Risk Aversion and Fiscal Consolidation Programs

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Abstract

In this paper we provide evidence that there are statistical and economically meaningful differences in terms of attitudes towards risk at the aggregate level across countries, as captured by country-specific estimations of the coefficient of relative risk aversion. This has important implications for fiscal policy as it leads to large differences in the output response to the same fiscal policy shock. When calibrating the risk aversion at the country level, using country-specific estimates of the coefficient of relative risk aversion, we find multipliers to the same fiscal consolidation shock to differ as much as between 0.35 and 0.55.

Key Words: CRRA, Fiscal Multipliers, Risk Aversion, Fiscal Consolidation Programs.

JEL Classification: D81, E21, E62, H63, O57

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1 Introduction

After the financial crisis of 2008, many European countries dealt with great national debts. As a result, several countries started advancing debt reduction plans, either through reduction in government spending, increasing taxation, or both. This event revitalized the role of fiscal consolidation programs, following a rekindled interest in fiscal policy and fiscal multipliers (see Blanchard & Leigh (2013) and Alesina *et al.* (2015)). Fiscal multipliers are not uniform across countries and time periods, since they depend on the type of fiscal instruments, country characteristics, and economic situation. The sensitivity of different microeconomics variables on fiscal multipliers has been studied in recent papers.

The classes of models used to perform cross-country comparisons of fiscal multipliers, as in Brinca *et al.* (2016) and Brinca *et al.* (2020), use preferences where attitudes towards risk are pinned down by the coefficient of relative risk aversion and are held constant across countries. However, we provide evidence that attitudes towards risk vary significantly across countries and these differences can imply meaningful differences in output responses to the same fiscal shock. Gandelman & Hernández-Murillo (2015) estimate the coefficient of relative risk aversion, employing a constant relative risk aversion utility function, for which the elasticity of the marginal utility of income related to income coincides to the coefficient of relative risk aversion. They find that coefficients of relative risk aversion, when estimated at the country level, have statistic and economically meaningful differences. Each risk aversion coefficient shows the rapidity of the marginal utility of income to decline as income rises. When the elasticity of marginal utility of income increases, the marginal utility of income drops faster, if income goes up, impacting negatively on consumption and positively on savings.

In our mechanism, the coefficients of risk aversion affect the output response to a fiscal shock, because they positively impact savings and negatively affect the level of agents constrained. When the fiscal shock hits, for less constrained agents, labor supply falls by more, and output drops are larger. Agents increase savings, because of precautionary motives and therefore, there is a lower % of credit-constrained agents, who are more affected from both fiscal consolidation programs.

To obtain these results, we employ the overlapping generations model introduced in Brinca *et al.*

(2016) and in Brinca *et al.* (2020), which is a model with exogenous credit constraints, heterogeneous agents, incomplete markets, uninsurable idiosyncratic risk and a bequest motive. We first calibrate the model to Germany, our benchmark economy, using different risk aversion coefficients. We find that increasing risk aversion, boosts savings and reduces the amount of individuals constrained in the economy. Moreover, there is a solid negative relationship between the share of credit-constrained and the fiscal multipliers. Therefore, Germany shows that increasing relative risk aversion leads to higher fiscal multipliers in absolute values, both for a cut in government spending, and an increase in taxes on labor income.

Additionally, we consolidate the robustness of our results, comparing Germany directly with Greece, which has a higher level of risk aversion, and a lower percentage of credit-constrained agents. The results show that the dimension of fiscal multipliers is larger for Greece than Germany, explaining the mechanism, and confirming our previous findings.

Finally, to study whether the relationship between the risk aversion parameter and the fiscal multiplier is robust enough to hold when considering several header country characteristics, we realize a multi-country experiment where we calibrate our model to match an extensive range of country-specific data moments for a sample of 10 European countries[1]. Calibrating the model for each country, we study how each economy responds to a gradual reduction in government debt, obtained by reducing government spending or increasing labor income taxes.

Our cross-country experiment confirms the negative relationship between fiscal multipliers and the percentage of constrained agents in the economy, as figure 4 shows. The Spearman correlation between the fiscal multipliers obtained with our model and the risk aversion is 72.1%, when considering an austerity-based consolidation, and -66.6% when considering a taxation one. These results show the relationship between risk and the fiscal multipliers holds, even when considering country-specific data moments.

The paper's organization is the following: it begins with the introduction of recent relevant literature in section 2. Section 3 contains a description of the overlapping generations model and the intuition beyond risk aversion, we delineate the competitive equilibrium, and describe the fiscal consolidation

[1]The 10 European countries are Austria (AUT), France (FRA), Germany (GER), Greece (GRE), Iceland(ICE), Italy (ITA), Portugal (PRT), Slovakia (SVK), Spain (ESP), and Sweden (SWE).

exercises. Section 4 details the calibration of the model. Section 5 assesses the empirical relationship between coefficient of risk aversion and the fiscal multipliers correlated with fiscal consolidations, followed by the cross-country analysis in section 6. Section 7 concludes.

2 Literature Review

This work connects two different areas of the economic literature: fiscal policy and risk aversion.

First, there is a vast part of literature that studies the size and the impact of fiscal consolidation programs, particularly after the 2008 crisis. Blanchard & Leigh (2013) and Blanchard & Leigh (2014) discover that the International Monetary Fund (IMF) did not consider crucial factors in assessing fiscal multipliers and this brought to the underestimation of their impact across European countries after the Great Recession. Consequently, Alesina *et al.* (2015) find tax-based consolidations aggravate the size of recessions more than austerity-based ones. According to them, the first ones are much more expensive in terms of loss of output, since it produces wider and more protracted recessions. Romei (2015) adds the importance of the architecture of fiscal consolidations, confirming the relevance of doing it rapidly and by cutting public expenditure. Other relevant country characteristics, such as the size of openness, the level of development and the exchange rate impact fiscal multipliers, as Ilzetzki *et al.* (2013) show. They state the fiscal effect is more prominent in developed countries that operate at a fixed exchange rate. Pappa *et al.* (2015) examine how shocks in fiscal consolidation are connected with corruption and tax evasion, identifying a connection between tax rising and production in the shadow economy. They also find the production falls if economies have significantly lower productivity. Anderson *et al.* (2016) show fiscal programs have heterogeneous effects on agents, according to age and income level. The most similar paper to ours is Brinca *et al.* (2020), where it is shown a positive correlation between labor share and fiscal multipliers. For the same purpose, Bernardino (2019) discovers the higher is the impact multiplier, the greater is the share of financially constrained agents in the economy. This is a consequence of agents with credit constraints, who have a higher marginal propensity to consume. Similarly, Brinca *et al.* (2016) emphasize greater wealth inequality is related to more substantial expansionary impacts of increases in government expenditures, since a larger share of constrained agents leads to more wealth inequality. Also Brinca *et al.* (2019a) identify a robust positive correlation between output losses and income inequality, following a fiscal consolidation shock. When income inequality leads to preventive savings behavior, it reduces the share of agents with credit constraints. Given that agents with credit constraints do not react to the future fluctuations in income, the smaller is the participation of these individuals in the economy, the larger is the production loss. Furthermore, Brinca *et al.* (2019b) demonstrate the response of output to a shock of government spending is not linear, and fiscal multipliers increase with the shock.

Second, there is a vast literature that tries to find an ordinary estimator for the risk aversion parameter. Risk attitudes control many economic variables, as precautionary savings, consumption, and hours worked. Even if many economists tried to measure different risk aversion coefficients, there is no standard estimator used in the literature. The parameter that has been used more often in economic research lies between 0 and 5. In the 1980's, the most systematic method to estimate risk aversion was focused on a consumption-based capital asset pricing model, and for example, Hansen & Singleton (1982) used the generalized method of moments to find risk aversion is relatively tiny. Neely *et al.* (2001) (2001), find CAPM fails estimating them, given the impossibility in forecasting consumption growth. The study of Gandelman & Hernández-Murillo (2015) is the most relevant to simplify the coefficient of risk aversion in a single parameter that can be used in macroeconomic models. They follow Layard *et al.* (2008), using happiness data to estimate how quickly the marginal utility of income falls when income increases, with a maximum likelihood estimation. They assume a constant relative risk aversion (CRRA) utility function, for which the elasticity of the marginal utility of income, with respect to income, coincides to the parameter of relative risk aversion. Gandelman & Hernández-Murillo (2015) do the same, but using the generalized method of moments (GMM) to perform the estimation. They use surveys of personal well-being from the Gallup World Poll. There are many reasons why their study is one of the most relevant. This is the starting point for the study of cross-country variations in risk aversion and their association with several economic parameters. Using the same methodology different times for 75 countries is a valid proof to assess the robustness of the estimates. Using GMM, their estimations provide asymptotically correct standard errors for these coefficients. Macroeconomic models, as the one we present in section 3, are usually based on calibrated coefficients of relative risk aversion, and it is difficult to find them for several countries. However, we demonstrate using country specific coefficients is economically and statistical significant in the model.

It is relevant to mention Gandelman & Hernández-Murillo (2015) find consistent risk aversion estimators around 0 and 3. In particular, for most of the countries, it is between 0.5 and 1.5. This is significantly useful, because a coefficient closer to 0 represents a linear utility function in terms of income, while a coefficient of 1 a logarithmic one. All the countries we use in our experiments are part of this last category, and this means they will follow the log utility function's behavior. When it has the value of 1, income and substitution effects, completely cancel out. When it is very close to 1, the effects are weak.

3 The Model

This section describes the model employed to examine the fiscal consolidation shocks. It is analogous to the one presented in Brinca *et al.* (2019a), an OLG model with partial uninsurable idiosyncratic risk, and with incomplete markets, that considers heterogeneous agents and has a bequest motive as in Brinca *et al.* (2019a)

3.1 Preferences and Relative Risk Aversion

An individual who has an utility of consumption function denoted $U(c)$ and positive, but diminishing marginal utility, is characterized by the following Relative Risk Aversion (RRA):

$$RRA = -c\frac{U''(c)}{U'(c)} \tag{1}$$

where RRA is a positive number, since the second derivative is negative in the numerator: a higher value of RRA shows a higher level of risk aversion. For each household $U(c, n)$, the model employs a constant relative risk aversion (CRRA) utility function. Utility of agents is declining in working hours, $n \in (0, 1]$, expanding in consumption, c, and assumes the following CRRA representation, considering also a pure public good, (G), arranged by the government:

$$U(c, n) = \frac{c^{1-\sigma}}{1-\sigma} - \chi\frac{n^{1+\eta}}{1+\eta} + log(G) \tag{2}$$

In the above equation, χ represents the disutility from work, η the inverse Frisch labor elasticity, and σ the risk aversion parameter. Households take decisions on how many hours to work, n, how much to consume, c, and how much to save, k'. Retired households do not supply labor, but receive a social security payment, ψ_t. For retired households, the utility function is extended with the amount of bequest they leave to future living generations when they die:

$$D(h') = \phi log(h') \tag{3}$$

3.1.1 Intuition Beyond the Coefficient of Relative Risk Aversion

As said, σ is the coefficient of relative risk aversion. If two individuals have different CRRA utility functions, the one with a higher value of σ is more risk averse. An individual with a higher level of σ has a lower level of certainty equivalent wealth, thus, he is willing to pay a higher risk premium in order to exchange the risky wealth for its expected value.

In inter-temporal choice problems of individuals, the elasticity of (inter-temporal) substitution cannot be distinguished from the coefficient of relative risk aversion. The isoelastic utility function $U(c,n) = \frac{c^{1-\sigma}}{1-\sigma}$ is relevant, because it includes the elasticity of intertemporal substitution: $\epsilon_{u(c)} = \frac{1}{\sigma}$. If $\sigma = 1$ the substitution effect and the income effect on savings exactly offset. When σ increases, there are 2 effects with the same directions. It increases the level of precautionary savings, that occur in case of increasing uncertainty about future income. The precautionary reason for delaying consumption and saving in the current period increases due to the absence of completeness in the insurance markets. Consequently, agents cannot insure themselves versus any bad state of the economy in the future. They predict that if this bad state occurs, they will earn less. To avoid the negative effects of fluctuations in future revenues and maintain a regular consumption pattern, they constitute a preventive reserve, called preventive savings, decreasing consumption in the present, to use it in the event of a bad state in the following period. The second effect is that since σ also represents how fast the marginal utility of income declines as income increases, when the elasticity of marginal utility of income increases, the marginal utility of income declines faster, reducing consumption and increasing, again, savings.

3.2 Technology

For the model it has been used a standard assumption of a representative firm that manufactures output, with the following Cobb - Douglas production function:

$$Y_t(K_t, L_t) = (K_t^{\alpha}, L_t^{1-\alpha}) \tag{4}$$

where the input of labor is L_t, using efficiency units, and the input of capital is K_t, in period t. The capital evolves as following:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{5}$$

where I_t represents the investment in period t and δ stands for depreciation rate of capital stock (annual). Each term, the maximization of the profits of the firm is obtained by accurately deciding L_t and K_t:

$$\max_{K_t, L_t} \Pi_t = Y_t - [w_t L_t + (r_t + \delta)K_t] \tag{6}$$

The wage per efficient unit of labor, w_t, corresponds to the marginal product of labor inside a competitive equilibrium, and the rental price of capital, r_t, corresponds to the marginal product of capital:

$$w_t = \frac{\partial Y_t}{\partial L_t} = (1-\alpha)\left(\frac{K_t}{L_t}\right)^{\alpha} \tag{7}$$

$$r_t = \frac{\partial Y_t}{\partial K_t} = \alpha \left(\frac{L_t}{K_t}\right)^{1-\alpha} - \delta \tag{8}$$

3.3 Demographics

There are J overlapping generations of household in the economy. Let j define their age. They start their life at 20 year's old and enter retirement at 65 year's old. After households' retirement, they experience a probability of death $\pi(j)$ that depends on age, and they certainly die when they are 100 year's old. Each period lasts 1 year, thus in the economy exist 45 time life periods of active work. The size of population is fixed over time. The survival probability is defined as $w(j) = 1 - \pi(j)$, thus $\Omega_j = \prod_{q=65}^{q=J-1} \omega(q)$ represents retired agents of age $j \geq 65$ still alive. A portion of households leave unintended bequests, defined by Γ (per-household bequest), since annuity markets do not exist. These bequests are redistributed with a lump-sum, between agents still alive. Furthermore, government provides a subsidy, Ψ, to each retired household.

Families are constrained to several persistent, idiosyncratic productivity shocks, asset holdings, permanent ability and a discount factor, $\beta \in (\beta_1, \beta_2, \beta_3)$, that is arranged across agents, uniformly. Each household realizes his permanent ability at birth that follows a normal distribution with zero mean, $\alpha \sim N(0, \sigma_\alpha^2)$.

3.4 Labor Income

The wage of every individual is based on their personal characteristics: j, age, permanent ability, $a \sim N(0, \sigma_a^2)$, and idiosyncratic productivity shock, u, which follows an AR(1) process:

$$u_{t+1} = \rho u_t + \epsilon_{t+1}, \epsilon \sim N(0, \sigma_\epsilon^2) \tag{9}$$

where ρ represents the persistence of the idiosyncratic shock and these characteristics define the amount of labor efficient units that the household possess. Moreover, individual wages depends on the wage per efficiency unit of labor w, and can be represented by:

$$w_i(j, a, u) = we^{\gamma_1 j + \gamma_2 j^2 + \gamma 3 j^3 + a + u} \tag{10}$$

where $\gamma_1, \gamma_2, \gamma_3$ represent the wages age profile.

3.5 Government

The social security system in managed by the government in an equilibrated way, balancing tax rates for the employer and the employees, defined respectively by $\tilde{\tau}_{ss}$ and τ_{ss}, and benefits paid to retirees, Ψ_t. In order to finance spending on pure public consumption goods, G_t, the government has the duty to tax capital, consumption, and labor income. Expenditures on pure public consumption goods G_t, interest payment on the national debt, rB_t, and the lump sum redistribution, g_t, are considered separable in the utility function and are financed by the government through taxes on consumption (τ_c), labor (τ_l) and capital (τ_k) income. The government uses flat rates on τ_c and

τ_k, whereas the labour income tax follows a non-linear functional form as in Benabou (2002) and Heathcote *et al.* (2020):

$$\tau_l(y) = 1 - \theta_0 y^{-\theta_1} \tag{11}$$

where y is the pre-tax labour income, $\tau_l(y)$ stands for the average tax rate given the pre-tax income of y. θ_0 and θ_1 represent respectively the level and progressivity of the tax schedule[1]. The government budget constraint is defined as follows:

$$g_t\left(45 + \sum_{j\geq 65} \Omega_j\right) = R - G - rB, \tag{12}$$

$$\Psi_t(\sum_{j\geq 65} \Omega_j) = R^{ss} \tag{13}$$

with R^{ss} being the social security revenues, R the revenues from the taxes collected on labor and T_t the other tax revenues.

3.6 Household Problem

We need to define a recursive formulation of the household problem. In any given period the agent is endowed with specific characteristics, defined by the vector *(k, β, a, u, j)* where j is the age of the household, k represents savings of households, $\beta \in \{\beta_1, \beta_2\, \beta_3\}$ stand as discount factor of time, a as the permanent ability, and u as a persistent idiosyncratic productivity shock.
Therefore, the household problem can be formulated in the following recursive form:

$$V(k, \beta, \alpha, u, j) = \max_{c,n,k'} \left[U(c, n) + \beta \mathbb{E}_{u'}\left[V(j + 1, k', \beta, \alpha, u')\right]\right]$$

$$s.t.: \qquad c(1 + \tau_c) + k' = (k + \Gamma)(1 + r(1 - \tau_k)) + g + Y^L$$

$$n \in [0, 1]\,, k' \geq -b, \qquad c > 0$$

where Y^L is the labour income of the household after deductions, b is the borrowing limit. τ_{ss} and $\tilde{\tau_{ss}}$ are social security taxes that are paid by the employee and the employer. A retired household

[1]A more extensive discussion about this tax function is provided in Appendix 9.1.

has an optimization problem that is close to that of an active one, apart from the fact that it does not supply any labor, receives annual retiree benefits and is characterized by the age dependent probability of dying $\pi(J)$. It gains an utility of $D(k')$, from leaving a bequest. The household's optimization problem can be defined as follows:

$$V(k, \beta, j) = \max_{c,h'} \left[U(c, n) + \beta(1 - \pi(j))V(j + 1, k', \beta) + \pi(j)D(k') \right]$$

$$s.t.: \qquad c(1 + \tau_c) + k' = (k + \Gamma)(1 + r(1 - \tau_k) + g + \Psi$$

$$k' \geq -0, \quad c > 0$$

3.7 Stationary Recursive Competitive Equilibrium

In the equilibrium, markets clear, budgets balance, and agents optimize their choices given prices. We define $\phi(k, \beta, a, u, j)$ as measure of households with the corresponding characteristics and the recursive competitive equilibrium in the following way:

1. The household's optimization problem is solved dynamically through the function $V(k, \beta, a, u, j)$ and three policy functions $c(k, \beta, a, u, j)$, $k'(k, \beta, a, u.j)$ and $n(k, \beta, a, u, j)$, given factor prices and initial conditions.

2. Markets clear:

$$K + B = \int k d\Phi$$

$$L = \int n(k, \beta, a, u, j) d\Phi,$$

$$\int c d\Phi + \delta K + G = K^{\alpha} L^{1-\alpha}$$

3. The factor prices satisfy:

$$w = (1 - \alpha) \left(\frac{K}{L} \right)^{\alpha} \tag{14}$$

$$r = \alpha \left(\frac{L}{K} \right)^{1-\alpha} - \delta \tag{15}$$

4. The government budget balances:

$$g \int d\Phi + G + rB = \int \left(\tau_k r \left(k + \Gamma \right) + \tau_c c + n \tau_l \left(\frac{nw \left(a, u, j \right)}{1 + \tilde{\tau}_{ss}} \right) \right) d\Phi.$$

5. The social security system balances:

$$\Psi \int_{j \geq 65} d\Phi = \frac{\tilde{\tau}_{ss} + \tau_{ss}}{1 + \tilde{\tau}_{ss}} \left(\int_{j<65} nwd\Phi \right)$$

6. The assets of the deceased at the beginning of the period are uniformly distributed among the living:

$$\Gamma \int w(j) d\Phi = \int (1 - w(j)) k d\Phi.$$

3.8 Transition and Fiscal Experiments

The fiscal consolidation experiments are similar to the ones of Brinca *et al.* (2019a). The economy starts from an initial situation of steady-state. The government, without previous announcement[2], decreases the sovereign debt-to-output ratio, B_y, by 10% of GDP, during the course of 50 periods. Two different policies are applied to obtain this contraction: for all agents, a reduction of the government spending, G, by 0.2% of the steady-state GDP every period, or a rise of the labor income tax, τ_l, by 0.1% of the steady-state GDP every period. After 50 periods of consolidation, the government spending or the labor tax return to the starting level. The economy needs 50 periods more to converge to the new steady-state equilibrium, now with a lower debt-to-GDP ratio.[3]

The difference with the stationary equilibrium is that for the dynamic-programming problem of households time, t, is needed to capture all the changes in policy and price variables relevant in this maximization problem, along to the transition to the lower debt-to-GDP steady state. This method is similar to the one used in Brinca *et al.* (2016) and Krusell & Smith (1998): the numerical solution is achieved by guessing paths for all the variables that will depend on time and then solving the maximization problem backward, after the guess is updated.

[2] Brinca *et al.* (2019a) find that anticipated fiscal consolidations do not have a statistically significant negative effect on output, while unanticipated consolidations do.

[3] The definition of a transition equilibrium following the fiscal experiment is in appendix 9.2.

3.9 Definition of the Fiscal Multiplier

The impact and cumulative multiplier are delineated as in Brinca *et al.* (2019a). We define fiscal multiplier as the net present value of the sum of all variations in output divided by the same period variations in the fiscal instrument. Consequently, the impact multiplier is the ratio of the variation of output to the fiscal instrument's change when the initial shock is realized. We consider the two multipliers separately. The first one comes from government expenditure. The second one from taxation. Considering the fiscal consolidation episode via government spending, the impact multiplier can be defined as:

$$G \text{ impact multiplier} = \frac{\Delta Y}{\Delta G_1} \tag{16}$$

where ΔY is the adjustment of output from period 0 to period 1 and ΔG_1 is the adjustment in government spending from period 0 to period 1. The corresponding cumulative multiplier, at time T, is:

$$G \text{ cumulative multiplier} = \frac{\sum_{t=1}^{t=T} (\Pi_{s=0}^{s=T-1} \frac{1}{1+r_s}) \Delta Y_t}{\sum_{t=1}^{t=T} (\Pi_{s=0}^{s=T-1} \frac{1}{1+r_s}) \Delta G_t} \tag{17}$$

The fiscal consolidation episode via taxation, has a different impact multiplier that can be defined as:

$$\tau_1 \text{ impact multiplier} = \frac{\Delta Y}{\Delta R_1} \tag{18}$$

where ΔY is the adjustment of output from period 0 to period 1 and ΔR_1 is the adjustment in revenues of government from period 0 to period 1. The related cumulative multiplier, at time T, is:

$$\tau_1 \text{ cumulative multiplier} = \frac{\sum_{t=1}^{t=T} (\Pi_{s=0}^{s=T-1} \frac{1}{1+r_s}) \Delta Y_t}{\sum_{t=1}^{t=T} (\Pi_{s=0}^{s=T-1} \frac{1}{1+r_s}) \Delta R_t} \tag{19}$$

4 Calibration

The model described in the previous section is calibrated to the German economy, with the same methodology of Brinca *et al.* (2016) and Brinca *et al.* (2019a). We choose Germany as a benchmark economy because it is the largest economy in Europe. Some parameters are calibrated exogenously, because they have straight theoretical or empirical correspondents. Tables 14 and 16 show the exogenous calibration for the whole set of countries. A simulated method of moments (SMM) is then used to calibrate all the remaining factors endogenously and table 15 lists the related results. The identical calibration strategy is then applied for the multi-country experiment, keeping constant the coefficients detailed in table 13.

4.1 Wages

For the estimation of the age profile of wages, (see equation 20), data of the Luxembourg Income Study (LIS) was used to run this regression for all the countries:

$$ln(w_i) = ln(w) + \gamma_1 j + \gamma_2 j^2 + \gamma_3 j^3 + \epsilon_i, \tag{20}$$

where j is the age of individual i and w is the wage rate of equation 7. The coefficient for the variance of ability, σ_a, is fixed between countries, corresponding to the average of σ_a for the European countries in Brinca *et al.* (2016). ρ is set equal to the amount used in Brinca *et al.* (2016), who employ U.S. data that come from PSID[4]. As in Brinca *et al.* (2019a) the variance of the idiosyncratic income risk, σ_ϵ, is calibrated to make the model match the variance of log wages according to the one choosen above.

4.2 Preferences and Borrowing Limit

The value of the inverse Frisch elasticity of labor supply, η, was strongly discussed in the literature. We follow Trabandt & Uhlig (2011) and Guner *et al.* (2016), setting it as 1. Seven values, χ, that governs the disutility of working an additional hour, ϕ, that controls the utility of leaving bequests, the discount factors $\beta \in \{\beta_1, \beta_2\, \beta_3\}$ and the borrowing limit, b, are calibrated endogenously so that the model output matches the data[5].

[4]Panel Study of Income Dynamics.

[5]The corresponding data moments are average yearly hours, taken from the OECD Economic Outlook, the ratio of capital to output, K/Y, taken from the Penn World Table 8.0, three wealth moments taken from the Luxembourg Wealth Study (LWS), namely the shares of wealth held by those between the 1st and 25th percentile, between the 1st and 50th percentile and between the 1st and 75th percentile and the mean wealth held by those aged 75 to 80 relative to mean wealth in the whole population, from LWS.

4.3 Taxes and Social Security

We utilize the previously described labor income tax function (equation 11, proposed by Benabou (2002)) and estimate tax income level and progressivity parameters, respectively θ_0 and θ_1, using the OECD's labor income tax data for families. The weighted average over the population of θ_0 and θ_1 are computed for different individuals, depending on their marriage status and on the amount of children. Social security parameters, $\tilde{\tau}_{ss}$ and τ_{ss}, are obtained from OECD Tax Data and τ_c and τ_k come from Trabandt & Uhlig (2011). Table 16 summarizes all tax data for the sample of countries.

4.4 Parameters calibrated endogenously using SMM

We employ the simulated methods of moments to calibrate parameters that do not have an empirical counterpart. This method is used to estimate $\psi, \beta_1, \beta_2, \beta_3, b, \sigma_\epsilon$ and χ, minimizing the following loss function between moments from the model, M_m, and moments observed in the data, M_d:

$$L(\psi, \beta_1, \beta_2, \beta_3, b, \sigma_\epsilon, \chi) = ||M_m - M_d|| \tag{21}$$

In our experiment, we endogenously calibrate the before mentioned seven parameters. For this, we need 7 target data moments to obtain a carefully identified system. The selected data moments, listed in table 14, are identical to Brinca *et al.* (2019a): the three quartiles of the cumulative net wealth distribution, Q_{25}, Q_{50}, Q_{75}, the average fraction of yearly hours worked, $\bar{n}$, the capital-to-output ratio, K/Y, the variance of the natural logarithm of wages, $Var(ln\text{w})$. Table 4 shows the endogenously calibrated parameters and the related calibration errors for Germany, the benchmark economy, while table 14 presents the parameters calibrated endogenously and the corresponding calibration errors for the cross-country experiment. We fit each targeted data moments to a high level of precision, since we obtain an average value across countries of the loss function of 1.45.

5 Quantitative Results

This section illustrates the simulations undertaken, each experiment's result and the significative relationship between the risk aversion coefficient and the fiscal consolidation programs. First, we use Germany as the benchmark nation to assess the empirical relationship between coefficients of relative risk aversion and fiscal multipliers. Second, we compare Germany and Greece to explain the mechanisms behind cumulative multipliers and to robust the first results. Third, we simulate a multi-country exercise to see if the empirical relation is valid, even when including several different country characteristics.

5.1 Fiscal Consolidation Programs: Explaining the Mechanism

To investigate the relationship between risk aversion and fiscal multipliers, it is useful to understand the meaning of σ in paragraph 3.1.1: it is relevant to notice the inverse relationship between σ and savings[6], and its negative impact on labor supply[7].

Following the fiscal experiment described in the previous section, the economy begins from the steady-state and the government declares a contraction of the sovereign debt-to-output ratio by 10% over 50 periods, without previous announcement. For both fiscal consolidation programs, the government pays its debt, reducing the amount of government bonds available in the economy and driving families to transfer their savings towards physical capital. This shift in savings rises the capital-to-labor ratio. The marginal productivity of labor increases, with the rise of capital per worker. Market clearing conditions suggest that labor's marginal productivity matches the wage rate[8], thus output and wages rise to a larger amount in the long-run, progressively. Since wages increase gradually, workers' expected income during life-time increases. Consequently, labor supply and output drop in the short-run. The consolidation via labor income taxes, τ_l, works in a different way: after rising the tax rate, workers' after-tax income drops and this decreases the opportunity cost of leisure. Consequently, labor supply and output decline more in the short-run.

[6]For empirical documentation of this fact, see Oduncu (2012).
[7]As documented in Chetty (2005).
[8]See equation 7 inside the model.

5.2 Fiscal Multipliers and Risk Aversion

We find that there is an empirical relationship between risk aversion parameters and fiscal multipliers. Using the model presented in chapter 3, we increase the risk aversion parameters for Germany, the benchmark economy, to estimate the sensibility of changing risk aversion coefficient on aggregate variables that determine the fiscal multiplier. We need to re-calibrate the model, every time we change the risk coefficient, to match the initial moments, in order to isolate its effects and to keep the loss function (eq. 21) close or below one, since, to ensure that this experiment is accurate, the average percentage deviation from the data has to be very low.[9]

Risk Aversion Germany Fiscal Multipliers	0.77	0.97	1.2	1.4
GDP per Capita	0.5809	0.5134	0.5030	0.4870
Average individual earnings	0.4463	0.4046	0.3964	0.3838
Gamma Redistribution	0.0256	0.0208	0.0183	0.0173
Lump Sum	0.0855	0.0781	0.0762	0.074
Capital-labor ratio	5.812	5.254	5.187	4.902
% Agents Constrained	4.81	3.99	3.36	2.82

Table 1: Effects of changing risk aversion on relevant parameters.

Table 1 contains the main divergences for Germany when the calibration is performed considering different risk aversion parameters[10].

This experiment related to Germany confirms literature assumptions. Figure 1 shows that, increasing risk aversion of agents, boosts savings, reduces consumption and decreases the speed of the economy. The two turning points are in coincidence with the change in risk aversion level. First, it is relevant to underline that, when calibrating, we need to adjust χ, the disutility of work, proportionally with the changing of σ, as expected from equation 2. Due to the higher risk aversion of agents, the elasticity of the marginal utility of income with respect to income is higher, and this is inversely related to consumption and labor supply. The level of income is lower and so is the capital. The marginal productivity of capital is negative correlated with risk aversion, and when this increases, there is less capital circulating. As known in literature, the marginal productivity

[9] In particular following the order of the columns in the table, L = 0.9174, L = 2.1820, L = 0.4238, L = 1.9778, e.g. the error of our result is minimized. For the full calibrations of Germany check tables 4,6,8,10.

[10] The first column of table 1 follows the empirical estimation of σ of Gandelman & Hernández-Murillo (2015)[11], while the second one is calculated following the risk preference study of l'Haridon & Vieider (2019). For more details, see Appendix 10.

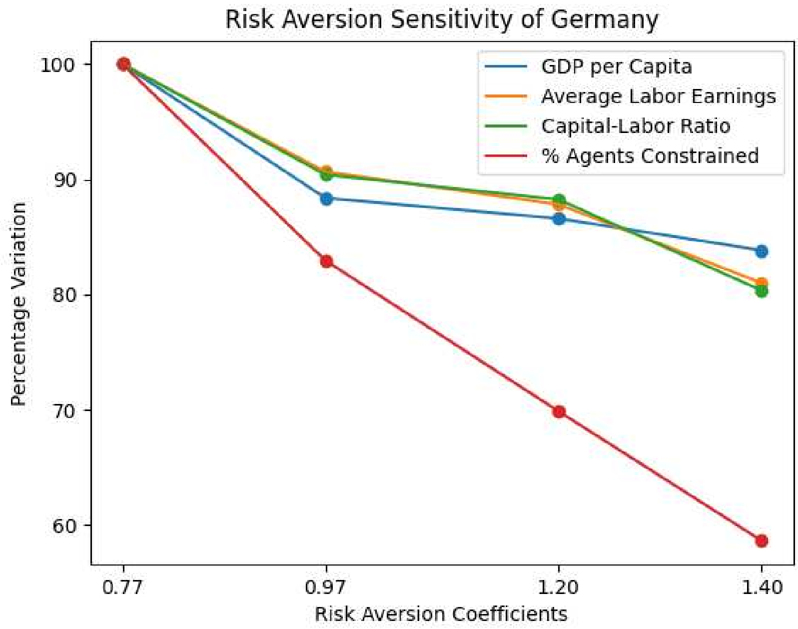

Figure 1: Fiscal Multiplier Benchmark Economy. The values have been normalized to assess the percentage variation.

of labor, and therefore GDP per capita, are positively associated to the capital-labor ratio, thus they both are lower with higher values of risk aversion. Higher risk aversion increases savings and decreases the percentage of agents constrained in the economy; since there is less capital circulating, this contributes to the contraction of average individual earnings, and has a final impact on GDP per capita, slowing down generally the economy. A lower level of risk aversion has the opposite result and this seems to have a multiplicative effect. In fact, from literature we know that a coefficient of 0 implies a linear utility function, while a coefficient of 1 implies a logarithmic utility function in terms of income. The more the parameter is close to zero, the faster the multiplier goes and the economy goes better; the closer it is to 1, the worst it goes. However, our finding is that once it gets higher than 1, the recessive impact reduces itself, being consistent with Gandelman & Hernández-Murillo (2015).

5.3 Impact Multipliers and Risk Aversion

Risk aversion influences also impact multipliers. Their definitions can be found inside paragraph 3.9. The difference with the previous chapter is that we do not only change the risk level, but we also apply the transition and the fiscal experiments studied in 9.2. Table 2 shows the different

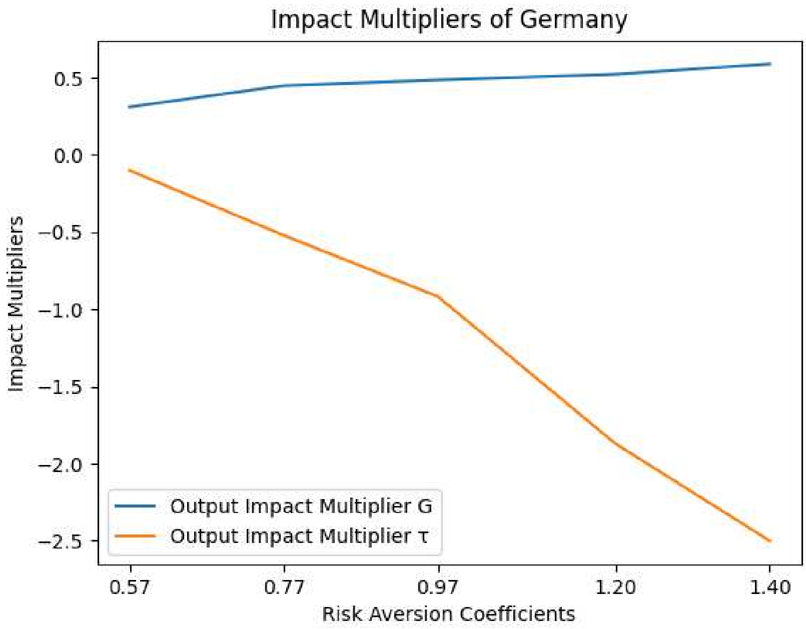

Figure 2: Impact Multipliers Benchmark Economy.

values of the impact multipliers in the case of Germany. Incrementing risk aversion leads to a rise in the impact multiplier from 0.4503 to 0.5348. This can be explained by the impact on labor supply and savings. Increasing the normal level of risk, leads households to exceed the certainty-equivalent level of saving, due to precautionary motive. If households are more risk-averse the marginal utility of income declines faster with respect to income: they increase their precautionary savings, protecting from eventual future declines in income. This culminates into a lower share of credit-constrained agents. Labor supply is less rigid, and both labor and output drop further.

Risk Aversion Germany Impact Multipliers	**0.77**	**0.97**	**1.2**
Multiplier G	0.4503	0.4839	0.5348
Multiplier t	-0.521	-0.918	-1.869

Table 2: Impact Multipliers for the benchmark economy.

5.4 Fiscal Consolidation Programs in Germany and Greece

To illustrate the significance of heterogeneity in risk aversion across countries, the impact of consolidation in Germany and in Greece was firstly compared, because they have opposite economic indicators and different level of risk aversion. In Greece the calibrated share of constrained households is 3.42%, while Germany shows a larger percentage of constrained agents, 4.81%. Furthermore, the calibrated disutility from work in Germany is 9.6, while in Greece is 15.4. We apply to both the economies the transition and fiscal experiment studied in chapter 3.8 and the results show that the cumulative multiplier is higher in Greece than in Germany. In Figure 3 we plot the output, labor supply and consumption output multiplier of the two countries for the government spending fiscal program, that are significantly larger in the Greek economy, where the level or risk aversion is higher. This reinforces the robustness of our previous results.

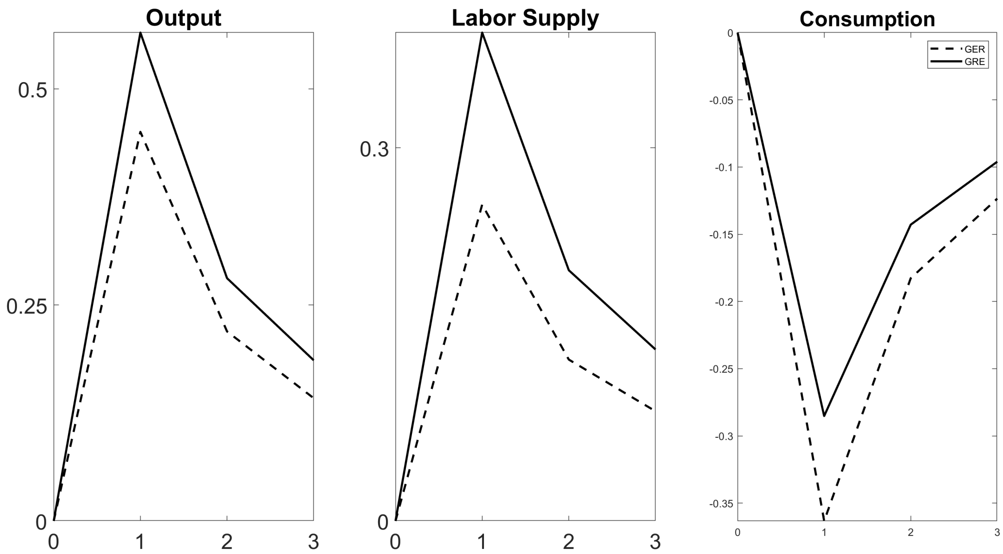

Figure 3: Government spending consolidation: Output cumulative multiplier (left panel), Labor Supply cumulative multiplier (middle panel) and Consumption cumulative multiplier (right panel) in the first three periods in Germany (dashed line) and Greece (solid line).

6 Cross-country Analysis

Section 5 shows the empirical relationship between the coefficient of relative risk aversion and fiscal multipliers, as a result of changing relative risk aversion. The present section shows that it holds and is relevant quantitatively, considering different country-specific data moments, developing a cross-country analysis. To do that, we calibrate the model presented in chapter 3 to match an extensive range of several country characteristics, where we match data, not only on the distribution of risk aversion, but also on government debt, taxes, income and wealth.

[11] For the full calibrations and loss functions, see table 16.

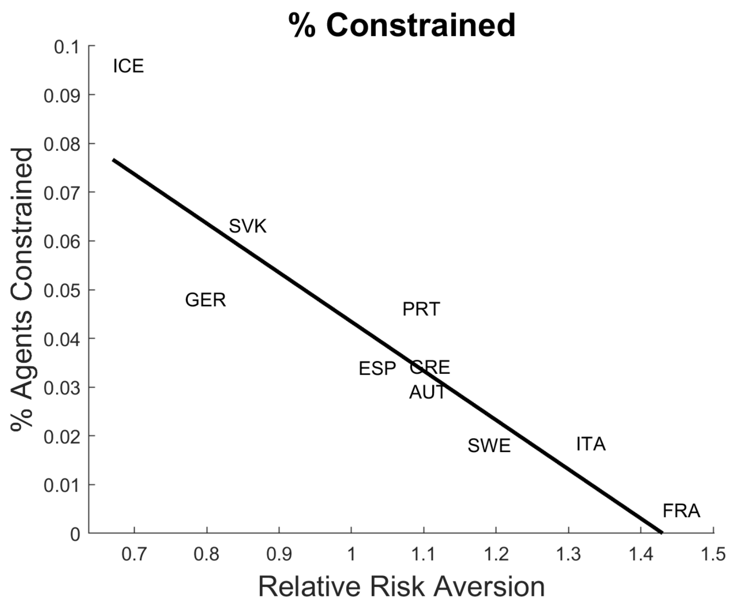

Figure 4: The y-axis considers the percentage share of agents constrained for each country and in the x axis the relative risk aversion. The Spearman correlation is -0.68 and the p-value of 0.001

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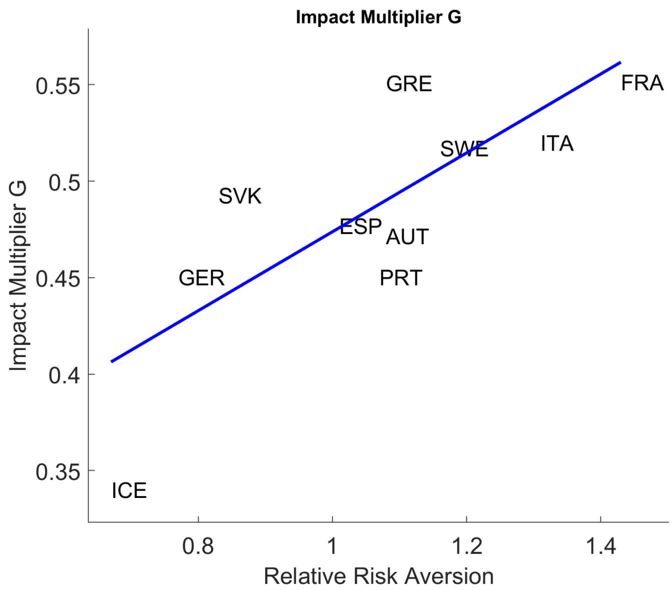

Figure 5: Impact multipliers and Risk Aversion. The consolidation through government spending for the cross-country experiment has Spearman correlation coefficient 0.72106 and p-value 0.121

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Figure 5 and 6 reveal that our model can recreate the cross-country empirical relationship between risk aversion and impact multipliers: countries with higher risk aversion suffer larger output drops for both fiscal consolidation programs. These results are statistical and economically relevant. Figure 4 shows the inverse relationship between risk aversion and the % of constrained households for the cross-country experiment, that explains our mechanism.

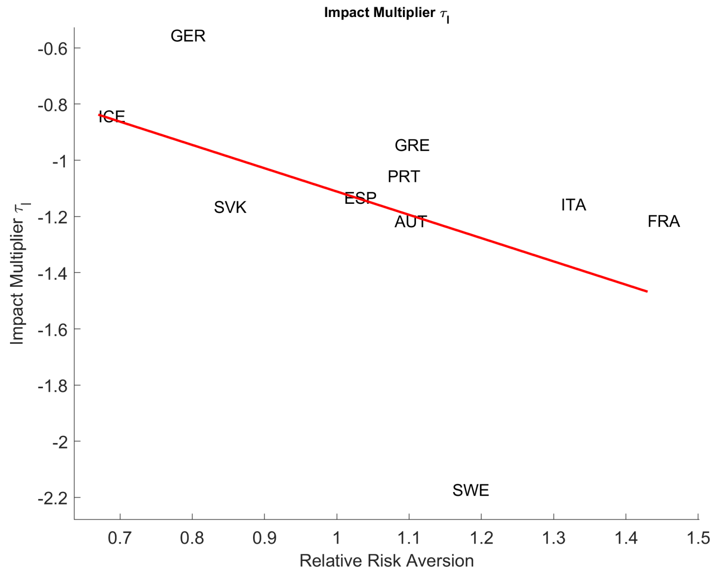

Figure 6: Impact multipliers and risk aversion. The consolidation through labor taxation in the cross-country experiment has Spearman correlation coefficient -0.66601 and p-value 0.0368).

The Spearman correlations between the impact multipliers and relative risk aversion are 72% for austerity-based programs, while they are -66% when considering a consolidation via taxation. We conclude that it is possible to assess the cross-country correlation between both fiscal consolidation programs and relative risk aversion, even when introducing country characteristics and high level of heterogeneity. Furthermore, and in accordance to literature (Alesina *et al.* (2015) and Brinca *et al.* (2019a)), consolidations that are obtained increasing labor income taxes generate more severe recessions than austerity-based consolidations. Table 17 displays that the fiscal multiplier is on average 2.385 times larger for the 10 European countries examined, when the consolidation is done through taxation. As seen in the previous experiments, countries with greater risk aversion, exhibit a smaller level of credit-constrained agents and a less rigid labor supply that generates more sizeable drops in output. Overall, countries with higher risk aversion have larger fiscal multipliers in absolute values.

7 Conclusions

This paper assesses how risk aversion influences the mechanisms behind fiscal consolidation programs. The work is motivated by the fact that risk aversion coefficients, when estimated at the country level, have statistic and economically meaningful differences. We provide evidence that this heterogeneity across countries implies meaningful differences in output responses to the same fiscal shock.

First, calibrating an overlapping generations model to a benchmark economy, under different risk aversion coefficients, we obtain that a higher level of risk aversion increases savings due to precautionary motives, leading to a lower share of credit-constrained agents. Thus, when the fiscal consolidation shock hits, the size of labor supply and output drops are larger than otherwise.

Second, we compare Germany, a country for which the coefficient of relative risk aversion is lower, to Greece, that has a higher level of risk aversion. Quantitative results show that Greece has a lower level of constrained agents, thus it suffers more the recessive impact of fiscal consolidation programs, with a larger drop both in labor supply and output.

Furthermore, the multi-country exercise shows the relation between risk aversion coefficients and impact multipliers across 10 European countries. Representing how each economy performs, after a not announced debt reduction program, financed through a decrease in government spending or, in alternative, an increase in labor income taxation, we find that impact multipliers are overall higher for economies with higher risk aversion, in absolute values.

Overall, this study is relevant to assess the significance of relative risk aversion on fiscal consolidation programs. During the COVID-19 pandemic, the level of uncertainty increased dramatically, thus the relevance of these differences across countries are likely to be even more significant for the upcoming years.

8 APPENDIX A

Additional relevant tables

8.1 Germany Data - Calibrations for the 2 countries experiment

Data Moment	Description	Source	Target	Model Value
$\bar{a}_{75-80}/\bar{a}$	Mean wealth age 75-80 / mean wealth	LWS	1	1
$\bar{n}$	Fraction of hours worked	OECD	0.190	0.191
Var $ln(w)$	Variance of log wages	LIS	0.354	0.406
K/Y	Ratio between capital and output	PWT	3.013	3.023
Q_{25}, Q_{50}, Q_{75}	Wealth Quartiles	LWS	-0.036;0.179;0.179	0.035;0.042;0.1735

Table 3: Calibration Fit - Germany with $\sigma = 0.77$

Parameters	Description	Value
ψ	Bequest utility	0.908
		0.940;0,993
$\beta_1, \beta_2, \beta_3$	Discount factors	0.966
b	Borrowing limit	0.02
χ	Disutility from work	9.9599
σ_ϵ	Variance of Risk	0.498

Table 4: Parameters Calibrated Endogenously - Germany with $\sigma = 0.77$

Data Moment	Description	Source	Target	Model Value
$\bar{a}_{75-80}/\bar{a}$	Mean wealth age 75-80 / mean wealth	LWS	1	1.03
$\bar{n}$	Fraction of hours worked	OECD	0.190	0.190
Var $ln(w)$	Variance of log wages	LIS	0.354	0.406
K/Y	Ratio between capital and output	PWT	3.013	3.0392
Q_{25}, Q_{50}, Q_{75}	Wealth Quartiles	LWS	-0.0036;0.179;0.179	0.0047;0.0423;0.168

Table 5: Calibration Fit - Germany with $\sigma = 0.97$

Parameters	Description	Value
ψ	Bequest utility	0.908
		0.94498;0,998993
$\beta_1, \beta_2, \beta_3$	Discount factors	0.96677
b	Borrowing limit	0.02
χ	Disutility from work	12.8999
σ_ϵ	Variance of Risk	0.498

Table 6: Parameters Calibrated Endogenously - Germany with $\sigma = 0.97$

Data Moment	Description	Source	Target	Model Value
$\bar{a}_{75-80}/\bar{a}$	Mean wealth age 75-80 / mean wealth	LWS	1	1
$\bar{n}$	Fraction of hours worked	OECD	0.190	0.190
Var $ln(w)$	Variance of log wages	LIS	0.354	0.406
K/Y	Ratio between capital and output	PWT	3.013	3.013
Q_{25}, Q_{50}, Q_{75}	Wealth Quartiles	LWS	-0.036;0.179;0.179	-0.0029;0.0257;0.1747

Table 7: Calibration Fit - Germany with $\sigma = 1.2$

Parameters	Description	Value
ψ	Bequest utility	0.908
		0.9298;1.00433
$\beta_1, \beta_2, \beta_3$	Discount factors	0.97377
b	Borrowing limit	0.09
χ	Disutility from work	17.319
σ_ϵ	Variance of Risk	0.49861

Table 8: Parameters Calibrated Endogenously - Germany Calibration Fit - Germany with $\sigma = 1.2$

Data Moment	Description	Source	Target	Model Value
$\bar{a}_{75-80}/\bar{a}$	Mean wealth age 75-80 / mean wealth	LWS	1	1
$\bar{n}$	Fraction of hours worked	OECD	0.190	0.189
Var $ln(w)$	Variance of log wages	LIS	0.354	0.406
K/Y	Ratio between capital and output	PWT	3.013	2.9
Q_{25}, Q_{50}, Q_{75}	Wealth Quartiles	LWS	-0.036;0.179;0.179	-0.0018;0.0288;0.1920

Table 9: Calibration Fit - Germany with $\sigma = 1.4$

Parameters	Description	Value
ψ	Bequest utility	0.645
		0.9298;1.00433
$\beta_1, \beta_2, \beta_3$	Discount factors	0.97377
b	Borrowing limit	0.09
χ	Disutility from work	22.108
σ_ϵ	Variance of Risk	0.49861

Table 10: Parameters Calibrated Endogenously - Germany Calibration Fit - Germany with $\sigma = 1.4$

Data Moment	Description	Source	Target	Model Value
$\bar{a}_{75-80}/\bar{a}$	Mean wealth age 75-80 / mean wealth	LWS	1	0.992
$\bar{n}$	Fraction of hours worked	OECD	0.230	0.230
Var $ln(w)$	Variance of log wages	LIS	0.22	0.22
K/Y	Ratio between capital and output	PWT	3.262	3.262
Q_{25}, Q_{50}, Q_{75}	Wealth Quartiles	LWS	-0.0111;0.1250;0.3667	0.0116;0.1112;0.3735

Table 11: Calibration Fit - Greece

Parameters	Description	Value
ψ	Bequest utility	0.730
$\beta_1, \beta_2, \beta_3$	Discount factors	0.9952;0.9971;0.9777
b	Borrowing limit	0
χ	Disutility from work	15.4
σ_ϵ	Variance of Risk	0.120

Table 12: Parameters Calibrated Endogenously - Greece

8.2 Cross Country data and Calibrations

Table 13: Parameters held constant across countries

Parameters	Description	Value	Source
δ	Depreciation of rate of capital	0.06	Literature
ρ	Persistence in equation	0.335	Estimated with PSID 1968-1977
σ_a	Variance of the ability	0.423	Brinca *et al.* (2016)
η	Inverse Frisch Elasticity	1	Trabandt & Uhlig (2011)

Table 14: Country-specific Calibration targets

Country	Q1	Q2	Q3	K/Y	$\bar{\eta}$	Var(lnw)
Austria	-0.001	0.022	0.186	3.359	0.226	0.174
France	0.0010	0.0539	0.2616	3.392	0.184	0.478
Germany	-0.0036	0.0273	0.1788	3.013	0.189	0.354
Greece	0.011	0.125	0.367	3.262	0.23	0.22
Iceland	0.005	0.077	0.276	4.334	0.308	0.249
Italy	0.0086	0.1025	0.3237	3.943	0.2	0.225
Portugal	0.0058	0.0821	0.2660	3.229	0.249	0.298
Spain	0.0175	0.1289	0.3417	3.378	0.183	0.225
Slovakia	0.0546	0.2069	0.4495	3.799	0.204	0.250
Sweden	-0.099	-0.078	0.115	2.155	0.233	0.315

1 2 3

[1] Macro ratios: K/Y comes from Penn World Table 8.0, average of 1990-2011 period; B/Y stands for the average of net public debt in 2001/2008 (IMF);

[2] Labor targets: $\bar{\eta}$ is hours worked per capita taken by OECD data, average of 1990-2011; Var(lnw) and g1; g2; g3 are from LIS survey available before 2008. Data from Portugal are taken by from Quadros de Pessoal 2009 database;

[3] Q1, Q2 and Q3 stand for the three quartiles of the cumulative distribution of net wealth, from LWS;

Table 15: Parameters calibrated endogenously using risk aversion estimators specific across countries, L corresponds to the Loss function value in equation 21

Country	β_1	β_2	β_3	b	χ	ϕ	σ_ϵ	L
Austria	0.8543	1.00936	0.98146	-0.08	13.51	1.14	0.18046	0.8189
France	0.97442	1.0291	0.9992	0.23	24.6	0.558	0.5067	2.0423
Germany	0.94098	0.99313	0.96677	0.02	9.9599	0.908	0.498	0.9174
Greece	0.99552	0.9971	0.9777	0	15.4	0.731	0.120	0.9185
Iceland	0.97245	1.00185	0.972659	0.08	5.743	2.45	0.294	1.4812
Italy	1.0023	1.02575	0.9948	0	24.1	0.225	0.3746	1.3469
Portugal	0.9620	0.9960	0.9715	0	10.60	1.4899	0.3796	0.9024
Spain	0.98599	1.0040	0.981	0	20.47	1.4	0.2366	2.8791
Slovakia	0.98480	0.99016	0.99025	0	12.35	2.15	0.3261	0.9480
Sweden	0.9736	0.9516	0.917	0.35	9.055	0.71	0.41067	2.312

Table 16: Parameters calibrated exogenously and Country-specific Calibration targets

	Age Profile Parameters			Taxes						Macro ratios	
Country	γ_1	γ_2	γ_3	θ_0	θ_1	$\tilde{\tau}_{ss}$	τ_{ss}	τ_c	τ_k	K/Y	B/Y
Austria	0.155	-0.004	3.0e-05	0.939	0.187	0.217	0.181	0.196	0.240	3.359	0.432
France	0.384	-0.008	6.0e-05	0.915	0.142	0.434	0.135	0.183	0.355	3.392	0.559
Germany	-0.176	0.003	2.3e-05	0.881	0.221	0.206	0.210	0.155	0.233	3.013	0.489
Greece	0.120	-0.002	1.3e-05	1.062	0.201	0.280	0.160	0.154	0.160	3.262	1.038
Iceland	0.161	-0.003	1.9e-05	0.868	0.204	0.055	0.000	0.253	0.200	4.334	0.213
Italy	0.114	-0.002	1.4e-05	0.897	0.180	0.329	0.092	0.145	0.340	3.943	0.893
Portugal	0.172	-0.004	2.6e-05	0.937	0.136	0.238	0.110	0.194	0.293	3.229	0.557
Spain	0.114	-0.002	1.4e-05	0.904	0.148	0.305	0.064	0.144	0.296	3.378	0.368
Slovakia	0.096	-0.002	1.7e-05	0.974	0.105	0.326	0.131	0.181	0.151	3.799	0.317
Sweden	-0.021	0.001	-1.2e-05	0.796	0.223	0.326	0.070	0.255	0.409	2.155	-0.034

1 3 4

Table 17: Cross-country Impact Multipliers for the model calibrated with relative risk aversion

Country	Calibrated σ	Loss Fun.	K/Y	Multiplier G	Multiplier τ_l	$\lvert$Multiplier $\tau_l\rvert$ / $\lvert$Multiplier G$\rvert$
Austria	1.08	0.8189	3.441	0.4717	-1.215	2.576
France	1.43	2.0423	3.392	0.5521	-1.417	2.566
Germany	0.77	0.9174	3.013	0.4503	-0.521	1.164
Greece	1.08	0.9185	3.262	0.5509	-0.941	1.708
Iceland	0.62	1.4812	4.333	0.3401	-0.837	2.461
Italy	1.31	1.3469	3.872	0.521	-1.227	2.417
Portugal	1.07	0.9024	3.233	0.4503	-1.055	2.343
Spain	1.01	2.8791	3.477	0.4771	-1.132	2.372
Slovakia	0.83	0.9480	3.747	0.4926	-1.165	2.365
Sweden	1.16	2.312	2.154	0.5727	-2.125	3.710
Average	1.036	1.456	3.392	0.4878	-1.1635	2.385

[1] γ_1, γ_2, γ_3 are obtained from equation 20, employing LIS survey accessible before 2008. Data for Portugal are from Quadros de Pessoal 2009 database;
[3] $\tilde{\tau}_{ss}$ and τ_{ss} represent the average taxes for social security with OECD data of 2001-2007;
[4] τ_c and τ_k come from Trabandt & Uhlig (2011), representing the average tax rate from 1995-2007.

9 APPENDIX B

9.1 Tax Function

Given the tax function[12]

$$ya = \theta_0 y^{1-\theta_1}$$

which we employ, the average tax rate is defined as

$$ya = (1 - \tau(y))y$$

thus,

$$\theta_0 y^{1-\theta_1} = (1 - \tau(y))y$$

which implies:

$$(1 - \tau(y)) = \theta_0 y^{-\theta_1}$$

$$\tau(y) = 1 - \theta_0 y^{-\theta_1}$$

$$T(y) = \tau(y)y = y - \theta_0 y^{1-\theta_1}$$

$$T'(y) = 1 - (1 - \theta_1)\theta_0 y^{-\theta_1}$$

In this way, the tax wedge for any two incomes (y_1;y_2) is given by:

$$1 - \frac{1 - \tau(y_2}{1 - \tau(y_1} = 1 - (\frac{y_2}{y_1})^{-\theta_1}$$

and thus independent of the parameter θ_0. In this manner, one can raise average taxes by lowering θ_0 and not the progressivity of the tax code, since the parameter θ_1 uniquely determines the progressivity.

[12]This appendix is borrowed from Brinca *et al.* (2019a).

9.2 Definition of a Transition Equilibrium After the Unanticipated Fiscal Consolidation Shock

A recursive competitive equilibrium along the transition between steady states is defined as: Given the capital stock present at the beginning, the initial distribution of households and initial taxes, respectively K_0, Φ_0 and $\{\tau_l, \tau_c, \tau_k, \tau_{ss}, \tilde{\tau}_{ss}\}_{t=1}^{t=\infty}$, a competitive equilibrium in a sequence of individual functions for the household, $\{V_t, c_t, k'_t, n_t\}_{t=1}^{t=\infty}$, of production plans for the firm, $\{K_t, L_t\}_{t=1}^{t=\infty}$, factor prices, $\{r_t, w_t\}_{t=1}^{t=\infty}$, government transfers, $\{g_t, \Psi_t, G_t\}_{t=1}^{t=\infty}$, government debt, $\{B_t\}_{t=1}^{t=\infty}$, inheritance from the dead, $\{\Gamma_t\}_{t=1}^{t=\infty}$, and of measures, $\{\Phi_t\}_{t=1}^{t=\infty}$, such that for all t:

1. The consumers' optimization problem is solved by the value function $V(k, b, a, u, j)$ and the policy functions, $c(k, b, a, u, j)$, $k'(k, b, a, u, j)$, and $n(k, b, a, u, j)$, given the factor prices and the initial conditions.

2. Markets clear.

$$K_{t+1} + B_t = \int k_t d\Phi_t \tag{22}$$

$$L_t = \int (n_t(k_t, \beta, a, u, j))d\Phi_t \tag{23}$$

$$\int c_t d\Phi_t + K_{t+1} + G_t = (1-\delta)K_t + K_t^{\alpha} L_t^{1-\alpha} \tag{24}$$

3. The factor prices satisfy:

$$w_t = (1-\alpha)\left(\frac{K_t}{L_t}\right)^{\alpha} \tag{25}$$

$$r_t = \alpha\left(\frac{L_t}{K_t}\right)^{1-\alpha} - \delta \tag{26}$$

4. The government budget balances:

$$g_t \int d\Phi_t + G_t + r_t B_t = \int \left(\tau_k r_t (k_t + \Gamma_t) + \tau_c c_t + n_t \tau_l \left(\frac{n_t w_t(a,u,j)}{1+\tilde{\tau}_{ss}} \right) \right) d\Phi_t + (B_{t+1} - B_t) \tag{27}$$

5. The social security system balances:

$$\Psi_t \int_{j \le 65} d\Phi_t = \frac{\tilde{\tau}_{ss} + \tau_{ss}}{1+\tilde{\tau}_{ss}} \left(\int_{j \le 65} n_t w_t d\Phi_t \right) \tag{28}$$

6. Dead's assets are consistently dispensed among the living:

$$\Gamma_t \int \omega(j) d\Phi_t = \int (1 - \omega(j)) k_t d\Phi_t \tag{29}$$

7. Aggregate law of motion:

$$\Phi_{t+1} = \gamma_t(\Phi_t) \tag{30}$$

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10 APPENDIX C

Micro Data and Estimation

Gandelman & Hernández-Murillo (2015) cross country estimators .

Gandelman & Hernández-Murillo (2015) estimate the coefficient of relative risk aversion for several countries with happiness data from the Gallup World Poll. Layard *et al.* (2008) already used happiness data to estimate the how fast the marginal utility of income falls when income rises with an iterated maximum likelihood procedure and with a constant relative risk aversion (CRRA) utility function. WIth this CRRA per-period utility function with time-separable preferences, σ is also the reciprocal of the elasticity of inter-temporal substitution (EIS). The form of the Constant Relative Risk Aversion (CRRA) function is:

$$g(y) = \begin{cases} \dfrac{y^{1-\sigma}}{1-\sigma} & \text{if } \sigma \neq 1 \\ \text{log(y)} & \text{if } \sigma = 1 \end{cases} \tag{31}$$

In order to calculate the utility function Gandelman and Hernandez-Murillo (2014) used a sample to give a value to the happiness of people from 0 to 10. The mean of this value has been calculated as 5.5 using a scale from 0 to 10 scale for the overall sample. There have been used also control variables. The sample contains adult people that have an average age of 42.4 years. More women participated (55.6 percent) than men (44.4 percent). In general, more people were married or formed a couple, with the 69.1 percent, while the single were the 30.9 percent. The 44.6 percent of these individuals live in a city. The 59.9 percent were employed during the period of the research.

l'Haridon & Vieider (2019) Risk Preferences Estimations .

Table 18: Data country by country l'Haridon & Vieider (2019)

Country	Sub.s	For.s	age	male	econ	math	natural	hum	arts	social	language	GDP	Gini
Czech R.	99	2	22.38	0.606	0.485	0.111	0.051	0.121	0.030	0.091	Czech	25,949	.310
France	93	8	21.30	0.527	0.430	0.054	0.022	0.043	0.032	0.032	French	35,194	.327
United Kingdom	80	0	20.77	0.450	0.700	0.000	0.025	0.013	0.025	0.075	English	36,511	.350
Germany	130	32	26.52	0.515	0.115	0.400	0.108	0.115	0.008	0.023	German	39,414	.270
Spain	80	3	20.94	0.513	0.450	0.037	0.000	0.100	0.037	0.225	Spanish	32,701	.320