increasing and concave. The representative firm maximizes¹³

$$J(K_t; \epsilon_t^1) = \max_{I_t, H_t} \left\{ \pi_t + E_t \left[\Lambda_{t+1} J(K_{t+1}; \epsilon_{t+1}^1) \right] \right\}, \quad (11)$$

238 subject to (10), and where Λ_{t+1} is the stochastic discount factor of the firm's
 239 shareholders, and after-tax profits, π_t , are given by

$$\pi_t = (1 - \tau_k) \left[\exp(\epsilon_t^1) K_t^\alpha H_t^{1-\alpha} - w_t H_t - I_t \right]. \quad (12)$$

240 3.4. Government

241 The government taxes capital income, labor income and consumption, at the
 242 rates τ_k , τ_h and τ_c , respectively. It spends G_t as government consumption and
 243 provides lump-sum transfers, L_t . The government budget constraint is

$$d_t B_{t+1} = G_t + L_t + B_t - \tau_k (Y_t - w_t H_t - I_t) - \tau_h w_t H_t - \tau_c C_t. \quad (13)$$

244 The dynamics of L_t and G_t are described by the following two equations

$$\widehat{L}_t = -\varphi_L \widehat{B}_t, \quad (14)$$

$$\widetilde{G}_t = \rho_G \widetilde{G}_{t-1} - \varphi_G \widehat{B}_t + \sigma_g \epsilon_t^2, \quad (15)$$

245 where ϵ_t^2 is an exogenous shock; $\widehat{L}_t \equiv (L_t - \bar{L})/\bar{Y}$ and $\widehat{B}_t \equiv (B_t - \bar{B})/\bar{Y}$
 246 are lump-sum transfers and debt in deviation from steady state as percentage
 247 of the steady state output; \widetilde{G}_t is government spending in log-deviation from
 248 steady state; the parameters φ_L , ρ_G and φ_G are positive, consistent with the

¹³The optimality condition solving the firm's problem are in Appendix B.2.

249 transversality condition of the government sector

$$E_t \left[\lim_{z \rightarrow \infty} (\Pi_{i=t}^z d_i) B_{z+1} \right] = 0. \quad (16)$$

250 3.5. Equilibrium and solution method

251 We consider the model's competitive equilibrium, carefully defined in the Ap-
 252 pendix B.3. As in Ríos-Rull (1996), the computation of equilibrium is based
 253 on linear decision rules. Following standard steps, the firm's and the individ-
 254 ual optimality conditions, and the market clearing conditions are log-linearized
 255 around steady state. A detailed derivation of the equilibrium conditions is col-
 256 lected in the Appendix B.4, while Appendix B.5 includes a detailed description
 257 of the algorithm to find the steady state equilibrium. The log-linear model is
 258 described in Appendix B.6.

259 4. Government size and aggregate labor supply elasticity

260 This Section, first characterizes the differences in employment volatility
 261 across demographic groups. Second, we ask how the employment share of each
 262 group varies as the size of the government is changed. Third, we show the
 263 relation between the aggregate labor supply elasticity and taxation.

264 4.1. Cyclical properties of hours over the life-cycle

265 The optimality condition for the choice of total hours and workweek length
 266 for an individual aged $i = 1, \dots, M$, is

$$n_{i,t} = \left[\left(\frac{1 - \tau_h}{1 + \tau_c} \right) \frac{g(h_{i,t}; i) h_{i,t}^{-1} w_t}{\lambda_i} \right]^{\eta_i}, \quad (17)$$

267 and

$$\frac{g(h_{i,t}; i)}{h_{i,t}} = g'(h_{i,t}; i). \quad (18)$$

268 From (18), $h_{i,t} = \bar{h}_i$, so that the workweek length is acyclical and all the cyclical
 269 fluctuations in total hours occur in the extensive margin. The result that follows
 270 compares total hours volatility across demographic groups.

271 **Lemma 1.** *Denote by σ_i the standard deviation of the logarithm of total hours*
 272 *worked by individuals aged i and σ_w the standard deviation of the logarithm of*
 273 *the wage rate. It follows that*

$$\sigma_i = \eta_i \sigma_w, \quad (19)$$

274 where η_i is the Frisch labor supply elasticity of individuals aged i .

275 Lemma 1 follows immediately from equation (17). The upshot is that the de-
 276 mographic groups with large labor supply elasticities display more volatile em-
 277 ployment rates (and, hence, total hours worked) over the business cycle.

278 *4.2. Steady state: taxation and labor force composition*

279 Let the employment rates of individuals aged i in two countries with different
 280 fiscal profiles be denoted \bar{e}_i and \bar{e}'_i , and the employment rates for a different
 281 demographic group j in the same two countries be \bar{e}_j and \bar{e}'_j . Then

$$\frac{\ln(\bar{e}_i/\bar{e}'_i)}{\ln(\bar{e}_j/\bar{e}'_j)} = \frac{\eta_i}{\eta_j} \quad (20)$$

282 This result is summarized in the following lemma (proven in Appendix C).

283 **Lemma 2.** *Consider the steady state of two economies with different fiscal*
 284 *policy profiles. The relative percentage difference in employment rates in the*
 285 *two countries for individuals aged i and individuals aged j , is given by (η_i/η_j) .*

286 The upshot is that an increase in tax rates changes the composition of the
 287 aggregate labor supply towards the less volatile individuals.

288 *4.3. The aggregate labor supply elasticity*

289 The third result we obtain is about the relationship between the aggregate
 290 labor supply elasticity and taxes. We establish the Proposition that follows.

291 **Proposition 1.** *Around steady state the aggregate labor supply elasticity is*

$$\frac{d \ln H_t}{d \ln w_t} \equiv \mathcal{E}_n = \sum_{i=1}^M \bar{s}_{hi} \eta_i, \quad (21)$$

292 where $\bar{s}_{hi} \equiv \mu_i g(\bar{h}_i; i) \bar{e}_i / \bar{H}$ is the share of efficient units of labor supplied by
 293 individuals aged i in steady state. Moreover,

$$\frac{d \mathcal{E}_n}{d \tau_j} = \mathfrak{J}_j \sigma_\eta, \forall j = \{h, k, c\}, \quad (22)$$

294 where $\sigma_\eta \equiv \sum_{i=1}^M \bar{s}_{hi} \eta_i^2 - (\sum_{i=1}^M \bar{s}_{hi} \eta_i)^2$ is the cross-sectional variance of the
 295 labor supply elasticities, and

$$\mathfrak{J}_j = \begin{cases} \frac{d \ln \bar{w}}{d \ln \tau_h} - \frac{\tau_h}{1-\tau_h} & \text{if } j = h, \\ \frac{d \ln \bar{w}}{d \ln \tau_c} - \frac{\tau_c}{1+\tau_c} & \text{if } j = c \text{ and} \\ \frac{d \ln \bar{w}}{d \ln \tau_k} & \text{if } j = k. \end{cases} \quad (23)$$

296 Thus, the sensitivity of the aggregate labor supply elasticity to changes in tax
 297 rates is increasing in the dispersion of the elasticities η_i across age groups.

298 The proof of Proposition 1 is in Appendix D.

299 **5. Quantitative evaluation**

300 In what follows, we study the quantitative importance of our mechanism to
301 generate a negative correlation between government size and aggregate volatil-
302 ity. Our strategy is the following. We first calibrate our model to the US, in
303 Section 5.1. In Section 5.2, we evaluate the model’s fit by looking at how it
304 matches some moments of the US economy that are not used as calibration tar-
305 gets. Finally, in Section 5.3, we let the fiscal profile of the calibrated economy
306 vary in the same way that it varies across the OECD countries, and evaluate
307 the implications of these changes for business cycle volatility. Based on this ex-
308 ercise, we study if our mechanism is quantitatively important by comparing the
309 strength of the relationship between government size and aggregate volatility
310 implied by the model and in the data.

311 *5.1. Calibration*

312 We calibrate the baseline economy to the US. The calibration makes use of
313 three types of data: i) the NIPA tables, ii) the US fiscal policy parameters, and
314 iii) life-cycle earnings, employment and hours data. We first describe the targets
315 determining the technology and the preference parameters that are stable over
316 the life-cycle, $(\alpha, \beta, \bar{\delta}, \varsigma, \phi, \sigma, \rho, \sigma_{\epsilon 1})$. Next, we explain how the parameters of the
317 government sector are set, $(\tau_k, \tau_c, \tau_h, \varphi_L, \rho_G, \varphi_G, \sigma_g, \bar{g}_y)$. Finally, we describe the
318 targets determining the preference parameters that change over the life-cycle.

319 The preference parameters that change over the life-cycle include those of
320 the function $g(h; i)$ and the parameters λ_i , for $i = 1, \dots, 50$, that determine
321 the life-cycle profile of earnings and hours worked by those in employment,
322 and the labor supply elasticities, η_i , for $i = 1, \dots, 50$. The main target we
323 use to calibrate these elasticities is the relative volatility of employment of the
324 young. This target allows us to pin down η_1 for a given list of relative elasticities
325 (η_i/η_1) , for $i = 2, \dots, 15$ and (η_i/η_{40}) , for $i = 41, \dots, 50$. In turn, as explained in
326 Section 5.1.4, we pin down these relative elasticities by making use of Lemma 2
327 and data on employment over the life-cycle in a second country with a different
328 fiscal profile from the US. This allows us to match the effect that changing the
329 tax profile exerts on the relative demographic composition of the workforce.

330 *5.1.1. Technology and stable preference parameters*

331 The calibration of the technology and preference parameters that are stable
332 over the life-cycle follows standard practices. The capital income share α is set
333 to 0.283 based on the NIPA. The discount factor β is set to 0.992, to match an
334 investment-output ratio of 14% (NIPA). The steady state annual depreciation
335 rate $\bar{\delta}$ is set to 0.05, as in Cooley and Prescott (1995). The elasticity of marginal
336 depreciation with respect to utilization is set to $\varsigma = 0.560$, as in Burnside and
337 Eichenbaum (1996). Based on Basu and Kimball (1997) ϕ , the elasticity of the
338 investment-capital ratio to Tobin’s Q , is set to 2.5. The inverse elasticity of
339 intertemporal substitution σ is set equal to 2, as in Greenwood et al. (1988).

340 Finally, based on an estimated AR(1) model for the Solow residuals (see Ap-
 341 pendix G for details), we set $\rho = 0.847$, while restricting $\sigma_{\epsilon^1} = 0.016$ to match
 342 the volatility of US output.

343 5.1.2. Government sector

344 We choose values for the tax rates on capital income, labor income and con-
 345 sumption based on evidence in Carey and Rabesona (2002), who have produced
 346 series for average effective tax rates in the OECD based on the methodology
 347 of Mendoza et al. (1994). The tax rates for the US are: $\tau_k = 0.3712$, $\tau_c = 0.0526$
 348 and $\tau_h = 0.2567$. We set values for the parameters φ_L , ρ_G , φ_G and σ_g , based
 349 on an estimated VAR model of government spending and public debt (see Ap-
 350 pendix F for details). This gives: $\rho_G = 0.913$, $\varphi_G = 0.110$, $\varphi_L = 0.180$ and
 351 $\sigma_{\epsilon^2} = 0.015$. Finally, using data from the BEA, the steady state ratio of gov-
 352 ernment consumption to GDP, \bar{g}_y , is calculated to be 22%, which corresponds
 353 to the average share of government spending in output over the period 1970 –
 354 2009.

355 5.1.3. Parameterization of $g(\bullet)$ and λ_i

356 We calibrate the $g(\bullet)$ function to match the life-cycle profile of earnings and
 357 hours by those in employment. We assume the following form for $g(\bullet)$

$$g(h; i) \equiv \frac{1}{1 + \kappa_i h^{-\varrho_i}}, \quad (24)$$

358 where $\kappa_i > 0$ and $\varrho_i > 1$ are age-specific parameters. From condition (3), the
 359 optimal number of hours by those in employment is

$$\bar{h}_i = [\kappa_i (\varrho_i - 1)]^{1/\varrho_i}. \quad (25)$$

360 Using (25) to substitute in (24), we obtain $g(\bar{h}_i; i) = 1 - 1/\varrho_i$. Thus, the labor
 361 services produced per week are dependent only on ϱ_i , and we set their values
 362 to match earnings over the life-cycle obtained from the PSID. We set κ_i to
 363 match the life-cycle profile of hours worked by those in employment, obtained
 364 from Blundell et al. (2013).¹⁴ We set λ_i to match the employment rates over
 365 the life-cycle in the US (Blundell et al., 2013) and, hence, match both hours
 366 and employment over the life-cycle, as shown in Figure 2.

367 [Figure 2 about here]

368 5.1.4. Calibration of the labor supply elasticities

369 We now describe the aspects of the calibration that have to do with the labor
 370 supply elasticity parameters, η_i . Prime aged workers (aged 30 to 54) all have the
 371 same labor supply elasticity $\eta_i = \eta_{\text{prime age}} = 0.20$ for all $i = 16 \dots 40$, based on
 372 the meta-analysis of quasi-experimental studies by Chetty et al. (2012). This

¹⁴We thank Antoine Bozio for kindly providing us with their data.

373 leaves the parameters $\eta_1 \dots \eta_{15}$, and $\eta_{41} \dots \eta_{50}$, still to be determined. They
374 are set to match two targets: the relative employment volatility of the young
375 (aged 15 to 29), and the relative life-cycle profile of employment in the US and
376 a second country with a different fiscal profile. The first target determines η_1
377 given the ratios (η_i/η_1) , for $i = 2 \dots 15$, and (η_i/η_{40}) , for $i = 41 \dots 50$. In turn,
378 these ratios are pinned down using the second target, based on Lemma 2. The
379 second country is chosen to be France because the data from Blundell et al.
380 (2013) is only for the US, UK and France and the latter has a tax profile that
381 contrasts more with the US than that of the UK.

382 The details are as follows. Let σ_{15-29}^n denote the standard deviation of total
383 hours (in logs) worked by the young, and σ_{30-64}^n that of those aged 30 to 64.
384 Given $\eta_{\text{prime age}} = 0.20$, we show in Appendix E that

$$\eta_1 \sum_{i=1}^{15} \frac{\mu_i \bar{n}_i (\eta_i/\eta_1)}{\bar{N}_{15-29}} = 0.20 \left[\frac{\bar{N}_{30-54}}{\bar{N}_{30-64}} + \sum_{i=41}^{50} \frac{\mu_i \bar{n}_i (\eta_i/\eta_{40})}{\bar{N}_{30-64}} \right] \frac{\sigma_{15-29}^n}{\sigma_{30-64}^n}, \quad (26)$$

385 where $\bar{N}_{15-29} = \sum_{i=1}^{15} \mu_i \bar{n}_i$ and $\bar{N}_{30-64} = \sum_{i=16}^{50} \mu_i \bar{n}_i$. In the above equation,
386 the parameters μ_i (the population of individuals aged i) are obtained from the
387 OECD population statistics.

388 Thus, we solve for the η_1 matching the relative volatility of employment of
389 the young, $(\sigma_{15-29}^n/\sigma_{30-64}^n)$. But, to do this we need values for the ratios (η_i/η_1) ,
390 for $i = 2 \dots 15$, and (η_i/η_{40}) , for $i = 41 \dots 50$, obtained based on Lemma 2, as
391 follows

$$\frac{\eta_i}{\eta_1} = \frac{\ln(\bar{e}_i^{\text{US}}/\bar{e}_i^{\text{FR}})}{\ln(\bar{e}_1^{\text{US}}/\bar{e}_1^{\text{FR}})}, \quad \text{and} \quad \frac{\eta_i}{\eta_{40}} = \frac{\ln(\bar{e}_i^{\text{US}}/\bar{e}_i^{\text{FR}})}{\ln(\bar{e}_{40}^{\text{US}}/\bar{e}_{40}^{\text{FR}})}. \quad (27)$$

392 Notice that, while we use data from a second country in (27) we do not target
393 employment levels in France. Only if the model is exactly correct and taxes are
394 the only explanation for differences in employment rates across countries, would
395 we match employment in France exactly.¹⁵

396 [Figure 3 about here]

397 Figure 3 contrasts employment in the US and France from the model and the
398 data. The fact that we match quite well France's employment is an encouraging
399 measure of the model's fit. This result is also consistent with the findings
400 in Chetty et al. (2012), who show that estimates of steady state elasticities of
401 the response of employment to taxes are similar whether one relies on macro or
402 micro data, although they differ when one estimates intertemporal substitution
403 elasticities based on short-run fluctuations.

¹⁵For example, the calibration strategy implies that although we match exactly the ratio

$$\ln(\bar{e}_{39}^{\text{US}}/\bar{e}_{39}^{\text{FR}}) / \ln(\bar{e}_1^{\text{US}}/\bar{e}_1^{\text{FR}}),$$

we may underestimate both e_{39}^{FR} and e_1^{FR} .

404 The life-cycle profile of labor supply elasticities is shown in Figure 4. For
405 all prime aged individuals, aged 30 to 54, the labor supply elasticity is set at
406 0.2. Instead, for young and old individuals, the elasticities are allowed to vary,
407 reaching a maximum of around 8.22.¹⁶ The implied aggregate labor supply
408 elasticity, \mathcal{E}_n , is 0.84. This is remarkably close to 0.86, the macro elasticity
409 recommended by Chetty et al. (2012). Thus, heterogeneity in labor supply
410 elasticities helps reconcile micro-econometric evidence and macro models.

411 [Figure 4 about here]

412 Table 3 summarizes the baseline calibration and corresponding targets.

413 [Table 3 about here]

414 5.2. Properties of the baseline economy

415 We now study the behavior of the model under the baseline calibration. In
416 particular, we look at the implications of our calibration for aggregate business
417 cycle statistics and for relative employment volatilities of different demographic
418 groups, not used as targets in the calibration.

419 5.2.1. Aggregate business cycle statistics

420 Panel A of Table 4, compares aggregate business cycle moments under the
421 baseline calibration to the US business cycle statistics. The table shows the
422 properties of output, consumption, investment, government spending and total
423 hours worked in both the data and the model.

424 [Table 4 about here]

425 The baseline model matches the volatility of aggregate variables at least
426 as well as the standard RBC model. Consumption and investment volatility
427 are similar to their empirical counterparts. The model suffers from the same
428 drawback as the standard RBC model: the volatility of total hours is about half
429 that of output, while the empirical counterpart is 90%. But, this is achieved with
430 a low labor supply elasticity for the prime aged population. So the fact that
431 it performs at least as well as the standard RBC model (typically calibrated
432 with an elasticity around 1) is significant. Also, since fluctuations in total
433 hours occur only through employment it is better to look at the volatility of
434 employment in the data. The model accounts for 75% of employment volatility.
435 The high correlations between output and the private components of aggregate
436 expenditure are the result of the model's RBC structure.

¹⁶The large elasticities for the young and the old are consistent with the evidence that is reviewed in Keane and Rogerson (2012) for some demographic groups.

437 *5.2.2. Employment fluctuations by age group*

438 One of our calibration targets was the volatility of the young relative to that
439 of those aged 30 to 64. This relative volatility is equal to 2.20 and is exactly
440 matched by the model. But, to judge the fit of the model, it is useful to look at
441 moments not used as targets for the calibration. Panel B of Table 4 looks at the
442 model's ability to match the volatility of employment for specific age groups,
443 the young (15 to 29), the prime aged (30 to 44) and the old (54 to 64), in levels
444 and relative to the total hours volatility. None of these moments is used as a
445 target in the calibration.

446 The model matches very well the relative volatility of the young (1.57 in the
447 data and 1.64 in the model), and also that of individuals aged 30 to 64 (0.70
448 versus 0.74). However, it produces a relative volatility for the prime aged that
449 is too low compared to the data (0.75 versus 0.20) and, as a consequence, a
450 relative volatility for those aged 55 to 64 that is too high. This follows from the
451 low labor supply elasticity attributed to this group.¹⁷

452 *5.3. Government size and automatic stabilizers*

453 Next, we solve the model under alternative fiscal policy parameters, with
454 each combination mimicking the fiscal profile of an OECD country, based on
455 the estimates by Carey and Rabesona (2002), and the observed government
456 spending to GDP ratios. In turn, for each OECD country, we calculate the
457 model implied government size and the corresponding business cycle volatility
458 measures.

459 Figure 5 shows that the link between government size, the demographic com-
460 position of the workforce and volatility is qualitatively consistent with the facts
461 documented in Section 2. Higher taxes imply a low volatile-worker employment
462 share. The smaller the employment share of volatile workers, the lower the
463 volatility of aggregate hours worked and output.

464 [Figure 5 about here]

465 Table 5 reports the estimates from a OLS regression between aggregate
466 volatility and government size using the empirical OECD data, and compared
467 to the same regression coefficients implied by the model. This exercise allows
468 us to interpret our results from a quantitative perspective.

469 [Table 5 about here]

470 Our baseline calibration implies a slope coefficient in the regression of output
471 volatility on government size that is 75% of its empirical counterpart. The slope
472 associated with the regression of hours volatility on government size corresponds
473 to 114% of its empirical counterpart. Thus, the model is able to reproduce
474 almost exactly the automatic stabilizers' strength.¹⁸

¹⁷In Appendix I, we consider an alternative calibration of the labor supply elasticities that overcomes this problem by attributing a larger elasticity to prime aged workers.

¹⁸In Appendix I we show that once we introduce exogenous demographic changes in the

475 **6. Conclusion**

476 Two empirical facts serve as motivation for this paper. The first is the strong
477 negative correlation between government size and the volatility of business cy-
478 cles across OECD countries. The second fact, is the substantial heterogeneity
479 across demographic groups in terms of the cyclical volatility of employment. We
480 develop a heterogeneous agent OLG model quantitatively consistent with these
481 empirical facts. Our results suggest that differences over the life-cycle in labor
482 supply behavior help explain salient business cycle features and, in particular,
483 automatic stabilizers.

484 **Appendix. Supplementary material**

485 **References**

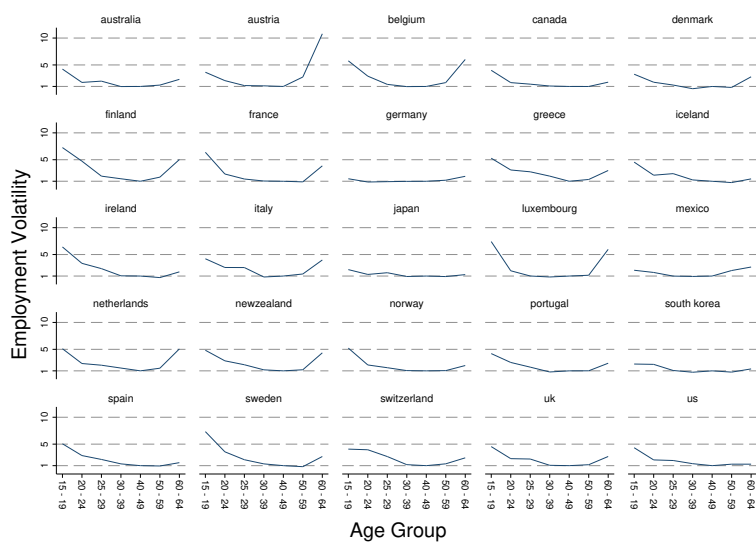
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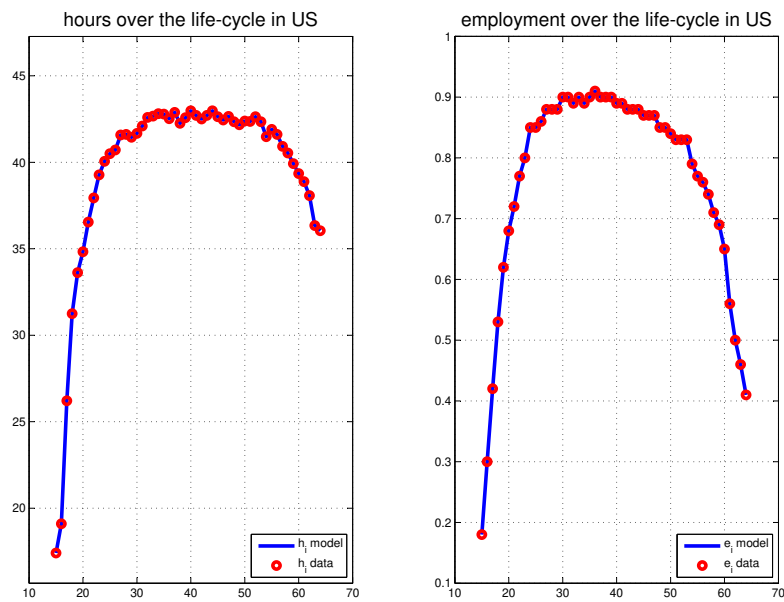
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Figure 1: volatility of employment by demographic group (OECD)



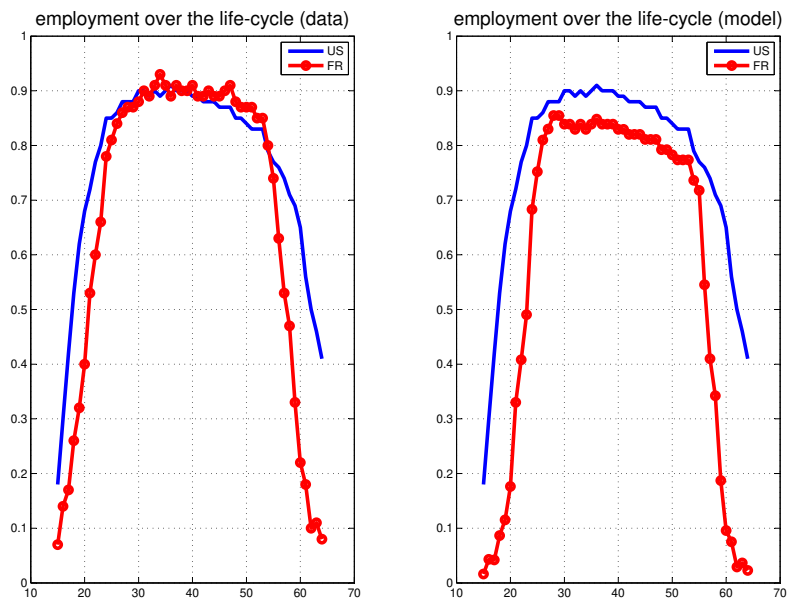
Note: The data is annual and the source is the OECD Labour Force Statistics. All variables are reported in logs as deviations from an HP trend with smoothing parameter 6.25. The volatility is expressed relative to the 40 – 49 age group.

Figure 2: Calibration targets: employment and hours over the life-cycle



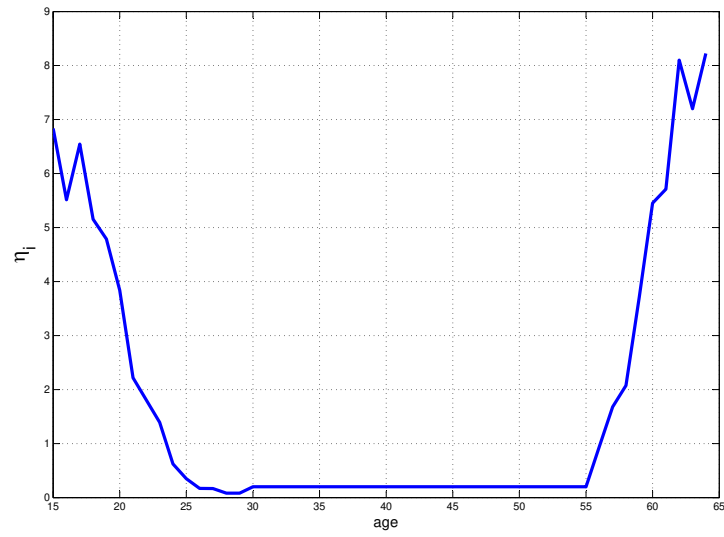
Note: the data source is Blundell, Bozio, and Laroque (2013).

Figure 3: Model evaluation: employment rates in two countries (model/data)



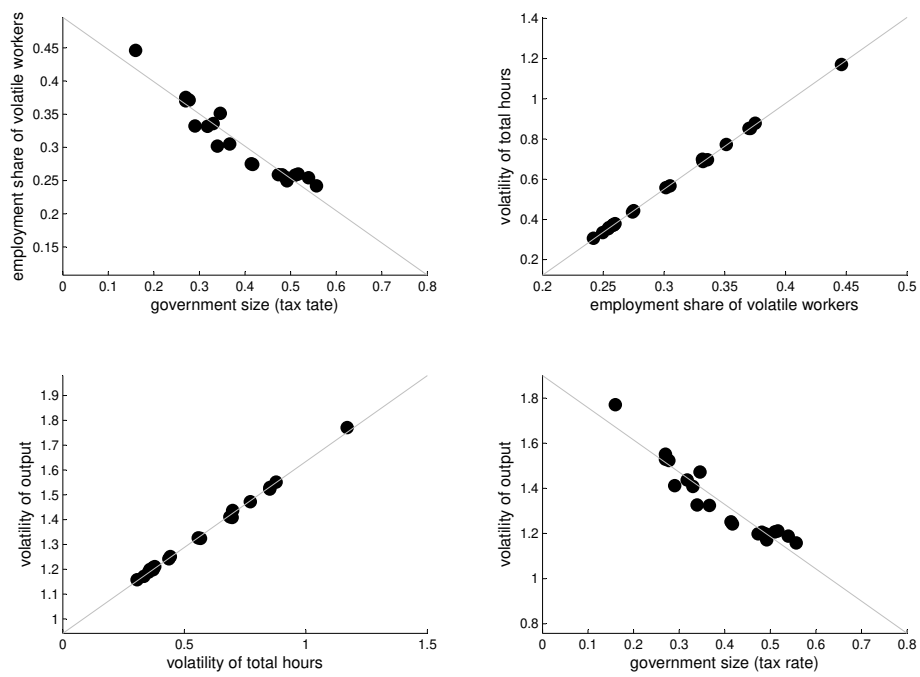
Note: the data source is Blundell, Bozio, and Laroque (2013). US employment is a calibration target while France's employment is not.

Figure 4: Calibrated parameters: labor supply elasticity over the life-cycle



Note: values for η_i for $i = 1, \dots, 50$, corresponding to workers aged between 15 and 64.

Figure 5: Quantitative results: government size and volatility (model)



Note: Volatility of output and hours from the model are the standard deviation of the HP filtered output and hours implied by the model. Each observation corresponds to an economy whose fiscal policy parameters are chosen to mimic the fiscal profile of a specific OECD economy.

Table 1: government size and demographic structure

| | (1) | (2) | (3) | (4) |
|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | vol. share | vol. share | young share | young share |
| Gov. Size | -20.180*** (5.226) | -16.250*** (5.256) | -20.145*** (5.232) | -16.217*** (5.263) |
| Share of 60+ in pop. | | -20.584** (8.009) | | -20.576** (8.019) |
| Obs. | 75 | 75 | 75 | 75 |
| R^2 | 0.472 | 0.518 | 0.471 | 0.517 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Each observation corresponds to a country and one of the following time periods: 1970 – 1979, 1980 – 1989, 1990 – 1999, and 2000 – 2009. Time dummies are included but not listed. The volatile share corresponds to the share of employment of the population aged 15 to 29 and 60 to 64 in the total employment of the population aged 15 to 64. The young share corresponds to the share of employment of the population aged 15 to 29 in the total employment of the population aged 15 to 64. Gov size is the ratio between total tax revenue and GDP. Share of 60+ in pop. is the share of individuals aged 60 or more in the population. See Appendix A for details about the data.

Table 2: government size, demographic structure and aggregate volatility

| | vol. hours | | | vol. GDP | | |
|--------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Gov. Size | | -1.819** (0.794) | -0.868 (0.848) | | -1.909** (0.768) | -1.275 (0.841) |
| Vol. Share | 0.056*** (0.016) | | 0.049*** (0.018) | | | 0.035** (0.017) |
| Vol. Hours | | | | 0.713*** (0.078) | | |
| % Change Fiscal Coef. | | | -52% | | | -33% |
| Obs. | 75 | 77 | 75 | 77 | 77 | 75 |
| R^2 | 0.169 | 0.099 | 0.182 | 0.565 | 0.134 | 0.180 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Each observation corresponds to a country and one of the following time periods: 1970 – 1979, 1980 – 1989, 1990 – 1999, and 2000 – 2009. Time dummies are included but not listed. Volatility of output and volatility of hours are the standard deviation of the respective cyclical component (calculated using the HP filter with smoothing parameter 6.25). The Vol. Share corresponds to the share of employment of the population aged 15 to 29 and 60 to 64 in the total employment of the population aged 15 to 64. Gov. Size is the ratio between total tax revenue and GDP. See Appendix A for details about the data.

Table 3: baseline calibration (summary)

| parameter | | target/source |
|--|--|--|
| stable parameters | | |
| α | 0.283 | Targets capital income share |
| β | 0.992 | Targets investment/GDP ratio of 14% |
| ρ | 0.847 | Targets Solow residuals autocorrelation |
| $\sigma_{\epsilon 1}$ | 0.016 | Targets US output volatility |
| ρ_G | 0.919 | Target: VAR estimation |
| $\sigma_{\epsilon 2}$ | 0.015 | Target: VAR estimation, standard deviation of residuals |
| φ_G | 0.110 | Target: VAR estimation |
| φ_L | 0.180 | Target: VAR estimation |
| \bar{g}_y | 0.220 | Targets government spending as fraction of GDP of 22% |
| $\bar{\delta}$ | 0.050 | Source: Cooley and Prescott (1995) |
| ϕ | 2.500 | Source: Basu and Kimball (1997) |
| ς | 0.560 | Source: Burnside and Eichenbaum (1996) |
| σ | 2.000 | Source: Greenwood et al. (1988) |
| τ_h | 0.256 | Source: Carey and Rabesona (2002) |
| τ_k | 0.371 | Source: Carey and Rabesona (2002) |
| τ_c | 0.053 | Source: Carey and Rabesona (2002) |
| life-cycle parameters | | |
| ϱ_i | $i=1, \dots, 50$ | Target weakly earnings (PSID) |
| κ_i | $i=1, \dots, 50$ | Target hours worked by employed (Blundell et al., 2013) |
| λ_i | $i=1, \dots, 50$ | Target life-cycle employment rates, US (Blundell et al., 2013) |
| μ_i | $i=1, \dots, 70$ | Target OECD population statistics, US |
| η_1 | 6.834 | Target relative volatility of workers aged 15 – 29, US |
| $\left\{ \begin{array}{l} \eta_i/\eta_1, \\ \eta_i/\eta_{40}, \end{array} \right.$ | $\left\{ \begin{array}{l} i = 2 \dots 15 \\ i = 41 \dots 50 \end{array} \right.$ | Target rel. emp. rates, US & FR (Blundell et al., 2013) |
| $\eta_{\text{prime age}}$ | 0.200 | Source: Chetty et al. (2012) |

Note: target/source indicates either the target used to obtain the parameter or the source informing the choice of parameter value. See Appendix A for details about the data. See Figure 4, which displays the calibrated values of each Frisch elasticity.

Table 4: Model evaluation: US business cycle statistics (model and data)

| PANEL A (aggregate vol.) | | | | | |
|--------------------------|-----------|-------|-------------|-------|--|
| variable | std. dev. | | correlation | | |
| | data | model | data | model | |
| output | 1.45 | 1.45 | 1.00 | 1.00 | |
| consumption | 1.20 | 1.42 | 0.90 | 0.99 | |
| investment | 5.13 | 4.00 | 0.94 | 0.98 | |
| government spending | 0.93 | 0.96 | -0.13 | 0.02 | |
| total hours | 1.28 | 0.78 | 0.92 | 1.00 | |
| employment rate 15 – 64 | 1.04 | 0.78 | 0.89 | 1.00 | |

| PANEL B (emp. vol. by group) | | | | | |
|------------------------------|---------|-------|----------------------------------|-------|--|
| age group | std.dev | | std. dev. relative to 15 – 64 | | |
| | data | model | data | model | |
| 15 – 29 | 1.63 | 1.27 | 1.57 | 1.64 | |
| 30 – 54 | 0.78 | 0.16 | 0.75 | 0.20 | |
| 55 – 64 | 0.70 | 2.73 | 0.66 | 3.52 | |
| 30 – 64 | 0.74 | 0.58 | 0.70 | 0.74 | |

Note: data on GDP, consumption, investment and government spending is from the NIPA tables. Inventories are excluded from the measure of investment. Data on hours worked is from the Conference Board Total Economy Database. Employment rate 15 – 64 is from the OECD and corresponds to the employment/population ratio among the individuals aged 15 to 64. Cyclical component is the log in deviations from an HP trend with smoothing parameter 6.25. The model's reported statistics are calculated under the US fiscal profile. See Appendix A for details about the data.

Table 5: Quantitative results: volatility and government size (model/data)

| $\sigma = \beta_0 + \beta_1$ (tax rate) | | data | model | $(\beta_1^{\text{model}}/\beta_1^{\text{data}})$ |
|---|-----------|--------|--------|--|
| std (Y) | β_1 | -1.909 | -1.428 | 75% |
| std (H) | β_1 | -1.819 | -2.074 | 114% |

Note: OLS regressions where the dependent variables are, respectively, output volatility, $\text{std}(Y)$, and aggregate hours volatility, $\text{std}(H)$, and the explanatory variable is the tax revenue to output ratio. The volatility of output and hours is the standard deviation of the series in log deviations from an HP trend with smoothing parameter 6.25. The tax rates used to calibrate the fiscal profile of each economy in the simulations are from Carey and Rabesona (2002). For the empirical regressions, each observation corresponds to a country and one of the following time periods: 1970 – 1979, 1980 – 1989, 1990 – 1999, and 2000 – 2009. Time dummies are included but not listed.