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Fiscal Consolidation Programs and Income Inequality*

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Abstract

Following the Great Recession, many European countries implemented fiscal consolidation policies aimed at reducing government debt. Using three independent data sources and three different empirical approaches, we document a strong positive relationship between higher income inequality and stronger recessive impacts of fiscal consolidation programs across time and place. To explain this finding, we develop a life-cycle, overlapping generations economy with uninsurable labor market risk. We calibrate our model to match key characteristics of a number of European economies, including the distribution of wages and wealth, social security, taxes and debt, and study the effects of fiscal consolidation programs. We find that higher income risk induces precautionary savings behavior, which decreases the proportion of credit-constrained agents in the economy. Credit-constrained agents have less elastic labor supply responses to fiscal consolidation achieved through either tax hikes or public spending cuts, and this explains the relationship between income inequality and the impact of fiscal consolidation programs. Our model produces a cross-country correlation between inequality and the fiscal consolidation multipliers, which is quite similar to that in the data.

Keywords: Fiscal Consolidation, Income Inequality, Fiscal Multipliers, Public Debt, Income Risk
JEL Classification: E21, E62, H31, H50

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1 Introduction

The 2008 financial crisis led several European economies to adopt counter-cyclical fiscal policy, often financed by debt. Government deficits exceeded 10% in many countries, and this created an urgency for fiscal consolidation policies as soon as times returned to normal. Many countries designed plans to reduce their debt through austerity, tax increases, or more commonly a combination of the two, see Blanchard and Leigh (2013), Alesina et al. (2015a). The process of fiscal consolidation across European countries, however, raised a number of important questions about the effects on the economy. Is debt consolidation ultimately contractionary or expansionary? How large are the effects and do they depend on the state of the economy? How does the impact of consolidation through austerity differ from the impact of consolidation through taxation? In this paper we contribute to this literature, both empirically and theoretically, by presenting evidence on a dimension that can help explain the heterogeneous responses to fiscal consolidation observed across countries: income inequality and in particular *the role of uninsurable income risk.*

We begin by documenting a strong positive empirical relationship between higher income inequality and stronger recessive impacts of fiscal consolidation programs across time and place. We do this by using data and methods from three recent, state-of-the-art, empirical papers, which cover various countries and time periods and make use of different empirical approaches: i) Blanchard and Leigh (2013) ii) Alesina et al. (2015a) iii) Ilzetzki et al. (2013)[1].

Next we study the effects of fiscal consolidation programs, financed through both austerity and taxation, in a neoclassical macro model with heterogeneous agents and incomplete markets. We show that such a model is well-suited to explain the relationship between income inequality and the recessive effects of fiscal consolidation programs. The mechanism we propose works through idiosyncratic income risk. In economies with lower risk, there are more credit constrained households and households with low wealth levels, due to less pre-

[1]While the first two papers study fiscal consolidation programs in Europe, Ilzetzki et al. (2013) study government spending multipliers using a greater number of countries. We include this study for completeness.

cautionary saving. Importantly, these credit constrained households have less elastic labor supply responses to increases in taxes and decreases in government expenditures.

Our empirical analysis begins with a replication of the recent studies by Blanchard and Leigh (2013) and Blanchard and Leigh (2014). These studies find that the International Monetary Fund (IMF) underestimated the impacts of fiscal consolidation across European countries, with stronger consolidation causing larger GDP forecast errors. In Blanchard and Leigh (2014), the authors find no other significant explanatory factors, such as pre-crisis debt levels[2] or budget deficits, banking conditions, or a country's external position, among others, can help explain the forecast errors. In Section 3.1 we reproduce the exercise conducted by Blanchard and Leigh (2013), now augmented with different metrics of income inequality. We find that during the 2010 and 2011 consolidation in Europe the forecast errors are larger for countries with higher income inequality, implying that inequality amplified the recessive impacts of fiscal consolidation. A one standard deviation increase in income inequality, measured as Y_{10}/Y_{90} [3] leads the IMF to underestimate the fiscal multiplier in a country by 66%.

For a second independent analysis, we use the Alesina et al. (2015a) fiscal consolidation episodes dataset with data from 12 European countries over the period 2007-2013. Alesina et al. (2015a) expands the exogenous fiscal consolidation episodes dataset, known as IMF shocks, from Devries et al. (2011) who use Romer and Romer (2010) narrative approach to identify exogenous shifts in fiscal policy. Again we document the same strong amplifying effect of inequality on the recessive impacts of fiscal consolidation. A one standard deviation increase in inequality, measured as Y_{25}/Y_{75}, increases the fiscal multiplier by 240%.

Our third empirical analysis replicates the paper by Ilzetzki et al. (2013). These authors use time series data from 44 countries (both rich and poor) and a SVAR approach to study the impacts of different country characteristics on fiscal multipliers. We find that countries

[2] In Section 8.1 we show that, in line with our proposed mechanism, household debt matters if an interaction term between debt and the planned fiscal consolidation is included in the regression.

[3] Ratio of top 10% income share over bottom 10% income share.

with higher income inequality experience significantly stronger declines in output following decreases in government consumption.

To explain these empirical findings, we develop an overlapping generations economy with heterogeneous agents, exogenous credit constraints and uninsurable idiosyncratic risk, similar to that in Brinca et al. (2016b). We calibrate the model to match data from a number of European countries along dimensions such as the distribution of income and wealth, taxes, social security and debt level. Then we study how these economies respond to gradually reducing government debt, either by cutting government spending or by increasing labor income taxes.

Output falls when debt reduction is financed through either a decrease in government spending or increased labor income taxes. In both cases, this is caused by a fall in labor supply. In the case of reduced government spending, the transmission mechanism works through a future income effect. As government debt is paid down, the capital stock and thus the marginal product of labor (wages) rise, and thus expected lifetime income increases. This will lead agents to enjoy more leisure and decrease their labor supply today, and output to fall in the short-run, despite the long run effects of consolidation on output being positive. Credit constrained agents and agents with low wealth levels do, however, have a lower marginal propensity to consume goods and leisure out of future income (for constrained agents the MPC to future income is zero[4]). Constrained agents do not consider changes to their lifetime budget, only changes to their budget in the current time period. Agents with low wealth levels are also less responsive to future income changes because they will be constrained in several future states of the world. Increases in expected future consumption and leisure levels will thus have a smaller effect on their labor supply today.

In the case of consolidation through increased labor income taxes there will also be a negative income effect on labor supply today, through higher future wages and increased life-time income. For constrained agents, who do not consider their life-time budget but

[4] The fact that constrained agents also very slightly change their labor supply in our model simulations is due to general equilibrium effects (price changes) today.

only their budget today, the tax would instead cause a drop in available income in the short-run, leading to a labor supply increase. However, the tax also induces a negative substitution effect on wages today, both for constrained and unconstrained agents. It turns out that all agents decrease their labor supply, but the response is weaker for constrained and low-wealth agents.

When higher income inequality reflects higher uninsurable income risk, there exists a negative relationship between income inequality and the number of credit constrained agents. Greater risk leads to increased precautionary savings behavior, thus decreasing the share of agents with liquidity constraints and low wealth levels. Since unconstrained agents have more elastic labor supply responses to the positive lifetime-income effect from consolidation, labor supply and output will respond more strongly in economies with higher inequality.

Through simulations in a benchmark economy, initially calibrated to Germany, we show that varying the level of idiosyncratic income risk strongly affects the fraction of credit constrained agents in the economy and the fiscal multiplier, both for consolidation through taxation and austerity. If we instead change inequality by changing the variance of initial conditions, prior to entering the labor market (permanent ability and the age-profile of wages in the model), there is very little effect on the fraction of credit constrained agents or on the fiscal multiplier.

In a multi-country exercise, we calibrate our model to match a wide range of data and country-specific policies from 13 European economies, and find that our simulations reproduce the anticipated cross-country correlation between income inequality and fiscal multipliers. Moreover, we show that in our model, countries with higher idiosyncratic uninsurable labor income risk have a smaller percentage of constrained agents and have larger multipliers, confirming our analysis and mechanism for the benchmark model calibrated to Germany.

We perform two empirical exercises to test the validity of the mechanism described above. First, in our calibrated model, higher levels of household debt are associated with a higher number of credit constrained households. This implies that countries with higher levels of debt should have experienced less recessive impacts of fiscal consolidation programs. We show that such relationship exists in the data, by again performing a similar exercise to Blanchard and Leigh (2013).

Second, the mechanism we propose implies that fiscal consolidations lead to decreases in labor supply, and that these are amplified by income inequality. We follow Alesina et al. (2015a) but now look at the impacts of fiscal consolidation and income inequality on hours worked. We find, precisely in line with our simulations, that fiscal consolidation programs have a negative impact on hours worked and that this impact is amplified by increases in income inequality.

In Section 9, we conduct a final validity test of the mechanism by using our model. In the empirical analysis we make the case that the IMF forecasts did not properly take income inequality into account. In this section we show that using data from our model, obtained by simulating the observed fiscal consolidation shocks in the data, we get similar results to Blanchard and Leigh (2013) when we shut down all labor income risk in our model. The difference between the output drop that our calibrated model predicts both with and in the absence of risk (which is our proxy for the forecast error), is explained by the size of the fiscal shock and its interaction with the same income inequality metrics as in our replication of the Blanchard and Leigh (2013) experiment (found in Section 3.1). The resulting pattern of regression statistics are strikingly similar to Blanchard and Leigh (2013).

The remainder of the paper is organized as follows: We begin by discussing some of the recent relevant literature in Section 2. In Section 3 we assess the empirical relationship between income inequality and the fiscal multipliers associated with consolidation programs. In Section 4 we describe the overlapping generations model, define the competitive equilibrium and explain the fiscal consolidation experiments. Section 5 describes the calibration of the model. In Section 6 we inspect the transmission mechanism, followed by the cross-country analysis in Section 7. In Section 8 we empirically validate the mechanism and in Section 9 we replicate the Blanchard and Leigh (2014) exercise with model data. Section 10 concludes.

2 Related Literature

There has been a surge in the literature studying the impacts of fiscal consolidation programs. Guajardo et al. (2014) focus on short-term effects of fiscal consolidations on economic activity for a sample of OECD countries, using the narrative approach as in Romer and Romer (2010), finding that a 1% fiscal consolidation shock causes GDP to to decline by 0.62%; Yang et al. (2015) build a sample of fiscal adjustment episodes in OECD countries over the period from 1970 to 2009 and find a somewhat smaller recessive impact: a 1% fiscal consolidation shock leads to a 0.3% fall in output. Blanchard and Leigh (2013) and Blanchard and Leigh (2014) find a negative effect of fiscal consolidation programs on output and shows that this effect is underestimated by the IMF. The conclusions in Alesina et al. (2015b) support previous studies, emphasizing that tax-based consolidations produce deeper and longer recessions than spending based ones. Pappa et al. (2015) study the impact of fiscal consolidation episodes in an environment with corruption and tax evasion, and find evidence that fiscal consolidation causes large output and welfare losses. They find that much of the welfare loss is due to increases in taxes, which creates the incentives to produce in the less productive shadow sector. Dupaigne and Fève (2016) focus on how the persistence of government spending can shape the short-run impacts on output through the response of private investment. More persistent government spending leads to greater fiscal multipliers.

Our paper is also more broadly related to the large literature studying fiscal multipliers, i.e. the response of output to changes in fiscal policy, and in particular the literature focusing on how these responses depends on income and wealth inequality. Heathcote (2005) studies the effects of changes in the timing of income taxes and finds that tax cuts can have large real effects and that the magnitude of the effect depends crucially on the degree of market incompleteness. Hagedorn et al. (2016), in a New Keynesian model, present further evidence of the relevance of market incompleteness in determining the size of fiscal multipliers. Ferriere and Navarro (2016) provide empirical evidence showing that in the post-war U.S., fiscal expansions are only expansionary when financed by increases in tax progressivity. Like in

Brinca et al. (2016b), Ferriere and Navarro (2016) can replicate this empirical finding using a neoclassical framework. Brinca et al. (2016) provide empirical evidence that higher wealth inequality is associated with stronger impacts of increases in government expenditures and show that an overlapping generations model with uninsurable income risk calibrated to match key characteristics of a number of OECD countries, can replicate this empirical pattern.

Krueger et al. (2016) assess how wealth, income and preference heterogeneity across households amplifies aggregate shocks. Krueger et al. (2016) conclude that, in an economy with the wealth distribution consistent with the data, the drop in aggregate consumption in response to a negative aggregate shock is 0.5 percentage points larger than in a representative household model. This is conditional on the economy featuring a sufficiently large share of agents with low wealth. Anderson et al. (2016) find that in the context of the U.S. economy, individuals respond differently to unanticipated fiscal shocks depending on age, income level, and education. The behavior of the wealthiest agents, in particular, is consistent with Ricardian equivalence but poor households show evidence of non-Ricardian behavior.

Relatedly Carroll et al. (2014) measure marginal propensities to consume for a large panel of European countries, and then calibrate a model for each country using net wealth and liquid wealth. The authors find that the higher the proportion of financially constrained agents in an economy, the higher the consumption multiplier. Kaplan and Violante (2014) propose a model with two types of assets that provides a rationale for relatively wealthy agents' choice of being credit constrained. In a context of portfolio optimization with one high-return illiquid asset and one low-return liquid asset, relatively wealthy individuals may end up credit constrained. Kaplan et al. (2014), using micro data from several countries, then argue that the percentage of financially constrained agents can be well above what is typically the outcome of models where very few agents have their wealth tied up in illiquid assets. Antunes and Ercolani (2017b) also highlight the relevance of borrowing constraints for the dynamics of public debt.

3 Empirical Analysis

In this section we document a strong empirical relationship between income inequality and the fiscal multiplier resulting from fiscal consolidation programs. We do this by replicating three recent empirical studies, which all use independent data sources and different empirical approaches. The two first studies, Blanchard and Leigh (2013) and Alesina et al. (2015a) study the impact of recent fiscal consolidation programs in Europe. The third study, Ilzetzki et al. (2013), has a slightly different focus as it looks at government spending multipliers in a larger sample of countries, including developing countries. We include it for completeness.

3.1 GDP Forecast Errors and Fiscal Consolidation Forecasts

Blanchard and Leigh (2013) propose a standard rational expectation model specification to investigate the relation between growth forecast errors and planned fiscal consolidation after the crisis. The approach consists on regressing forecast errors for real GDP growth on forecasts of fiscal consolidation made in the beginning of 2010. The specification proposed by Blanchard and Leigh is the following

$$\Delta Y_{i,t:t+1} - \hat{E}\{\Delta Y_{i,t:t+1}|\Omega_t\} = \alpha + \beta \hat{E}\{F_{i,t:t+1|t}|\Omega_t\} + \epsilon_{i,t:t+1} \tag{1}$$

where α is a constant, $\Delta Y_{i,t:t+1}$ is the cumulative year-to-year GDP growth rate in economy i from period t to t+1 (years 2010 and 2011 respectively), and the forecast error is measured as $\Delta Y_{i,t:t+1} - \hat{E}\{\Delta Y_{i,t:t+1}|\Omega_t\}$, with $\hat{E}$ being the forecast conditioned on the information set Ω at time t. $\hat{E}\{F_{i,t:t+1|t}|\Omega_t\}$ denotes the planned cumulative change in the general government structural fiscal balance in percentage of potential GDP, and is used as a measure of discretionary fiscal policy.

Under the null hypothesis that the IMF's forecasts regarding the impacts of fiscal consolidation were accurate, β should be zero. What Blanchard and Leigh (2013) find is that β not only is statistically different from zero, but negative and around 1. This means that the IMF severely underestimated the recessive impacts of austerity, implying that for every additional percentage point of fiscal consolidation, output was about 1 percent lower than what was forecast. [5]

Blanchard and Leigh (2013) then investigate what else could explain the forecast errors. The authors test for initial level of financial stress, initial level of external imbalances, trade-weighted forecasts of trading partners' fiscal consolidation forecasts, the initial level of household debt[6], the IMF's Early Warning exercise vulnerability ratings computed in early 2010 and other variables. The results are robust and no control is significant. Two conclusions are drawn from this. First, that none of the variables examined are correlated with both the forecast error and planned fiscal consolidation and thus the under-estimation of the recessive impacts of consolidation are not related with these different dimensions. Second, since none are statistically significant, none of these dimensions significantly affected the forecast errors of the IMF.

We expand Equation (1) to account for several different metrics of income inequality[7]. Using the European Union Statistics on Income and Living Conditions (EU-SILC) dataset, we construct various measures of income inequality for the same 26 European economies used by Blanchard and Leigh (2013). [8]

Moreover, to test whether inequality helps to explain the impact of fiscal consolidation, we include in the regression an interaction between the planned fiscal consolidation and inequality. To provide better intuition, we re-parametrize the specification and demean the inequality measures in the interaction term. Therefore, we estimate the following equation

[5] Blanchard and Leigh (2013) also investigates whether this result could have been driven by the fact that planned fiscal consolidations were different from actual ones. The authors show that this was not the case, as planned and actual consolidations have a correlation close to one.

[6] In Section 8 we show that household debt matters if interacted with the planned fiscal consolidation.

[7] The shares of income of top 25%, 20%, 10%, 5% and 2% over the share of the bottom 25%, 20%, 10%, 5% and 2% respectively and the income Gini coefficient

[8] The 26 economies used by Blanchard and Leigh were Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Germany, Denmark, Finland, France, Greece, Hungary, Ireland, Iceland, Italy, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.

$$\Delta Y_{i,t:t+1} - \hat{E}\{\Delta Y_{i,t:t+1}|\Omega_t\} = \alpha + \beta \hat{E}\{F_{i,t:t+1|t}|\Omega_t\} + \gamma I_{i,t-1} + \iota((\hat{E}\{F_{i,t:t+1|t}|\Omega_t\})(I_{i,t-1} - \mu_I)) + \epsilon_{i,t:t+1} \quad (2)$$

where $I_{i,t-1}$ is the inequality measure for country i and μ represents the mean of I. We use lagged inequality to guarantee that it is not influenced by GDP growth rate or by the fiscal consolidation measures. The results are presented in Table 1. When the demeaned inequality measures are included the β coefficients have a convenient interpretation as how much the effects of fiscal consolidation were underestimated for a country with inequality equal to the sample mean. The ι coefficients tell us by how much more (relative to the β coefficients) the IMF underestimated the fiscal consolidation effects for a country with inequality one percentage point above the sample mean.

First, relative to the benchmark case of Blanchard and Leigh (2013), we see that even though the consolidation variable is still statistically significant, the coefficient point estimates are now smaller in absolute value. This tells us that including income inequality and its interaction with planned consolidation, reduces the impacts of the size of fiscal consolidation in itself.

Second, note that an increase of 1% above the mean of income inequality amplifies the forecast error of the effects of fiscal consolidation by ι. This means that if the forecasters had taken income inequality into account, the effects of fiscal consolidation would have been more accurately anticipated.

The results are not only statistically significant and robust but are also economically meaningful. For example, an increase in one standard deviation of the income share of agents in the top 10% of the income distribution over the bottom 10% leads to an underestimation of the fiscal multiplier of 66%, for a country with an average consolidation[9].

[9]Note also that even though this is a statement about IMF's forecast errors, if we use as dependent variable output alone, we still find the same results, showing that higher income inequality is associated with a higher impact of fiscal consolidation, as shown in Table 11 in Appendix.

Table 1: Blanchard and Leigh (2013) Regressions Augmented with Measures of Income Inequality

Coefficients	(1) Blanchard-Leigh	(2) Y25/Y75	(3) Y20/Y80	(4) Y10/Y90	(5) Y5/Y95	(6) Y2/Y98	(7) Income Gini
β	-1.095***	-0.841***	-0.806***	-0.697**	-0.759***	-0.750***	-1.267***
	(0.255)	(0.227)	(0.234)	(0.252)	(0.240)	(0.238)	(0.275)
γ		-0.194	-0.144	-0.065	0.008	0.018	0.273**
		(0.385)	(0.291)	(0.120)	(0.036)	(0.032)	(0.121)
ι		-0.251	-0.238	-0.154***	-0.071***	-0.066***	-0.085
		(0.208)	(0.153)	(0.054)	(0.021)	(0.019)	(0.084)
Constant	0.775*	2.150	2.041	1.812	0.805	0.558	-9.344**
	(0.383)	(2.632)	(2.422)	(1.758)	(0.928)	(0.597)	(4.463)
Observations	26	26	26	26	26	26	26
R-squared	0.496	0.545	0.559	0.612	0.600	0.610	0.624

[a] *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.
[b] The table displays the results from augmenting the regression in Blanchard and Leigh (2013) with different measures of income inequality and an interaction term between income inequality and planned fiscal consolidation.
[c] Y25/Y75, Y20/Y80, Y10/Y90, Y5/Y95 and Y2/Y98 represent the share of income of the top 25%, 20%, 10%, 5% and 2% divided by the share of the bottom 25%, 20%, 10%, 5% and 2%.

3.2 IMF Shocks

In this subsection we show that the link between income inequality and the output response to fiscal consolidations is not exclusive to the years of 2010 and 2011. We use the Alesina et al. (2015a) annual dataset on fiscal consolidation episodes in 12 European economies [10] between 1978 and 2013. The authors expand the exogenous fiscal consolidation episodes dataset in Devries et al. (2011), known as IMF shocks, which is constructed using the Romer and Romer (2010) narrative approach to identify fiscal consolidations solely driven by the need to reduce deficits. The use of the narrative approach makes it possible to filter out all policy actions driven by the economic cycle and guarantees exogeneity of the shifts in fiscal policy.

Alesina et al. (2015a) expand the Devries et al. (2011) dataset, but use the methodological innovation proposed by Alesina et al. (2015b), who notice that a fiscal adjustment is not an isolated change in expenditure or taxes, it is a multi-year plan, in which some policies are known in advance and others are implemented unexpectedly. Ignoring the connection between the unanticipated and announced consolidation measures can lead to biased results.

In the Alesina et al. (2015a) dataset, fiscal consolidations are measured as expected

[10] Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Ireland, Italy, Portugal and Sweden.

revenue effects of changes in the tax code and as deviations of expenditure relative to the expected level of expenditure absent the policy changes. The fiscal consolidation episodes are assumed to be fully credible, and announcements which were not implemented are dropped from the database.

Once again, we use total income inequality data from the EU-SILC dataset and construct the same measures of income inequality as in Section 3.1. The EU-SILC data goes from 2007 to 2015 for all the 12 European economies in the Alesina et al. (2015a) dataset. The equation that we estimate is the following:

$$\Delta Y_{i,t} = \alpha + \beta_1 e^u_{i,t} + \beta_2 e^a_{i,t} + \gamma I_{i,t-1} + \iota_1 e^u_{i,t}(I_{i,t-1} - \mu_I) + \iota_2 e^a_{i,t}(I_{i,t-1} - \mu_I) + \delta_i + \omega_t + \epsilon_{i,t} \quad (3)$$

where ΔY_{it} is the GDP growth rate in economy i in year t, e^u_{it} is the unanticipated consolidation shock while e^a_{it} is the announced shock. I_{it-1} is the inequality measure in year t-1 and μ represents the sample mean of I. We consider the lagged value of inequality to guarantee that inequality is not affected by current changes in output and current fiscal consolidation. We re-parametrize the interaction terms by demeaning the inequality measures so that β_1 and β_2 have the more convenient interpretation of how much, for a country with average inequality, an increase in fiscal consolidation of one percent affects output growth for a country with average inequality. Moreover, ι_1 and ι_2 also have the more convenient interpretation of by how much more (relative to a country with average inequality) fiscal consolidation affects the GDP growth rate for a country with inequality 1 percentage point above the sample mean. δ_i and ω_t are country and year fixed effects.

The results are presented in Table 2. Notice that, from the two interaction terms, only the interaction with unanticipated IMF shocks is statistically significant. This tells us that, for an unanticipated fiscal consolidation, an increase in inequality by 1 percentage point is going to amplify the recessive impacts of fiscal consolidation (the fiscal multiplier) by ι_1.

Once again, the results are not only robust and statistically significant, but also economically meaningful. An increase of one standard deviation in the share of the income of the top 25% over the share of the bottom 25% leads to an increase in the multiplier of an unanticipated shocks of 240%, for a country with an average unanticipated consolidation.

Table 2: Regressions on Data from Alesina et al. (2015a)

Coefficients	(1) Benchmark	(2) Y25/Y75	(3) Y20/Y80	(4) Y10/Y90	(5) Y5/Y95	(6) Y2/Y98	(7) Income Gini
β_1	-0.003	0.006	0.004	-0.004	-0.004	-0.004	0.011
	(0.005)	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)
β_2	-0.002	-0.003	-0.002	-0.000	-0.002	0.001	-0.001
	(0.005)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)
γ		-2.294**	-1.308*	-0.024	0.036	0.009	-1.100***
		(1.001)	(0.756)	(0.344)	(0.135)	(0.049)	(0.380)
ι_1		-1.363**	-0.882*	0.103	0.069	-0.005	-0.501**
		(0.590)	(0.501)	(0.232)	(0.077)	(0.030)	(0.191)
ι_2		-0.357	-0.213	-0.094	-0.017	0.022	-0.112
		(0.633)	(0.510)	(0.245)	(0.091)	(0.026)	(0.173)
Constant	0.014***	0.171**	0.123*	0.018	0.005	0.012	0.434***
	(0.005)	(0.069)	(0.063)	(0.050)	(0.034)	(0.014)	(0.145)
Observations	84	84	84	84	84	84	84
R-squared	0.008	0.132	0.086	0.012	0.030	0.021	0.179
Number of countries	12	12	12	12	12	12	12

[a] *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.
[b] The table displays the results from estimating the regression in Equation (3) on data from Alesina et al. (2015a) and measures of income inequality from the EU-SILC.
[c] Y25/Y75, Y20/Y80, Y10/Y90, Y5/Y95 and Y2/Y98 represent the share of income of the top 25%, 20%, 10%, 5% and 2% divided by the share of the bottom 25%, 20%, 10%, 5% and 2%.

3.3 SVAR

In this subsection we provide additional evidence on the link between income inequality and the recessive impacts of fiscal contractions, using a larger dataset containing 44 countries, see data description in Section 11.3. We use the data and methodology from Ilzetzki et al. (2013), to run VARs for two different groups of countries pooled by their position whether income inequality int he country is above or below the median. We use three different measures of inequality: i) the income share of the top 20% divided by the share of the bottom 20% ii) the income share of the top 10% divided by the income share of the bottom 10% iii) the income Gini coefficient. We find that the results are consistent across the three different metrics of income inequality. For countries with income inequality metric above the median, the recessive impacts of decreases in government consumption expenditures are stronger and statistically different from the impacts for the group of countries with income inequality metrics below the median.

The objective is to estimate the following system of equations

$$AY_{nt} = \sum_{k=1}^{K} C_k Y_{n,t-k} + u_{n,t} \tag{4}$$

where Y_{nt} is a vector containing the endogenous variables for country n in quarter t. The variables considered are the same as in Ilzetzki et al. (2013): government consumption, output, current account in percentage of GDP and the natural logarithm of the real effective exchange rate. C_k is a matrix of lag own and cross effects of variables on their current observations. Given that A is not observable we cannot estimate this regression directly. We need to pre-multiply everything by A^{-1} and, using OLS, we can recover the matrix $P = A^{-1}C_k$ and $e_{n,t} = A^{-1}u_{n,t}$. So we estimate the system

$$Y_{nt} = \sum_{k=1}^{K} A^{-1} C_k Y_{n,t-k} + A^{-1} u_{n,t} \tag{5}$$

To be able to estimate the effects of fiscal consolidation, we need more assumptions on A so that we can identify the innovations by solving $e_{n,t} = A^{-1}u_{n,t}$. We use the same assumption used by Ilzetzki et al. (2013) and first introduced by Blanchard and Perotti (2002), to identify the responses of output to government consumption expenditures: government consumption cannot react to shocks in output within the same quarter. The plausibility of this assumption comes from the fact that the government's budget is typically set on a yearly basis and can only react to changes in output with a lag. For the ordering of the remaining variables, we also follow Ilzetzki et al. (2013) and let the current account follow output and the real exchange rate follow the current account. Given this, we can identify the impulse responses to a primitive shock in government spending. In Figures 1, 2 and 3 we plot the cumulative output multiplier to a government consumption shock, defined as:

$$\textit{cummulative multiplier } G(T) = \frac{\sum_{t=0}^{t=T} \left(\frac{1}{(1+r_m)}\right)^t \Delta Y_t}{\sum_{t=0}^{t=T} \left(\frac{1}{(1+r_m)}\right)^t \Delta G_t} \tag{6}$$

r_m is here the median interest rate in the data sample. The output multipliers shown in Figures 1, 2 and 3 suggest that in countries with higher income inequality, contractions in government spending have a more recessive impact.

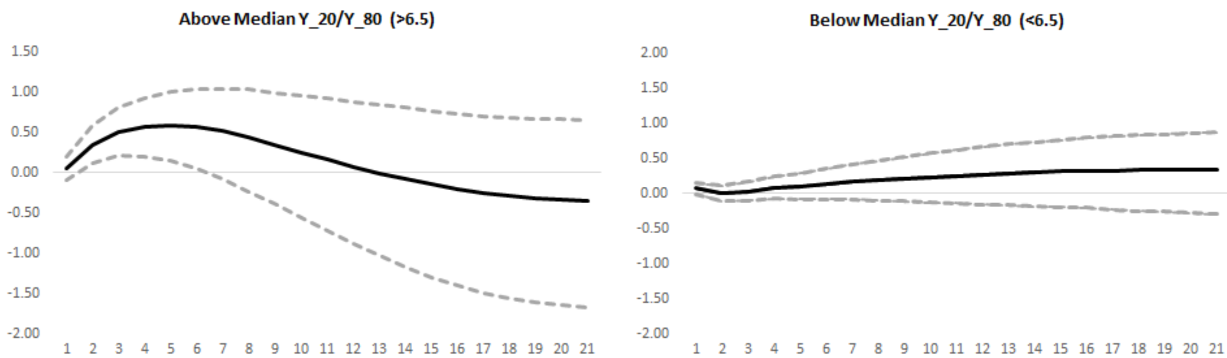

Figure 1: Cumulative output multiplier, as defined in (6), to a government consumption shock (90% error bands in gray)

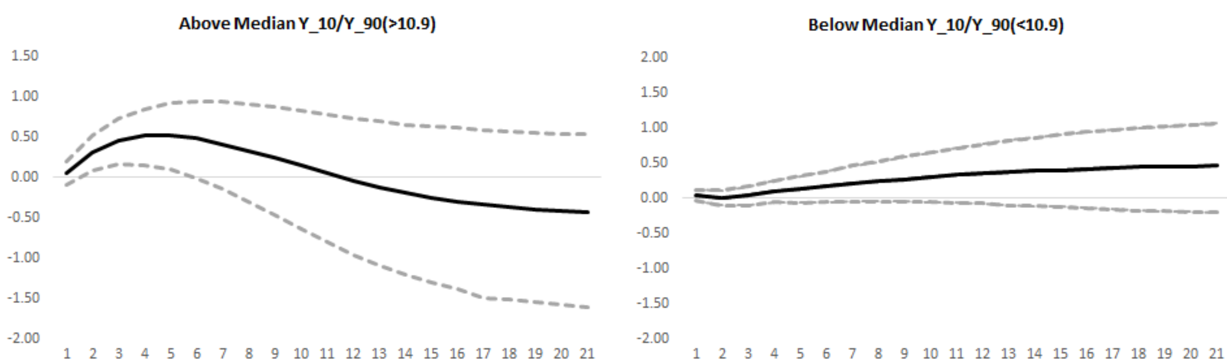

Figure 2: Cumulative output multiplier, as defined in (6), to a government consumption shock (90% error bands in gray)

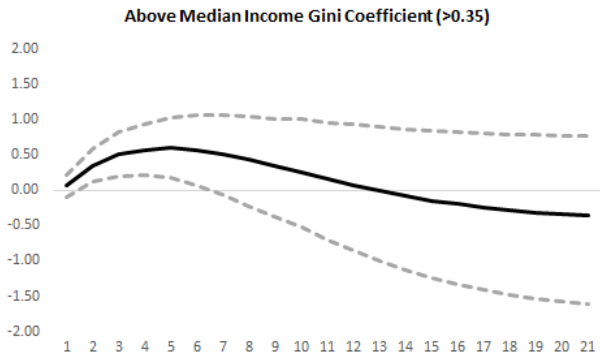

Figure 3: Cumulative output multiplier, as defined in (6), to a government consumption shock (90% error bands in gray)

The empirical findings in Section 3 together suggest that income inequality is a relevant dimension to take into account when studying the effects of fiscal policy. In particular, they suggest that higher inequality amplifies the recessive impacts of fiscal consolidation and decreases in government expenditures. In order to understand the mechanism through which income inequality may play such role, we build a structural model that is introduced in the next section.

4 Model

In this section, we describe the model we will use to study the effects of a fiscal consolidation in different countries. Our model is a relatively standard life-cycle economy with heterogeneous agents and incomplete markets. It is similar to the model in Brinca et al. (2016b), except that we have introduced a bequest motive to get a more realistic distribution of wealth over the life-cycle.

Technology

There is a representative firm, producing output with a Cobb-Douglas production function:

$$Y_t(K_t, L_t) = K_t^{\alpha} \left[L_t\right]^{1-\alpha} \tag{7}$$

where K_t is the capital input and L_t the labor input in efficiency units. The evolution of capital evolution is given by:

$$K_{t+1} = (1 - \delta)K_t + I_t \tag{8}$$

where I_t is gross investment and δ the capital depreciation rate. Each period, the firm hires labor and capital to maximize its profits:

$$\Pi_t = Y_t - w_t L_t - (r_t + \delta)K_t. \tag{9}$$

In a competitive equilibrium, the factor prices will be equal to their marginal products given by:

$$w_t = \partial Y_t / \partial L_t = (1 - \alpha) \left(\frac{K_t}{L_t} \right)^{\alpha} \tag{10}$$

$$r_t = \partial Y_t / \partial K_t - \delta = \alpha \left(\frac{L_t}{K_t} \right)^{1-\alpha} - \delta \tag{11}$$

Demographics

The economy is populated by J overlapping generations of finitely lived households[11]. All households start life at age 20 and enter retirement at age 65. Let j denote the household's age. Retired households face an age-dependent probability of dying, $\pi(j)$ and die for certain at age 100.[12]. A model period is 1 year, so there are a total of 40 model periods of active work life. We assume that the size of the population is fixed (there is no population growth). We normalize the size of each new cohort to 1. Using $\omega(j) = 1 - \pi(j)$ to denote the age-dependent survival probability, by the law of large numbers the mass of retired agents of age $j \geq 65$ still alive at any given period is equal to $\Omega_j = \prod_{q=65}^{q=J-1} \omega(q)$.

In addition to age differences, households are heterogeneous with respect to asset holdings, idiosyncratic productivity, and their subjective discount factor, which for each household is constant over time but takes one out of the three values $\beta \in \{\beta_1, \beta_2, \beta_3\}$; the dis-

[11]Recent work by Peterman and Sager (2016) makes the case for having a life-cycle dimension when studying the impacts of government debt.

[12]This means that $J = 81$.

tribution of discount factors is uniformly distributed across agents in each cohort. Finally, they also differ in terms of a permanent ability component, i.e., they have a starting level of productivity that is realized at birth. Every period of active work-life they decide how many hours to work, n, how much to consume, c, and how much to save, k. Retired households make no labor supply decisions but receive a social security payment, Ψ_t.

There are no annuity markets, so that a fraction of households leave unintended bequests which are redistributed in a lump-sum manner between the households that are currently alive. We use Γ to denote the per-household bequest. Retired households' utility is increasing in the bequest they leave when they die. This helps us calibrate the asset holdings of old households.

Labor Income

The wage of an individual depends on his/her own characteristics: age, j, permanent ability, $a \sim N(0, \sigma_a^2)$, and idiosyncratic productivity shock, u, which follows an AR(1) process:

$$u_{t+1} = \rho u_t + \epsilon_{t+1}, \quad \epsilon \sim N(0, \sigma_\epsilon^2) \tag{12}$$

These characteristics will dictate the number of efficient units of labor the household is endowed with. Individual wages will also depend on the wage per efficiency unit of labor w. Thus, individual i's wage is given by:

$$w_i(j, a, u) = we^{\gamma_1 j + \gamma_2 j^2 + \gamma_3 j^3 + a + u} \tag{13}$$

$\gamma_{1\iota}$, $\gamma_{2\iota}$ and $\gamma_{3\iota}$ capture the age profile of wages.

Preferences

The momentary utility function of a household, $U(c,n)$, depends on consumption and work hours, $n \in (0,1]$, and takes the following form:

$$U(c,n) = \frac{c^{1-\sigma}}{1-\sigma} - \chi \frac{n^{1+\eta}}{1+\eta}. \tag{14}$$

Retired households gain utility from the bequest they leave when they die:

$$D(k) = \varphi \log(k) \tag{15}$$

Government

The government runs a balanced social security system where it taxes employees and the employer (the representative firm) at rates τ_{ss} and $\tilde{\tau}_{ss}$ and pays benefits, Ψ_t, to retirees. The government also taxes consumption and labor and capital income to finance the expenditures on pure public consumption goods, G_t, which enter separably in the utility function, interest payments on the national debt, rB_t, and a lump-sum redistribution, g_t. We assume that there is some outstanding government debt and that government debt-to-output ratio, $B_Y = B_t/Y_t$, does not change over time. Consumption and capital income are taxed at flat rates the τ_c and τ_k. To model the non-linear labor income tax, we use the functional form proposed in Benabou (2002) and recently used in Heathcote et al. (2017) and Holter et al. (2017):

$$\tau(y) = 1 - \theta_0 y^{-\theta_1} \tag{16}$$

where y denotes pre-tax (labor) income and $\tau(y)$ the average tax rate given a pre-tax income of y. The parameters θ_0 and θ_1 govern the level and the progressivity of the tax code, respectively.[13]. Heathcote et al. (2017) argue that this function fits the U.S. data well.

In a steady state, the ratio of government revenues to output will remain constant. G_t,

[13]A further discussion of the properties of this tax function is provided in the appendix

g_t, and Ψ_t must also remain proportional to output. Denoting the government's revenues from labor, capital, and consumption taxes by R_t and the government's revenues from social security taxes by R_t^{ss}, the government budget constraint in steady state takes the following form:

$$g\left(45+\sum_{j\geq 65}\Omega_j\right)=R-G-rB, \tag{17}$$

$$\Psi\left(\sum_{j\geq 65}\Omega_j\right)=R^{ss}. \tag{18}$$

Recursive Formulation of the Household Problem

At any given time a household is characterized by (k,β,a,u,j), where k is the household's savings, $\beta\in\beta_1,\beta_2,\beta_3$, is the time discount factor, a is permanent ability, u is the idiosyncratic productivity shock, and j is the age of the household. We can formulate the household's optimization problem over consumption, c, work hours, n, and future asset holdings, k', recursively as follows:

$$\begin{aligned}
V(k,\beta,a,u,j) &= \max_{c,k',n}\left[U\left(c,n\right)+\beta E_{u'}\left[V(k',\beta,a,u,j+1)\right]\right] \\
&\text{s.t.:} \\
c(1+\tau_c)+k' &= (k+\Gamma)\left(1+r(1-\tau_k)\right)+g+Y^L \\
Y^L &= \frac{nw\left(j,a,u\right)}{1+\tilde{\tau}_{ss}}\left(1-\tau_{ss}-\tau_l\left(\frac{nw\left(j,a,u\right)}{1+\tilde{\tau}_{ss}}\right)\right) \\
n\in[0,1], &\quad k'\geq -b, \quad c>0
\end{aligned} \tag{19}$$

Here, Y^L is the household's labor income after social security taxes and labor income taxes. τ_{ss} and $\tilde{\tau}_{ss}$ are the social-security contributions paid by the employee and by the employer, respectively. The problem of a retired household, who has a probability $\pi(j)$ of dying and gains utility $D(k')$ from leaving a bequest, is:

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

s.t.:

$$c(1+\tau_c) + k' = (k+\Gamma)\left(1 + r(1-\tau_k)\right) + g + \Psi,$$

$$k' \geq 0, \quad c > 0 \tag{20}$$

Stationary Recursive Competitive Equilibrium

Let the measure of households with the corresponding characteristics be given by $\Phi(k,\beta,a,u,j)$. The stationary recursive competitive equilibrium is defined by:

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

2. Markets clear:

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

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

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

3. The factor prices satisfy:

$$\begin{aligned} w &= (1-\alpha)\left(\frac{K}{L}\right)^{\alpha} \\ r &= \alpha\left(\frac{K}{L}\right)^{\alpha-1} - \delta \end{aligned}$$

4. The government budget balances:

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

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 dead are uniformly distributed among the living:

$$\Gamma \int \omega(j) d\Phi = \int \left(1-\omega(j)\right) kd\Phi$$

Fiscal Experiment and Transition

The fiscal experiments that we analyze in this paper is 50 periods of reduction in government debt, B, either financed through a decrease in government spending, G, by 0.2% of benchmark GDP[14], or an increase in the labor income tax τ_l, by 0.1% for all agents. The economy is initially in a steady state and the 50 periods of fiscal consolidation is unanticipated until it is announced[15]. After the 50 periods either the government spending or the labor tax go back to the initial level. The lumpsum transfer, g is set to clear the government budget, and we assume that the economy takes an additional 50 periods to converge to the new steady state equilibrium, with lower debt to GDP ratio.

To save space, the definition of a transition equilibrium after the fiscal experiment is stated in Appendix 11.2. The key change compared to the steady state is that the dynamic-programming problem of households need another state variable: time, t, capturing all the changes in policy and price variables relevant in this maximization problem. The numerical solution of the model necessitates guessing on paths for all the variables that will depend

[14]The total revenue available for debt repayment over the 50-year period is thus 10% of benchmark GDP

[15]In Section 3.2, we found that unanticipated but not anticipated fiscal consolidations have a statistically significant negative effect on output.

on time and then solving this maximization problem backward, after which the guess is updated; the method is similar to that used in Brinca et al. (2016b) and Krusell and Smith (1999).

Definition of the Fiscal Multiplier in the Context of a Fiscal Consolidation Shock

In the experiment with debt reduction financed by a reduction in G, we define the impact multiplier as:

$$\textit{impact multiplier } G = \frac{\Delta Y_0}{\Delta G_0} \tag{21}$$

where ΔY_0 is the change in output from period 0 to period 1 and ΔG_0 is the change in government spending from period 0 to period 1. The cumulative multiplier at time T is defined as:

$$\textit{cummulative multiplier } G(T) = \frac{\sum_{t=0}^{t=T} \left(\prod_{s=0}^{s=t} \frac{1}{(1+r_s)} \right) \Delta Y_t}{\sum_{t=0}^{t=T} \left(\prod_{s=0}^{s=t} \frac{1}{(1+r_s)} \right) \Delta G_t} \tag{22}$$

where ΔY_t is the change in output from period 0 to period t and ΔG_0 is the change in government spending from period 0 to period t When the consolidation is financed through an increase in the labor income tax, τ_l, we define the impact multiplier as:

$$\textit{impact multiplier } \tau_l = \frac{\Delta Y_0}{\Delta R_0} \tag{23}$$

where ΔY_0 is the change in output from period 0 to period 1 and ΔR_0 is the change in government revenue from period 0 to period 1. Government spending, G and lumpsum redistribution, g, are kept constant during this consolidation. For the tax-based consolidation we define the cumulative multiplier as:

$$\textit{cummulative multiplier } \tau_l(T) = \frac{\sum_{t=0}^{t=T}\left(\Pi_{s=0}^{s=t}\frac{1}{(1+r_s)}\right)\Delta Y_t}{\sum_{t=0}^{t=T}\left(\Pi_{s=0}^{s=t}\frac{1}{(1+r_s)}\right)\Delta R_t} \tag{24}$$

where ΔY_t is the change in output from period 0 to period t and ΔR_t is the change in government revenue from period 0 to period t.

5 Calibration

Our benchmark model is calibrated to match moments of the German economy. Germany is a natural choice as it is the largest economy in Europe. For the cross-country analysis in Section 7, calibration is performed using the same strategy and is described in the Appendix. Certain parameters can be calibrated outside the model using direct empirical counterparts. Tables 14 and 16 lists the parameters calibrated outside of the model. The remaining parameters, listed in Tables 4 (only Germany) and 15, are calibrated using a simulated method of moments (SMM) approach.

Wages

To estimate the life cycle profile of wages (see Equation (13)), we use data from the Luxembourg Income Study (LIS) and run the below regression for each country:

$$\ln(w_i) = \ln(w) + \gamma_1 j + \gamma_2 j^2 + \gamma_3 j^3 + \varepsilon_i, \tag{25}$$

where j is the age of individual i. The parameter for the variance of ability, σ_a, is assumed to be equal across countries and set equal to the average of σ_a for the European countries in Brinca et al. (2016b). Due to the lack of panel data on individual incomes for European economies, which we could use to estimate the persistence of the idiosyncratic shock ρ, we set it equal to the value used in Brinca et al. (2016b), who use U.S. data from the Panel Study of Income Dynamics (PSID). The variance of the idiosyncratic income risk σ_ϵ is then calibrated to make the model match the variance of log wages in the data.

Preferences and the Borrowing Limit

The value of the Frisch elasticity of labor supply, η, has been much debated in the literature. We set it to 1, which is similar to that used in a number of recent studies; see, e.g., Trabandt and Uhlig (2011) and Guner et al. (2016). The parameters χ, governing the disutility of working an additional hour, φ, governing the utility of leaving bequests, the discount factors β_1, β_2, β_3, and the borrowing limit, b, are calibrated so that the model output matches the data. 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, and 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. Lastly, in order to have a realistic age profile of wealth, we also match the mean wealth held by 75 to 80-year olds relative to mean wealth in the whole population, from LWS.[16].

Taxes and Social Security

As described in Section 11.1 we apply the labor income tax function in Equation (16), proposed by Benabou (2002). We use U.S. labor income tax data provided by the OECD to estimate the parameters θ_0 and θ_1 for different family types. To obtain a tax function for the single individual households in our model, we take a weighted average of θ_0 and θ_1, where the weights are each family type's share of the population.[17].

For Germany we estimate θ_0 and θ_1 to be 0.881 and 0.221 respectively. The employer social security rate on behalf is set to 0.206 and the employee social security rate to 0.21, taking the average tax rates between 2001 and 2007 from the OECD. Finally, consumption and capital tax rates are set to 0.233 and 0.155 respectively, following Trabandt and Uhlig (2011). The tax parameters for other countries is found in Table 14 in the Appendix

[16]Due to the small number of observations per cohort for most European countries, we match mean wealth held by 75 to 80-year olds in the US economy

[17]As we do not have detailed data for the population share of each family for European countries, we use U.S. family shares, as in Holter et al. (2017).

summarizes our findings for different countries.

Endogenously Calibrated Parameters

To calibrate the parameters that do not have any direct empirical counterparts, φ, β_1, β_2, β_3, b, χ and σ_ϵ, we use the simulated method of moments. We minimize the following loss function:

$$L(\varphi, \beta_1, \beta_2, \beta_3, b, \chi, \sigma_\epsilon) = ||M_m - M_d|| \tag{26}$$

where M_m and M_d are the moments in the data and in the model respectively.

Given that we have seven parameters, we need seven data moments to have an exactly identified system. The seven moments we target in the data are the ratio of the average net asset position of households in the age cohort 75 to 80 year old relative to the average asset holdings in the economy, three wealth quartiles, the variance of log wages and the capital to output ratio. All the targeted moments are calibrated with less than 2% of error margin, as displayed in Table 3. Table 4 presents the calibrated parameters. To illustrate that the model can also match some moments, not targeted in the calibration, Figure 4 compares the distribution of agents with negative wealth by age decile in the model and in the data for the German benchmark economy. Since the fraction of borrowing constrained agents in the economy is important for our mechanism, it is reassuring that the model does quite well at matching the fraction of agents with negative wealth by age.

Table 3: Calibration Fit

Data Moment	Description	Source	Data Value	Model Value
$\bar{a}_{75-80}/\bar{a}$	Mean wealth age 75-80 / mean wealth	LWS	1.51	1.51
K/Y	Capital-output ratio	PWT	3.013	3.013
$\text{Var}(\ln w)$	Variance of log wages	LIS	0.354	0.354
$\bar{n}$	Fraction of hours worked	OECD	0.189	0.189
Q_{25}, Q_{50}, Q_{75}	Wealth Quartiles	LWS	-0.004, 0.027, 0.179	-0.005, 0.026, 0.182

Table 4: Parameters Calibrated Endogenously

Parameter	Value	Description
Preferences		
φ	3.6	Bequest utility
$\beta_1, \beta_2, \beta_3$	0.952, 0.997, 0.952	Discount factors
χ	16.93	Disutility of work
Technology		
b	0.09	Borrowing limit
σ_ϵ	0.439	Variance of risk

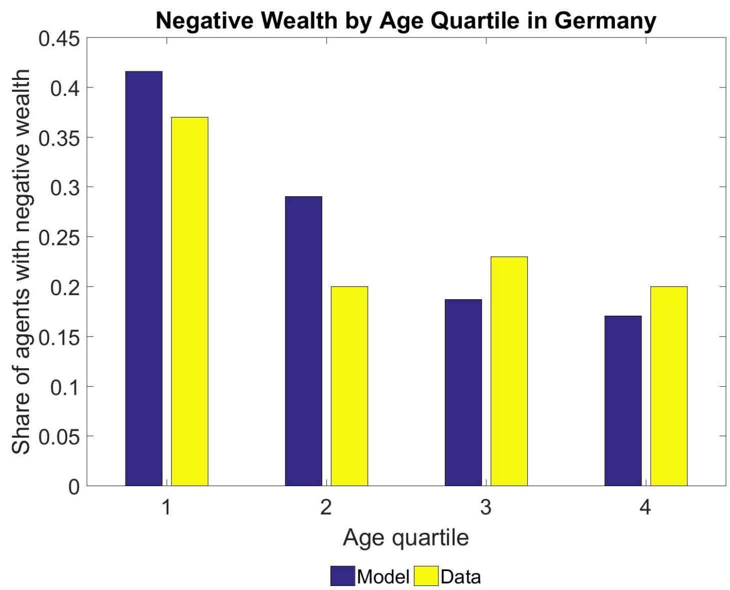

Figure 4: % of agents with negative wealth by age quartile in the model (blue bars) vs. empirical observations (yellow bars), in the benchmark economy Germany.

6 Income Inequality and Fiscal Consolidation

In Section 3 we documented a strong empirical relationship between income inequality and the recessive impact of fiscal consolidation programs. This finding motivates the study, in this section, of the impact of income inequality on fiscal consolidations in a structural model.

In the model, there are three sources of wage inequality: income risk, the permanent ability level and the age-profile of wages. We abstract from population growth and demographic differences across countries with respect to the relative sizes of each cohort[18]. There is an

[18] For studies of the effects of age structure on fiscal multipliers, see Basso and Rachedi (2017) and Antunes and Ercolani (2017a).

ongoing debate regarding whether income inequality is mainly due to differences between agents determined before the entry into the labor market or differences in the realization of income shocks during the life-course. Huggett et al. (2011) do for instance find that about 60% of the variance in lifetime earnings in the U.S. is due to initial conditions. This suggests that both initial conditions and market luck play an important role in generating the observed heterogeneity in the data.

In our structural model we find that there is a link between income inequality, due to income risk, and the recessive impacts of fiscal consolidations. For inequality due to differences in initial conditions (ability and the age-profile of wages in the model), this relationship is weak or non-existent.

To understand how the mechanism works, consider first the fiscal consolidation experiment where debt is reduced through a reduction in government spending, in the context of our model. The decrease in government debt will gradually shift households' savings to physical capital, driving the capital to labor ratio up. The marginal product of labor in future time periods increases and for households this generates a positive shock to expected life-time income, which causes a decrease in labor supply in the short run. This effect also leads to a drop in output in the short run. However, given that productive capital increases during the transition to a new steady state, the economy will converge to a higher level of output in the long run.

To understand the link between inequality and the initial drop in labor supply and output, note that the elasticity of labor supply to a shock to future income is smaller for credit constrained and low-wealth agents, see Figure 5. Constrained agents do not consider changes to their lifetime budget, only changes to their budget today. Agents with low wealth levels are also less responsive to future income changes because they will be constrained in several future states of the world. An economy with high income inequality, arising from idiosyncratic productivity risk, has a smaller percentage of constrained and low-wealth agents, due to precautionary savings behavior, and a higher aggregate elasticity of labor supply with respect to our fiscal experiment, which causes a positive shock to future income. Therefore, a fiscal consolidation will be more recessive on impact in economies with high income inequality due to risk. In contrast, the variance of initial ability or the steepness of the age-profile of wages will not affect the precautionary saving behavior of the agents, and changing the variance of ability changing the slope of the age-profile will have little or no impact on the number of credit constrained agents.

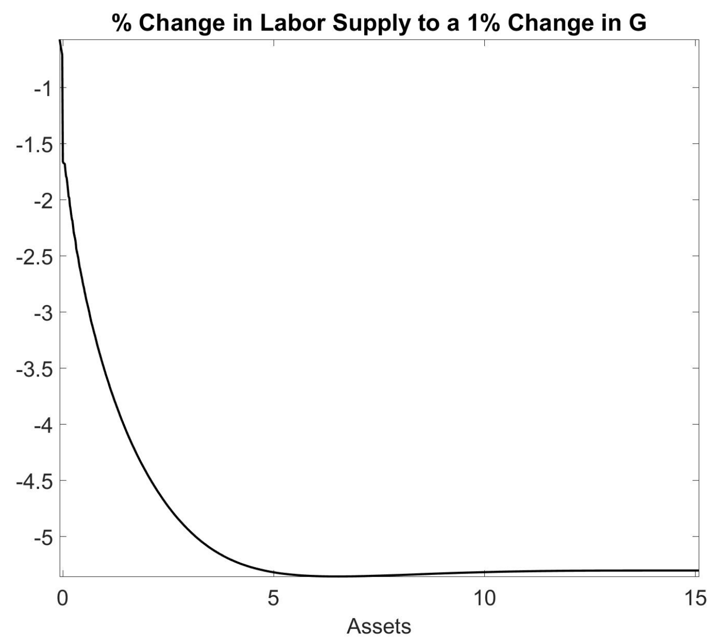

Figure 5: The labor supply response to a 1% change in G by asset level in the German benchmark economy.

In the case of consolidation through increased labor income taxes, the mechanism through which inequality matters is the same. There will be a negative income effect on labor supply today, through higher future wages and increased life-time income. For constrained agents, who do not consider their life-time budget but only their budget today, the tax would instead cause a drop in available income in the short-run, leading to a labor supply increase (the income effect would be positive). However, the tax also induces a negative substitution effect on wages today, both for constrained and unconstrained agents. It turns out that all agents decrease their labor supply, but the response is weaker for constrained and low-wealth agents, for which the short run income effect on labor supply is positive.

6.1 Illustrating the Mechanism: Comparing Fiscal Consolidation in Germany and the Czech Republic

To illustrate the impact of differences in inequality, we first compare the effects of consolidation in Germany and in the Czech Republic, two European countries on the opposite side of the spectrum in terms of wage inequality. Germany with the second highest variance of log wages, 0.354, and Czech Republic with the lowest value, 0.174. These two countries differ along several dimensions, but the reason why we choose Germany and Czech Republic is due to their differences in wage inequality, idiosyncratic risk and the percentage of constrained agents. In the Czech Republic the calibrated variance of the idiosyncratic risk is 0.145 and the percentage of constrained agents is 7.39%, while Germany has a higher variance of risk, 0.439, and a lower percentage of constrained agents, 3.41%. We find what our mechanism suggests that the output multiplier following the unanticipated fiscal consolidation shock is larger in Germany than in Czech Republic.

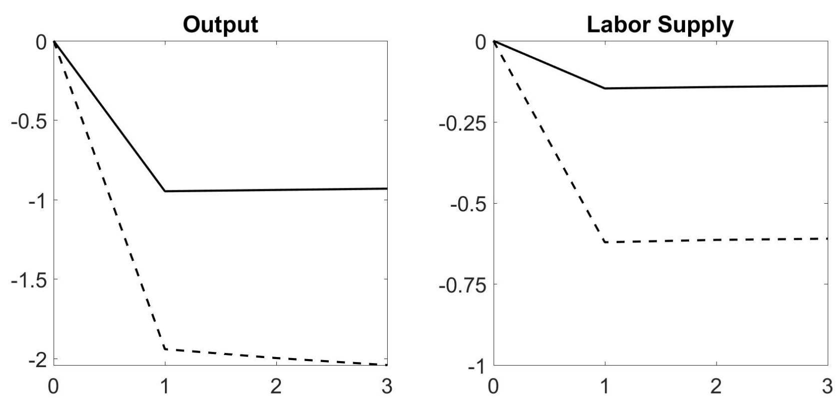

Figure 6: Labor tax consolidation: Output cumulative multiplier (left panel) and Labor Supply cumulative multiplier (right panel) in the first three periods in Germany (dashed line) and Czech Republic (solid line)

In Figures 6 and 7 we plot the cumulative output multiplier and labor supply response to labor tax and government spending consolidations respectively, for the two countries. Both the labor supply responses and the output multipliers are significantly larger in the German economy, where wage inequality is higher. As Germany has a smaller share of constrained and low-wealth agents, the output drop is more pronounced. One should also note that the consolidation through increased labor income taxes causes deeper recessions than the

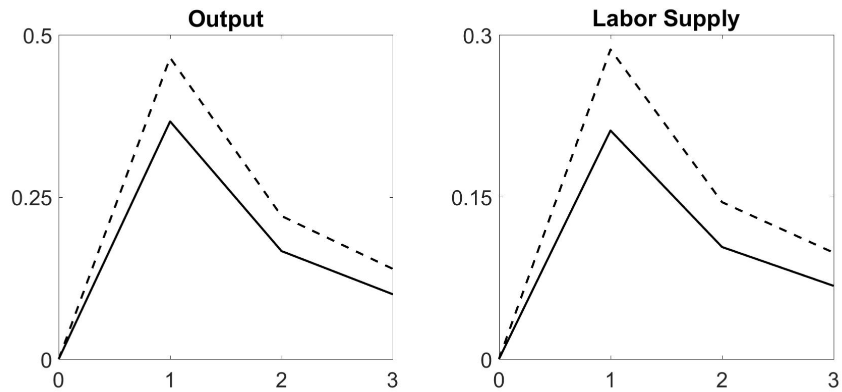

Figure 7: Government spending consolidation: Output cumulative multiplier (left panel) and Labor Supply cumulative multiplier (right panel) in the first three periods in Germany (dashed line) and Czech Republic (solid line)

consolidation financed by a reduction in government spending. This is consistent with the results by Alesina et al. (2017).

6.2 Inequality: Variance of Risk vs. Variance of Ability vs. Age Profiles

Next, we perform three experiments in our German benchmark economy to verify the mechanism described above. We focus on understanding the role of the different parameters that drive wage inequality in our model, σ_ϵ, σ_a, and γ_1, γ_2, γ_3. These parameters govern the variance of idiosyncratic wage shocks, the variance of permanent ability and the shape of the age-progile of wages. We find that the correlation between wage inequality and fiscal multipliers that we documented in the empirical section can only be explained by differences in idiosyncratic risk and not by predetermined differences in ability or in the age-profile of wages. We perform three different experiments:

1. We gradually change $Var(\ln w)$ from in the benchmark model by changing the variance of the innovations to the stochastic income process, σ_ϵ^2, from low to high.

2. We gradually change $Var(\ln w)$ in the benchmark model calibrated to Germany, by changing the variance of ability, σ_a^2, from low to high.

3. We gradually change $Var(\ln w)$ in the benchmark model calibrated to Germany, by multiplying the age-profile of wages, governed by γ_1, γ_2, γ_3, by a *Scalar*, going from low to high.

In all cases we adjust γ_0 by a constant to guarantee that average productivity in the economy stays unchanged. Then for each value of σ_u, σ_a and the *Scalar* we perform our two fiscal consolidation experiments: i) consolidation through government spending and ii) consolidation through the labor income tax.

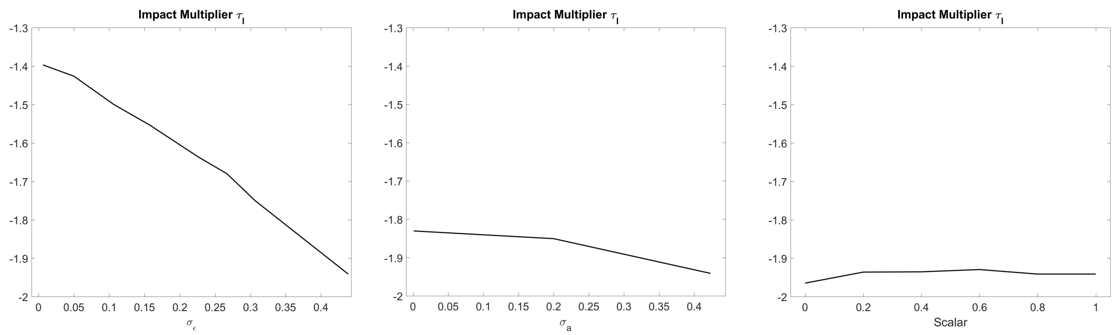

Figure 8: Impact multiplier for the labor tax consolidation in the benchmark model for Germany when changing the variance of risk (left panel), the variance of ability (middle panel), and the age profile of wages (right panel).

In Figure 8 we plot the impact multiplier in the experiment with fiscal consolidation through labor income taxes for different values of σ_ϵ, σ_a and the *Scalar*. In the left panel we observe that the fiscal multiplier is very sensitive to changes in income risk. When we change the variance of the innovations to the idiosyncratic shock, ϵ, from 0 to 0.45 the impact multiplier falls from about -1.40 to -1.95. In the middle and right panels we observe that it is relatively inelastic with respect to changes in ability and the steepness of the age-profile of wages[19].

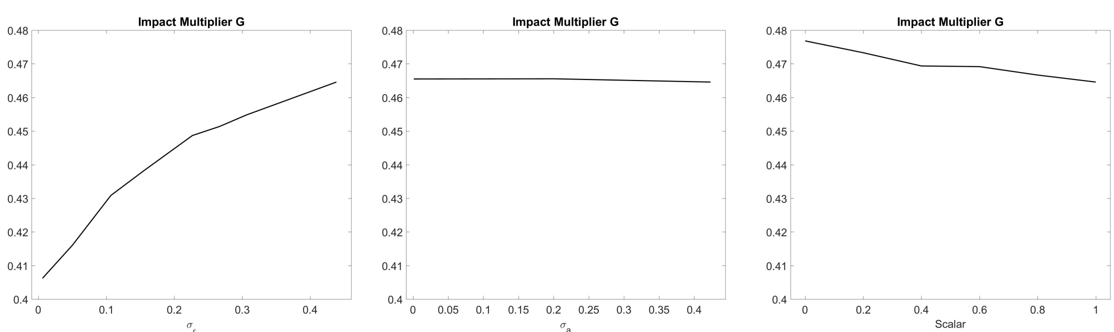

Figure 9: Impact multiplier for the consolidation through government spending in the German benchmark economy when changing the variance of risk (left panel), the variance of ability (middle panel), and the age profile of wages (right panel).

[19] Germany has one of the steepest age-profiles in our sample of countries. We therefore let the scalar go from 0 to 1, capture the effect of going from a steep age-profile to a completely flat age-profile.

The experiment with consolidation through government spending generates similar results. In the left panel of Figure 9, we observe that as we change the variance of the innovations to the idiosyncratic shock, governed by σ_ϵ, from 0 to 0.45 the impact multiplier increases from about 0.41 to 0.47. In the middle and the right panels of the figure we observe that the changes in the multiplier induced by changing the variance of ability and the steepness of the age-profile of wages are small. We conclude that only through changes in income risk can we generate a positive relationship between the impact of fiscal consolidation programs and income inequality.

The analysis in Figures 8 and 9 covers changes in risk that go from zero to the highest value obtained in our calibration of the model to 13 different European countries. In our calibration exercise, the lowest value of the variance of risk was obtained for Greece and equal to 0.12 and the highest was equal to 0.5, for France. One should note that the relative magnitude of changes in the multiplier induced by changing the risk is larger for tax-based than for spending-based consolidation. Going from the lowest to the highest level of risk, implies a 30% increase in the impact multiplier for the tax-based consolidation and an 8% increase in the impact multiplier for the spending-based consolidation. As mentioned before it is worth noting that the actual consolidations studied in Section 3 include both changes in taxes and spending.

In Figure 10 we verify our hypothesis about the relationship between income risk and the fiscal consolidation multipliers stemming from the fact that economies with higher income risk have a lower share of credit-constrained agents. In the left panel of the figure we document a strong, negative relationship between the variance of risk and the proportion of credit constrained agents in the economy. In the middle panel we see that changing the variance of ability does not affect the share of agents with liquidity constraints, as we anticipated. A steeper age-profile of wages leads to more liquidity-constrained agents (as one would expect[20]) but the effect is very weak compared to the impact of income risk.

[20]With a steeper age profile agents will save less early in the life-cycle.

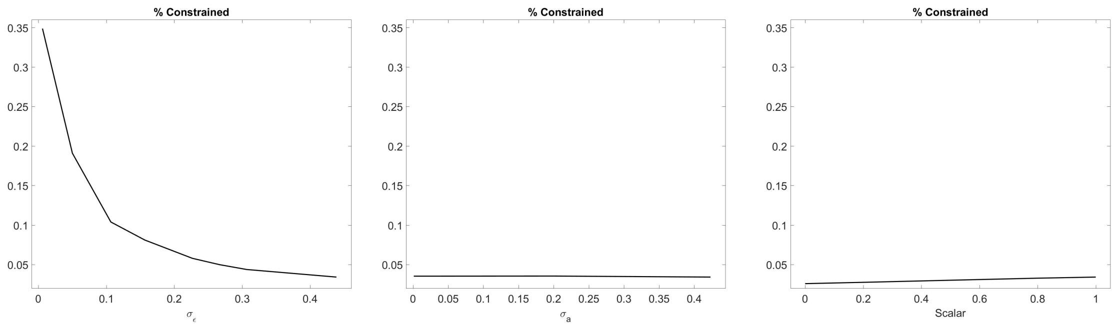

Figure 10: Share of credit-constrained agents in the German benchmark economy when changing the variance of risk (left panel), the variance of ability (middle panel), and the age profile of wages (right panel).

In Figure 11 we illustrate the relationship between the share of agents with liquidity constraints and the impact multiplier, for both spending-based and tax-based fiscal consolidation, as we change income risk. We observe that there is a strong negative relationship between the share of credit constrained agents and the fiscal consolidation multipliers.

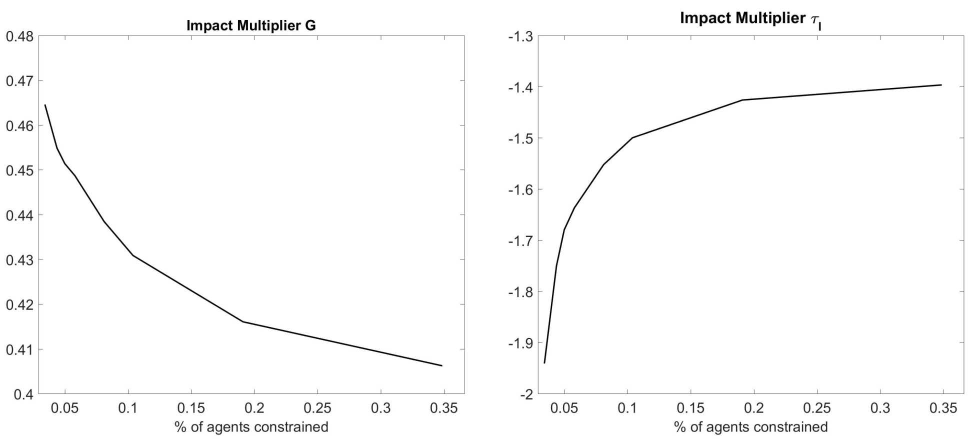

Figure 11: Impact multiplier for the G-consolidation (left panel) and for the τ_l-consolidation (right panel) plotted against the share of credit-constrained agents in the German benchmark economy, when decreasing the variance of risk.

Finally, as a last robustness test to verify that the relationship between inequality and fiscal multipliers comes from the variance of risk we conduct the following experiment: we keep wage inequality constant by choosing different combinations of risk and ability, going from one extreme, where all wage inequality (except from the age-profile) is due to the variance of risk, to the other extreme, where wage inequality is fully explained by variance of ability. Figure 16 in the Appendix shows that the multiplier is largest when all inequality is explained by income risk and smallest when all inequality is explained by the variance of ability, for both tax-based and expenditure-based consolidations.

7 Cross-country Analysis

In the previous Section we demonstrated that our model is able to reproduce the empirical relationship between income inequality and fiscal multipliers, through variation in income risk. In this Section we perform a cross-country analysis to show that this mechanism is strong enough to matter empirically. We calibrate our model to match a wide range of different country characteristics, where, in addition to the distributions of income and wealth, we match data on taxes, social security and government debt. We show that even when introducing substantial country heterogeneity, we are able to reproduce the cross-country relationship between both tax- and spending-based fiscal consolidation and income inequality.

The model is calibrated to 13 European countries[21] using country-specific age-profiles of wages, keeping the variance of the permanent ability fixed and changing the variance of the idiosyncratic shock to match the variance of log wages in the data. Tables 10 and 14 summarize the wealth distribution, the other country specific data used to calibrate the model, and the country specific parameters estimated outside of the model. Table 15 summarizes the country specific parameters estimated through the simulated method of moments, as described in Section 5. Parameters kept constant for all the countries, are summarized in Table 16.

Figure 12 reveals that our model is able to reproduce the cross-country empirical relationship between income inequality and the impacts of fiscal consolidation: countries with higher inequality experience larger output drops on impact, both for tax and spending based consolidations. These effects are large and economically meaningful, in particular for tax-based

[21] For this exercise we use only countries which actually went through fiscal consolidation processes after 2009. Compared to Blanchard and Leigh (2013), we are forced to exclude Belgium, Cyprus, Denmark, Ireland, Malta, Norway, Poland, Romania and Slovenia due to data limitations. The results in Section 3.1 are, however, robust to considering only these 13 countries. See Table 12 in Appendix.

consolidations. Using the coefficient found when regressing the multiplier on income inequality, we find that the response between the country with the lowest income inequality (Czech Republic) and the highest (France) leads to a 90% increase in the tax-based multiplier. One should also note that tax-based consolidations in general produce deeper recessions across countries than spending based consolidations.

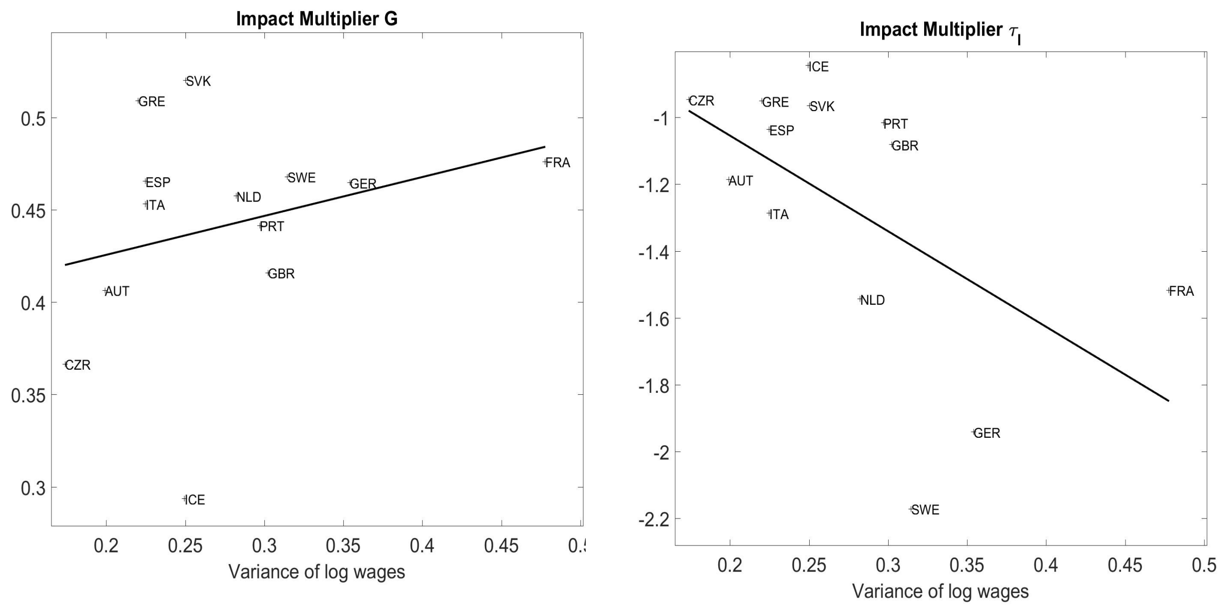

Figure 12: Impact multiplier and Var(ln(w)). On the left panel we have the cross-country data for a consolidation done by decreasing G (correlation coefficient 0.35 , p-val 0.25), while on the right panel we have the cross-country data for a consolidation done by increasing the labor tax (correlation coefficient -0.60 , p-val 0.03).

In the previous section we argued that the mechanism through which higher income risk translates into larger multipliers is through changes in the share of credit-constrained agents. In Figure 13 this relation is documented for the 13 economies for which we calibrate the model. Countries with a higher standard deviation of the innovations to idiosyncratic income risk, σ_ϵ, have a smaller share of constrained agents.

As argued before, the labor supply of constrained agents is less elastic with respect to the fiscal shock, and the larger the percentage of constrained agents the smaller the multiplier. In Figure 14 this relationship is documented for the cross country analysis. Countries with a larger share of liquidity constrained agents experience a smaller output drop for both spending- and tax-based consolidations.

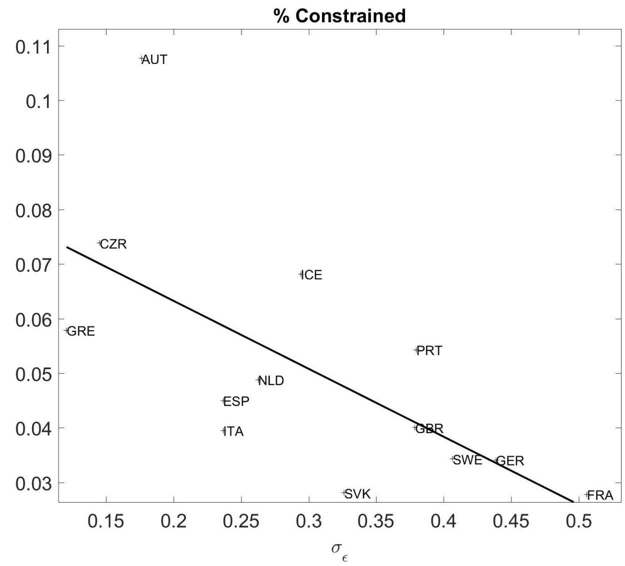

Figure 13: Percentage of agents constrained in the y-axis and variance of idiosyncratic risk on the x axis. Correlation coefficient of -0.73 and p-value of 0.00

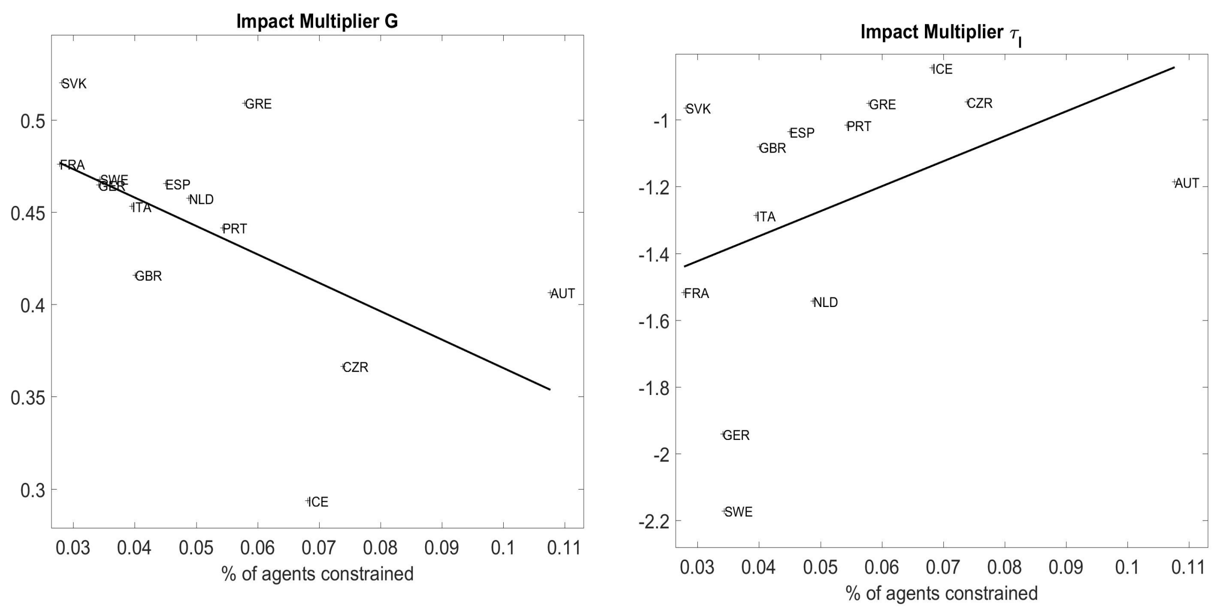

Figure 14: Impact multiplier and percentage of agents constrained. On the left panel we have the cross-country data for a consolidation done by decreasing G (correlation coefficient -0.68 , p-val 0.01), while on the right panel we have the cross-country data for a consolidation done by increasing the labor tax (correlation coefficient 0.55 , p-val 0.06)

8 Empirical Validation of the Mechanism

In Section 3 we established that income inequality amplifies the recessive effects of fiscal consolidations. In Section 6 we study a mechanism that leads to this amplification effect:

labor supply responds stronger in countries with higher income inequality, leading to a larger output drop.

In this section we present two pieces of empirical evidence that supports our mechanism. First, we use the fact that household debt and the share of credit-constrained agents are strongly correlated in our benchmark economy. If our mechanism is correct, the output drop in response to fiscal consolidations should be smaller in countries with higher household debt because they have more constrained agents. We expand the Blanchard and Leigh (2014) regression with an interaction term between household debt and the planned fiscal consolidation and find exactly this: household debt diminishes the recessive effects of fiscal consolidation. The larger the household debt, the smaller the forecast error.

Then, to test how income inequality affects the labor supply response to fiscal consolidation programs, we use the Alesina et al. (2015a) dataset but instead of considering GDP growth rates as our dependent variable, we use annual hours worked per capita. We find that for countries with higher income inequality, labor supply is more responsive to fiscal consolidation programs, just as our mechanism suggests.

8.1 Household Debt

Blanchard and Leigh (2014) test whether pre-crisis household debt was one of the dimensions the IMF did not take properly into consideration when forecasting the GDP growth rates. Like all the other variables they test, they find that debt does not affect the forecast error. However, our mechanism suggests that debt should have affected the recessive impacts of fiscal consolidation programs. Decreasing risk, induces less precautionary savings, which results in higher household debt and consequently in a higher share of credit-constrained agents, as can be seen in Figure 15. Higher household debt should, according to our model, translate into smaller multipliers.

To test whether household debt helps to explain the impacts of fiscal consolidation programs, besides extending Equation (1) with pre-crisis household debt, as already done by Blanchard and Leigh (2014), we also include an interaction term between planned fiscal

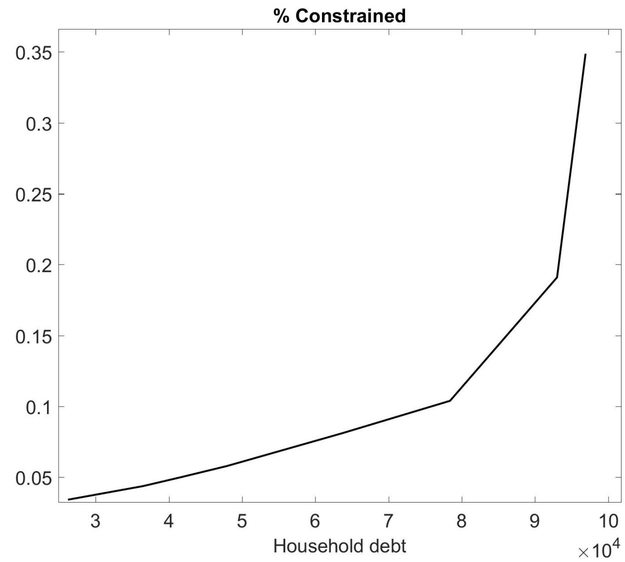

Figure 15: The fraction of liquidity constrained agents (y-axis) and household debt level (x-axis), when changing the level of idiosyncratic risk in the German benchmark economy.

consolidation and pre-crisis household debt. The equation that we estimate is:

$$\Delta Y_{i,t:t+1} - \hat{E}\{\Delta Y_{i,t:t+1}|\Omega_t\} = \alpha + \beta\hat{E}\{F_{i,t:t+1|t}|\Omega_t\} + \gamma HD_{i,t-1} + \iota((\hat{E}\{F_{i,t:t+1|t}|\Omega_t\})(HD_{i,t-1} - \mu_{HD})) + \epsilon_{i,t:t+1} \quad (27)$$

$HD_{i,t-1}$ is here pre-crisis household debt in country i, measured as total financial liabilities in percent of household disposable income. We use pre-crisis household debt so that it is exogenous to the fiscal shocks and to the output variation. Once again, we reparametrize the interaction term.

The results in Table 5 are consistent with our mechanism. The interaction term is positive and statistically significant. Moreover, the R^2 is substantially higher than in the specification without the interaction term, and the coefficient associated with the planned consolidation is more negative and statistically different from the specification without the interaction. This suggests that during the consolidations in the European countries in 2010 and 2011, higher pre-crisis household debt contributed to diminish the recessive effects of fiscal consolidation programs, just as our mechanism suggests. Increasing pre-crisis household debt by one standard deviation decreases the recessive impacts of fiscal consolidation by 52%.

Table 5: Blanchard and Leigh (2013) Regressions Augmented with Household Debt

Coefficients	(1) Blanchard-Leigh	(2) Blanchard-Leigh Pre-crisis household debt	(3) Pre-crisis household debt
Consolidation	-1.095***	-1.086***	-1.389***
	(0.255)	(0.262)	(0.117)
Household Debt		-0.001	-0.004
		(0.006)	(0.003)
Interaction			0.010***
			(0.001)
Constant	0.775*	0.887	1.422***
	(0.383)	(0.699)	(0.420)
Observations	26	25	25
R-squared	0.496	0.489	0.690

[a] *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.
[b] The table displays the results from augmenting the regression in Blanchard and Leigh (2013) with household debt and an interaction term between household debt and planned fiscal consolidation.

8.2 Labor Supply Responses to Fiscal Consolidation Programs

In the previous section we provide empirical evidence showing that the recessive impact of fiscal consolidation is decreasing in the percentage of constrained agents, just as our mechanism suggests. The only part of our mechanism still missing validation is how the labor supply response depends on income inequality. Remember that in our model, countries with higher income inequality have more elastic labor supply and therefore the multiplier is larger.

To investigate how the labor supply response depends on income inequality we use the Alesina et al. (2015a) dataset and hours worked per capita from OECD, from 2007 until 2012. We estimate the following equation:

$$H_{i,t} = \alpha + \beta_1 e^u_{i,t} + \beta_2 e^a_{i,t} + \gamma I_{i,t-1} + \iota_1 e^u_{i,t}(I_{i,t-1} - \mu_I) + \iota_2 e^a_{i,t}(I_{i,t-1} - \mu_I) + \delta_i + \omega_t + \epsilon_{i,t} \quad (28)$$

$H_{i,t}$ is normalized annual hours worked per capita[22] in country i in year t. The right-hand side of the equation is the same as in Equation (3). The results are presented in Table 6 and establish that labor supply is more responsive to fiscal consolidations in countries with higher

[22] We follow Brinca et al. (2016a) and express hours worked as a share of the working day and compute it by using OECD data and multiplying hours worked per employee by total employment, per capita, divided by 5200.

inequality, just as our mechanism suggests. Notice that, similar to the results in Section 3.2, it is the interaction with the unanticipated fiscal consolidations that is statistically significant. For a country with income inequality 1 percentage point above the sample mean, the drop in hours worked is larger by ι_1. Increasing the share of income in the top 10% over the share in the bottom 10% by one standard deviation causes hours worked to drop by 124% more than for a country with average inequality.

Table 6: Regressing Labor Supply on Data from Alesina et al. (2015a)

Coefficients	(1) Benchmark	(2) Y25/Y75	(3) Y20/Y80	(4) Y10/Y90	(5) Y5/Y95	(6) Y2/Y98	(7) Income Gini
β_1	-0.004***	-0.003**	-0.003*	-0.003**	-0.003***	-0.007***	-0.004**
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
β_2	-0.004***	-0.001	-0.002	-0.006***	-0.006***	-0.004**	0.000
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)
γ		0.319	0.191	0.100	0.026	0.023**	0.068
		(0.232)	(0.167)	(0.068)	(0.027)	(0.010)	(0.093)
ι_1		-0.116	-0.155	-0.134***	-0.045***	-0.014**	-0.029
		(0.123)	(0.103)	(0.045)	(0.015)	(0.006)	(0.040)
ι_2		-0.266	-0.161	0.091	0.044**	0.005	-0.114
		(0.206)	(0.171)	(0.070)	(0.020)	(0.006)	(0.068)
Constant	0.211***	0.188***	0.194***	0.196***	0.204***	0.204***	0.184***
	(0.001)	(0.016)	(0.014)	(0.010)	(0.007)	(0.003)	(0.036)
Observations	55	55	55	55	55	55	55
R-squared	0.502	0.582	0.577	0.601	0.618	0.563	0.567
Number of countries	11	11	11	11	11	11	11

[a] *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.
[b] The table displays the results from estimating the regression in Equation (28) on data from Alesina et al. (2015a) and measures of income inequality from the EU-SILC.
[c] Y25/Y75, Y20/Y80, Y10/Y90, Y5/Y95 and Y2/Y98 represent the share of income of the top 25%, 20%, 10%, 5% and 2% divided by the share of the bottom 25%, 20%, 10%, 5% and 2%.

9 Replication of Blanchard and Leigh (2013) with Model Data

In this Section we reproduce the empirical exercise in Section 3.1 using simulated data from our model. To replicate the empirical exercise we need to create the forecast for the output response to the fiscal shock. In Section 3.1 we follow Blanchard and Leigh (2013) and document that income inequality was one variable that the IMF failed to properly take into consideration when predicting the effects of fiscal consolidation programs. In Sections 6 and 7 we establish that only the stochastic component of the income process can explain this relationship between inequality and the effects of the fiscal consolidation. Therefore we let our forecasts consist of the model output response to the fiscal consolidation when shutting down the stochastic component of the income process. In other words, we assume that the IMF had a model that was similar to ours, except that it did not have idiosyncratic income risk[23]. We then assume that the actual output response is given by our benchmark model, which properly model income risk.

For each of the 13 economies considered here, we calibrate the consolidation accordingly, matching them with the data on planned fiscal consolidations used in Section 3.1. The data is reported in Table 13 in the Appendix.

Table 7: Blanchard and Leigh (2013) Regressions with Model Generated Forecast Errors for *G*-Consolidations

Coefficients	(1) Blanchard-Leigh	(2) Y25/Y75	(3) Y20/Y80	(4) Y10/Y90	(5) Y5/Y95	(6) Y2/Y98	(7) Income Gini
G consolidation	-0.610***	-0.634***	-0.654***	-0.747***	-0.879***	-0.844***	-0.623***
	(0.154)	(0.097)	(0.095)	(0.099)	(0.113)	(0.129)	(0.123)
Inequality		-0.064	-0.028	0.010	0.021	0.013	-0.097
		(0.155)	(0.110)	(0.049)	(0.027)	(0.019)	(0.081)
Interaction		-0.073	-0.072*	-0.068***	-0.063***	-0.040***	0.002
		(0.053)	(0.038)	(0.019)	(0.017)	(0.011)	(0.027)
Constant	-0.652*	-0.321	-0.447	-0.640	-0.772	-0.723	2.283
	(0.348)	(0.803)	(0.744)	(0.647)	(0.613)	(0.576)	(2.208)
Observations	13	13	13	13	13	13	13
R-squared	0.370	0.444	0.444	0.450	0.456	0.442	0.510

[a] *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.
[b] The table displays the results from running the regression in Equation (2), using model generated forecast errors for spending-based consolidations.
[c] Y25/Y75, Y20/Y80, Y10/Y90, Y5/Y95 and Y2/Y98 represent the share of income of the top 25%, 20%, 10%, 5% and 2% divided by the share of the bottom 25%, 20%, 10%, 5% and 2%.

The results from estimating Equation (2) for spending- and tax-based consolidation, using data from the model simulations, are presented in Tables 7 and 8 respectively.[24] Notice that, as in Table 1, the coefficients for the interaction between the different measures of income

[23]By assumption the IMF model had some income inequality modeled as variation in permanent abilities but it was similar for all countries.

[24]Both spending- and tax-based consolidations are presented in absolute values, so an increase in both variables translates into a stronger consolidation.

inequality and both types of consolidations indicate that the effects of fiscal consolidation are amplified by income inequality[25]. The results for both the spending-based and the tax-based consolidations are statistically significant. Regardless of only having 13 observations and not matching any measure of labor income inequality to calibrate the model, the results are remarkably similar to the empirical ones presented in Section 3.1.

Just as in the empirical exercise, the implications of abstracting from inequality are economically meaningful. A one standard deviation increase in income inequality leads to an underestimation of the multiplier by 35% and 52%, for spending- and tax-based consolidation respectively.

Table 8: Blanchard and Leigh (2013) Regressions with Model Generated Forecast Errors for τ_l-Consolidations

Coefficients	(1) Blanchard-Leigh	(2) Y25/Y75	(3) Y20/Y80	(4) Y10/Y90	(5) Y5/Y95	(6) Y2/Y98	(7) Income Gini
τ_l consolidation	-2.578	-2.321***	-2.662***	-4.134***	-5.987***	-5.603***	-2.475***
	(2.143)	(0.656)	(0.657)	(0.691)	(0.825)	(1.134)	(0.656)
Inequality		-2.144***	-1.500***	-0.549**	-0.189	-0.143	-0.880***
		(0.524)	(0.377)	(0.187)	(0.117)	(0.089)	(0.187)
Interaction		-0.006	-0.219	-0.563***	-0.635***	-0.407***	0.148
		(0.341)	(0.243)	(0.117)	(0.099)	(0.092)	(0.117)
Constant	-4.263**	5.694*	4.208	1.389	-0.422	-0.554	22.246***
	(1.508)	(2.621)	(2.443)	(2.173)	(2.065)	(1.989)	(5.478)
Observations	13	13	13	13	13	13	13
R-squared	0.129	0.657	0.649	0.646	0.634	0.599	0.784

[a] *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.
[b] The table displays the results from running the regression in Equation (2), using model generated forecast errors for tax-based consolidations.
[c] Y25/Y75, Y20/Y80, Y10/Y90, Y5/Y95 and Y2/Y98 represent the share of income of the top 25%, 20%, 10%, 5% and 2% divided by the share of the bottom 25%, 20%, 10%, 5% and 2%.

10 Conclusion

In this paper, we use three independent data sources and three different empirical approaches to document a positive relationship between income inequality and the recessive impacts of fiscal consolidation programs. Income inequality is an important factor to account for when quantifying the impacts of fiscal consolidation.

[25] The inequality measures reflect total income inequality, as in Section 3.1

To explain the amplification effect that income inequality has on the recessive impacts of fiscal consolidation programs, we develop a life-cycle, overlapping generations economy with uninsurable labor market risk. We calibrate the model to data from European economies and study the effects of fiscal consolidation programs, both financed through austerity and through taxation. We find that if cross-country differences in inequality is due to income risk, then the model can explain the relationship between inequality and consolidation. Differences in initial conditions, modeled as permanent ability and the life cycle profile of wages, cannot account for the cross-country variation in the impacts of fiscal consolidation we observe in the data.

The relationship between risk and the impact of consolidation arises because in countries with higher income risk, agents will have higher savings due to precautionary motives and thus there will be a smaller share of credit constrained and low-wealth agents. These agents have less elastic labor supply responses to expected life-time income shocks. A decrease in government debt leads to an increase of productive capital in the economy. The marginal product of labor (wages) in future time periods increases and this is equivalent to a permanent positive income shock, causing labor supply and output to fall in the short run. The response is, however, smaller in economies with more credit constrained agents. These agents respond only to current not to future income changes.

To show that the mechanism we propose is consistent with the data we conduct two exercises. First, making use of the positive correlation between household debt and credit-constrained agents, we establish that countries with higher household debt experience a smaller output drop during a fiscal consolidation. This is just as our mechanism suggests. Second, we show that labor supply is more responsive to unanticipated fiscal consolidations in countries with a higher income inequality, just as our model results suggest.

There are still many open questions regarding the fiscal policy transmission mechanisms. Nonetheless, we present evidence showing that income inequality is an important determinant of the impacts of fiscal consolidation programs.

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11 Appendix

11.1 Tax Function

[26] Given the tax function

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

which we employ, the average tax rate is defined as

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

and thus

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

and thus

$$\begin{aligned} 1 - \tau(y) &= \theta_0 y^{-\theta_1} \\ \tau(y) &= 1 - \theta_0 y^{-\theta_1} \\ T(y) &= \tau(y)y = y - \theta_0 y^{1-\theta_1} \\ T'(y) &= 1 - (1 - \theta_1)\theta_0 y^{-\theta_1} \end{aligned}$$

Thus the tax wedge for any two incomes (y_1, y_2) is given by

$$1 - \frac{1 - \tau(y_2)}{1 - \tau(y_1)} = 1 - \left(\frac{y_2}{y_1}\right)^{-\theta_1} \tag{29}$$

and therefore independent of the scaling parameter θ_0. Thus by construction one can raise average taxes by lowering θ_0 and not change the progressivity of the tax code, since (as

[26]This appendix is borrowed from Holter et al. (2017)

long as tax progressivity is defined by the tax wedges) the progressivity of the tax code[27] is uniquely determined by the parameter θ_1.

11.2 Definition of a Transition Equilibrium after the Unanticipated Fiscal Consolidation Shock

We define a recursive competitive equilibrium along the transition between steady states as follows:

Given the initial capital stock, 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 is 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. Given the factor prices and the initial conditions the consumers' optimization problem is solved by the value function $V(k, \beta, a, u, j)$ and the policy functions, $c(k, \beta, a, u, j)$, $k'(k, \beta, a, u, j)$, and $n(k, \beta, a, u, j)$.

2. Markets clear:

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

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

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

[27] Note that

$$1 - \tau(y) = \frac{1 - T'(y)}{1 - \theta_1} > 1 - T'(y)$$

and thus as long as $\theta_1 \in (0, 1)$ we have that

$$T'(y) > \tau(y)$$

and thus marginal tax rates are higher than average tax rates for all income levels.

3. The factor prices satisfy:

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

4. The government budget balances:

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

5. The social security system balances:

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

6. The assets of the dead are uniformly distributed among the living:

$$\Gamma_t \int \omega(j) d\Phi_t = \int (1-\omega(j))\, k_t d\Phi_t$$

7. Aggregate law of motion:

$$\Phi_{t+1} = \Upsilon_t(\Phi_t)$$

11.3 Description of Data used in Sections 3, 8, and 9

The data series used in Sections 3.1 and 3.2 for the inequality measures are from the European Union Statistics on Income and Living Conditions (EU-SILC). The EU-SILC is a survey aiming at collecting cross-sectional and longitudinal microdata on income, poverty, social exclusion and living-conditions. Data collected is based on a nationally representative probability sample of the population residing in private households within the country. Cross-sectional data series used is gross income - total monetary and non-monetary income received by the household before deduction of taxes.

The growth forecast error and planned fiscal consolidation series are taken from Blanchard and Leigh (2014), who use data from the IMF's WEO database. The forecasts used were made for the European Economies in early 2010. The growth forecast error consist on the difference between actual cumulative growth in 2010-11 and the IMF forecast prepared for the April 2010 WEO. The planned fiscal consolidation is the IMF forecast of the cumulative changes of structural fiscal balance as percent of potential GDP, also prepared for the April 2010 WEO. The household debt variable used in Section 6 also comes from Blanchard and Leigh (2014), who take it from the dataset of the April 2012 WEO chapter on household debt. Household debt consists on total financial liabilities in percent of household disposable income.

The data series used in Section 3.3 are taken from Ilzetzki et al. (2013). The data series consist of quarterly observations (not interpolated) on real government consumption, GDP, the ratio of current account to GDP, and the real effective exchange rate for 44 countries, roughly balanced between developed and developing economies (see Table 9 for the list of included countries). Nominal series are deflated using a GDP deflator when available (and CPI when not). Consumption, GDP, and exchange rate variables are transformed by taking natural logarithms. These series are de-seasonalized and analyzed as deviations from their quadratic trend given they exhibit strong seasonality and are non-stationary. Data in Table 9 comes from the World Bank's World Development Indicators for the years of 2009 for Botswana and Malaysia, 2010 for Australia, Canada and Israel, 2011 for Germany and South Africa, 2012 for Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Mexico, Netherlands, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden and United Kingdom, and 2013 for all the other countries.

Table 9: Income Inequality measures for 44 Selected Countries

Country	Income Gini	Y20/Y80	Y10/Y90
Argentina	0.42	9.8	19.1
Australia	0.35	5.9	10.2
Belgium	0.28	4.2	6.7
Botswana	0.61	23.1	45.0
Brazil	0.53	17.4	41.8
Bulgaria	0.36	6.9	13.7
Canada	0.34	5.8	9.5
Chile	0.51	12.3	24.4
Colombia	0.54	17.1	38.1
Croatia	0.33	5.7	9.6
Czech Republic	0.26	3.8	5.7
Denmark	0.29	4.4	8.4
Ecuador	0.47	11.5	22.8
El Salvador	0.43	9.1	16.4
Estonia	0.33	5.7	10.1
Finland	0.28	3.9	5.7
France	0.33	5.3	8.6
Germany	0.30	4.6	7.0
Greece	0.37	7.6	15.7
Hungary	0.31	4.9	8.0
Iceland	0.27	4.0	6.0
Ireland	0.33	5.3	8.3
Israel	0.43	10.3	18.4
Italy	0.35	6.7	13.8
Latvia	0.36	6.7	12.1
Lithuania	0.35	6.5	11.7
Malaysia	0.46	11.2	19.2
Mexico	0.48	11.0	20.5
Netherlands	0.28	4.2	6.6
Norway	0.26	3.8	5.8
Peru	0.45	11.3	22.3
Poland	0.33	5.2	7.8
Portugal	0.36	6.6	12.6
Romania	0.28	4.1	6.0
Slovakia	0.26	4.1	6.6
Slovenia	0.26	3.7	5.7
South Africa	0.63	27.6	57.0
Spain	0.36	7.2	15.2
Sweden	0.27	4.2	6.7
Thailand	0.38	6.5	10.1
Turkey	0.40	8.0	13.9
United Kingdom	0.33	5.4	8.5
United States	0.41	9.1	17.8
Uruguay	0.42	9.3	16.3
Sample median	0.35	6.5	10.9

11.4 Eurosystem Household Finance and Consumption Survey - Summary Wealth Statistics

Table 10 presents the cumulative wealth distributions for the countries in the Eurosystem Household Finance and Consumption Survey. We include four additional countries' wealth distributions, from the Luxembourg Wealth Study's compilation of various household wealth surveys.

Table 10: Cumulative Distribution of Net Wealth

	25%	50%	75%
HFCS sample[a]			
Austria	-1.0	2.2	18.6
France	0.1	5.4	26.2
Germany	-0.4	2.7	17.9
Greece	1.1	12.5	36.7
Italy	0.9	10.2	32.4
Netherlands	-2.5	5.0	30.3
Portugal	0.6	8.2	26.6
Slovakia	5.5	20.7	45.0
Spain	1.7	12.9	34.2
Other sources[b]			
Czech Republic[c]	0.4	6.1	22.1
Iceland	0.5	7.7	27.6
Sweden	-9.9	-7.8	11.5
UK	-0.7	5.4	27.0

[a] Cumulative distribution of net wealth (survey variable designation: *DN3001*) for a selection of countries from the first wave of the ECB's HFCS.
[b] Sourced from Luxembourg Wealth Study's most recent entry for each respective country (survey variable designation: *nw1*).
[c] Sourced from the Stierli et al. (2014). We use 2009 data provided by the authors.

11.5 Additional Figures and Tables

Table 11: Blanchard and Leigh (2013) Regressions with GDP as the Dependent Variable

Coefficients	Blanchard-Leigh	Y25/Y75	Y20/Y80	Y10/Y90	Y5/Y95	Y2/Y98	Income Gini
β	-1.556***	-1.116**	-1.078**	-0.901**	-0.901**	-1.026***	-1.696***
	(0.467)	(0.441)	(0.436)	(0.379)	(0.339)	(0.339)	(0.406)
γ		-0.402	-0.302	-0.170	-0.039	0.019	0.286
		(0.578)	(0.444)	(0.191)	(0.053)	(0.050)	(0.169)
ι		-0.405	-0.365	-0.229*	-0.116***	-0.098**	-0.000
		(0.388)	(0.304)	(0.113)	(0.036)	(0.035)	(0.115)
Constant	3.763***	6.545*	6.335*	6.264**	4.938***	3.612***	-6.990
	(0.576)	(3.760)	(3.493)	(2.578)	(1.302)	(1.057)	(6.402)
Observations	26	26	26	26	26	26	26
R-squared	0.465	0.533	0.544	0.607	0.634	0.587	0.542

[a] *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.
[b] The table displays the results from estimating the regression in (1) with GDP as the dependent variable.
[c] Y25/Y75, Y20/Y80, Y10/Y90, Y5/Y95 and Y2/Y98 represent the share of income of the top 25%, 20%, 10%, 5% and 2% divided by the share of the bottom 25%, 20%, 10%, 5% and 2%.

Table 12: Blanchard and Leigh (2013) Regressions for the Countries in Section 7

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coefficients	Blanchard-Leigh	Y25/Y75	Y20/Y80	Y10/Y90	Y5/Y95	Y2/Y98	Income Gini
β	-1.430***	-1.161***	-1.170***	-1.204***	-1.286***	-1.259***	-1.378***
	(0.182)	(0.131)	(0.134)	(0.172)	(0.164)	(0.176)	(0.204)
γ		-0.490	-0.303	-0.033	0.031	0.048	0.365**
		(0.750)	(0.534)	(0.165)	(0.034)	(0.046)	(0.120)
ι		-0.122	-0.119	-0.073	-0.039*	-0.040**	-0.053
		(0.187)	(0.134)	(0.047)	(0.017)	(0.017)	(0.063)
Constant	1.207*	4.304	3.553	1.712	0.616	0.228	-12.831**
	(0.567)	(5.167)	(4.552)	(2.709)	(1.233)	(0.840)	(4.458)
Observations	13	13	13	13	13	13	13
R-squared	0.715	0.755	0.750	0.736	0.736	0.748	0.919

[a] *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.
[b] The table displays the results from estimating the regression in (1) just for the countries in Section 7. These are the countries for which we have enough data to calibrate the model.
[c] Y25/Y75, Y20/Y80, Y10/Y90, Y5/Y95 and Y2/Y98 represent the share of income of the top 25%, 20%, 10%, 5% and 2% divided by the share of the bottom 25%, 20%, 10%, 5% and 2%.

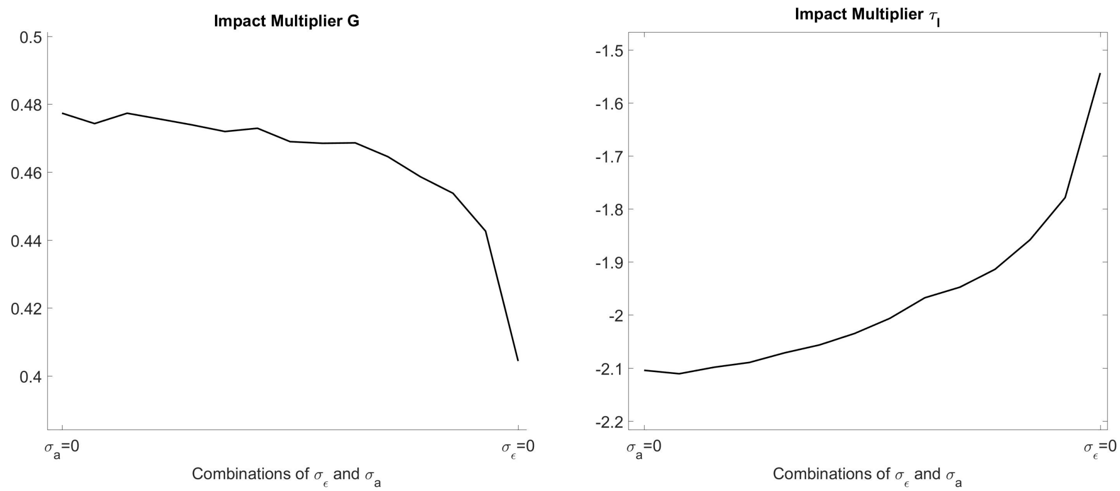

Figure 16: Impact multiplier for the G-consolidation (left panel) and for the τ_l-consolidation (right panel) for different combinations of variance of ability and risk on the x-axis, keeping variance of log wages constant. The variance of ability is increasing from left to right. When the variance of ability is zero, all inequality is due to risk, which is calibrated to keep the variance of log wages at the benchmark value. When the variance of risk is zero, all inequality is due to the variance of ability, which is calibrated to match the variance of log wages.

Table 13: Actual Fiscal Consolidation for Selected Countries.

Country	Actual Consolidation
Austria	1.0
Czech Republic	2.1
France	1.2
Germany	0.3
Greece	10.3
Iceland	4.0
Italy	0.2
Netherlands	0.1
Portugal	2.7
Spain	1.5
Slovakia	2.0
Sweden	0.9
UK	3.0

The Table displays actual fiscal consolidations undertaken during the years 2010-2011. Positive values represent a consolidation. All values are in percentage of GDP.

Table 14: Country-specific Calibration Targets

	Macro ratios		Labor targets		Income profile parameters	Taxes			
	K/Y	B/Y	$\bar{n}$	Var$(\ln w)$	$\gamma_1, \gamma_2, \gamma_3$	θ_1, θ_2	$\tilde{\tau}_{ss}, \tau_{ss}$	τ_c	τ_k
Austria	3.359	0.432	0.226	0.199	0.155, -0.004, 3.0E-05	0.939, 0.187	0.217, 0.181	0.196	0.240
Czech Republic	6.203	0.206	0.236	0.174	0.174, -0.004, 3.0E-05	0.988, 0.143	0.350, 0.125	0.182	0.220
France	3.392	0.559	0.184	0.478	0.384, -0.008, 6.0E-05	0.915, 0.142	0.434, 0.135	0.183	0.355
Germany	3.013	0.489	0.189	0.354	0.176, -0.003, 2.3E-05	0.881, 0.221	0.206, 0.210	0.155	0.233
Greece	3.262	1.038	0.230	0.220	0.120, -0.002, 1.3E-05	1.062, 0.201	0.280, 0.160	0.154	0.160
Iceland	4.334	0.213	0.308	0.249	0.161, -0.003, 1.9E-05	0.868, 0.204	0.055, 0.000	0.253	0.200
Italy	3.943	0.893	0.200	0.225	0.114, -0.002, 1.4E-05	0.897, 0.180	0.329, 0.092	0.145	0.340
Netherlands	2.830	0.232	0.200	0.282	0.307, -0.007, 4.9E-05	0.938, 0.254	0.102, 0.200	0.194	0.293
Portugal	3.229	0.557	0.249	0.298	0.172, -0.004, 2.6E-05	0.937, 0.136	0.238, 0.110	0.208	0.234
Spain	3.378	0.368	0.183	0.225	0.114, -0.002, 1.4E-05	0.904, 0.148	0.305, 0.064	0.144	0.296
Slovakia	3.799	0.317	0.204	0.250	0.096, -0.002, 1.7E-05	0.974, 0.105	0.326, 0.131	0.181	0.151
Sweden	2.155	-0.034	0.233	0.315	-0.021, 0.001, -1.2E-05	0.796, 0.223	0.326, 0.070	0.255	0.409
UK	2.315	0.371	0.231	0.302	0.183, -0.004, 2.2E-05	0.920, 0.200	0.105, 0.090	0.163	0.456

[1] Macro ratios: K/Y is derived from Penn World Table 8.0, average from 1990-2011; B/Y is the average of net public debt from 2001-8 (IMF)

[2] Labor targets: $\bar{n}$ is hours worked per capita derived from OECD data, average from 1990-2011; Var$(\ln w)$ and $\gamma_1, \gamma_2, \gamma_3$ are from the most recent LIS survey available before 2008. Data from Portugal comes from Quadros de Pessoal 2009 database.

[3] Taxes: θ_1, θ_2 are as discussed in Section 11.1; $\tilde{\tau}_{ss}, \tau_{ss}$ are the average social security withholdings faced by the average earner (OECD) from 2001-7; τ_k and τ_c are either taken from Trabandt and Uhlig (2011) or calculated using their approach, representing average effective tax rates from 95-07. τ_k for Iceland comes from the Iceland Ministry of Industries and Innovation.

Table 15: Country-specific Paramater Values
Estimated by SMM

Country	β_1	β_2	β_3	χ	b	σ_u	φ
Austria	0.959	1.003	0.964	14.40	0.00	0.176	4.30
Czech Republic	0.999	1.041	0.996	21.00	0.00	0.145	11.70
France	0.957	1.013	0.990	18.03	0.25	0.506	3.24
Germany	0.952	0.997	0.952	16.93	0.09	0.439	3.60
Greece	0.989	0.997	0.969	16.50	0.00	0.121	3.70
Iceland	0.962	0.996	0.962	7.53	0.08	0.294	9.60
Italy	0.992	1.016	0.984	20.30	0.00	0.237	6.00
Netherlands	0.942	0.986	0.973	14.75	0.15	0.263	2.98
Portugal	0.960	0.991	0.960	11.50	0.00	0.380	5.20
Spain	0.970	0.997	0.983	24.47	0.00	0.237	5.00
Slovakia	0.984	0.993	0.984	20.40	0.00	0.326	7.20
Sweden	0.917	0.971	0.944	9.40	0.33	0.407	2.20
UK	0.939	0.968	0.939	12.40	0.10	0.379	4.90

Table 16: Parameters Held Constant across Countries

Parameter	Value	Description	Source
Preferences			
η	1	Inverse Frisch Elasticity	Trabandt and Uhlig (2011)
σ	1.2	Risk aversion parameter	Literature
Technology			
α	0.33	Capital share of output	Literature
δ	0.06	Capital depreciation rate	Literature
ρ	0.335	$u' = \rho u + \epsilon, \quad \epsilon \sim N(0, \sigma_\epsilon^2)$	PSID 1968-1997
σ_a	0.423	Variance of ability	European economies average from Brinca et al (2016)