Essays on the Great Recession and the Austerity

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Abstract

This thesis is devoted to the study of two of the most important macroeconomic events from recent times: the Great Recession of 2008-09, and Austerity in 2010-13. We argue that both phenomena have been primarily demand-driven, with the former taking the form of a synchronized self-fulfilling panic, and recessions in several advanced countries during the latter being driven by the increased desire of households to save due to cuts in welfare state spending.

In Chapter 1, *"The Great Recession: Divide between Integrated and Less Integrated Countries"* (joint with Eric van Wincoop and Gang Zhang), we confirm previous evidence about the absence of a monotonic relationship between the decline in growth of countries during the Great Recession and their level of trade or financial integration, but document instead a strong discontinuous relationship. Countries whose level of economic integration (trade and finance) was above a certain cutoff saw a much larger drop in growth than less integrated countries, a finding that is robust to a wide variety of controls. We argue that standard models based on transmission of exogenous shocks across countries cannot explain these facts. Instead, we explain the evidence in the context of a multi-country model with business cycle panics that are endogenously coordinated across countries.

In Chapter 2, *"A Welfare State-based Fiscal Multiplier"*, we argue that current new-Keynesian theory cannot explain empirical evidence of larger-than-normal fiscal multipliers during the 2010-13 period if the combination of countries committing to a sizable reduction of public debt and low output growth expectations led agents to believe that austerity measures were permanent. Instead, we explain the evidence in the context of a new-Keynesian model with incomplete markets and heterogeneous households, where the reduced level of public insurance implied by a permanent cut of welfare spending increases incentives to save for precautionary reasons, thus leading to a Paradox-of-Thrift type of recession. Consistent with this view, we find empirically that the welfare state spending multiplier was significantly larger than the non-welfare and tax multipliers for advanced countries engaging in fiscal adjustments over this time period.

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To Beltran and Paloma

Chapter 1

The Great Recession: Divide between Integrated and Less Integrated Countries[1] *(with Eric van Wincoop and Gang Zhang)*

1.1 Introduction

There are two important features of business cycle synchronization across countries during the 2008-2009 Great Recession. The first is that synchronicity during this period was unparalleled historically. Perri and Quadrini (2014) show that business cycle correlations were much higher among industrialized countries during this period than any earlier time since 1965.[2] Remarkably, even though the origin of the recession is widely associated with the United States, the decline in GDP, investment, consumption and corporate profits were of a very similar magnitude in the rest of the world as in the United States.[3] The decline was also similar in emerging economies as in industrialized countries, and was of a similar magnitude in Europe, the US and Asia.[4]

[1]This chapter has been published as: Hausmann-Guil, Guillermo, Eric van Wincoop, and Gang Zhang. "The great recession: Divide between integrated and less integrated countries." IMF Economic Review 64.1 (2016): 134-176.

[2]See also Imbs(2010) and International Monetary Fund (2013).

[3]See Bacchetta and van Wincoop (2014).

[4]We are interested here in the unusual and sudden increase in synchronicity of business cycles during the Great Recession as opposed to trends in synchronicity over time. Regarding the latter, Bordo and Helbling (2011) find that there has been a trend towards increased integration during most of the twentieth century, while Hirata, Kose and Otrok (2014) find that over the past 25 years the global component of business cycles has declined relative to local components (region and country-specific).

A second feature relates to the link between business cycle synchronization and economic integration. There is an existing empirical literature that finds no robust relationship between measures of trade and financial integration on the one hand and the decline in growth during the Great Recession on the other hand.[5] In this paper we confirm the absence of a robust monotonic relationship between business cycle synchronization and measures of trade and financial integration. However, we find that integration does matter beyond some threshold. When integration is sufficiently low, below a particular threshold, countries are considerably less impacted by the Great Recession. This finding is robust to introducing a wide variety of controls, different measures of crisis performance, and different subsets of countries. It holds for both trade and financial integration separately as well as for a combined index of trade and financial integration.

The paper develops a theory that accounts for these two features of business cycle synchronization during the Great Recession. It is useful to start though by pointing out that the evidence goes against most existing theories of business cycles in open economy models. In most models synchronicity occurs either because of a common shock that affects all countries or because an exogenous fundamental shock is transmitted across countries through trade and financial linkages. Regarding the former, shocks that are typically attributed to this period apply to the housing market and financial markets. Those shocks, however, originated largely in the United States rather than being common across countries. Regarding transmission of shocks, it is well known that this depends on the nature of the shocks and even perfect integration does not need to imply perfect business cycle synchronization.[6] Even when a model implies that higher trade or financial integration leads to higher business cycle synchronization, transmission of shocks across countries is significantly limited by home bias in both goods and financial markets.[7]

The theory we develop to explain the two features of business cycle synchronization during the Great Recession is based on an extension of Bacchetta and van Wincoop (2014), from here on BvW. BvW explain the Great Recession as the result of a self-fulfilling expectations shock as opposed to an exogenous shock to fundamentals. When agents believe that income will be lower in the future, they reduce

[5]Among many others, see Rose and Spiegel (2010,2011), Kamin and Pounder (2012), Kalemli-Ozcan et al.(2013) and International Monetary Fund (2013). Cecchetti, King and Yetman (2013) contain an overview of all the relevant studies.

[6]For example, a standard open economy real business cycle model with perfect integration of goods and financial markets, such as Backus, Kehoe and Kydland (1992), implies that output is negatively correlated across countries.

[7]As an example of this, van Wincoop (2013) shows that under realistic financial home bias, transmission across countries of balance sheets shocks experienced by leveraged institutions is limited.

current consumption, which reduces current output and firm profits. This in turn reduces investment and therefore future output, making beliefs self-fulfilling. However, the novel aspect of BvW is not the idea of self-fulfilling expectations shocks to explain business cycles. There are many such models.[8] The novel aspect is to show that in an open economy context such self-fulfilling beliefs are necessarily coordinated across countries beyond a certain threshold of integration. This coordination occurs because their interconnectedness makes it impossible for one country to have very pessimistic beliefs about the future, while the other country has very optimistic beliefs. BvW show that partial integration is therefore sufficient to generate a perfectly synchronized decline in output across countries.

However, the model in BvW does not address the second feature of business cycle synchronization, the non-linear relationship between economic integration and business cycle synchronization seen during the Great Recession. The model consists of only two countries, so that it cannot study cross-sectional variation in the degree of economic integration. Moreover, BvW only consider trade integration and abstract from financial integration. We therefore develop a model that extends the framework of BvW to analyze the case where there is a continuum of countries, with the extent of both trade and financial integration varying across countries.

The model is able to generate equilibria that are consistent with the empirical evidence. We find that a global panic will involve all countries whose level of integration is above a certain level, while in general at most a subset of the remaining less integrated countries will panic. The relationship between integration and business cycles is therefore discontinuous as in the data. Within these two groups of countries there is no relationship between their level of integration and the drop in their output, confirming that there is no monotonic relationship between integration and output during a global panic. We also find that trade and financial integration are substitutes in the threshold level of integration, which is confirmed as well by the evidence. Finally, in an extension with country-specific productivity shocks we can explain why not all integrated countries performed worse than less integrated countries. Such differences in performance due to country-specific shocks are unrelated to levels of integration.

Two other papers have looked at self-fulfilling beliefs in an open economy framework. Bacchetta and van Wincoop (2013) develop a two country model with self-fulfilling shifts in perceived asset price risk. Perri and Quadrini (2014) consider

[8]These are generally closed economy models. Examples include Aruoba and Schorfheide (2013), Bacchetta et.al (2012), Benhabib et al. (2016), Farmer (2012a,b), Heathcote and Perri (2015), Liu and Wang (2014), Mertens and Ravn (2014), Schmitt-Grohe and Uribe (2012) and Schmitt-Grohe(1997).

self-fulfilling credit shocks in a two-country setup. If the resale price of assets of firms is low, collateral is weak and it is harder to borrow. This makes it more difficult for other firms to purchase the assets of defaulting firms, which indeed leads to a low resale value of their assets. These papers differ from the framework considered here in several ways. First, these papers do not highlight the coordination of self-fulfilling beliefs under partial integration. In Perri and Quadrini (2014) there is perfect business cycle synchronization, but this is a result of perfect financial and goods market integration and occurs also with exogenous credit shocks. In Bacchetta and van Wincoop (2013), risk panics are generally not synchronized across countries under either partial or perfect integration. Second, these papers have two country models and therefore cannot consider the role of heterogeneity in financial integration in accounting for the different growth performance across countries during the Great Recession. Finally, the nature of self-fulfilling beliefs is quite different in this paper and is unrelated to asset prices or asset price risk.

Another related literature is that of complex financial networks. Some papers in this literature have shown that with limited financial interconnectedness there can be a tipping point where shocks are spread across the entire network of financial institutions.[9] But these tipping points refer to a general level of interconnectedness rather than the cross-sectional variation in interconnectedness that we will consider here. Moreover, it is much harder to tell such network stories based on a standard business cycle model with firms and households.[10]

The remainder of the paper is organized as follows. Section 2 discusses the empirical evidence on the relationship between output growth during the Great Recession and the extent of trade and financial integration. Section 3 describes the model and Section 4 analyzes the equilibria. Section 5 concludes.

1.2 Empirical Evidence

We collect data for a sample of 151 countries, based on data availability. The precise sample of countries is tabulated in Table 1.[11] Our main data sources are the

[9] See for example Gai et.al. (2011) or Nier et.al. (2007).

[10] While one can easily imagine a financial institution being a critical node in a broader network, it is much harder to argue so for an individual household or firm, particularly on a global scale.

[11] We also had data available for Armenia, Equatorial Guinea and Luxembourg, but we decided to exclude these countries from all our regressions. We excluded Armenia because, in addition to being one of the most affected countries by the crisis, it is more integrated than what our measures of economic integration reflect due to remittances. We excluded Equatorial Guinea for overall problems with data quality (see Lane and Milesi-Ferretti (2011)), and Luxembourg because of its extreme value for financial openness, which is well known to be associated with measurement error. Including these three countries does not substantially change our main results, though.

April 2014 World Economic Outlook (WEO) Database, and the World Development Indicators (WDI) from the World Bank Database. In addition, we get data on financial variables from the "External Wealth of Nations" dataset, constructed by Lane and Milesi-Ferretti (2007), data on the exchange rate regime from the "Shambaugh exchange rate classification" dataset, and data on the manufacturing share of GDP from the United Nations Database. Table 2 shows some descriptive statistics, together with the specific data source of each variable.

The set of countries and variables used in the regressions is similar to Lane and Milesi-Ferretti (2011). In particular, we use their same measures of integration, namely trade openness (defined as imports plus exports divided by GDP) and financial openness (defined as external assets plus external liabilities divided by GDP), both in percentage terms. We deviate from them, though, by choosing the forecast errors (the actual 2009 GDP growth rate minus the April 2008 WEO pre-crisis forecast) as our preferred measure of crisis performance. This measure, first proposed by Berkmen et al. (2012), has the advantage of controlling for other factors unrelated to the impact of the crisis that may have affected countries' growth rates during this period. Nevertheless, we use the 2009 GDP growth rate as an alternative measure of the crisis intensity in the robustness checks, with similar results.

In our main regressions, we exclude from our sample countries with a GDP per capita below a thousand 2007 dollars (poor countries), as well as countries above the 95^{th} percentile in financial openness (financial centers).[12] We exclude poor countries, both because of data quality issues and because extremely poor countries tend to rely heavily on official forms of international finance, thus being less exposed to private-sector financial flows (see Lane and Milesi-Ferretti (2011)). For these countries, high values of financial openness can be quite misleading. Similarly, we exclude financial centers because their extreme values of financial openness tend to reflect their role as financial intermediaries rather than true integration. We have 34 countries classified as poor and 7 countries classified as financial centers, thus leaving us with a benchmark sample of 110 countries. We will consider specifications including these subsets of countries in our robustness analysis.

We follow the empirical literature by regressing the forecast errors on several 2007 pre-crisis variables, as a way to identify "initial conditions" that help to explain the slowdown during the crisis. These variables include our two measures of economic integration, plus the following controls: the average GDP growth rate from 2004 to 2007; the trend growth rate (proxied by the average GDP growth rate from 1996 to 2007); the growth in the ratio of private credit to GDP over the period 2004-07;

[12] These include Mauritius, Iceland, Bahrain, Switzerland, Hong Kong, Ireland and Singapore.

the share of the manufacturing sector in GDP (in percentage terms); the current account to GDP ratio; the net foreign asset position (as a percentage of GDP); the external reserves to GDP ratio; the log of country population (in millions); the level of GDP per capita (in thousands of 2007 dollars); the level of GDP (in billions of dollars); a dummy that equals 1 if the country had a de facto fixed exchange regime during 2007; and an oil dummy.[13] All these variables have been widely used in the literature examining what factors played a role in the cross country variation of business cycles during the Great Recession.[14]

In addition to this, we consider different integration dummies as we are mainly interested in whether the level of economic integration matters in a non-continuous or monotone way. We first experiment with simple trade and financial dummies, which take a value of 1 if the level of trade/financial openness is above some percentile level, and zero otherwise. We also consider a joint trade and financial integration dummy, constructed as follows. We first take a linear combination of our two measures of integration:

$$Integration_i = \alpha \, trade_i + (1 - \alpha) \, financial_i,$$

where $trade_i$ and $financial_i$ are our two measures of trade and financial openness of country i, and $\alpha \in [0, 1]$ is a parameter to be chosen. The joint dummy then equals 1 when the combined integration measure is above some cutoff γ, and zero otherwise.

Since we have a priori no idea about the proper values for α and γ, we follow the Threshold Estimation literature and estimate them by means of Maximum Likelihood (MLE), in a way similar to Hansen (2000). Specifically, we want to estimate the following model:

$$y_i = \theta_0 + \beta' x_i + e_i, \qquad q_i(\alpha) \leq \gamma$$

$$y_i = \theta_1 + \beta' x_i + e_i, \qquad q_i(\alpha) > \gamma$$

where y_i is a measure of the crisis performance, x_i is our vector of pre-crisis controls, β' is a vector of coefficients, θ_0 and θ_1 are the intercepts, $q_i(\alpha)$ is our combined measure of integration described above, and e_i is an error term. Thus, in this model we allow the intercept θ to change when the threshold variable q is above some unknown cutoff γ, which is assumed to be restricted to a bounded set $[\underline{\gamma}, \overline{\gamma}] = \Gamma$. Moreover, the threshold variable depends on some unknown parameter α.[15] To

[13] We define as oil exporters the 2007 OPEC members, plus the following countries: Azerbaijan, Belize, Brunei, Chad, Gabon, Kazakhstan, Republic of Congo, Russia, Sudan, and Trinidad and Tobago.

[14] See Cecchetti, King and Yetman (2013) for a summary of selected studies examining crisis impact, their main explanatory variables, and their findings.

[15] The procedure described here also applies to the simpler case with a trade or a financial dummy.

write the model in a single equation, define the dummy variable

$$d_i(\alpha, \gamma) = \{q_i(\alpha) > \gamma\}$$

where $\{\cdot\}$ denotes the indicator function. Then, the model above can be rewritten as

$$y_i = \theta_0 + \eta d_i(\alpha, \gamma) + \beta' x_i + e_i,$$

where η is the dummy coefficient. The regression parameters are $(\beta', \theta_0, \eta, \alpha, \gamma)$, and the natural estimator is least squares (LS), which is also the MLE if one assumes that e_i is iid $N(0, \sigma^2)$. By definition, the LS estimators $(\widehat{\beta}', \widehat{\theta}_0, \widehat{\eta}, \widehat{\alpha}, \widehat{\gamma})$ jointly minimize the sum of the squared errors S_n. To compute these estimators, we proceed as follows. First, we choose some values for $\alpha \in A$ and $\gamma \in \Gamma_n$, where A is an evenly spaced grid such that $0 = \alpha_0 < \alpha_1 < ... < \alpha_J = 1$, and $\Gamma_n = \Gamma \cap \{q_{(1)}, ..., q_{(n)}\}$ where $q_{(j)}$ denotes the jth percentile of the sample $\{q_1, ..., q_n\}$.[16] Conditional on these values, we run an OLS regression and obtain the sum of squared errors $S_n(\alpha, \gamma)$, where we just make explicit that S_n depends upon α and γ. Then, the MLE estimator $(\widehat{\alpha}, \widehat{\gamma})$ are those values for α and γ that minimize $S_n(\alpha, \gamma)$, or more formally,

$$(\widehat{\alpha}, \widehat{\gamma}) = \underset{\alpha \in A, \gamma \in \Gamma_n}{\arg\min} \; S_n(\alpha, \gamma)$$

In practice, this reduces to choose the regression in the $A \times \Gamma_n$ space for which the sum of the squared residuals is the smallest. Finally, we can test whether the estimated threshold is significant or not just by checking the p-value of $\widehat{\eta}$. After following this procedure for different subsets of the controls, we consistently find point estimates of $\widehat{\alpha} = 0.10$ and $\widehat{\gamma} = 137.61$, which corresponds to the 37^{th} percentile of the combined integration variable.[17]

Figure 1 provides a visual illustration with raw data. In this picture, we plot two subsets of countries in the trade-financial openness space. Specifically, we distinguish between good performers (countries with a forecast error higher than the mean plus $\frac{1}{2}$ of the standard deviation) and bad performers (with a forecast error lower than the mean minus $\frac{1}{2}$ of the standard deviation).[18] The plotted line consists of all the values in the trade-financial space for which the combined integration variable, with

One just has to set either $\alpha = 1$ or $\alpha = 0$.

[16]In the numerical search, we use .05 increments for A.

[17]During the search process, we sometimes found another local minimum for a much higher value of γ around the 70^{th} percentile, but this finding was not robust to different subsets of the controls.

[18]Recall that in general the forecast error are negative, meaning that countries tended to perform worse in the crisis than expected. Thus, a more negative forecast error implies a worse crisis performance.

$\alpha = 0.10$, takes a value of 137.61. We refer to the region above the line as the integrated region, and to the region below as the not-integrated region.

Two facts are immediate from Figure 1. First, we have both good and bad performers in each region. Second, the ratio of bad performers to good performers is much higher in the integrated region than in the not-integrated one (2.18 in the former, 0.41 in the latter). Finally, a simple regression of the forecast error on the joint dummy plus the logs of trade and financial openness gives a coefficient of -4.09 on the joint dummy with a p-value well below 0.01. It means that, on average, countries in the integrated region suffered an unexpected GDP growth downturn around 4 percentage points compared to the others. These initial results may look encouraging, but it remains to be seen whether they still hold after a more formal econometric analysis, introducing various controls, to which we turn next.

1.2.1 Regression results

1.2.1.1 Without integration dummies

Table 3 reports the results from regressions without integration dummies included. In Column 1 we regress the forecast error on the logs of trade and financial openness and the controls discussed above. We observe that neither the trade openness nor the financial openness variables are significant. Column 2 runs the same regression but with 2009 GDP growth as the dependent variable. Since we include both the growth trend and the pre-crisis average GDP growth in the regressors, this specification is the same as one where the dependent variable is the change in the growth rate relative to trend or relative to the period 2004-07. As before, both integration coefficients are insignificant.

Column 3 includes the financial centers and column 4 includes the poor countries. The inclusion of these subsets of countries makes trade openness significant at the 10% level, but financial openness remains insignificant. Columns 5 and 6 replicates our first two columns but including all the countries in our sample. In column 5 trade openness now becomes significant at the 5% level, but this is not a robust finding as it loses significance once we change our measure of crisis performance in column 6. Overall, we have little success finding any robust relationship between pre-crisis variables and measures of crisis performance, in line with the previous crisis literature.[19]

[19] See for example Rose and Spiegel (2011).

1.2.1.2 With integration dummies

In Table 4 we experiment with the different integration dummies discussed before. Column 1 regresses the forecast errors on all the explanatory variables plus a trade dummy that equals one when the value of trade openness is above the 42^{th} percentile. The coefficient of this dummy alone is quite negative (-3.01) and significant at the 5% level. The coefficients of trade and financial openness are still insignificant, and the remaining controls follow the same pattern as in Table 3. In column 2 we run the same regression, but this time with a financial dummy that equals one if financial openness is above the 36^{th} percentile instead. The coefficient of this financial dummy (-4.54) is even lower than the trade one, and strongly significant.

Column 3 includes the joint dummy in the regression. It has a coefficient of -4.72 that is significant at all the conventional levels. It means that, everything else equal, the forecast errors of countries above the 37^{th} percentile in the combined integration measure were on average 4.72 percentage points lower. Given that the average forecast error was around -5, this represents a highly sizable effect. Moreover, the subset of countries for which this dummy equals 1 comprises a high share of World's GDP, as it includes the U.S., Japan, and most of the E.U. countries.[20]

1.2.2 Robustness checks

In this subsection we choose the joint dummy as our most preferred measure of a non-continuous effect of integration on crisis performance, and run several robustness tests on it.

First, in Table 6 we explore the sensitivity of the dummy to different choices of α and percentiles' cutoffs. In this table, different rows correspond to different values of α, ranging from 0 to 1, and different columns correspond to different choices of the percentile cutoff, ranging from the 19^{th} percentile of the combined integration variable to the 45^{th} percentile. The numerical entries in the table are the coefficient values of joint dummies from regressions with the same specification as in column 3 of Table 4. Bold numbers mean that the dummy is significant at the 10% level at least. We find that coefficients between the 19^{th} and the 43^{th} percentile tend to be significant at the 10% level, and in most cases (specially around our benchmark joint dummy with $\alpha = 0.10$ and the 37^{th} cutoff) we achieve significance at the 5% or 1% level. These results suggest that the discontinuous effect of integration on crisis performance is not particularly sensitive to different choices of the parameter values or percentile cutoffs.

[20] Table 5 provides the specific list of countries for which the joint dummy equals 0 (the less integrated countries).

Next, in Table 7 we run additional robustness checks for alternative measures of crisis performance and different subsets of countries. Here, column 1 simply replicates our results from column 3 in Table 4, just for comparison purposes. In column 2 we change our measure of crisis performance and use the 2009 GDP growth as our dependent variable. As we see, the magnitude of the dummy coefficient (-4.41) is similar to column 1, and it is also significant at all the conventional levels.

In column 3 we recover the forecast error as our dependent variable and explore whether extreme outcomes in the forecast errors might be driving our results by excluding countries with forecast errors below the 5^{th} percentile. In this case, the coefficient takes a value of -2.89, higher than in column 1 but still significant at the 1% level. Columns 4 and 5 include the financial centers and the poor countries. In both cases the coefficient on the dummy is higher than in column 1, but they remain strongly significant. In columns 6 and 7 we include all the countries in our sample. With the forecast errors as the dependent variable, we still achieve significance at the 1% level and a coefficient of -3.46, and with the 2009 GDP growth we achieve significance at the 5% level and a coefficient of -2.79. Finally, in the last column we replace the joint dummy with the integration dummy computed based on the principal component of the trade and financial integration variables. This is another way of combining the two instead of the linear aggregate that we have used. The results are again very similar. The threshold now occurs at the 31st percentile. The integration dummy is again substantial and highly significant.

Additionally, we tested whether our integration dummy might just be capturing some non-linear, but still continuous effect by including different combinations of second and higher order terms of trade and financial openness. The results (not reported) indicate that this is not the case, as all the higher order terms are insignificant whereas the dummy still shows a strong and statistical significant effect. If anything, the coefficient on the dummy decreases. We also tried to control for trade linkages with the US using a measure analogous to the overall trade openness, but it did not affect our results. We experimented with different subsets of the controls as well. The coefficients on trade and financial openness may or may not become significant, depending on the specification, but we consistently find that the integration dummy is significant at the 5% level at least, and in most cases with a coefficient below -3.[21]

Finally, we turn our attention to the role of households' expectations during the Great Recession. In our theory, a coordinated self-fulfilling shift in expectations among countries in the integrated region is the key driver of a global panic. One

[21] We also run regressions excluding the oil exporters, but it did not affect our results.

implication of this theoretical result is a discontinuity in the growth performance across countries, which we have already documented. But we can also test whether there was a significant difference in expectations of integrated versus less integrated countries. We do so by using a measure of consumer confidence. To perform this test, we collect cross-country data from the Nielsen's Global Consumer Confidence Trend Tracker, an index whose value is 100 if consumer confidence is neutral, below 100 if pessimistic and above 100 if optimistic. The data are quarterly and available for 43 of the countries in our sample, of which we classify 32 as integrated and 11 as less integrated using our previous results.[22] We take the difference between the index in Q3 of 2008 and Q1 of 2007 and regress this measure on the integration dummy in order to obtain the average difference between the two groups and see if this difference is statistically significant. We find that the drop in confidence for the integrated countries more than doubles the drop for the less integrated: 15.06 against 7.09, with an average difference of 7.97 that is statistically significant at the 5% level (p-value of 0.024).

In summary, the empirical evidence presented here suggests that there was indeed a strong, non-continuous effect of trade and financial integration on crisis performance during the Great Recession. This effect is robust to the inclusion of a variety of controls, different parameter values or percentile cutoffs, different measures of crisis performance, and different subsets of countries. We now turn to a model aimed at explaining these empirical findings.

1.3 Model Description

There are different modeling approaches one could adopt to illustrate the role of trade and financial integration heterogeneity in self-fulfilling business cycles. However, since the empirical evidence we aim to shed light on relates specifically to the Great Recession, we chose to extend the BvW setup as it connects well to the Great Recession along various dimensions. First, the model highlights particular vulnerabilities to a global panic that were in place at the time. One such vulnerability is tight credit, which plays a key role in the model. Another is limited flexibility of central banks as we were close to the ZLB. Finally, increased trade and financial integration in previous decades is a key source of vulnerability to global panics in the model. BvW show that if we relax such vulnerabilities, a global panic equilibrium would not exist. Second, a sharp drop in profits during a panic is a key ingredient of the model, which together with the tight credit drives the results. As BvW show,

[22]The data can be found at http://viz.nielsen.com/consumerconfidence/.

there was indeed a very steep synchronized global decline in profits during the Great Recession. Finally, the self-fulfilling expectation shock in the model leads to a sharp drop in demand. This is consistent with micro evidence that firms were affected more by a sudden drop in demand than sudden reduced access to credit (e.g. Kahle and Stulz (2013), Nguyen and Qiuan (2014)).[23]

The model has two periods and a continuum of countries distributed uniformly on the unit square. We will first describe households, firms, central banks and market clearing conditions. The entire model is then summarized in a condensed form that is used in the next section to analyze the equilibria. The model has a New Keynesian flavor in the sense that nominal wages are determined at the start of each period and are sticky within a period. This feature, together with a potential sunspot shock during period 1 that can generate self-fulfilling shifts in expectations, may lead to involuntary unemployment in the first period.[24]

Some words about notation are in order before describing the model. Countries are heterogeneous in two dimensions, trade and financial integration. Trade integration will be indicated by a country-specific parameter ψ_i, with $i \in [0,1]$. Financial integration will be indicated by a country-specific parameter ϕ_k with $k \in [0,1]$. Thus country (i,k) has parameters ψ_i and ϕ_k. When dealing with integrals, j will refer to the trade dimension and l to the financial dimension.

1.3.1 Households

Utility of households in country (i,k) is

$$\frac{\left(c_1^{ik}\right)^{1-\lambda}}{1-\lambda} + \beta \frac{\left(c_2^{ik}\right)^{1-\lambda}}{1-\lambda} \tag{1.1}$$

where c_t^{ik} is the period t consumption index:

$$c_t^{ik} = \left(\frac{c_{ik,t}^{ik}}{\psi_i}\right)^{\psi_i} \left(\frac{c_{F,t}^{ik}}{1-\psi_i}\right)^{1-\psi_i} \tag{1.2}$$

[23]Tight credit is a parameter of the model. There is no shock to credit in the model.

[24]This is a small deviation from BvW, who introduce nominal rigidities through sticky prices. This makes little difference when we only consider heterogeneity in trade integration. But assuming wage stickiness simplifies the analysis when we also consider heterogeneous financial integration.

where $c^{ik}_{ik,t}$ is an index of country (i,k) goods consumed by country (i,k) residents and $c^{ik}_{F,t}$ is an index of foreign goods consumed by country (i,k) residents:

$$ln\left(c^{ik}_{F,t}\right) = \int\int_0^1 \frac{1-\psi_j}{1-\bar{\psi}}\left(ln\left(c^{ik}_{jl,t}\right) - ln\left(\frac{1-\psi_j}{1-\bar{\psi}}\right)\right) djdl \tag{1.3}$$

Here $\bar{\psi} = \int_0^1 \psi_j dj$ and

$$c^{ik}_{jl,t} = \left(\int_0^1 \left[c^{ik}_{jl,t}(m)\right]^{\frac{\sigma-1}{\sigma}} dm\right)^{\frac{\sigma}{\sigma-1}} \tag{1.4}$$

is an index of country (j,l) goods consumed by country (i,k) residents, with $c^{ik}_{jl,t}(m)$ being consumption at time t by country (i,k) of good m from country (j,l).

The parameter ψ_i is a measure of trade integration for country i, ranging from 0 if it is perfectly integrated to 1 when it is in autarky. A couple of comments about this utility specification are in order. The friction we introduce to generate imperfect trade integration is home bias in preferences.[25] There are two types of home bias in preferences. First, country (i,k) has a bias towards its own goods and therefore a bias away from foreign goods. This is captured by the parameter ψ_i in the overall consumption index (1.2). In this case a larger ψ_i reduces imports. Second, to the extent that countries buy foreign goods, they have a different bias against goods from different countries. The index (1.3) implies that a larger ψ_j leads country (i,k) to have a larger bias against goods from country (j,l). Similarly, a larger ψ_i implies that all countries other than (i,k) have a larger bias against (i,k) goods, which reduces exports of country i. Putting the two together, a higher ψ_i simultaneously reduces imports and exports of (i,k). If we allowed a higher ψ_i only to reduce the imports by country (i,k), and not exports, a higher ψ_i would have a large effect on relative prices to generate balanced trade, which significantly complicates the analysis.

The budget constraint in period 1 is:

$$\int_0^1 P^{ik}_1(m)c^{ik}_{ik,1}(m)dm + \int\int\int_0^1 S_{ik,1}\frac{P^{jl}_1(m)}{S_{jl,1}}c^{ik}_{jl,1}(m)dmdjdl + B_{ik} + M^{ik}_1 = W^{ik}_1(1-u^{ik}) + \Pi^{ik}_1 + \bar{M}^{ik}_1 + S_{ik,1}T^{ik}_1 \tag{1.5}$$

[25] An alternative would be to introduce trade costs, while leaving preferences the same for all countries. However, proportional trade costs have the disadvantage that no matter the level of these costs, as the relative size of countries goes to zero, the fraction of home goods countries consume approaches zero as well. One would need to introduce a fixed cost of goods trade to generate a positive fraction of home goods consumed for infinitesimally small countries, but this significantly complicates the analysis.

Here $P_1^{ik}(m)$ is the price of good m from country (i,k) measured in the currency of country (i,k), $S_{ik,1}$ is units of country (i,k) currency per unit of a base currency (denoted by b) and B_{ik} is holdings of a domestic bond. The latter is only domestically traded. M_1^{ik} are money holdings and $\bar{M}_1^{ik}$ is a money transfer at period 1 from the central bank. W_1^{ik} is the nominal wage rate, u^{ik} is the unemployment rate and Π_1^{ik} is profits from firms.[26] Thus, with a labor supply of 1, $W_1^{ik}(1-u^{ik})+\Pi_1^{ik}$ is nominal GDP of country (i,k) measured in its own currency. Finally T_1^{ik} is a net transfer from abroad measured in the base currency that will be discussed below.

The domestic bond of country (i,k) is in zero net supply and delivers R^{ik} units of country (i,k) currency in period 2. As we discuss further below, the absence of unexpected shocks in period 2 ensures that full employment is achieved in the last period. The period 2 budget constraint is then

$$\int_0^1 P_2^{ik}(m)c_{ik,2}^{ik}(m)dm + \int\int\int_0^1 S_{ik,2}\frac{P_2^{jl}(m)}{S_{jl,2}}c_{jl,2}^{ik}(m)dmdjdl + M_2^{ik} = \quad (1.6)$$
$$W_2^{ik} + \Pi_2^{ik} + M_1^{ik} + R^{ik}B_{ik} + (\bar{M}_2^{ik} - \bar{M}_1^{ik}) + S_{ik,2}T_2^{ik}$$

We assume a cash-in-advance constraint with the buyer's currency being used for payment:

$$\int_0^1 P_t^{ik}(m)c_{ik,t}^{ik}(m)dm + \int\int\int_0^1 S_{ik,t}\frac{P_t^{jl}(m)}{S_{jl,t}}c_{jl,t}^{ik}(m)dmdjdl \leq M_t^{ik} \quad (1.7)$$

Let P_t^{ik} denote the country (i,k) consumer price index in the local currency and $P_t(i,k)$ the price index of country (i,k) goods measured in the country (i,k) currency. $P_{F,t}$ is the price index of all Foreign goods measured in the base currency.

[26] In principle unemployment implies that some workers do not earn any labor income, but there may be a redistribution mechanism such that all households end up receiving $W_1^{ik}(1-u^{ik})$ regardless of their working status.

The first-order conditions are then[27]

$$\frac{1}{\left(c_1^{ik}\right)^\lambda} = \beta R^{ik} \frac{P_1^{ik}}{P_2^{ik}} \frac{1}{\left(c_2^{ik}\right)^\lambda} \tag{1.8}$$

$$c_{ik,t}^{ik} = \psi_i \frac{P_t^{ik}}{P_t(i,k)} c_t^{ik} \tag{1.9}$$

$$c_{F,t}^{ik} = (1-\psi_i) \frac{P_t^{ik}}{S_{ik,t} P_{F,t}} c_t^{ik} \tag{1.10}$$

$$c_{jl,t}^{ik} = \frac{1-\psi_j}{1-\bar{\psi}} \frac{S_{jl,t} P_{F,t}}{P_t(j,l)} c_{F,t}^{ik} \quad (i,k) \neq (j,l) \tag{1.11}$$

$$c_{jl,t}^{ik}(m) = \left(\frac{P_t(j,l)}{P_t^{jl}(m)}\right)^\sigma c_{jl,t}^{ik} \quad \forall (i,k),(j,l) \tag{1.12}$$

where the price indices are

$$P_t^{i,k} = P_t(i,k)^{\psi_i} (S_{i,k,t} P_{F,t})^{1-\psi_i} \tag{1.13}$$

$$P_t(i,k) = \left(\int_0^1 [P_t^{i,k}(m)]^{1-\sigma} dj dl\right)^{\frac{1}{1-\sigma}} \tag{1.14}$$

$$ln\left(P_{F,t}\right) = \int\int_0^1 \frac{1-\psi_j}{1-\bar{\psi}} ln\left(\frac{P_t(j,l)}{S_{jl,t}}\right) dj dl \tag{1.15}$$

Countries are linked through both trade and financial integration. Financial integration occurs through risk-sharing, which leads to net transfers between countries. Country (i,k) receives a net transfer T_t^{ik} from abroad. We assume

$$T_t^{ik} = \int\int_0^1 E_t^W \phi_k \phi_l ln\left(\frac{g_1^{jl}}{g_1^{ik}}\right) dj dl \tag{1.16}$$

Here E_t^W is nominal world exports in the base currency and g_1^{ik} is period 1 real output of country (i,k) relative to its expected value. The parameter ϕ_k is a measure of financial integration for country (i,k) and similarly ϕ_l for country (j,l). Under this specification, countries agree to pay to each other a fraction $\phi_k \phi_l ln\left(\frac{g_1^{jl}}{g_1^{ik}}\right)$ of nominal world exports. Country (i,k) receives a payment from country (j,l) when $g_1^{jl} > g_1^{ik}$ and makes a payment to (j,l) when $g_1^{jl} < g_1^{ik}$. Countries therefore make payments to each other based on their unexpected relative output performances. The size of these payments will be determined by their financial integration level, as well as by the integration level of the partners.[28] The transfers are scaled by world trade

[27] There is no expectation operation in the consumption Euler equation (1.8) as there are no unexpected period 2 shocks.

[28] Also note that net payments are zero in aggregate because a positive payment to country (i,k) from country (j,l) implies a negative payment to country (j,l) by the exact same amount as

as transfers must necessarily vanish in the absence of trade. Transfers are only meaningful if countries can use them to buy goods from each other.

In Appendix C we show that the expression for T_t^{ik} can be seen as the result of a particular asset market structure with a limited commitment financial friction. Also note that the transfers are assumed to be the same fraction of world exports in periods 1 and 2. They only depend on unexpected period 1 relative output. There will be two shocks in the model, country-specific productivity shocks and sunspot shocks. The country-specific productivity shocks occur in period 1 and are permanent (last two periods). For simplicity we assume that the sunspot shocks does not affect the risksharing scheme as it has infinitesimal probability from the perspective of period 0. Risk sharing is therefore based on the permanent productivity shocks.

1.3.2 Firms

In each country there is a continuum of firms of mass one. Each firm produces a different variety and sets its optimal price each period. Output of good m in period t of country (i, k) is

$$y_t^{ik}(m) = e^{x_{ik}} A_{ik,t}(m) L_t^{ik}(m) \tag{1.17}$$

where $L_t^{ik}(m)$ is labor input and $e^{x_{ik}} A_{ik,t}(m)$ is labor productivity. $A_{ik,t}(m)$ is an endogenous component of labor productivity that will be discussed below. The exogenous component x_{ik} is a country-specific i.i.d. shock with zero mean that is realized in period 1 and lasts both periods.

Since the production function is linear and all demands faced by the firm are CES with elasticity σ, the optimal price is a constant markup over marginal costs:

$$P_t^{ik}(m) = \frac{\sigma}{\sigma - 1} \frac{W_t^{ik}}{e^{x_{ik}} A_{ik,t}(m)} \tag{1.18}$$

In equilibrium all firms will set the same price, produce the same amount and hire the same number of workers, so that $P_t^{ik}(m) = P_t(i, k)$, $y_t^{ik}(m) = y_t^{ik}$ and $L_t^{ik}(m) = L_t^{ik}$. Thus profits can be written as

$$\Pi_t^{ik} = P_t(i, k) y_t^{ik} - W_t^{ik} L_t^{ik} = \frac{1}{\sigma} P_t(i, k) y_t^{ik} \tag{1.19}$$

That is, nominal profits are just a fraction $1/\sigma$ of nominal output. Dividing by the

measured by the base currency.

consumer price index, we obtain real profits:

$$\pi_t^{ik} = \frac{\Pi_t^{ik}}{P_t^{ik}} = \frac{1}{\sigma}\frac{P_t(i,k)}{P_t^{ik}} y_t^{ik} \tag{1.20}$$

Next consider the firm's intertemporal problem. In period 1 the productivity component $A_{ik,1}$ is assumed to be 1 for all countries and firms. In period 2 firms can maintain this productivity level if they pay a fixed cost κ, which is real (in terms of the consumption index). Otherwise this endogenous productivity component decreases to $A_L < 1$. The cost κ represents an investment required to maintain the productivity of the firm. This is a fixed cost. For example, a firm might shut down a department, branch, other facility or machine if it is unable or unwilling to bear the fixed costs associated with their operation. It might also shut down a worker training program, assuming again that this is a discrete choice. We assume that the cost κ is paid to intermediaries who bear no production costs and whose profits are simply returned to the households that own them. This simplifies in that the investment does not involve a real use of resources.

We assume that firms are borrowing constrained, so that they can only invest if they have sufficient internal funds. For simplicity, although this is not important, assume that firms cannot borrow at all and therefore need to finance the cost κ entirely from internal funds. The following borrowing constraint therefore holds if firms make the investment κ:

$$\pi_1^{ik} \geq \kappa \tag{1.21}$$

We will refer to this constraint as the borrowing condition. It is important to the mechanism of the model as it leads to a feedback from profits in period 1 to investment, which in turn affects productivity in period 2. We could relax the condition by assuming that firms can only borrow up to an amount of say z. In that case κ on the right hand side becomes $\kappa - z$. BvW show that if we relax the borrowing constraint enough, firms will always invest and we do not have self-fulfilling panics in the model. Tight credit is therefore an important vulnerability in the model, consistent with conditions during the Great Recession.

If firms can afford the real cost κ, they will invest as long as the present discounted value of profits when they invest is at least as high as when they do not invest. Using that the pricing kernel in this model is just β [29], this condition can summarized as

$$\Pi_1^{ik} + \beta\Pi_{2,I}^{ik}(m) - P_1^{ik}\kappa \geq \Pi_1^{ik} + \beta\Pi_{2,NI}^{ik}(m) \tag{1.22}$$

[29] The follows from the households' intertemporal consumption Euler Equation in equilibrium.

where $\Pi^{ik}_{2,I}(m)$ is second period profits if firm m invests and $\Pi^{ik}_{2,NI}(m)$ is second period profits if it does not invest. Rearranging this condition, we obtain

$$\frac{\beta\left(\Pi^{ik}_{2,I}(m) - \Pi^{ik}_{2,NI}(m)\right)}{P^{ik}_1} \geq \kappa \tag{1.23}$$

We will refer to this constraint as the incentive condition. It follows that $A_{ik,2}(m) = 1$ if and only if both the borrowing and the incentive condition are satisfied. Otherwise $A_{ik,2}(m) = A_L$.

1.3.3 Central Banks

We will be brief about central banks as they behave the same way as in BvW. They set the second period money supply to stabilize prices, so that $P^{ik}_2 = P^{ik}_1$. They set the first period interest rate such that $R^{ik}\beta = 1$. This corresponds to the interest rate in the flexible price version of the model. BvW also consider counter-cyclical monetary policy, but they show that this will not help to avoid a self-fulfilling panic when the central bank has little room to maneuver close to the ZLB. This is again a feature that was relevant during the Great Recession.

1.3.4 Market Clearing

The market clearing equations are

$$y^{i,k}_t(m) = c^{i,k}_{i,k,t}(m) + \int\int_0^1 c^{j,l}_{i,k,t}(m)djdl \quad \forall(i,k), m \tag{1.24}$$

$$\int_0^1 L^{i,k}_t(m)dm = L^{i,k}_{S,t} \quad \forall(i,k) \tag{1.25}$$

$$M^{i,k}_t = \bar{M}^{i,k}_t \quad \forall(i,k) \tag{1.26}$$

$$B_{i,k} = 0 \quad \forall(i,k) \tag{1.27}$$

where $L^{ik}_{S,1} = 1 - u^{ik}$ in period 1 and $L^{ik}_{S,2} = 1$ in period 2. Equation (1.25) says that in both periods the number of workers hired by firms must equal the measure of employed workers. We assume that the wage is set at the start of each period. The wage is set such that the labor market is expected to clear without unemployment.[30] In period 2 there are no unexpected shocks, so that there will be full employment. In period 1 an unexpected sunspot shock will reduce demand for labor, which leads

[30] See Taylor (1999) for a review of models using the expected market clearing mechanism.

to unemployment.[31]

1.3.5 Condensed Version of the Model

Using the budget constraints, first-order conditions, optimal price setting and market clearing equations, Appendix A derives a condensed version of the model that solves consumption, output and real profits as a function of second period productivity in all countries. From hereon we will denote the endogenous component of second period productivity as A_{ik}, omitting the period 2 subscript. It turns out that consumption, output and real profits will be the same in both periods, so we also omit time subscripts. Appendix A shows that

$$c^{ik} = G^{ik}\left(\frac{V_{ik}}{D_{ik}}\right)^{\psi_i}\bar{V}^{1-\psi_i} \tag{1.28}$$

$$y^{ik} = V_{ik} \tag{1.29}$$

$$\pi^{ik} = \frac{1}{\sigma}V_{ik}^{\psi_i}\left(D_{ik}\bar{V}\right)^{1-\psi_i} \tag{1.30}$$

where

$$V_{ik} = e^{x_{ik}}A_{ik} \tag{1.31}$$

$$G_{ik} = 1 + \left(\frac{1-\bar{\psi}}{1-\psi_i}\right)\phi_k\left(Q - \bar{\phi}ln\ V_{ik}\right) \tag{1.32}$$

$$D_{ik} = 1 + \left(\frac{1-\bar{\psi}}{1-\psi_i}\right)\psi_i\phi_k\left(Q - \bar{\phi}ln\ V_{ik}\right) \tag{1.33}$$

$$Q = \int_0^1\int_0^1 \phi_l ln\ V_{jl}djdl \tag{1.34}$$

$$ln\ \bar{V} = \int_0^1\int_0^1 \frac{1-\psi_j}{1-\bar{\psi}}ln\left(\frac{V_{jl}}{D_{jl}}\right)djdl \tag{1.35}$$

and

$$\bar{\phi} = \int_0^1 \phi_l dl$$

This gives the solutions of c^{ik}, y^{ik} and π^{ik} as a function of second period productivity in all countries. This is not a complete solution to the model though as we have not yet solved for the endogenous productivity component A_{ik}. This in turn depends on whether the borrowing and incentive conditions are satisfied. If both are satisfied, $A_{ik} = 1$. Otherwise $A_{ik} = A_L$. We will refer to $A_{ik} = A_L$ as the panic

[31] The permanent productivity shocks do not lead to unemployment. Higher permanent productivity leads to a higher real wage in both periods as a result of a lower price level. This follows from the price setting equation.

state and $A_{ik} = 1$ as the non-panic state.

Appendix B shows that the incentive condition can be expressed as

$$\frac{\beta\left(1 - A_L^{\sigma-1}\right)}{A_{ik}^{\sigma-1}}\pi^{ik} \geq \kappa \tag{1.36}$$

When a country does not panic ($A_{ik} = 1$), the term multiplying profits is lower than 1, so that the incentive condition is tighter than the borrowing condition. Under Assumption 1 below, when a country panics ($A_{ik} = A_L$) the term multiplying profits in the incentive condition is greater than 1, which implies that the borrowing constraint is more easily violated and is the binding condition.

$$A_L < \sigma\kappa < \beta\left(1 - A_L^{\sigma-1}\right), \quad \textit{and } \sigma \geq 2 \tag{1.37}$$

Therefore (see also Appendix B) it follows that

$$\begin{aligned} A_{ik} &= A_L \text{ when } \pi^{ik} < \kappa && (1.38) \\ &= 1 \quad \text{when } \beta\left(1 - A_L^{\sigma-1}\right)\pi^{ik} \geq \kappa && (1.39) \end{aligned}$$

The panic condition in (1.38) is the violation of the borrowing condition when $A_{ik} = A_L$, which is the binding condition with a panic. The non-panic condition in (1.39) is the incentive condition when $A_{ik} = 1$, which is the binding condition without a panic.

A full solution of the model now involves a set of A_{ik} for all (i, k) that is consistent with (1.30)-(1.35) and (1.38)-(1.39). Any such set of A_{ik} describes an equilibrium to the model. In the next section we analyze such equilibria.

1.4 Analysis of Equilibria

Equilibria of the model depend on the assumed distribution across countries of the integration parameters ψ_i and ϕ_k. We first consider the case where all countries are equally integrated, so that $\psi_i = \psi$ and $\phi_k = \phi$ are equal across all countries. This allows us to generalize the two-country results from BvW to a multi-country setup with both partial trade and financial integration. After that we consider the implications of introducing integration heterogeneity across countries. We first discuss analytical results in two particular cases, one with heterogeneous trade integration but no financial integration and another with heterogeneous financial integration but homogeneous trade integration. After that we present numerical results for the case of both heterogeneous trade and financial integration, which connects most closely to the empirical evidence. These results are all derived in the absence of country-specific productivity shocks x_{ik}. At the end of the section we provide numerical results for the case where heterogeneous trade and financial integration is combined with country-specific productivity shocks. The proofs of all Propositions are available in a separate Technical Appendix.

1.4.1 Multiple Equilibria and Uniform Integration

Consider first the case of homogeneous integration: $\psi_i = \psi$ and $\phi_k = \phi$ for all (i,k) and $x_{ik} = 0$. It is easy to verify that under Assumption 1 there exists both an equilibrium where all countries panic and an equilibrium where none of the countries panic. To see this, when no country panics, we have $A_{ik} = 1$ for all (i,k). Then $Q = 0$, $D_{ik} = 1$ and $\bar{V} = 1$, so that (1.39) becomes $\beta\left(1 - A_L^{\sigma-1}\right) \geq \sigma\kappa$. This holds by Assumption 1. Similarly, when all countries panic we have $A_{ik} = A_L$ for all (i,k). This implies $Q = \bar{\phi} ln\ A_L$, $D_{ik} = 1$ and $\bar{V} = A_L$, so that (1.38) becomes $A_L < \sigma\kappa$. This again holds by Assumption 1.

The existence of both a symmetric panic and non-panic equilibrium can be understood as follows. If all households in the world expect a high level of income in period 2, first period consumption will be strong. Profits will then be high enough, so that all firms will invest and productivity and income will be high in period 2, consistent with expectations of high future income. If instead all households in the world expect much lower income in period 2, they reduce consumption in period 1. This reduces demand for goods, which reduces period 1 output and profits. Since profits are now insufficient to cover the investment cost, productivity and output will be lower in period 2, consistent with expectations of lower income in period 2. Beliefs about future income are therefore self-fulfilling.

Next consider whether there exist asymmetric equilibria, where a subset of countries panic ($A_{ik} = A_L$), while subset does not ($A_{ik} = 1$). In the Technical Appendix we prove the following proposition:

Proposition 1. *When $\psi_i = \psi$ and $\phi_k = \phi$ for all countries, there exists a continuous function $h(\psi,\phi)$, with $h > 0$ under perfect integration and $h < 0$ under autarky, such that*

when $h(\psi,\phi) > 0$, there exist only equilibria where either all countries panic or all countries do not panic.

when $h(\psi,\phi) \leq 0$, there also exist equilibria where only a subset of countries panic

$h(\psi,\phi)$ is decreasing in ψ and increasing in ϕ.

There is more integration when ψ is lower (trade integration) and ϕ is larger (financial integration). The third part of the proposition then says that the function $h(\psi, \phi)$ is higher the more integration. Under perfect integration $h > 0$, while under complete autarky $h < 0$. The proposition then says that when countries are sufficiently integrated ($h(\psi, \phi) > 0$), asymmetric equilibria do not exist. Either all countries panic or none of the countries panic. If instead countries are insufficiently integrated ($h(\psi, \phi) \leq 0$), asymmetric equilibria do exists where some countries panic and others do not.

Several points should be made about this result. First, only partial integration is sufficient to ensure that equilibria are coordinated across countries, where either all countries panic or none do. The function $h(\psi, \phi)$ will be positive under less than full integration.[32] Second, the two sources of economic integration are substitutes: with more financial integration, less trade integration is required to ensure that $h(\psi, \phi)$ is positive, so that a panic is necessarily global by part 1 of the proposition.

The proposition generalizes the results of BvW to a multi-country setup with both trade and financial integration. To understand these results, it is important to point out that there are positive linkages in the model through both trade and financial integration. A higher level of income in one region of the world leads to a higher demand for goods from the rest of the world (trade integration), while it also leads to higher net transfers to the rest of the world (financial integration). These positive linkages create an interdependence that leads to the coordination of panics when countries are sufficiently integrated.

Consider for example the case where a large subset of countries panics, while a smaller subset does not panic. When the level of integration is relatively high, this cannot be an equilibrium. The smaller subset is very negatively impacted by the panic in most of the world. This will reduce their income and profits through both trade and financial linkages, so that (1.39) does not hold and they must necessarily panic as well. Similarly, it is not possible for only a small subset of countries to panic under sufficient integration. They will be positively affected by the absence of a panic in most of the world. Their profits will then be high, so that they can cover the investment cost, (1.38) does not hold and they cannot panic in equilibrium. Sufficient integration assures that countries share a common fate.[33]

[32] Note that $h(\psi, \phi)$ is positive under perfect integration. Together with the fact that it is a continuous function that is decreasing in ψ and increasing in ϕ, it follows that the cutoff $h(\psi, \phi) = 0$ occurs under partial integration.

[33] The same intuition applies as well when half the countries panic and half do not. This brings us essentially in the BvW framework of a two-country model.

1.4.2 Integration Heterogeneity

We can provide theoretical results for two intermediate cases of integration heterogeneity. The first is one of heterogeneous trade integration, but no financial integration, where $\psi_i = 1 - i$ and $\phi_k = 0$. The second is one with heterogeneous financial integration and homogenous trade integration, where $\phi_k = k$ and $\psi_i = \psi$. In the latter case, trade integration cannot be too low as financial integration is meaningless without the ability to trade goods. At the same time, trade integration cannot be too high as it would obviate the need for financial integration by generating endogenous risksharing through the terms of trade familiar from Cole and Obstfeld (1991). After discussing these two cases, we consider numerically the case of both trade and financial integration heterogeneity.

1.4.2.1 Trade Integration Heterogeneity

First consider the case where countries are in financial autarky and trade integration varies uniformly across countries from 0 (perfect integration) to 1 (autarky), with $\psi_i = 1 - i$. It follows that $\bar{\phi} = 0$, $Q = 0$ and $D_{ik} = 1$. Conditions (1.38)-(1.39) and (1.35) then become

$$A_{ik} = A_L \text{ when } A_L^{\psi_i}\bar{V}^{1-\psi_i} < \sigma\kappa \tag{1.40}$$

$$= 1 \quad \text{when } \beta\left(1 - A_L^{\sigma-1}\right)\bar{V}^{1-\psi_i} \geq \sigma\kappa \tag{1.41}$$

$$ln\ \bar{V} = \int\int_0^1 \frac{1-\psi_j}{1-\bar{\psi}} ln\ A_{jl} dj dl \tag{1.42}$$

Define $\tilde{\psi}_1(\bar{V})$ as the value of ψ_i for which the panic condition (1.40) holds with equality and $\tilde{\psi}_2(\bar{V})$ as the value of ψ_i for which the non-panic condition (1.41) holds with equality. The Technical Appendix defines $\bar{\sigma}$, $\bar{V}_1$ and $\bar{V}_2$ as a function of model parameters, with $A_L < \bar{V}_2 < \bar{V}_1 < 1$. It then provides a proof for the following Proposition:

Proposition 2. *Assume that $\psi_i = 1 - i$, $\phi_k = 0$, and $\sigma > \bar{\sigma}$. Then there exists a continuum of equilibria of two types:*

There is an interval $[\bar{V}_1, 1]$ such that for each $\bar{V}$ in the interval there are equilibria with two features. First, none of the countries in the interval $\psi_i \in [0, \tilde{\psi}_1(\bar{V})]$ panic. Second, when $\bar{V} < 1$ at least some of the remaining countries will panic.

There is an interval $\left[A_L, \bar{V}_2\right]$ or $\left[A_L, \bar{V}_2\right\rangle$ such that for each $\bar{V}$ in the interval there are equilibria with two features. First, all countries in the interval $\psi_i \in [0, \tilde{\psi}_2(\bar{V})]$ panic. Second, when $\bar{V} > A_L$ at most a subset of remaining countries will panic.

There is a continuum of equilibria characterized by different values for $\bar{V}$ and, for a given $\bar{V}$, by different sets of countries that panic that is consistent with that $\bar{V}$. The first part of the proposition is relevant for large values of $\bar{V}$. In all of these equilibria none of the most integrated set of countries ($\psi_i \leq \tilde{\psi}_1(\bar{V})$) will panic, while in general a subset of the less integrated countries does panic. From the point of view of the Great Recession, the second type of equilibria in Proposition 2 is of most interest. It is relevant for low values of $\bar{V}$. In all of these equilibria all of the most integrated countries ($\psi_i \leq \tilde{\psi}_2(\bar{V})$) will panic together, while at most a subset of the less integrated countries panic. In the second set of equilibria there is a minimum set of integrated countries that panics, defined as $\psi_i \in [0, \tilde{\psi}_2(\bar{V}_2)]$. When this minimum set of integrated countries panics, none of the less integrated countries will panic.

The most integrated countries either panic together as a group or do not panic as a group, while the less integrated countries generally do not share their fate. The intuition for this is exactly the same as for Proposition 1. The interdependence of the integrated countries through trade and financial linkages implies a coordination of equilibria among the most integrated countries. The less integrated countries generally do not share this fate as they are less affected by what is happening in the rest of the world.

1.4.2.2 Financial Integration Heterogeneity

The second case that is analytically tractable allows for financial integration heterogeneity ($\phi_k = k$) while keeping constant the level of trade integration for all countries ($\psi_i = \psi$). As already discussed, in this case the level of trade integration cannot be too low or too high. We assume that $\psi \in (\psi_{low}, \psi_{high})$, where ψ_{low} and ψ_{high} are defined in the Technical Appendix as a function of model parameters. Rather than consider all possible equilibria, we will focus here on the ones most relevant in the context of the Great Recession, where the most integrated countries panic. This is analogous to the second part of Proposition 2 for the case of trade heterogeneity.[34] In the Technical Appendix, we are able to prove the following Proposition:

Proposition 3. *Assume that $\phi_k = k$ and $\psi_i = \psi$. For each $\psi \in (\psi_{low}, \psi_{high})$, the following equilibria exist:*

There is an equilibrium where $\left(\bar{V}, Q\right) = \left(\bar{V}^*, Q^*\right)$, such that all countries on the interval $\left\langle \tilde{\phi}, 1\right]$ panic and none of the countries in the interval $\left[0, \tilde{\phi}\right]$ panic.

In addition, there are equilibria where $\left(\bar{V}, Q\right) < \left(\bar{V}^*, Q^*\right)$, such that all countries on the interval $\left[\tilde{\phi}\left(\bar{V}, Q\right), 1\right]$ panic, with $\tilde{\phi} < \tilde{\phi}^*$. When $\left(\bar{V}, Q\right) > \left(A_L, \bar{\phi} \ln A_L\right)$, a

[34] One can show that equilibria analogous to the first part of Proposition 2 still exist as well.

subset of the remaining countries also panics.

The message from this proposition is analogous to what we found for the second type of equilibria in Proposition 2, as we now have that countries that are sufficiently financially integrated must panic together as a group. There is a minimum set of integrated countries that panics in these equilibria, defined as $\phi_k \in [\tilde{\phi}^*, 1]$. When this minimum set of integrated countries panics, none of the less integrated countries will panic.

1.4.2.3 Trade and Financial Integration Heterogeneity

We now consider the general case with both trade and financial integration heterogeneity. This case is too complex for a general analytical solution and we proceed numerically. Using the equilibrium expression for profits, we can write (1.38)-(1.39) as

$$\begin{aligned} A_{ik} &= A_L \text{ if } A_L^{\psi_i}\left[1+\left(\frac{1-\bar{\psi}}{1-\psi_i}\right)\psi_i\phi_k\left(Q-\bar{\phi}\ln\, A_L\right)\right]^{1-\psi_i}\bar{V}^{1-\psi_i} < \sigma\kappa \quad (1.43) \\ &= 1 \quad \text{if } \beta\left(1-A_L^{\sigma-1}\right)\left[1+\left(\frac{1-\bar{\psi}}{1-\psi_i}\right)\psi_i\phi_k Q\right]^{1-\psi_i}\bar{V}^{1-\psi_i} \geq \sigma\kappa \quad (1.44) \end{aligned}$$

In the cases discussed above that we could solve analytically, we saw that there is a minimum set of integrated countries that panics. If only this minimum set of integrated countries panics, none of the less integrated countries panic. We can associate this equilibrium with a pair $(Q^*, \bar{V}^*)$. We will focus on this equilibrium in the numerical solution. In general, as we have seen, there will also be equilibria where a larger group of integrated countries panics and a subset of the less integrated countries panics as well.

We briefly describe the numerical solution method. We start with a given pair $(Q_0, \bar{V}_0)$ large enough so that $(Q_0, \bar{V}_0) > (Q^*, \bar{V}^*)$ but low enough so that (1.43) holds even for the most integrated countries. For each country we then evaluate (1.44). If this condition does not hold, only the panic equilibrium is feasible for this country and we correspondingly assign $A_{ik} = A_L$. If (1.44) holds, we assume that the country does not panic, so $A_{ik} = 1$, as we are seeking the minimum set of countries that must panic. These solutions for A_{ik} imply new values Q_1 and $\bar{V}_1$ such that either $Q_1 < Q_0$ or $\bar{V}_1 < \bar{V}_0$ or both hold.[35] It follows that the original

[35] We compute these values of Q and $\bar{V}$ using the concept of the Riemann sum as an approximation to the Riemann integral. We first set a grid of 200^2 points in the unit square to approximate a continuum of countries, and then we approximate the integrals (1.34)-(1.35) computing the corresponding Riemann sums for all small increments in the two-dimensional grid. We test the accuracy of this method by calculating the equilibrium value of $\bar{V}_2$ in the context of Proposition 2, which

pair $(Q_0, \bar{V}_0)$ cannot be an equilibrium, because setting $A_{ik} = A_L$ for any set of countries that also satisfy (1.44) only decreases Q_1 and $\bar{V}_1$ even further. We then proceed as before by picking the new pair $(Q_1, \bar{V}_1)$, solving the A_{ik} and continue to iterate along this line until Q and $\bar{V}$ converge to the equilibrium pair $(Q^*, \bar{V}^*)$. Thus the numerical method allows us to establish that there are only equilibria such that $(Q, \bar{V}) \leq (Q^*, \bar{V}^*)$, and at the same time it provides an iterative procedure to find the equilibrium.[36]

The process of numerical convergence is closely connected to the economic intuition behind these equilibria. When a sufficiently large set of countries panics, the interdependence of the integrated countries through trade and financial linkages implies that even more countries must panic. In turn this increased set of countries triggers a panic in some of the less integrated countries. This process continues until the remaining countries are sufficiently disconnected from the rest of the world that they can avoid a panic even if most of the world panics.

Figure 2 provides an illustration. We assume that countries are distributed such that $\psi_i = (1 - \theta_T)(1 - \alpha_T i)$ and $\phi_k = \theta_F + \alpha_F k$, where $\theta_T = 0.07$, $\alpha_T = 0.34$, $\theta_F = 0$ and $\alpha_F = 1.83$. These values are chosen such that the most integrated country enjoys full risk-sharing in normal times (when $A_{ik} = 1$ for all countries), while at the same time there are no countries in complete autarky.[37] The remaining parameter values $\sigma = 28.95$, $\kappa = 0.03$, $\beta = 1$ and $A_L = 0.9$ are chosen such that Assumption 1 holds, monetary policy is constrained at the ZLB, and output drops by 10% during a panic.

The figure is in the space of trade and financial integration. On the horizontal axis we have $1 - \psi_i$, a measure of trade integration. On the vertical axis we have ϕ_k, a measure of financial integration. These correspond well to the counterparts of trade and financial integration in the empirics. In Appendix A we show that total exports by country (i, k) are proportional to $(1 - \psi_i)$. Similarly, we show in Appendix C that ϕ_k can be seen as the theoretical counterpart of the measure of financial integration from the empirics.

In the equilibrium that we analyze all the integrated countries panic, while all the less integrated countries do not panic. All the integrated countries are above the

can also be computed with a standard numerical solver as the solution of a non-linear equation. Due to the density of the two-dimensional grid we employ, we find that both methods provide the exact same solution.

[36]Given that the left-hand-side of (1.44) is decreasing in Q and $\bar{V}$, other possible equilibrium pairs necessarily involve a larger set of countries that panic than the set associated with $(Q^*, \bar{V}^*)$.

[37]The values also ensure that (1.38)-(1.39) cannot hold simultaneously for very integrated countries. This way we ensure the existence of the same type of equilibria as in the second part of Proposition 2.

threshold line shown in Figure 2, while all the less integrated countries are below the threshold line. This corresponds well to the empirical results for the Great Recession. First, it is consistent with the result that the drop in output was larger during the Great Recession for countries whose integration level was beyond some threshold than for countries that were less integrated.[38] Second and related, it is consistent with evidence that there is no monotonic relationship between integration and the drop in output. Within each group of countries the level of output is identical. Integration only matters in terms of what side of the threshold countries are. Third, trade and financial integration are substitutes. As a country's trade integration increases, a lower level of financial integration is needed to reach the threshold line. It follows that it is a combination of the two types of economic integration that matters in classifying countries as integrated or less integrated.

Finally, it is worth noting the crucial role that financial integration plays in this example. If all countries were in financial autarky ($\phi_k = 0$), with the remaining parameter values the same, there do not exist coordinated equilibria as the level of trade integration is too low. It is the extent of heterogenous financial integration across countries that makes the difference here, by strengthening the positive linkages within the integrated group.

1.4.3 Allowing for Random Shocks

We finally consider the most general possible case, with both trade and financial integration heterogeneity and country-specific productivity shocks x_{ik} that last both periods. From a mathematical perspective, little changes relative to the previous subsection. Using the Law of Large Numbers, we can replace each random term inside the integrals (1.34)-(1.35) by its expectation.[39] The aggregate solution of the model will therefore not depend on which particular countries are hit by good or bad shocks, or the magnitude of these shocks. In terms of $(Q, \bar{V})$ space, the equilibria are therefore the same as before: $(Q, \bar{V}) \leq (Q^*, \bar{V}^*)$, with the latter solved with the same iteration procedure as before.

Once we have the pair $(Q^*, \bar{V}^*)$, we can evaluate the non-panic condition (1.39), which now depends on ψ_i, ϕ_k and x_{ik}, to decide which countries necessarily panic. What changes now is that relatively integrated countries can avoid a panic if they get hit by a big enough positive shock x_{ik} because good domestic conditions keep profits strong so that lucky countries can invest and avoid a panic. Similarly some relatively less integrated countries hit by a negative shock can fall in a panic because

[38] Output equals respectively A_L and 1 for integrated and less integrated countries.
[39] See Uhlig (1996).

bad domestic conditions exacerbate the impact of poor foreign conditions.

An intuitive way to illustrate the role of trade and financial integration is in terms of probabilities of experiencing a panic. Conditional on the pair $(Q^*, \bar{V}^*)$, these probabilities are given by

$$\Pr(\pi^{ik}(\psi_i, \phi_k, x_{ik}, Q^*, \bar{V}^*) < \kappa/[\beta\left(1 - A_L^{\sigma-1}\right))] \tag{1.45}$$

This is the probability that (1.39) does not hold, so that the country must panic. A panic then occurs when $x_{ik} < x(\psi_i, \phi_k)$, where $x(\psi_i, \phi_k)$ is the value of x_{ik} such that $\pi^{ik} = \kappa/[\beta\left(1 - A_L^{\sigma-1}\right)]$ as an equality. Solving for $x(\psi_i, \phi_k)$ then easily lets us compute the panic probability for a given distribution of the x_{ik}.

Figure 3 provides an illustration. The equilibrium $(Q^*, \bar{V}^*)$ is computed for the same parameter values as in the previous subsection and we plot the continuum of countries in the unit square.[40] We assume $x_{ik} \sim N(0, 0.005)$ for all countries. The figure plots the probability contour map associated with the equilibrium pair $(Q^*, \bar{V}^*)$.

It is clear from this picture that it is no longer the case that necessarily all integrated countries panic as a group. The probabilities of a panic are much higher for integrated countries, but it is now possible that an integrated country does not panic if it gets a very positive productivity shock. Similarly, less integrated countries may be hit by a very bad shock and together with the negative spillovers from the global panic could fall into a panic. This leads to differences across countries in growth that are unrelated to levels of integration. It remains the case that there is a strong threshold, but consistent with the data there are now some less integrated countries that perform very poorly and some integrated countries that perform well. This is consistent with Figure 1, where we saw that not all integrated countries are bad performers and not all less integrated countries are good performers. Integration matters in a threshold type of way, but pure country-specific randomness certainly plays a role as well.

1.5 Conclusion

In the introduction we argued that two features characterize cross-country business cycle synchronicity during the Great Recession. The first is that the degree of business cycle synchronicity at this time was historically unparalleled. The second feature is about the relationship between economic integration and the extent that

[40] Since the expressions for ψ and ϕ are linear in i and k, the unit square can also be interpreted as the trade/financial space.

countries were impacted by the Great Recession. While there is no robust monotonic relationship between levels of integration and the drop in output during the Great Recession, we have developed evidence of a strong non-linear relationship. Countries below a certain threshold of integration, capturing both trade and financial integration, were much less affected than those above the threshold.

We have shown that these features are consistent with a model that extends the two-country BvW model of self-fulfilling business cycles to a multi-country setting with heterogeneity across countries with regard to both trade and financial integration. We find that integrated countries necessarily panic as a group as their interconnectedness makes it impossible to have widely varying outlooks on the future. At the same time less integrated countries are less dependent on other countries and therefore in equilibrium may not panic even if most of the rest of the world panics. This creates a dichotomy, with a larger drop in output for countries whose level of integration is above a certain threshold cutoff than those that are less integrated. Within both groups of countries the theory implies no relationship between the decline in output and the level of integration. This explains why integration only matters in a discontinuous way.

Appendix

A. Condensed Version of the Model

In this Appendix we derive the condensed version of the model described in section 3.5. We first establish that all prices are constant across periods, from which it follows that real variables are also constant. This allows us to solve the relevant variables of the model as a function of second period productivities. Throughout the process we will drop the time index from those variables that are known to be constant over time.

As a starting point, we know that the assumed monetary policy and the consumption Euler Equation imply that both P^{ik} and c^{ik} are constant. The transfer component $ln\left(g_1^{jl}/g_1^{ik}\right)$ is also constant as it only depends on first period real outputs. To see this, note that by definition $g_1^{ik} = y_1^{ik}/E_0[y_1^{ik}]$. Prior to the realization of any shock all countries are expected to have the same real output, hence $ln\left(g_1^{jl}/g_1^{ik}\right) = ln\ y_1^{jl} - ln\ y_1^{ik}$.

In equilibrium all firms in country (i,k) set the same price and output in all firms is the same, hence goods market equilibrium is described by

$$y_t^{ik} = c_{ik,t}^{ik} + \int\int_0^1 c_{ik,t}^{jl} dj dl \tag{1.46}$$

Substituting the expressions for consumption we have

$$P_t(i,k) y_t^{ik} = \psi_i P^{ik} c^{ik} + S_{ik,t} E_t^{ik} \tag{1.47}$$

where E_t^{ik} is nominal exports of country (i,k), measured in the base currency and given by

$$E_t^{ik} = (1-\psi_i)\int\int_0^1 \frac{1-\psi_j}{1-\bar{\psi}} \frac{P^{jl}}{S_{jl,t}} c^{jl} dj dl$$

Integrating E_t^{jl} over j and l we obtain world exports:

$$E_t^W = \int\int_0^1 E_t^{jl} dj dl = (1-\bar{\psi})\int\int_0^1 \frac{1-\psi_j}{1-\bar{\psi}} \frac{P^{jl}}{S_{jl,t}} c^{jl} dj dl$$

It follows that

$$E_t^{ik} = \frac{(1-\psi_i)}{(1-\bar{\psi})} E_t^W$$

so that (1.47) becomes

$$P_t(i,k)y_t^{ik} = \psi_i P^{ik}c^{ik} + S_{ik,t}\frac{(1-\psi_i)}{(1-\bar{\psi})}E_t^W \tag{1.48}$$

Using the budget constraint of country (i,k), and imposing money and bond market equilibrium, we can write

$$P^{ik}c^{ik} = P_t(i,k)y_t^{ik} + S_{ik}E_t^W\phi_k\left(Q - \bar{\phi}ln\ y_1^{ik}\right) \tag{1.49}$$

where $Q = \int\int_0^1 \phi_l ln\ y_1^{jl} dj dl$ and $\bar{\phi} = \int_0^1 \phi_l dl$. If we substitute this expression into (1.48) and rearrange terms we get

$$\frac{P^{ik}c^{ik}}{S_{ik,t}G^{ik}} = \frac{E_t^W}{1-\bar{\psi}} \tag{1.50}$$

where $G_{ik} = 1 + \left(\frac{1-\bar{\psi}}{1-\psi_i}\right)\phi_k\left(Q - \bar{\phi}ln\ y_1^{ik}\right)$. Then, using that the previous equation also holds for the base country b and that for this country $S_{b,t} = 1$ we obtain the following equivalence

$$\frac{P^{ik}c^{ik}}{G_{ik}S_{ik,t}} = \frac{P^b c^b}{G_b} \tag{1.51}$$

which implies that $S_{ik,t}$ is constant. Now, take logs on both sides of the consumer price index equation and rearrange terms such that

$$ln\ P_t(i,k) = \frac{ln\ P^{ik}}{\psi_i} - \frac{(1-\psi_i)}{\psi_i}ln\ S_{ik} - \frac{(1-\psi_i)}{\psi_i}ln\ P_{F,t} \tag{1.52}$$

Substituting this expression into the Foreign price index equation and rearranging terms delivers

$$ln\ P_{F,t} = \left(1 + \int\int_0^1 \frac{(1-\psi_j)^2}{(1-\bar{\psi})\psi_j}djdl\right)^{-1}\int\int_0^1 \frac{1-\psi_j}{(1-\bar{\psi})\psi_j}ln\left(\frac{P^{jl}}{S_{jl}}\right)dj \tag{1.53}$$

which implies that $ln\ P_{F,t}$ is also constant, as all the elements of the RHS of this equation are constant. In turn, (1.52) now implies that $P(i,k)$ is also constant. Thus, we have established that all prices are constant across periods.[41] Finally, we note from (1.49) and (1.50) that world exports and output must also be the same in both periods, which means that all nominal and real variables of the model are constant.

[41] The only exception is the second period wage. Using that $P_1(i,k) = P_2(i,k)$ and equation (1.18) for both periods, we get $W_2^{ik} = A_{ik}\bar{W^{ik}}$, where $\bar{W^{ik}}$ is the nominal wage in period 1 that is predetermined.

Note that in period 2 $L_2^{ik} = 1$ and that in equilibrium all firms in country (i, k) will make the same investment decision so that $A_{ik,2}(m) = A_{ik}$, where A_{ik} can be either 1 or A_L depending on whether firms incur the investment cost or not. Using (1.17) it follows that country (i, k) output is given by

$$y^{i,k} = V_{ik} \tag{1.54}$$

where $V_{ik} = e^{x_{ik}} A_{ik}$. In period 1 we have $A_{ik,1}(m) = 1$ and $L_1^{ik} = 1 - u^{ik}$ from the labor market equation. Since output is the same in both periods, $u^{ik} = 1 - A_{ik}$.

Next, combine (1.50) and (1.54) with the budget constraint to find

$$\frac{P^{ik} c^{ik}}{G_{ik}} = \frac{P(i,k) V_{ik}}{D_{ik}} \tag{1.55}$$

where $D_{ik} = 1 + \left(\frac{1-\bar{\psi}}{1-\psi_i}\right) \psi_i \phi_k \left(Q - \bar{\phi} ln\ V_{ik}\right)$. Substituting this equation into (1.51) for both (i, k) and the base country we find an expression for the exchange rate:

$$S_{ik} = \frac{D_b P(i,k) V_{ik}}{D_{ik} P(b) V_b} \tag{1.56}$$

Taking logs on this equation and substituting it into the Foreign price index formula gives

$$ln\ P_F = \int \int_0^1 \frac{1-\psi_j}{1-\bar{\psi}} \left(ln\ P(b) V_b - ln\ D_b + ln\ D_{jl} - ln\ V_{jl}\right) dj dl \tag{1.57}$$

Define

$$ln\ \bar{V} = \int \int_0^1 \frac{1-\psi_j}{1-\bar{\psi}} ln\ \left(\frac{V_{jl}}{D_{jl}}\right) dj dl \tag{1.58}$$

so that the Foreign price index becomes

$$P_F = \frac{P(b) V_b}{D_b \bar{V}} \tag{1.59}$$

Substituting (1.56) and (1.59) into the consumer price index formula delivers

$$\frac{P(i,k)}{P^{ik}} = \left(\frac{\bar{V} D_{ik}}{V_{ik}}\right)^{1-\psi_i} \tag{1.60}$$

Then, if we substitute this last expression into (1.55), we can solve for country (i, k) consumption as follows

$$c^{ik} = G^{ik} \left(\frac{V_{ik}}{D_{ik}}\right)^{\psi_i} \bar{V}^{1-\psi_i} \tag{1.61}$$

We finally need to derive an expression for profits. We can substitute into the formula for real profits (1.20) $y^i = V_{ik}$ and (1.60). Rearranging, the expression for profits becomes

$$\pi^{ik} = \frac{1}{\sigma} V_{ik}^{\psi_i} \left(D_{ik} \bar{V} \right)^{1-\psi_i} \tag{1.62}$$

B. Incentive and borrowing conditions

If all firms in country (i, k) are investing, we must make sure that any individual firm indeed must be able and willing to invest. If no firm is investing, we must make sure that for an individual firm either profits are not enough to cover the fixed cost or investing lowers the present discounted value of its profits. To check all this, we have to look at the incentive and borrowing conditions for an individual firm. We therefore need to derive expressions for second period profits for an individual firm m. We first derive an expression for second period profits of an individual firm, then derive the incentive and borrowing conditions, and finally we establish which condition is the relevant one to look at for each of the two possible states of the economy (panic or non-panic).

Using the optimal price equation and the production function, we can rewrite second period profits as

$$\Pi_2^{ik}(m) = \frac{1}{\sigma - 1} \frac{W_2^{ik} y_2^{ik}(m)}{e^{x_{ik}} A_{ik,2}(m)}$$

To determine firm's demand $y_2^{ik}(m)$, use the market clearing condition for good m (1.24), substitute the CES demands (1.12) and rearrange terms to get

$$y_2^{ik}(m) = \left(c_{ik,2}^{ik} + \int \int_0^1 c_{ik,2}^{jl} dj dl \right) \left(\frac{P_2(i,k)}{P_2^{ik}(m)} \right)^{\sigma}$$

From (1.46) we know that the first term in brackets equals y^{ik}. In any equilibrium we have that $P(i,k) = [\sigma/(\sigma - 1)] \left(W^{ik}/(e^{x_{ik}} A_{ik}) \right)$. Using again the optimal price equation, the price ratio becomes

$$\frac{P(i,k)}{P_2^{ik}(m)} = \frac{A_{ik,2}(m)}{A_{ik}}$$

Substituting this ratio and the solution for output gives

$$y_2^{ik}(m) = V_{ik} \left(\frac{A_{ik,2}(m)}{A_{ik}} \right)^{\sigma}$$

Together with the fact that $W^{ik} = ((\sigma - 1)/\sigma) \, P(i,k) V_{ik}$ (just rearrange the optimal price in equilibrium) second period profits become

$$\Pi_2^{ik}(m) = \frac{1}{\sigma} P(i,k) V_{ik} \left(\frac{A_{ik,2}(m)}{A_{ik}} \right)^{\sigma - 1}$$

We have that $A_{ik,2}(m) = 1$ if the firm invests and $A_{ik,2}(m) = A_L$ otherwise. Substituting the corresponding expressions into the incentive condition (1.23), together with (1.60) and rearranging, we obtain the condensed version of the incentive condition:

$$\frac{\beta \left(1 - A_L^{\sigma-1}\right)}{\sigma A_{ik}^{\sigma-1}} V_{ik}^{\psi_i} \left(D_{ik} \bar{V}\right)^{1-\psi_i} \geq \kappa \tag{1.63}$$

Using (1.62), we also can write it as:

$$\frac{\beta \left(1 - A_L^{\sigma-1}\right)}{A_{ik}^{\sigma-1}} \pi^{ik} \geq \kappa \tag{1.64}$$

whereas the condensed version of the borrowing condition is

$$\pi^{ik} \geq \kappa \tag{1.65}$$

Now suppose that country (i,k) is not in a panic state, so that $A_{ik} = 1$. Since we have that $\beta \left(1 - A_L^{\sigma-1}\right) < 1$, it follows that (1.64) is a necessary and sufficient condition to ensure that (i,k) is not in a panic. Suppose instead that country (i,k) is in a panic state, so that $A_{ik} = A_L$. This will be the case if the incentive condition (1.64) does not hold, or the borrowing condition (1.65) does not hold, or neither holds. Using Assumption 1, we have

$$A_L^{\sigma-1} \leq A_L < \sigma\kappa < \beta \left(1 - A_L^{\sigma-1}\right) \tag{1.66}$$

It follows that $\beta \left(1 - A_L^{\sigma-1}\right) > A_L^{\sigma-1}$, which in turn implies that

$$\pi^{ik} < \kappa \tag{1.67}$$

is a sufficient and necessary condition to ensure that country (i,k) is in a panic state.

C. Microfoundations behind the transfer function

In this Appendix we argue that the transfer function T^{ik} can be seen as the reduced form of a country's net payouts structure under a particular asset market structure. The setup is related to previous work (Mendoza and Quadrini (2010)), and aims to capture in a simple way (with only one parameter) cross-country variation in financial integration and partial risk-sharing.

Suppose that, in addition to periods 1 and 2, there is a period 0 where households can trade assets that will generate payouts in the following two periods. Households from country (i, k) can sell a^{ik}_{jl} units of the asset to country (j, l) residents, with a promised payment of each asset equal to a fraction $ln\left(\frac{g^{ik}}{g^{jl}}\right)$ of nominal world exports if $g^{ik} - g^{jl} \geq 0$ and zero otherwise. Recall that $g^{ik} = y^{ik}_1 / E_0 y^{ik}_1$. The asset provides income to country (j, l) residents when (j, l) performs unexpectedly worse in terms of output, with larger payments received the higher the unexpected output difference. Equal payments happen both periods as exogenous productivity shocks are permanent and the probability of a period 1 sunspot is assumed infinitesimal from the perspective of time 0.

The asset is obviously valuable so its price will be positive in equilibrium. Also note that all countries make the same type of promise and that all of them have the same independent distribution of the shocks. Therefore the price of each of these assets is the same and we can normalize them to one.

In principle full risk-sharing is possible with these assets, but we assume a standard financial friction in the form of a commitment problem. For each pair $((i, k).(j, l))$, country (i, k) can avoid the payment by paying a penalty p of

$$p = \phi_k \phi_l E^W ln\left(\frac{g^{ik}}{g^{jl}}\right) \tag{1.68}$$

Therefore

$$a^{ik}_{jl} \leq \phi_k \phi_l \tag{1.69}$$

This puts a limit on the size of the contracts that each country pair can trade. If $\phi_k \phi_l$ is low enough the constraint will be binding, so that country (i, k) will make a payment of

$$a^{ik}_{jl} E^W ln\left(\frac{g^{ik}}{g^{jl}}\right) = \phi_k \phi_l E^W ln\left(\frac{g^{ik}}{g^{jl}}\right) \tag{1.70}$$

to country (j, l) if $g^{i,k} - g^{j,l} \geq 0$, and zero otherwise. By symmetry country (i, k) receives a payment if its income is unexpectedly low relative to that of (j, l). Putting the two together, (i, k) receives a net transfer (positive or negative) from (j, l) equal to

$$\phi_k \phi_l E^W ln\left(\frac{g^{jl}}{g^{ik}}\right) \tag{1.71}$$

Integrating over all the countries, the net transfer received by (i, k) is

$$\int \int_0^1 \phi_k \phi_l E^W ln\left(\frac{g^{jl}}{g^{ik}}\right) dj dl = T^{ik} \tag{1.72}$$

which is the same transfer function we assume in the paper.

It remains to be seen under which circumstances $a_{jl}^{ik} \leq \phi_k \phi_l$ is binding. From Appendix A, the solution for consumption in normal times (the non-panic state) is given by

$$c^{ik} = G^{ik} \left(\frac{e^{x_{ik}}}{D_{ik}} \right)^{\psi_i} \bar{V}^{1-\psi_i} \tag{1.73}$$

where $\overline{V}$ is the aggregate component common to all countries. The key risk-sharing component is the ratio $G^{ik}/D_{ik}^{\psi_i}$. In order for the assets to provide risk-sharing, this ratio should move in the opposite direction of the country-specific component $e^{\psi_i x_{ik}}$: if this component increases then $G^{ik}/D_{ik}^{\psi_i}$ must decrease, and vice versa. In addition, the opposite effect of $G^{ik}/D_{ik}^{\psi_i}$ cannot more than offset the change in $e^{\psi_i x_{ik}}$ or we would not have full risk-sharing either. In the good equilibrium we find that the derivative dc^{ik}/dy^{ik} evaluated at $x_{ik} = 0$ (an approximation for shocks of small magnitude) is given by

$$\left| \frac{dc^{ik}}{dx^{ik}} \right|_{x^{ik}=0} = \psi_i - \phi_k \bar{\phi}(1 + \psi_i)(1 - \bar{\psi}) \tag{1.74}$$

the constraint is that this derivative must be non negative.[42] If $dc^{ik}/dx^{ik} = 0$ we have full risk-sharing, as (i, k) consumption does not depend on the country-specific component $e^{x_{ik}}$. If $\phi_k = 0$ we have the well-known result that risk-sharing depends on the level of trade integration. We will make the following risk-sharing assumption: for the most integrated country $(1, 1)$ we have that

$$\phi_1 \leq \frac{1}{\bar{\phi}} \frac{\psi_1}{(1 + \psi_1)(1 - \bar{\psi})} \tag{1.75}$$

Since $\frac{\psi}{1+\psi}$ is increasing in ψ, $\frac{\psi_1}{1+\psi_1}$ is the minimum this object can be, and ϕ_1 is the maximum value that ϕ_k can take. It follows that if the risk-sharing assumption is satisfied then $dc^{ik}/dx^{ik} \geq 0$ for all countries. Also, note that dc^{ik}/dx^{ik} is decreasing in the size of ϕ_k. This means that a) countries are partially insured at best, and b) the level of risk-sharing (lower dc^{ik}/dx^{ik}) increases when we relax the constraint $a_{jl}^{ik} \leq \phi_k \phi_l$ by increasing the country-specific parameter ϕ_k. More risksharing is therefore always desirable, so that the constraint $a_{jl}^{ik} \leq_l \phi_k \phi_l$ is always binding.

Finally, let us point out a nice connection between the theory and the empirics under this setup. From the discussion above, the total value of the assets bought by

[42] To derive this result, note that $Q = 0$ by a Law of Large Numbers (see Uhlig (1996)) and that $\bar{V}$ equals 1 when $x^{jl} = 0$.

country (i,k) in period 0 is

$$\int\int_0^1 a_{ik}^{jl} dj dl = \int\int_0^1 \phi_k \phi_l dj dl = \bar{\phi}\phi_k \tag{1.76}$$

It follows that the total value of (external) assets is proportional to the level of financial integration, which by symmetry also equals the total value of liabilities. But the total value of external assets and liabilities is precisely the measure we use in the empirical section.

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TABLE 1: List of countries

ALB	Albania
DZA	Algeria
AGO	Angola
ATG	Antigua and Barbuda
ARG	Argentina
AUS	Australia
AUT	Austria
AZE	Azerbaijan
BHR	Bahrain
BGD	Bangladesh
BLR	Belarus
BEL	Belgium
BLZ	Belize
BEN	Benin
BTN	Bhutan
BOL	Bolivia
BWA	Botswana
BRA	Brazil
BRN	Brunei Darussalam
BGR	Bulgaria
BFA	Burkina Faso
BDI	Burundi
CPV	Cabo Verde
CMR	Cameroon
CAN	Canada
CAF	Central African Republic
TCD	Chad
CHL	Chile
CHN	China
COL	Colombia
COM	Comoros
CRI	Costa Rica
HRV	Croatia
CYP	Cyprus
CZE	Czech Republic
CIV	Côte d'Ivoire
ZAR	Democratic Republic of the Congo
DNK	Denmark
DJI	Djibouti
DMA	Dominica
DOM	Dominican Republic
EGY	Egypt
SLV	El Salvador
EST	Estonia
ETH	Ethiopia
MKD	FYR Macedonia
FJI	Fiji
FIN	Finland
FRA	France
GAB	Gabon
GEO	Georgia
DEU	Germany
GHA	Ghana
GRC	Greece
GRD	Grenada
GTM	Guatemala
GIN	Guinea
GNB	Guinea-Bissau
HTI	Haiti
HND	Honduras
HKG	Hong Kong SAR
HUN	Hungary
ISL	Iceland
IND	India
IDN	Indonesia
IRL	Ireland
IRN	Islamic Republic of Iran
ISR	Israel
ITA	Italy
JAM	Jamaica
JPN	Japan
JOR	Jordan
KAZ	Kazakhstan
KEN	Kenya
KOR	Korea
KWT	Kuwait
KGZ	Kyrgyz Republic
LAO	Lao P.D.R.
LVA	Latvia
LBN	Lebanon
LSO	Lesotho
LBY	Libya
LTU	Lithuania
MDG	Madagascar
MWI	Malawi
MYS	Malaysia
MDV	Maldives
MLI	Mali
MUS	Mauritius
MEX	Mexico
MDA	Moldova
MNG	Mongolia
MAR	Morocco
MOZ	Mozambique
NAM	Namibia
NPL	Nepal
NLD	Netherlands
NZL	New Zealand
NIC	Nicaragua
NER	Niger
NGA	Nigeria
OMN	Oman
PAK	Pakistan
PAN	Panama
PRY	Paraguay
PER	Peru
PHL	Philippines
POL	Poland
PRT	Portugal
QAT	Qatar
COG	Republic of Congo
ROM	Romania
RUS	Russia
WSM	Samoa
SAU	Saudi Arabia
SEN	Senegal
SYC	Seychelles
SLE	Sierra Leone
SGP	Singapore
SVK	Slovak Republic
SVN	Slovenia
ZAF	South Africa
ESP	Spain
LKA	Sri Lanka
KNA	St. Kitts and Nevis
LCA	St. Lucia
VCT	St. Vincent and the Grenadines
SDN	Sudan
SWZ	Swaziland
SWE	Sweden
CHE	Switzerland
STP	São Tomé and Príncipe
TJK	Tajikistan
TZA	Tanzania
THA	Thailand
GMB	The Gambia
TGO	Togo
TON	Tonga
TTO	Trinidad and Tobago
TUN	Tunisia
TUR	Turkey
UGA	Uganda
UKR	Ukraine
ARE	United Arab Emirates
GBR	United Kingdom
USA	United States
URY	Uruguay
VUT	Vanuatu
VEN	Venezuela
VNM	Vietnam
ZMB	Zambia

TABLE 2: Descriptive statistics and data source

Variable	Mean	Std. Dev.	Min	Max	Source
Forecast error 09	-5.11	4.38	-20.35	5.80	WEO April 2008 and April 2014
GDP growth 09	-0.15	5.14	-17.70	11.96	WEO April 2014
GDP growth trend 96/07	4.43	2.28	0.70	15.29	WEO April 2014
Avrg. GDP growth 04/07	5.69	3.17	-0.71	24.03	WEO April 2014
Trade openness	92.95	50.55	25.21	398.66	World Bank WDI
Financial openness	290.33	418.86	47.75	2604.66	Lane and Milesi-Ferretti
GDPpc (thousands of 2007 dollars)	12.11	16.41	0.17	69.17	WEO April 2014
GDP (billions of 2007 dollars)	365.40	1334.82	0.14	14480.35	WEO April 2014
Population (in millions)	41.45	145.84	0.05	1321.29	WEO April 2014
Manufacturing share	13.55	6.91	1.99	40.78	United Nations database
Current account (% of GDP)	-2.34	13.02	-31.91	47.82	WEO April 2014
Net foreign assets (% of GDP)	-15.95	161.56	-201.39	1618.02	Lane and Milesi-Ferretti
Reserves minus gold (% of GDP)	19.26	17.92	0.21	117.31	Lane and Milesi-Ferretti
Private credit growth 04/07 (% of GDP)	33.39	45.93	-41.18	287.91	World Bank WDI

TABLE 3: Regressions without integration dummies

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Forecast error	GDP growth 09	Forecast error	Forecast error	Forecast error	GDP growth 09
Log(Trade openness)	-1.774	-0.589	-1.906*	-2.080*	-2.301**	-1.660
	(1.1057)	(1.1415)	(1.0700)	(1.0962)	(1.0032)	(1.0556)
Log(Financial openness)	-0.679	-1.116	0.125	0.058	0.743	0.848
	(1.1011)	(1.1730)	(0.9351)	(0.9542)	(0.8433)	(0.9990)
Current account	0.044	0.013	0.027	0.109**	0.081*	0.090*
	(0.0734)	(0.0879)	(0.0546)	(0.0535)	(0.0455)	(0.0524)
Net foreign assets	-0.002	0.002	0.001	-0.007	-0.000	0.001
	(0.0068)	(0.0079)	(0.0017)	(0.0057)	(0.0017)	(0.0019)
Reserves	-0.021	-0.014	-0.012	-0.025	-0.021	-0.024
	(0.0333)	(0.0347)	(0.0316)	(0.0301)	(0.0295)	(0.0292)
Credit growth 04/07	-0.036**	-0.046**	-0.035**	-0.018*	-0.018*	-0.017
	(0.0172)	(0.0193)	(0.0169)	(0.0102)	(0.0106)	(0.0105)
Manufacturing share	-0.069	-0.151	-0.036	-0.085	-0.067	-0.150**
	(0.0869)	(0.0938)	(0.0740)	(0.0708)	(0.0613)	(0.0653)
Growth trend	0.042	0.396	0.062	0.158	0.169	0.440**
	(0.2597)	(0.2386)	(0.2507)	(0.2762)	(0.2589)	(0.2186)
Avrg. GDP growth 04/07	-0.187	0.108	-0.157	-0.272	-0.244	0.011
	(0.2061)	(0.2265)	(0.1978)	(0.2010)	(0.1891)	(0.2014)
Peg dummy	0.439	-0.087	-0.024	0.639	0.323	-0.130
	(0.8667)	(0.8715)	(0.8309)	(0.7240)	(0.7093)	(0.7591)
Oil dummy	-0.665	0.649	-0.490	-1.510	-1.658	-0.869
	(1.5216)	(1.6488)	(1.4453)	(1.2915)	(1.2445)	(1.3775)
GDPpc	-0.038	-0.069	-0.039	-0.082	-0.088*	-0.149**
	(0.0589)	(0.0730)	(0.0498)	(0.0557)	(0.0463)	(0.0625)
GDP	-0.000	-0.000	-0.000	0.000	-0.000	-0.000
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Log(Population)	0.203	0.512	0.151	0.129	0.122	0.392
	(0.3192)	(0.3543)	(0.2846)	(0.2806)	(0.2514)	(0.2785)
Constant	6.172	1.679	2.839	5.613	3.177	-0.115
	(9.6579)	(10.7313)	(8.0674)	(8.5209)	(7.1908)	(8.4511)
Observations	110	110	117	144	151	151
R-squared	0.232	0.319	0.214	0.235	0.213	0.319

Robust standard errors in parentheses
***** p<0.01, ** p<0.05, * p<0.1**

TABLE 4: Regressions with integration dummies

	(1)	(2)	(3)
VARIABLES	Forecast error	Forecast error	Forecast error
Trade dummy	-3.011**		
	(1.3572)		
Financial dummy		-4.541***	
		(1.1794)	
Joint dummy			-4.716***
			(1.2050)
Log(Trade openness)	0.779	-1.973*	-1.458
	(1.5560)	(1.0923)	(1.0370)
Log(Financial openness)	-0.408	2.019	1.963
	(1.1011)	(1.2854)	(1.2686)
Current account	0.054	0.036	0.031
	(0.0720)	(0.0731)	(0.0737)
Net foreign assets	-0.002	-0.005	-0.005
	(0.0069)	(0.0067)	(0.0068)
Reserves	-0.019	-0.004	-0.004
	(0.0327)	(0.0321)	(0.0321)
Credit growth 04/07	-0.035**	-0.038**	-0.038**
	(0.0155)	(0.0163)	(0.0161)
Manufacturing share	-0.060	-0.044	-0.055
	(0.0830)	(0.0711)	(0.0706)
Growth trend	-0.032	0.079	0.120
	(0.2246)	(0.2069)	(0.2102)
Avrg. GDP growth 04/07	-0.100	-0.169	-0.215
	(0.1844)	(0.1912)	(0.1923)
Peg dummy	0.484	0.356	0.164
	(0.8470)	(0.8264)	(0.8270)
Oil dummy	-0.376	-0.213	-0.065
	(1.5516)	(1.4742)	(1.4753)
GDPpc	-0.040	-0.042	-0.036
	(0.0589)	(0.0596)	(0.0599)
GDP	0.000	0.000	0.000
	(0.0002)	(0.0002)	(0.0002)
Log(Population)	0.035	0.060	0.082
	(0.3409)	(0.2898)	(0.2888)
Constant	-2.708	-2.926	-4.987
	(8.8620)	(9.2963)	(9.3826)
Observations	110	110	110
R-squared	0.265	0.325	0.330

Robust standard errors in parentheses

***** p<0.01, ** p<0.05, * p<0.1**

TABLE 5: List of less integrated countries

Albania	India
Algeria	Indonesia
Angola	Islamic Republic of Iran
Argentina	Korea
Azerbaijan	Maldives
Belarus	Mexico
Bolivia	Mongolia
Brazil	Morocco
Cameroon	Nigeria
China	Oman
Colombia	Peru
Costa Rica	Philippines
Dominican Republic	Poland
Egypt	Romania
El Salvador	Samoa
Fiji	Sri Lanka
Gabon	Swaziland
Georgia	Tonga
Ghana	Turkey
Guatemala	Venezuela
Honduras	

TABLE 6

PERCENTILE	19	21	23	25	27	29	31	33	35	37	39	41	43	45
ALPHA														
0	**-2.72**	**-2.76**	**-2.65**	**-2.56**	**-2.36**	**-2.28**	**-2.76**	**-3.59**	**-4.35**	**-3.69**	**-3.90**	**-3.38**	**-2.51**	-0.61
0.05	**-2.64**	**-2.76**	-2.12	**-2.56**	**-2.45**	**-2.28**	**-2.76**	**-3.59**	**-4.35**	**-3.69**	**-3.90**	**-3.17**	**-2.51**	-0.61
0.1	**-2.64**	**-2.76**	-2.12	**-2.56**	**-2.45**	**-2.28**	**-2.54**	**-3.29**	**-3.91**	**-4.72**	**-3.90**	**-3.29**	**-2.51**	-0.61
0.15	**-2.64**	**-2.23**	**-2.68**	**-2.31**	**-2.45**	**-2.25**	**-2.73**	**-3.09**	**-3.64**	**-4.32**	**-3.90**	**-3.29**	-1.87	-0.61
0.2	**-2.64**	**-2.23**	**-2.49**	**-2.31**	**-2.45**	**-2.25**	**-2.73**	**-3.09**	**-3.64**	**-3.35**	**-3.13**	**-3.29**	-2.10	-0.37
0.25	**-2.99**	**-2.52**	**-2.49**	**-2.31**	**-2.45**	**-2.52**	**-2.98**	**-3.06**	**-3.64**	**-3.35**	**-3.13**	-2.01	-1.57	-1.23
0.3	**-3.17**	**-2.93**	**-2.49**	**-2.17**	**-2.45**	**-2.52**	**-2.98**	**-3.48**	**-3.41**	**-3.35**	**-3.13**	-2.04	-1.18	-0.64
0.35	**-3.17**	**-2.93**	**-2.60**	**-2.17**	**-2.45**	**-2.49**	**-2.71**	**-2.84**	**-3.41**	**-3.35**	-1.51	-0.87	-1.18	-1.07
0.4	**-3.17**	**-2.93**	**-2.60**	**-2.46**	-2.22	**-2.51**	**-2.23**	**-2.84**	**-3.41**	**-3.35**	-1.51	-1.29	-0.74	0.26
0.45	**-3.17**	**-2.93**	**-3.17**	**-2.90**	**-2.49**	-2.01	**-2.23**	**-2.84**	**-3.41**	**-2.62**	-1.17	-1.38	-0.74	0.26
0.5	**-3.36**	**-2.93**	**-3.17**	**-2.95**	**-2.46**	**-2.30**	**-2.26**	**-2.84**	**-3.41**	**-3.02**	-2.25	-1.38	-0.74	0.26
0.55	**-3.41**	**-2.86**	**-2.63**	**-2.95**	**-2.46**	**-3.08**	**-2.73**	**-2.78**	**-2.81**	-2.01	-2.25	-0.58	-0.25	-0.07
0.6	**-3.41**	**-2.86**	**-2.63**	**-2.34**	**-2.44**	**-2.25**	-1.76	**-2.30**	-1.98	-2.16	-2.36	-0.58	-0.70	0.35
0.65	**-3.68**	**-3.06**	-2.16	**-2.34**	-1.71	-2.04	-1.87	**-2.38**	**-2.41**	**-2.82**	**-2.70**	-1.36	-0.54	-1.19
0.7	**-2.74**	**-3.00**	-2.16	-1.41	-1.71	**-2.41**	**-2.71**	-2.15	**-2.22**	**-2.69**	**-3.33**	**-2.28**	-2.23	-1.19
0.75	**-2.16**	-1.54	-1.73	-1.41	-1.77	-1.96	**-2.38**	**-3.21**	**-3.15**	**-2.90**	**-3.04**	**-2.24**	-1.66	-1.21
0.8	**-2.16**	-1.34	-0.66	-2.09	**-2.63**	**-2.84**	**-2.77**	**-3.05**	**-3.47**	**-2.90**	**-2.65**	-1.91	-0.91	-1.02
0.85	-0.58	-1.65	**-2.05**	-1.39	-1.48	**-2.82**	**-3.42**	**-2.88**	**-3.34**	**-3.12**	**-2.95**	**-2.64**	-1.67	-0.88
0.9	-0.14	-1.27	**-2.05**	-1.72	-1.57	-1.54	**-2.74**	**-3.06**	**-2.96**	**-3.42**	**-3.12**	**-2.51**	-1.72	-1.08
0.95	0.00	-0.26	-1.32	-1.88	-1.81	-1.64	-1.32	-1.69	-2.09	**-3.24**	**-3.76**	**-4.13**	**-2.77**	-2.00
1	0.59	0.27	0.36	0.60	-0.83	-1.38	-1.87	-1.23	-1.26	-2.13	-1.30	**-2.56**	**-2.50**	-2.33

Notes: bold numbers imply significance at the 10% level at least

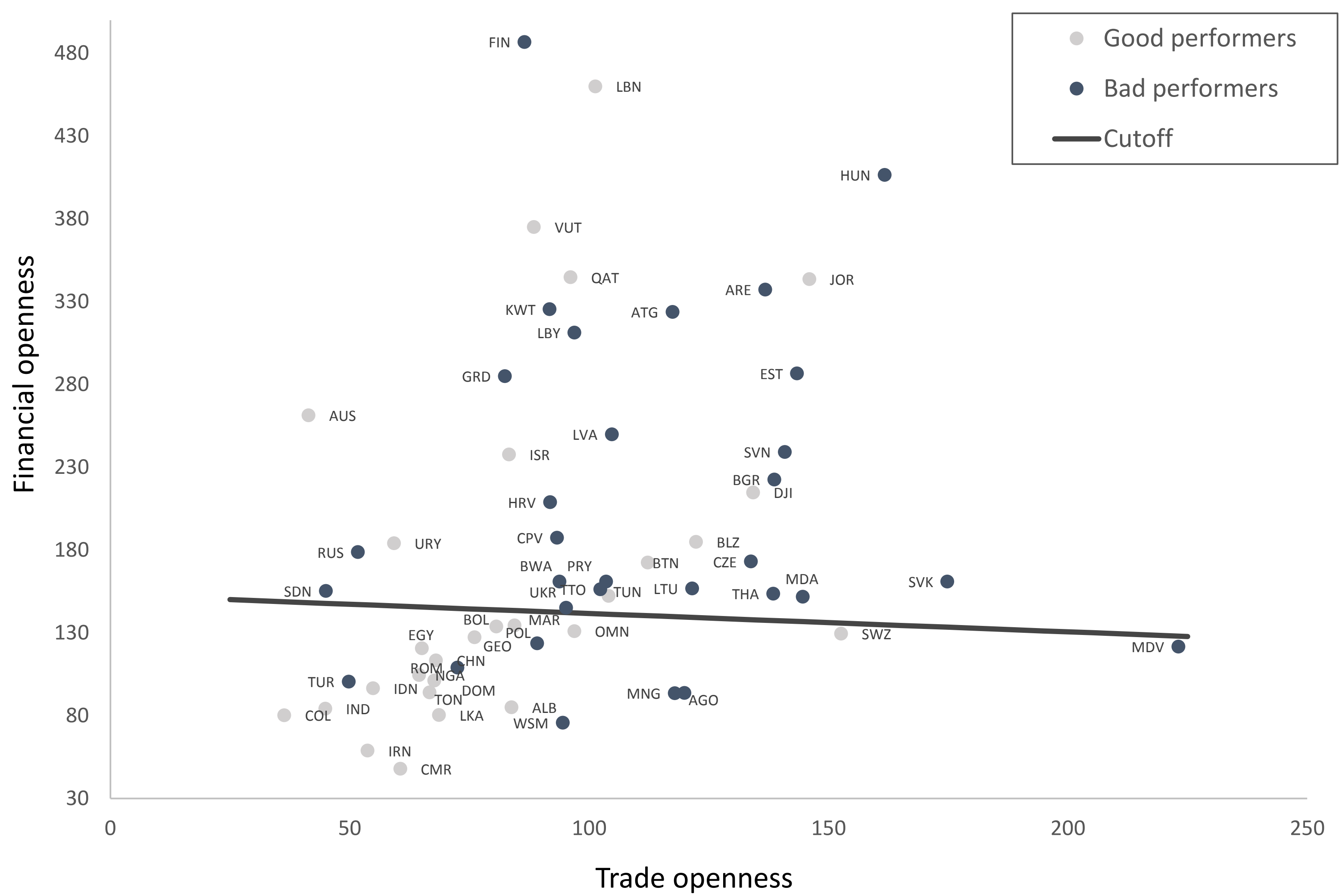
TABLE 7: Robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	**Forecast error**	**GDP growth 09**	**Forecast error**	**Forecast error**	**Forecast error**	**Forecast error**	**GDP growth 09**	**Forecast error**
Joint dummy	-4.716***	-4.413***	-2.895***	-4.454***	-3.714***	-3.457***	-2.792**	
	(1.2050)	(1.2721)	(0.9886)	(1.0596)	(1.1579)	(1.0382)	(1.1807)	
Principal component dummy								-3.415***
								(1.2599)
Log(Trade openness)	-1.458	-0.294	-1.588	-1.716*	-2.057*	-2.310**	-1.667	0.604
	(1.0370)	(1.1670)	(0.9591)	(0.9934)	(1.0760)	(0.9952)	(1.0973)	(1.3252)
Log(Financial openness)	1.963	1.357	1.500	1.803*	2.305*	2.420**	2.203*	0.092
	(1.2686)	(1.3848)	(1.1052)	(1.0062)	(1.2180)	(1.0478)	(1.2796)	(1.1109)
Current account	0.031	0.000	-0.034	0.006	0.113**	0.076*	0.086*	0.057
	(0.0737)	(0.0884)	(0.0648)	(0.0535)	(0.0531)	(0.0445)	(0.0516)	(0.0709)
Net foreign assets	-0.005	-0.001	-0.001	-0.001	-0.011*	-0.003	-0.001	-0.003
	(0.0068)	(0.0080)	(0.0062)	(0.0019)	(0.0059)	(0.0021)	(0.0024)	(0.0066)
Reserves	-0.004	0.002	0.007	-0.004	-0.016	-0.018	-0.021	-0.026
	(0.0321)	(0.0333)	(0.0297)	(0.0281)	(0.0282)	(0.0266)	(0.0272)	(0.0316)
Credit growth 04/07	-0.038**	-0.048***	-0.029**	-0.040**	-0.019*	-0.019*	-0.018	-0.036**
	(0.0161)	(0.0183)	(0.0143)	(0.0157)	(0.0101)	(0.0107)	(0.0107)	(0.0152)
Manufacturing share	-0.055	-0.138*	-0.032	-0.039	-0.078	-0.060	-0.143**	-0.080
	(0.0706)	(0.0806)	(0.0617)	(0.0601)	(0.0626)	(0.0535)	(0.0610)	(0.0870)
Growth trend	0.120	0.469**	0.069	0.102	0.166	0.158	0.431**	0.001
	(0.2102)	(0.2252)	(0.2078)	(0.2031)	(0.2352)	(0.2216)	(0.2079)	(0.2516)
Avrg. GDP growth 04/07	-0.215	0.082	-0.046	-0.197	-0.265	-0.254	0.003	-0.121
	(0.1923)	(0.2266)	(0.1714)	(0.1857)	(0.1906)	(0.1802)	(0.2056)	(0.1975)
Peg dummy	0.164	-0.344	0.805	-0.095	0.454	0.165	-0.257	0.435
	(0.8270)	(0.8410)	(0.7240)	(0.7663)	(0.7030)	(0.6885)	(0.7590)	(0.8516)
Oil dummy	-0.065	1.210	0.085	0.070	-1.203	-1.252	-0.541	-0.681
	(1.4753)	(1.6049)	(1.2201)	(1.3980)	(1.2171)	(1.1742)	(1.3339)	(1.5382)
GDPpc	-0.036	-0.067	-0.042	-0.037	-0.086	-0.098*	-0.157**	-0.038
	(0.0599)	(0.0744)	(0.0496)	(0.0519)	(0.0584)	(0.0503)	(0.0672)	(0.0572)
GDP	0.000	-0.000	0.000	0.000	0.000	0.000	-0.000	0.000
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Log(Population)	0.082	0.398	0.161	0.038	0.045	0.015	0.306	0.075
	(0.2888)	(0.3288)	(0.2863)	(0.2552)	(0.2621)	(0.2343)	(0.2693)	(0.3069)
Constant	-4.987	-8.765	-5.614	-2.488	-2.932	-1.855	-4.180	-4.092
	(9.3826)	(10.6979)	(8.8354)	(7.9585)	(8.5642)	(7.4135)	(9.1567)	(8.9662)
Observations	110	110	103	117	144	151	151	110
R-squared	0.330	0.383	0.240	0.326	0.294	0.278	0.349	0.273

Robust standard errors in parentheses

***** p<0.01, ** p<0.05, * p<0.1**

Figure 1



Good performers
Bad performers
Cutoff
Financial openness
Trade openness
480
430
380
330
280
230
180
130
80
30
0
50
100
150
200
250
FIN
LBN
HUN
VUT
QAT
JOR
ARE
KWT
ATG
LBY
GRD
EST
AUS
LVA
ISR
SVN
BGR
DJI
HRV
CPV
BLZ
RUS
URY
BWA
PRY
BTN
CZE
MDA
SVK
SDN
UKR
TTO
TUN
LTU
THA
BOL
MAR
EGY
POL
OMN
SWZ
GEO
MDV
CHN
ROM
NGA
TUR
IDN
DOM
MNG
AGO
TON
COL
IND
LKA
ALB
WSM
IRN
CMR

Figure 2 Countries in the trade/financial space

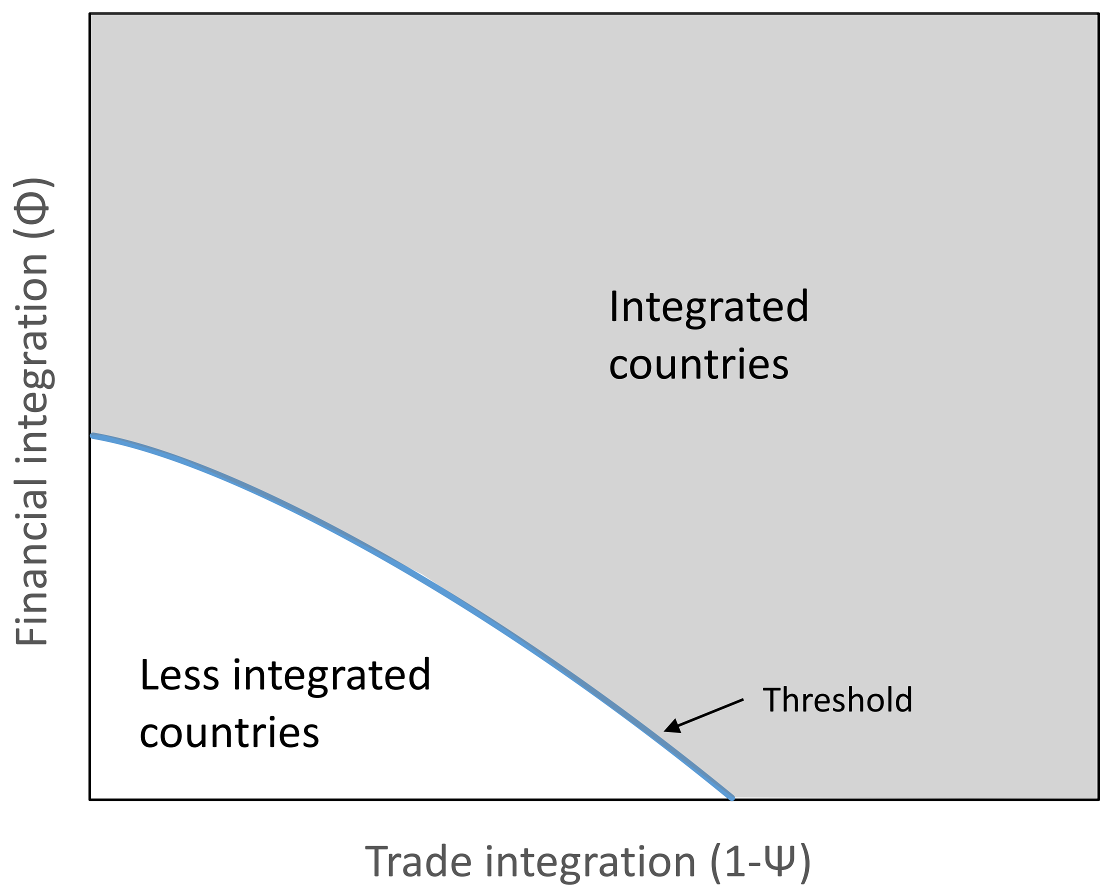
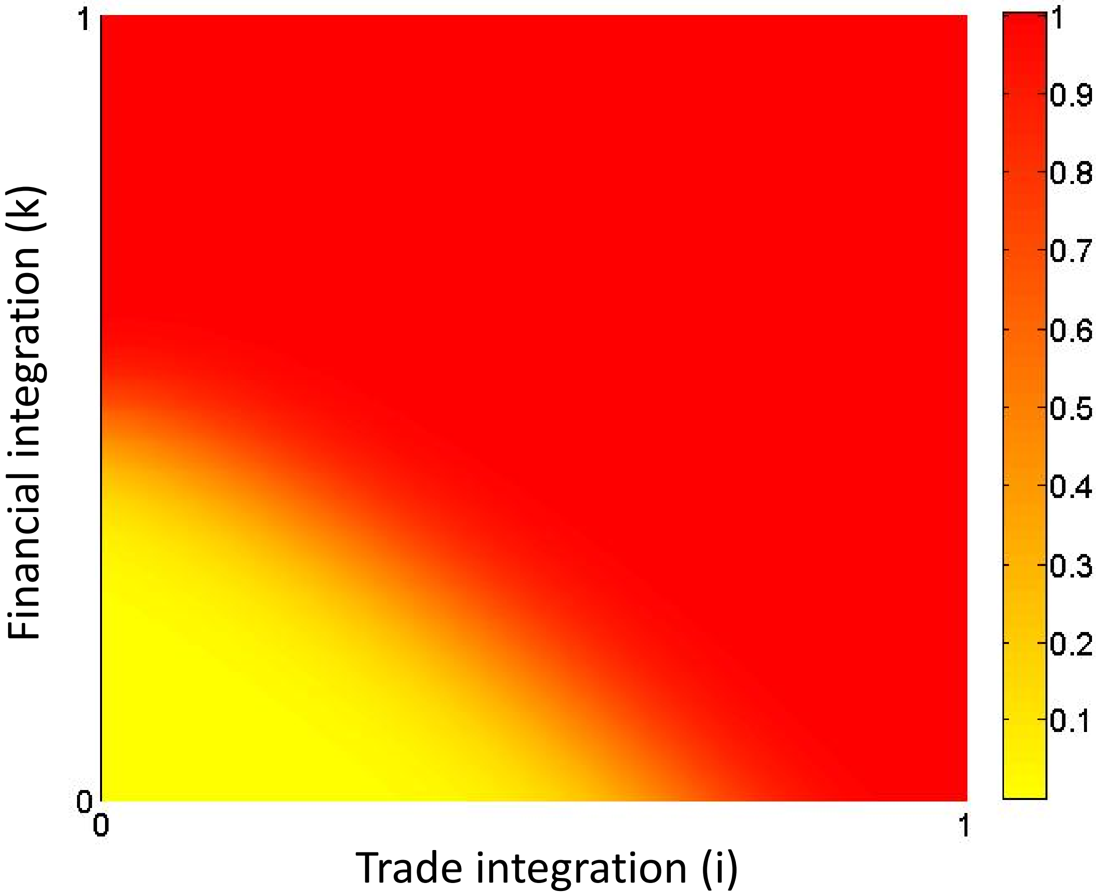


Figure 3 Probability Contour Map



Chapter 2

A Welfare State-based Fiscal Multiplier

2.1 Introduction

In a box published in the October 2012 *World Economic Outlook*, followed by a paper by Olivier Blanchard and Daniel Leigh, the authors provided evidence suggesting that forecasters tended to systematically underestimate fiscal multipliers during the 2010-12 period, when many advanced economies planned and implemented strong fiscal consolidation plans. Moreover, Blanchard and Leigh did not find evidence of this phenomenon for episodes of fiscal consolidation before the 2010-12 period, indicating that fiscal multipliers were abnormally larger during this specific time frame. They also found evidence of a slightly larger degree of underestimation associated with changes in government spending compared to changes in revenue.

To make sense of the results, the authors cited several theoretical studies showing that, if interest rates are stuck at the zero lower bound, then a temporary change in government spending can have a substantially larger effect on output than in normal times, leading to a fiscal multiplier well above one. Examples of such studies are Hall (2009), Christiano, Eichenbaum, and Rebelo (2011), Woodford (2011), and Eggertsson and Krugman (2012). However, a critical feature shared by all these models is that, to achieve a spending multiplier larger than normal, the change in government spending must be temporary, and it cannot be expected to persist beyond the period over which monetary policy is constrained by the zero lower bound. Intuitively, this follows because a permanent change in government's purchases does not affect households' incentives to save, thus making any real interest rate rigidity implied by the zero lower bound irrelevant.

It follows that this feature does not help to explain the empirical results if spending cuts associated with fiscal adjustments were expected to be permanent, or at least expected to last longer than the zero lower bound constraint. There are reasons to believe this was indeed the case. First, there were extended concerns about the unusual high debt/GDP ratios of several advanced countries, fueled either by empirical research contemporaneous to the events or by fears about the risk of multiple equilibria associated with high levels of debt.[1] This led the majority of countries to conclude that a sizable reduction of public debt was both necessary and desirable, and they looked for showing a credible commitment to this goal by adopting new fiscal rules or strengthening existing ones, sometimes even by amending their constitutions.[2] Second, expectations about future GDP growth for many advanced countries were low, with several observers claiming that recent declines in output could in fact be permanent.[3] These low output expectations may have precluded any hope of a rapid reduction of debt/GDP ratios through large increases in public revenues that could allow for a reversion of austerity measures in the foreseeable future. In view of these facts, it seems plausible that governments meant (and the public believed) austerity measures to be permanent in nature. If so, we are left with a theoretical puzzle, as the conventional explanation of a larger-than-normal multiplier falls apart when one takes into account the nature of fiscal adjustments.[4]

To solve this theoretical problem, we build a new-Keynesian model with incomplete markets, heterogeneous households exposed to idiosyncratic health shocks, and two types of government spending: welfare state spending in the form of public healthcare, and non-welfare spending as in standard models. We show that when the zero lower bound is binding and the mechanism leading to a higher-than-normal multiplier due to temporary changes in non-welfare spending holds good, permanent changes in welfare spending also lead to a large multiplier. Hence, a careful distinction between which type of government spending changes and the expected length in time of that change becomes critical. Our theory predicts that, in a zero lower bound scenario, permanent welfare spending cuts lead to a higher-than-normal multiplier whereas permanent non-welfare cuts do not.[5] The theory also predicts

[1] In an influential paper at the time, Reinhart and Rogoff claimed (wrongly) that, historically, countries whose debt/GDP ratio was above 90% tended to perform significantly worse in terms of output growth. Regarding the risk of multiple equilibria, see Blanchard, Dell'Ariccia and Mauro (2013).

[2] This was the case of Germany, Italy and Spain.

[3] See Blanchard, Dell'Ariccia and Mauro (2013), and IMF (2012).

[4] In addition, in most new-Keynesian models the mechanism behind a larger-than-normal multiplier relies on big changes in inflation that we do not observe in the data. See Rendahl (2016) for a discussion of this aspect as well as for a model that does not rely on this mechanism.

[5] Regarding the comparison between the welfare and tax multipliers, this mostly depends on the type of model and taxation scheme considered. For example, a lump-sum tax in a model where Ricardian Equivalence holds delivers a tax multiplier of zero.

that the welfare multiplier increases with the size of the adjustment, and that it can be even larger when households are borrowing constrained.

The intuition behind a larger-than-normal welfare multiplier has to do with the public insurance aspect of welfare spending under incomplete markets. In our model, the Government buys medicines in the private market and gives them to sick households as a transfer in kind. If the amount of medicines provided by the Government is not enough to recover their health, sick households will buy the remaining amount of medicines required out-of-pocket. Thus, a health shock translates into an income shock, whose size depends on the level of welfare spending. It follows that if the Government cuts welfare spending today and this cut is expected to be permanent, future income distribution becomes riskier for all households. This increases their incentives to reduce consumption and save more today for precautionary reasons. But if the zero lower bound is binding and inflation is expected to be zero, the real interest rate cannot fall enough to clear the bond market, and current output must drop to discourage savings.[6]

The second contribution of this paper is to provide an independent piece of evidence consistent with the theoretical model. Specifically, we test the hypothesis of a welfare spending multiplier significantly larger than the multipliers of the remaining fiscal variables (non-welfare spending and taxes) during the austerity period. As anyone familiar with the empirical literature on fiscal multipliers knows well, this is a priori a rather difficult task. Any study aiming to estimate fiscal multipliers has to deal with a potential endogeneity problem, arising from the fact that, while output might respond to discretionary changes in fiscal policy, current economic conditions driving output might also affect policy choices that determine those discretionary changes. In our case, an unbiased estimation of the fiscal multipliers becomes even a more difficult task because the most convincing methods designed to deal with this type of endogeneity rely on quarterly data to impose reasonable identification restrictions, and data on different types of spending for advanced economies is only available at the yearly frequency.[7]

There is an empirical literature that uses annual data relying on the so-called *"Narrative Approach"*, which consists of examining official government documents in order to collect evidence of exogenous fiscal policy shocks by focusing on the subset of policy actions taken by authorities with the aim to reduce their budget

[6]This mechanism can be seen as a version of the Paradox of Thrift where the increased desire to save that leads to a recession is triggered by the reduced level of public insurance. Ercolani and Pavoni (2012) also consider a model where changes in government spending affect precautionary savings, but they do so in the context on a RBC model, and thus they cannot generate significant effects on short-term output.

[7]See, among others, Blanchard and Perotti (2005) and Ramey (2011).

deficits. The assumption is that these policy actions are, in principle, unrelated to contemporaneous or prospective economic conditions. In turn, this evidence is used to construct a variable that can be used to instrument the degree of fiscal consolidation.[8] However, in the context of our study this approach is likely to fall short for two reasons. On the one hand, Jorda and Taylor (2016) have shown that an instrumental variable constructed this way has a significant forecastable element driven by plausible state variables such as the debt-to-GDP ratio, which calls into question the validity of the instrument. On the other hand, the fiscal outlook of a country can be correlated with the business cycle if the public finances are strained, a feature shared by several countries during the austerity period.[9] Since this would imply that narratively identified fiscal shocks are not orthogonal to the cycle, the identification assumption is violated.

To overcome these difficulties, we build on the suggestion of a paper by Alesina and Ardagna (2010) and exploit the cross-sectional variation in the composition of fiscal adjustments for a sample of developed countries during the austerity period to recover information about the relative sizes of the multipliers. The idea is quite simple: provided that the composition of fiscal adjustments is exogenous to the cycle, one should be able to infer from changes in the composition of the adjustments which multiplier was the largest. For example, if we observe that economies with fiscal consolidations putting more weight on the spending side tended to perform worse than economies with fiscal consolidations putting more weight on the revenue side, we can conclude that the spending multiplier was larger than the tax multiplier. Essentially, we use the weights measuring the composition of fiscal adjustments (which can be recovered from the data) to instrument for changes in the endogenous fiscal variables.[10]

To see why there is a good chance that our instruments are indeed exogenous, it is important to understand that the potential endogeneity problem associated with the composition of adjustments is quite different from the standard one associated with changes in the fiscal variables. In the later, endogeneity follows almost by construction. For example, a negative output shock that reduces tax revenue and thus increases the budget deficit induces the Government to apply austerity measures,

[8] Romer and Romer (2010) were the first to use the narrative approach in the context of research on fiscal policy, although they used quarterly data and their study was based on U.S. data. Examples of the narrative approach applied to a panel of countries using yearly data are Guajardo et al. (2014) and Alesina et al. (2015).

[9] See the Discussion of Alesina et al. (2015) by Gernot Muller.

[10] A shortcoming of this approach is that, by construction, the weights measuring the composition of a fiscal adjustment must add up to one. Hence any of the weights can be expressed as a linear combination of the others, precluding a point identification of the multipliers. This explains why we only focus on the relative sizes of the multipliers.

either because raising deficits lead to a higher sovereign rate that the Government cannot afford, or because the Government follows a tight fiscal rule based on debt stabilization. In contrast, potential endogeneity related to the composition of adjustments is likely to be conditional on governments beliefs about the relative sizes of the multipliers: a rational Government has incentives to change the composition in response to a bad output shock if it believes that by doing so it can alleviate its negative impact on output.

We argue that, based on available evidence, incentives to change the composition of adjustments in response to output shocks must have been very small. First, it is well documented that uncertainty about the size of multipliers on the eve of the austerity period was (and still is) remarkably high.[11] Second and related, there was little evidence at the time that multipliers of different fiscal instruments were systematically different. These two reasons together —a small (if any) expected gain from changing the composition and a big risk of making a mistake— must have discouraged risk-averse governments from changing systematically the composition in response to output shocks. If so, the observed cross-sectional variation in the composition of adjustments must have come from another source, and a natural candidate, as suggested by Alesina and Argadna, are idiosyncratic political preferences and political bargain exogenous to the cycle.

We also argue that both the observed marginal and joint distributions of the weights measuring the composition are consistent with this interpretation. On the one hand, marginal distributions generated by risk-averse governments choosing the weights based on output considerations and facing a high degree of uncertainty about multipliers should have been nearly degenerate. Instead, we find that they exhibit sizable standard deviations. On the other hand, if the compositions were mainly driven by the cycle we should expect the weights measuring them to have depended on output shocks, which in turn would have led to a systematic correlation between the weights. Instead, we find that the weights of welfare and non-welfare spending are independently distributed.

Our empirical results strongly support the hypothesis of a welfare spending multiplier significantly larger than the others. In particular, we find that for a country performing an average improvement of its cyclically adjusted primary balance of about 3% of GDP, switching from a fiscal adjustment with no weight on welfare spending cuts to a fiscal adjustment fully based on welfare spending cuts reduces output growth by about six percentage points. This suggests that the choice of

[11] See Blanchard et al. (2009) and Schinder et al. (2009) for discussions emphasizing uncertainty that are contemporaneous to the events, and Leeper et al. (2017) for a more recent acknowledgment.

the composition of a fiscal adjustment is far from trivial, as depending on how this adjustment is executed, output performance can go from a mild recession to a deep one. We also find effects of a similar magnitude when we use household consumption growth as the dependent variable, which connects the empirical results to the theory even further.

The remaining of the paper is organized as follows. In the Theoretical Part, Section 2 introduces the model, Section 3 analyzes the output implications of different types of spending cuts when the zero lower bound binds, and Section 4 analyzes the consequences of a borrowing constraint on the households. In the Empirical Part, Section 5 discusses the methodology, Section 6 discusses the main features of the data, and Section 7 presents the empirical results. Finally, Section 8 concludes.

Theoretical Part

2.2 Model setup

We consider a finite-time, closed-economy model with a New Keynesian structure in line to other models found in the literature, starting with Krugman (1998).[12] Prices are pre-set, while wages are flexible. There are households exposed to idiosyncratic health shocks, firms, a central bank, and a Government controlling fiscal policy. Markets are incomplete, with a one-period bond as the only asset available for trade. The economy has three periods $\{0, 1, 2\}$, and in period 1 unexpected fiscal shocks are realized. We first describe how households and firms behave, and then describe the monetary policy of the central bank and the fiscal policy of the Government. We conclude this section by describing the market clearing conditions of the economy and providing a definition for an equilibrium of this model.

2.2.1 Households

Consider an economy with a continuum of households distributed on the unit interval. Households are heterogeneous as they are exposed to idiosyncratic health shocks. In each period, a household gets sick with probability q. Due to the Law of Large Numbers, at each period we have that a fraction q of households gets sick and a fraction $(1-q)$ remains healthy. Omitting for now time subscripts, the intra-period utility of household i is

[12] See Mankiw and Weinzierl (2011), Fernandez-Villaverde et al. (2014) and Bacchetta and van Wincoop (2016) for recent contributions.

$$U_i = \log\left(\hat{c}_i^{\mu}(1-n_i)^{1-\mu}\right) + \nu\left(G_n\right) \tag{2.1}$$

where n_i is the fraction of time of household i devoted to work, G_n is regular government consumption as an argument of a concave function $\nu(\cdot)$, and $\hat{c}_i$ is a consumption aggregator that takes the following form:

$$\hat{c}_i = c_i + \gamma h_i - \frac{\eta}{2}h_i^2 - \frac{(\gamma^2-1)}{2\eta}, \tag{2.2}$$

Here c_i is private consumption of a homogeneous good and h_i units of health given by

$$h_i = v_i + m_i + g_{\omega,i}, \tag{2.3}$$

where v_i is idiosyncratic health status, m_i are units of medicine bought by the household and $g_{\omega,i}$ units of medicine provided by the government. If the household is healthy, $v_i = \frac{\gamma-1}{\eta}$ and $g_{\omega,i} = 0$.[13] Otherwise, $v_i = 0$ and $g_{\omega,i} = g_\omega$. Since both the consumption good and the medicines are produced with the same technology by perfectly competitive firms, they share the same price. Hence the intra-period budget constraint is

$$c_i + m_i = wn_i + \frac{I_i}{P} \tag{2.4}$$

where w is the real wage and $\frac{I_i}{P}$ real disposable income net of savings and wages.

The solution to this problem gives $m_i = \theta - v_i - g_{\omega,i}$, where $\theta = \frac{\gamma-1}{\eta}$. It follows that the healthy household H does not buy any medicine whereas the sick household S buys $m_S = \theta - g_\omega$ units of medicine, where $g_\omega \leq \theta$ to ensure that $m_S \geq 0$. Also, note that $h_i = \theta$ regardless of the health status. We also have an individual labor supply for household i, given by

$$n_i = \mu - \left(\frac{1-\mu}{w}\right)\left(\frac{I_i}{P} - m_i\right) \tag{2.5}$$

and an individual consumption demand given by

$$c_i = \mu\left(w + \frac{I_i}{P} - m_i\right), \tag{2.6}$$

so that the intra-temporal utility function becomes

$$U_i = \log c_i + \nu\left(G_n\right) + (1-\mu)\log\left(\frac{1-\mu}{\mu w}\right) \tag{2.7}$$

[13] We assume $\gamma > 1$.

Since households do not control G_n and the last term is a constant from the optimization point of view, we will ignore these terms in what follows.

The purpose of the above utility specification is to capture the notion that health "goes first", in the sense that households will keep it constant no matter what the idiosyncratic health status is (sick or healthy). If a household gets sick, he will buy enough medicines to recover his health. It follows that a health shock translates into an income shock, with less consumption of the homogeneous good available to the households other things equal.

As already noted, this is an incomplete markets model where the only asset available for trade is a non-contingent, risk-free bond. It is therefore clear the role of g_ω, the Welfare-State (welfare for short) per-person government spending: it is a way to provide public insurance against income shocks derived from individual health status shocks. If for example $g_\omega = \theta$ there is perfect public insurance as the government provides all the medicines that a sick household requires, in which case the model collapses to a standard representative household model. If $g_\omega < \theta$ instead, we are in an heterogeneous agents framework. Finally, and as another way of looking at the insurance aspect of welfare spending, note that since private and public medicines are perfect substitutes from the household point of view, a sick household would be indifferent between receiving g_ω units of medicines and a contingent transfer of dollars worth g_ω in real terms.

To keep things simple, we assume that in period 0 $g_\omega = \theta$, implying that all households are alike and it does not matter who gets sick in this period. Given that there are no expected changes in fiscal policy in the remaining periods, utility at time 0 common to all households is

$$\log c_0 + \beta \log c_1 + \beta^2 \log c_2 \tag{2.8}$$

In period 0 households receive profits Π_0 from firms they own, pay a lump-sum tax T_0 and purchase one-period bonds B_0. Using equation (2.6), the constraint in period 0 is

$$\frac{c_0}{\mu} = w_0 + \frac{1}{P_0}\left(\Pi_0 - T_0 - B_0\right) \tag{2.9}$$

If there are not spending cuts in period 1 households will receive profits from firms and bond payments, they will pay taxes and purchase new issued bonds, so that the constraint is

$$\frac{c_1}{\mu} = w_1 + \frac{1}{P_1}\left(\Pi_1 + (1+R_1)B_0 - T_1 - B_1\right) \tag{2.10}$$

where R_1 is the nominal rate of interest. In turn, the constraint in period 2 is

$$\frac{c_2}{\mu} = w_2 + \frac{1}{P_2}\left(\Pi_2 + (1+R_2)B_1 - T_2\right) \tag{2.11}$$

In the absence of unexpected fiscal shocks, the representative household will choose (c_0, c_1, c_2) and (B_0, B_1) to maximize (2.8) subject to (2.9)-(2.11). The solution to this problem is described by equations (2.9)-(2.11) and the two following Euler Equations:

$$\frac{1}{c_0} = \left(\frac{1+R_1}{1+\pi_1}\right)\frac{\beta}{c_1} \tag{2.12}$$

$$\frac{1}{c_1} = \left(\frac{1+R_2}{1+\pi_2}\right)\frac{\beta}{c_2} \tag{2.13}$$

where $\pi_t = \frac{P_t}{P_{t-1}} - 1$ denotes inflation.

In period 1 there may be unexpected fiscal shocks taking the form of public spending cuts, which can apply to periods 1 and 2 (permanent) or to period 1 only (temporary), and based on regular government spending $G_{n,t}$ or on aggregate welfare spending $G_{w,t}$.[14] If these spending cuts only affect regular spending we are still in a representative household framework, so that the solution for (c_1, c_2) and B_1 will still be described by equations (2.10), (2.11) and (2.13), properly updated to account for the fiscal shock.

However, if due to these public spending cuts $g_\omega < \theta$, we have to differentiate between two possible types of households in period 1, H with mass $(1-q)$ and S with mass q, and four possible types of households in period 2, HH with mass $(1-q)^2$, HS with mass $(1-q)q$, SH with mass $q(1-q)$ and SS with mass q^2.[15] Therefore, the inter-temporal expected utilities of the healthy and sick households at time 1 are

$$EU_H = \log c_H + \beta\left((1-q)\log c_{HH} + q\log c_{HS}\right) \tag{2.14}$$

$$EU_S = \log c_S + \beta\left((1-q)\log c_{SH} + q\log c_{SS}\right) \tag{2.15}$$

Using $m_S = \theta - g_\omega$, equation (2.6) and the fact that $G_w = qg_\omega$, the corresponding

[14] By an unexpected shock we mean a shock whose probability of occurring is infinitesimally small from the perspective of period 0. This explains why we do not put an expectator operator in (2.8).

[15] As the reader may have guessed, H stands for "healthy in period 1", HH means "healthy in periods 1 and 2", S means "sick in period 1", and so forth.

constraints for types H and S are given by

$$\frac{c_H}{\mu} = w_1 + \frac{1}{P_1}\left(\Pi_1 + (1+R_1)B_0 - T_1 - B_H\right) \tag{2.16}$$

$$\frac{c_S}{\mu} = w_1 + \frac{1}{P_1}\left(\Pi_1 + (1+R_1)B_0 - T_1 - B_S\right) - \left(\theta - \frac{G_{\omega,1}}{q}\right) \tag{2.17}$$

In turn, the constraints for the four different types of households in period 2 are:

$$\frac{c_{HH}}{\mu} = w_2 + \frac{1}{P_2}\left(\Pi_2 + (1+R_2)B_H - T_2\right) \tag{2.18}$$

$$\frac{c_{HS}}{\mu} = w_2 + \frac{1}{P_2}\left(\Pi_2 + (1+R_2)B_H - T_2\right) - \left(\theta - \frac{G_{\omega,2}}{q}\right) \tag{2.19}$$

$$\frac{c_{SH}}{\mu} = w_2 + \frac{1}{P_2}\left(\Pi_2 + (1+R_2)B_S - T_2\right) \tag{2.20}$$

$$\frac{c_{SS}}{\mu} = w_2 + \frac{1}{P_2}\left(\Pi_2 + (1+R_2)B_S - T_2\right) - \left(\theta - \frac{G_{\omega,2}}{q}\right) \tag{2.21}$$

and the Euler Equations resulting from the maximization problems are:

$$\frac{1}{c_H} = \beta\left(\frac{1+R_2}{1+\pi_2}\right)\left(\frac{(1-q)}{c_{HH}} + \frac{q}{c_{HS}}\right) \tag{2.22}$$

$$\frac{1}{c_S} = \beta\left(\frac{1+R_2}{1+\pi_2}\right)\left(\frac{(1-q)}{c_{SH}} + \frac{q}{c_{SS}}\right) \tag{2.23}$$

Some final comments about the household's problem. From the visual inspection of the constraints, it is clear how health shocks translate into income shocks, as the only difference between a healthy and a sick household is that the latter subtracts a payment of private medicines $\left(\theta - \frac{G_\omega}{q}\right)$ from his overall income. This implies that H will be a net lender and S a net borrower.

2.2.2 Firms

The final good and the medicines are produced by competitive firms using the technology

$$Y_t = \left(\int_0^1 Y_t(k)^\varepsilon dk\right)^{\frac{1}{\varepsilon}} \tag{2.24}$$

where $Y_t(k)$, $k\in[0,1]$ denotes intermediate good k, with $\varepsilon \in [0,1]$.

Profit maximization implies the following well known first-order condition:

$$\frac{Y_t}{Y_t(k)} = \left(\frac{P_t(k)}{P_t}\right)^{\frac{1}{1-\varepsilon}} \tag{2.25}$$

where $P_t(j)$ denotes the price of the intermediate good k and P_t is the price of the homogeneous final good and the medicines.

The intermediate good $Y_t(k)$ is produced by a monopolist using the following technology:

$$Y_t(k) = n_t(k) \tag{2.26}$$

where $n_t(k)$ denotes employment by monopolist k.

There is no entry or exit into the production of the intermediate good. Per period nominal profits are

$$\Pi_t(k) = P_t(k)Y_t(k) - P_t w_t n_t(k) \tag{2.27}$$

Firms set prices at the start of each period and before the realization of any shock. Since all firms face the same problem, they set the same price. In the absence of shocks, this will correspond to the optimal price set by a monopolist, which pins down the real wage:

$$w_t = \varepsilon \tag{2.28}$$

In case there are unexpected shocks in period 1, $w_t = \varepsilon$ will still hold provided the central bank sets the nominal rate equal to the flexible price version of the model (more on this below). However, this might not be possible if the economy is stuck at the zero lower bound, in which case firms will simply adjust their production to demand.

2.2.3 Money Market and Monetary Policy

Here we follow closely Mankiw and Weinzierl (2011) and Bacchetta and van Wincoop (2016). Households are required to hold money to buy the consumption good and the medicines. The money market is described by the aggregate quantity condition:

$$\phi P_t C_t \leq M_t \tag{2.29}$$

where $C_t = \int_0^1 (c_{it} + m_{it})\, di$, M_t is money supply, and $\phi > 0$ is a parameter small enough so that we can ignore the cost of holding money in the households' budget constraints. The condition will always hold with equality in periods 0 and 2, but it might not in period 1 if the zero lower bound (ZLB) binds.

We assume that monetary policy follows the rule:

$$R_{t+1} = \max\left(Z_{t+1}, 0\right), \tag{2.30}$$

where Z_{t+1} equals the equilibrium real interest rate in the flexible price version of the model. Whenever Z_{t+1} is negative, the central bank simply sets the nominal interest rate to zero. The central bank also targets zero inflation, which can be accomplished by properly controlling future money supply.[16] This implies that if the ZLB binds, then there is perfect downward real rate rigidity, as in that case $(1 + R_{t+1})/(1 + \pi_{t+1}) = 1$.

2.2.4 Fiscal Policy

The fiscal authority keeps an inter-temporal balanced budget. To simplify our analysis, we assume that welfare spending $G_{\omega t}$ and non-welfare spending G_{nt} are financed with lump-sum taxes. The exact timing of these taxes is irrelevant because Ricardian equivalence holds under our assumptions. In period 0 the Government chooses $G_{\omega 0} = q\theta$ (which implies perfect public insurance) and $G_{n0} = \bar{G}_n$, and households expect this policy to hold for the remaining periods. However, in period 1 the Government may impose unexpected spending cuts, which can affect welfare or non-welfare spending, and can be temporary (so that they only apply to period 1) or permanent (lasting two periods).

2.2.5 Market Clearing

The economy's resource constraint is

$$C_t + G_t = Y_t \tag{2.31}$$

where

$$C_t = \int_0^1 (c_{it} + m_{it})\, di \tag{2.32}$$

$$G_t = G_{nt} + G_{\omega t} \tag{2.33}$$

Equilibrium in the labor market requires

$$\int_0^1 n_t(k) dk = \int_0^1 n_{it} di \tag{2.34}$$

[16] It is possible to derive (2.29) and the ZLB as an outcome of the model rather than just imposing it, as well as to show that the central bank can keep inflation equal to zero at the ZLB. However, this requires to build a significantly more complex model with outside and inside money and an intra-period bond as in Dubey and Geanakoplos (2006). Given that the more complex model delivers the same equilibrium conditions, the current setup can be thought as a reduced form of it.

Similarly, equilibrium in the bond market requires

$$\int_0^1 b_{it} di = 0 \tag{2.35}$$

where b_{it} is real bond holdings.

An equilibrium of this model is an allocation of individual real variables

$$\{c_{it}, m_{it}, n_{it}, b_{it}\},$$

and an allocation of aggregate real variables and prices

$$\{C_t, Y_t, w_t, R_t\}$$

such that for given $\{G_{nt}, G_{\omega t}\}$ the household and firm problems are satisfied, the monetary and fiscal policy rules are satisfied, markets clear, and the aggregate resource constraint is satisfied.

2.3 Analysis of Equilibria

In this section we analyze different equilibria of this model with an special focus on the effects of public spending cuts on output. Throughout most of the section we will assume $\beta = 1$. As we will show shortly, this implies that in the flexible price version of the model $Z_{t+1} = 0$, so that the ZLB is at the edge of being binding. We start by solving for the equilibrium without unexpected shocks, and then looking at the effects of unexpected spending cuts on the economy, distinguishing between the type of spending shock (welfare and non-welfare) and the duration of the shock (temporary vs. permanent).

When analyzing equilibria with unexpected shocks, it will prove convenient to impose a change of variables such that we solve for equilibria in terms of the change of the variables with respect to their equilibrium values without unexpected shocks. We therefore define $\Delta Y_t = Y_t - \bar{Y}$, $\Delta G_{wt} = G_{wt} - \theta q$ and $\Delta G_{nt} = G_{nt} - \bar{G}_n$, where $(\bar{Y}, \theta q, \bar{G}_n)$ are the values of output, welfare spending and non-welfare spending corresponding to the initial equilibrium without unexpected shocks. Given that these values are constant over time, in period 1 these changes can also be interpreted as the change of a variable from $t = 0$ to $t = 1$.

2.3.1 The Equilibrium without Unexpected Shocks

This equilibrium is the most straightforward to solve. Since there are no unexpected shocks, and the central bank sets the nominal interest rate equal to the value of the real interest rate in the flexible price version of the model, $w_t = \varepsilon$ in all periods. Then, we show in the Appendix how to combine equations (2.5)-(2.6) and (2.31)-(2.34) to solve for the equilibrium values of aggregate output and consumption, which are constant over time and given by

$$\bar{Y} = \frac{\mu\varepsilon + (1-\mu)\left(\bar{G}_n + \theta q\right)}{1-\mu+\mu\varepsilon} \tag{2.36}$$

$$\bar{C} = \frac{\mu\varepsilon(1-\bar{G}_n - \theta q)}{1-\mu+\mu\varepsilon} \tag{2.37}$$

where we assume $\bar{G}_n + \theta q < 1$ to ensure that consumption is positive. An implication of this is that both output and consumption are between zero and one.

The remaining equilibrium variables are easy to determine. Since there is perfect public insurance, all households are alike and they do not buy any medicines. Hence $c_{it} = \bar{C}$, $m_{it} = 0$, $n_{it} = \bar{Y}$ and $b_{it} = 0$. Applying these results in the Euler Equations (2.12) and (2.13), the nominal rate of interest set by the Central bank is $R_t = \frac{1}{\beta} - 1$. In case we assume $\beta = 1$, the nominal rate is zero and we are at the edge where the ZLB starts to be binding.

2.3.2 The Effects of non-Welfare Spending Cuts

Here we analyze the consequences of an unexpected drop in non-welfare Government consumption at $t = 1$ such that $\Delta G_{n1} < 0$. In case this policy shock is permanent, we have $\Delta G_{n2} = \Delta G_{n1} = \Delta G_n$ with $\Delta G_n < 0$. If instead the shock is temporary, $\Delta G_{n1} = \Delta G_n$ and $\Delta G_{n2} = 0$.

The first step is to determine whether the ZLB will bind or not under this new environment. We do this by solving for the real interest rate of the flexible price equilibrium. As discussed above, we still have that $w_t = \varepsilon$ regardless of the time period. This implies that the change in output at time t is given by

$$\Delta Y_t = \left(\frac{1-\mu}{1-\mu+\mu\varepsilon}\right)\Delta G_{nt} \tag{2.38}$$

It follows that $\frac{d\Delta Y_t}{d\Delta G_{nt}} = \frac{1-\mu}{1-\mu+\mu\varepsilon}$ is the multiplier of non-welfare spending in the flexible price equilibrium, measuring by how much ΔY_t decreases when we decrease

ΔG_{nt} (i.e we increase the spending cut) by an infinitesimal amount.[17] The reason why the multiplier is positive is standard: from the resource constraint (2.31) a decrease in non-welfare spending increases consumption other things equal, which reduces the marginal cost of leisure. This induces households to supply less labor, which in turn decreases output. As a result, consumption increases by less than the decrease in non-welfare spending, which explain why the multiplier is positive.

Taking differences in the resource constraint at time t with respect to the equilibrium without unexpected shocks gives $\Delta Y_t = \Delta C_t + \Delta G_{nt}$. Then, combine this with the fact that $C_t = \bar{C} + \Delta C_t$, and substitute the resulting expressions for $t = 1, 2$ into the Euler Equation (2.13) to obtain:

$$\frac{1}{\bar{C} + \Delta Y_1 - \Delta G_{n1}} = \frac{\beta(1 + Z_2)}{\bar{C} + \Delta Y_2 - \Delta G_{n2}} \tag{2.39}$$

where Z_2 is the real interest rate of a bond sold at $t = 1$. Substituting (2.38) and the expression for $\bar{C}$, we find:

$$Z_2 = \frac{1}{\beta}\frac{(1 - \bar{G}_n - \theta q) - \Delta G_{n2}}{(1 - \bar{G}_n - \theta q) - \Delta G_{n1}} - 1 \tag{2.40}$$

It follows that if the spending cut is permanent the real interest rate in the flexible price equilibrium would still be $\frac{1}{\beta} - 1$. Even if $\beta = 1$ (so that the nominal interest rate was zero in the initial equilibrium) the Taylor Rule would call for setting the interest rate equal to the flexible price equilibrium. The consequence is that the solution to the model coincides with the flexible price equilibrium, *regardless of whether the ZLB binds or not.* Therefore, we have already derived our first key result: if non-welfare spending cuts are permanent, the value of the non-welfare multiplier is invariant to the ZLB constraint. It follows that permanent non-welfare spending cuts cannot explain larger-than-normal multipliers at the ZLB.

In contrast, the real interest rate would become negative if the spending cut is temporary and $\beta = 1$. In this case, the ZLB is binding and the Taylor Rule calls for setting the nominal interest rate equal to zero, which opens the door to the possibility of a fiscal multiplier higher than normal. If we replace $\beta(1 + Z_2)$ by 1 in (2.39) (as $\beta = 1$ and the nominal rate must be zero) and use $\Delta G_{n1} = \Delta G_n$, $\Delta G_{n2} = 0$, and $\Delta Y_2 = 0$, we find

$$\Delta Y_1 = \Delta G_n \tag{2.41}$$

[17] In fact, note that because $\bar{Y}$ and $\bar{G}_n$ are predetermined, $\frac{d\Delta Y_t}{d\Delta G_{nt}} = \frac{d(Y_t - \bar{Y})}{d(G_{nt} - \bar{G}_n)} = \frac{dY_t}{dG_{nt}}$, which is the standard appearance of a fiscal multiplier.

which implies a multiplier of one, thus higher than $\left(\frac{1-\mu}{1-\mu+\mu\varepsilon}\right)$. Therefore, we have shown that, consistent with the previous literature, temporary non-welfare spending cuts do lead to a multiplier larger than normal.[18]

The intuition behind this result has to do with changes in the incentives to save and the downward real interest rate rigidity. A temporary decrease in non-welfare spending means that, other things equal, there is more consumption available to the households at $t = 1$ but not at $t = 2$. It follows that, despite of the decrease in output associated with the elastic labor supply mechanism, consumption at $t = 1$ will remain higher than consumption at $t = 2$. Since households value consumption smoothing, this increases their demand for bonds. In a flexible price equilibrium, or in an equilibrium where the Taylor Rule is not constrained by the ZLB, the lower marginal utility of consumption at $t = 1$ would be compensated by a drop of the interest rate. However, at the ZLB the nominal rate cannot decrease, and due to the zero inflation policy the real interest rate does not fall. As a result, current output must fall by more than usual in order to preserve the bond market clearing condition.[19]

2.3.3 The Effects of Welfare Spending Cuts

As before, we analyze the consequences of an unexpected drop in welfare Government consumption at $t = 1$ such that $\Delta G_{w1} < 0$. In case this policy shock is permanent, we have $\Delta G_{w2} = \Delta G_{w1} = \Delta G_w$ with $\Delta G_w < 0$. If instead the shock is temporary, $\Delta G_{w1} = \Delta G_w$ and $\Delta G_{w2} = 0$.

Again as before, the first step is to determine the response of the real interest rate in the flexible price equilibrium. We still have $w_t = \varepsilon$ regardless of the time period. As shown in the Appendix, the consequence is that both ΔY_1 and ΔY_2 equal zero. The intuition behind this result is that, in a given period, a welfare spending cut implies a transfer of resources from the sick households to the healthy households. A particular feature of this model is that this transfer of resources does not affect aggregate labor supply, as the drop in labor supplied by the healthy, driven by the income effect, is perfectly offset by the increase in labor supplied by the sick.[20]

[18]Obviously, the particular size of the multiplier at the ZLB depends on different modeling assumptions. For example, in a version of the model with a Phillips Curve linking current marginal costs to future inflation the non-welfare multiplier is smaller than 1 (but still larger than outside the ZLB). The multiplier could also be larger than 1 if changes to current employment were persistent as in Rendahl (2016).

[19]In turn, this explains why permanent non-welfare spending cuts do not lead to a higher-than-normal multiplier. Since non-welfare spending falls in both periods, the incentives to increase savings due to consumption smoothing reasons are missing.

[20]What would definitely affect output is a change in overall spending of medicines, but this

The behavior of the real interest rate is not as straightforward to characterize as before because now we have two types of households who make different saving decisions. Nevertheless, in the Appendix we prove the following statement:

Proposition. *Let $\Delta G_{w1} < 0$. Then, in a flexible price equilibrium $Z_2 = \frac{1}{\beta} - 1$ if the welfare spending cut is temporary and $Z_2 < \frac{1}{\beta} - 1$ if the spending cut is permanent.*

According to the proposition, the response of the real interest rate to a drop in welfare spending depending on its duration is the opposite to the case of a drop of non-welfare spending. Now we have that a temporary spending cut does not drive the real interest rate down. The consequence is that, regardless of whether the ZLB binds or not, a temporary cut in welfare spending does not affect output, and therefore the welfare multiplier is zero. The intuition behind this result is that the increase in the demand of bonds due to a temporary increase in the disposable income of the healthy is perfectly offset by an increase of the supply of bonds from the sick, so that the real interest rate does not change.

Regarding the effect of a permanent welfare spending cut on current output, this clearly depends on the initial value of the nominal interest rate. If $\beta < 1$ and provided that the unexpected spending cut is not too high, the Central Bank would set the new nominal interest rate equal to a value lower that $\frac{1}{\beta} - 1$ but higher than zero. The resulting equilibrium would therefore be identical to the flexible price equilibrium, hence $\Delta Y_1 = 0$ and the welfare multiplier associated with a permanent spending cut is zero when the ZLB does not bind. The reason why the real interest rate falls is that when $\Delta G_{w2} = \Delta G_w < 0$ all households, independently of their current health status, will face a riskier income distribution in period 2. With probability $(1 - q)$ they will be healthy and see their income increased by $-\mu \Delta G_w$, but with probability q they will be sick and see their income decreased by $\mu \frac{(1-q)}{q} \Delta G_w$. Given that households are risk averse, they will try to compensate this increase in riskiness by saving more today, a classical precautionary motive.

However, this outcome changes dramatically when the economy is stuck at the ZLB. Under this scenario all households would like to save more but, since the nominal rate stays at zero and prices are sticky, the real interest does not fall enough to ensure that the bond market clearing condition holds. Therefore, the only way to prevent households from increase their savings is that they become poorer, and current output falls. This is in essence a version of the Paradox of Thrift driven by the increased desire to save due to a decrease in future public insurance.

spending is constant and equal to $q\theta$ (recall that a decrease in medicines supplied by the Government is perfectly compensated by an increase in medicines bought by the households, as they want to keep their level of health constant).

We now proceed to formalize this intuition. In the Appendix, we show how to combine the equilibrium conditions so that the Euler Equations of the healthy and the sick can be written in terms of current output and real bond holdings of the healthy household, as follows:

$$\frac{1}{\bar{C}+\Delta Y_1-\mu(\Delta G_w+b_H)} = \frac{1-q}{\bar{C}-\mu(\Delta G_w-b_H)} + \frac{q}{\bar{C}+\mu(\frac{(1-q)}{q}\Delta G_w+b_H)} \tag{2.42}$$

$$\frac{1}{\bar{C}+\Delta Y_1+\mu\frac{(1-q)}{q}(\Delta G_w+b_H)} = \frac{1-q}{\bar{C}-\mu(\Delta G_w+\frac{(1-q)}{q}b_H)} + \frac{q}{\bar{C}+\mu\frac{(1-q)}{q}(\Delta G_w-b_H)} \tag{2.43}$$

From here, in the Appendix we are able to prove the following:

Proposition. *Let* $-q((1-q)\mu)^{-1}\bar{C} < \Delta G_w < 0$. *Then, the solution to (2.42)-(2.43) has the following properties:*

i) There exist two real-valued functions of ΔG_w, $v_1(\Delta G_w)$ *and* $v_2(\Delta G_w)$, *such that* $\Delta Y_1 = v_1$ *and* $b_H = v_2$.

ii) $b_H > 0$ and $\frac{d\Delta Y_1}{d\Delta G_w} > 0$.

The lower bound on welfare spending cuts ensures that individual consumption is always positive. The first part of the proposition establishes that the equilibrium of this economy exists and is unique. The second part says that the healthy household is a net lender, and that the welfare multiplier associated with permanent welfare spending cuts is always positive. Thus, the model can account for a larger-than-normal spending multiplier at the ZLB. In fact, a numerical approach by exhaustion shows that $\frac{d^2\Delta Y_1}{d\Delta G_w^2} < 0$. That is, the welfare spending multiplier increases with the size of the spending cut. The intuition behind this outcome is clear: the larger the spending cut, the stronger the incentives to save for precautionary reasons, and the deeper the current recession must be to discourage savings.

Panel A of Figure 1 provides a numerical illustration of the results by plotting in the same figure the welfare and non-welfare multipliers associated with temporary and permanent spending cuts at the ZLB as a function of the size of the spending cut. The chosen values of the parameters are $\left(\mu,\varepsilon,q,\theta,\bar{G}_n,\right) = (0.5, 0.5, 0.05, 2, 0.1)$. They correspond to an economy where μ and ε are in the middle of their possible range, a 5% of the population gets sick at each period, and the benchmark size of public spending is roughly 40% of initial output, which equal 0.47.[21] As expected,

[21] We are not trying to match any particular data, as the model is too stylized for that.

the non-welfare multiplier equals one if the spending cut is temporary and is less than one otherwise, and the welfare multiplier starts at zero and increases with the size of the spending cut, eventually surpassing both non-welfare multipliers. When $\Delta G_w = -0.02$, the spending cut is 10% of previous total spending (or 4.3% of previous GDP), and the welfare spending multiplier is about 5.

2.4 Extension with a Borrowing Constraint

A common feature associated with the aftermath of the Great Recession and the Sovereign European Crisis is that credit dried up, as many banks in the Eurozone (especially in the periphery) were dealing with financial turmoil and raising sovereign rates. In this section we introduce this realistic feature in the model by imposing a borrowing constraint on the households and looking at its consequences for the welfare multiplier of a permanent spending cut.[22] Therefore, we now require $B_{i,t} \geq 0$ for all households. The rest of the model remains unchanged.

It turns out that introducing the borrowing constraint simplifies our previous analysis, allowing us to derive a closed-form solution for the change in output. Since the bond market clearing condition must hold but nobody can borrow, $b_H = 0$. Also, note that with a borrowing constraint (2.43) does not hold with equality, as for the sick household the borrowing constraint binds. Thus, we end up with one equation with one unknown given by (2.42). Solving for ΔY_1, we obtain:

$$\Delta Y_1 = -\bar{C} + \mu \Delta G_w + \left(\frac{1-q}{\bar{C} - \mu \Delta G_w} + \frac{q}{\bar{C} + \mu \frac{(1-q)}{q} \Delta G_w} \right)^{-1} \tag{2.44}$$

It is easy to check that $\Delta Y_1 = 0$ if $\Delta G_w = 0$, and that $\frac{d\Delta Y_1}{d\Delta G_w} > 0$ and $\frac{d^2 \Delta Y_1}{d\Delta G_w^2} < 0$. It is also easy to check that $\frac{d\Delta Y_1}{d\Delta G_w} \to \mu$ as $\Delta G_w \to 0$.

Since before we had that the multiplier was zero as the spending cut approached zero, imposing a borrowing constraint increases the multiplier for low values of the spending cut. Panel B of Figure 1 illustrates this result by comparing the welfare multiplier with and without the borrowing constraint. The intuition is that the excess demand for bonds caused by the current transfer from the sick to the healthy implied by the spending cut cannot be offset by an increase in the supply of bonds from the sick. Hence output must fall even by more than before to clear the bond market. This is captured by the component $\mu \Delta G_w$ in (2.44). The other component captures the precautionary channel due to the increased riskiness in future income as

[22] See Guerrieri and Lorenzoni (2017) for a related model with heterogeneous households exposed to a unexpected tightening in their borrowing capacity.

perceived by the healthy. The multiplier without borrowing constraints eventually catches up the multiplier with constraints due to the strong precautionary effect from the sick, as they may face a state of the World where they must repay their debt and in addition purchase medicines out-of-pocket.

Empirical Part

2.5 Methodology

We devote this section to explain our instrumental variables (IV) approach, how we cyclically adjust fiscal variables, and how we select episodes of fiscal adjustment.

2.5.1 The IV Approach: an Indirect Least Squares Estimator

Consider the following structural econometric model describing the behavior of output growth and the change of fiscal variables for a population of countries engaging in fiscal adjustments:

$$\Delta g^Y_{j,t} = \beta_0 + \beta^w s^w_{j,t-1} g^w_{j,t} + \beta^n s^n_{j,t-1} g^n_{j,t} - \beta^\tau (1+g_j)\Delta\tau_{j,t} + u^Y_{j,t} \quad (2.45)$$

$$s^w_{j,t-1} g^w_{j,t} = \psi^w_0 - \lambda\alpha^w_{j,t} + \psi^w_1 \Delta g^Y_{j,t} + u^w_{j,t} \quad (2.46)$$

$$s^n_{j,t-1} g^n_{j,t} = \psi^n_0 - \lambda\alpha^n_{j,t} + \psi^n_1 \Delta g^Y_{j,t} + u^n_{j,t} \quad (2.47)$$

$$(1+g_j)\Delta\tau_{j,t} = \psi^\tau_0 + \lambda\alpha^\tau_{j,t} - \psi^\tau_1 \Delta g^Y_{j,t} - u^\tau_{j,t} \quad (2.48)$$

$$1 = \alpha^w_{j,t} + \alpha^n_{j,t} + \alpha^\tau_{j,t} \quad (2.49)$$

Here $\Delta g^Y_{j,t}$ is output growth of country j at year t relative to its long-run average g_j, $g^w_{j,t}$ and $g^n_{j,t}$ are the growth rates of welfare and non-welfare spending, $s^w_{j,t-1}$ and $s^n_{j,t-1}$ are the ratios of welfare and non-welfare spending with respect to output at year $t-1$, $\Delta\tau_{j,t}$ is the difference between the tax rates of years t and $t-1$ for country j, $\alpha^i_{j,t}$ is the weight measuring the contribution of the change in fiscal item i to the fiscal adjustment in year t, and the u's are zero-mean error terms that are correlated with each other. The fiscal variables are assumed to be free of any automatic stabilizer component.[23] The remaining symbols are parameters, satisfying $\lambda > 0$, $\sum_i \psi^i_0 = 0$ and $\sum_i \psi^i_1 = \psi_1 < 1$.

[23]That is, they do not react automatically to changes in output. In general, fiscal variables may react to the cycle for two reasons: automatic stabilizers and discretionary actions from the Government as shown by (2.46)-(2.48). The former can be corrected with a cyclical adjustment of the fiscal variables as we discuss in subsection 5.3. The latter cannot, which motivates our IV approach.

Equation (2.45) is our main object of interest, as it relates output growth to changes in the fiscal variables that follow from a fiscal adjustment. Since the growth rates of welfare and non-welfare spending are multiplied by their ratios with respect to output at $t-1$, the coefficients β^w and β^n effectively measure their multipliers.[24] Similarly, β^τ measures the tax multiplier, defined as the increase in output when the tax revenue decreases by an infinitesimal amount, *as if the change in the tax revenue were due to a change in the tax rate only.*[25] Since our goal is testing which multiplier was the largest during the austerity period, these are the parameters we would like to estimate and compare.

Equations (2.46)-(2.48) relate each of the changes in the fiscal variables that characterize a fiscal adjustment to government preferences about the composition of the adjustment, as well as to output growth and shocks possibly correlated with output shocks. In the Appendix we provide a formal derivation of these equations. But to better understand them, define the improvement of the structural primary balance ($\Delta SPB_{j,t}$) as

$$\Delta SPB_{j,t} = (1+g_j)\Delta\tau_{j,t} - s^n_{j,t-1}g^n_{j,t} - s^w_{j,t-1}g^w_{j,t} \tag{2.50}$$

Note that we can also write $\Delta SPB_{j,t} = \frac{\hat{Y}_t\Delta\tau_t - \Delta W_t - \Delta N_t}{Y_{t-1}}$, where $\hat{Y}_t\Delta\tau_t$ is the change in aggregate revenue only due to changes in the tax rate, and ΔW_t and ΔN_t are the aggregate changes in welfare and non-welfare spending. Thus $\Delta SPB_{j,t}$ is the change in the aggregate structural primary balance as a percentage of $t-1$ output. Next, subtract (2.46) and (2.47) from (2.48) to obtain:

$$\Delta SPB_{j,t} = \lambda - \psi_1\Delta g^Y_{j,t} - \varepsilon_{j,t} \tag{2.51}$$

and note that if we impose $\beta^w = \beta^n = \beta^\tau = \beta$ in (2.45), we get:

$$\Delta g^Y_{j,t} = \beta_0 - \beta\Delta SPB_{j,t} + u^Y_{j,t} \tag{2.52}$$

Thus, under the constraint that all multipliers are the same (2.52) says that output growth depends negatively on the size of the fiscal adjustment as measured

[24] To see this, note that $\frac{d(g^Y_t - g)}{d(s^w_{t-1}g^w_t)} = d\left(\frac{Y_t - Y_{t-1}}{Y_{t-1}}\right)/d\left(\frac{W_t - W_{t-1}}{Y_{t-1}}\right) = \frac{dY_t}{dW_t}$, which is the welfare spending multiplier. The equalities follows because g, Y_{t-1} and W_{t-1} are predetermined.

[25] The tax multiplier is defined this way because we want to make the multipliers comparable, so that they measure the change in output due to a change in an aggregate quantity. To see why β^τ measures the tax multiplier, assume as a useful approximation that in the absence of shocks output grows at rate g, so that $\hat{Y}_t = (1+g)Y_{t-1}$ is what output would be absent any shock, and note that $\frac{d(g^Y_t - g)}{d(1+g)\Delta\tau_t} = d\left(\frac{Y_t - Y_{t-1}}{Y_{t-1}}\right)/d\left(\frac{\hat{Y}_t}{Y_{t-1}}(\tau_t - \tau_{t-1})\right) = \frac{dY_t}{d\tau_t\hat{Y}_t}$.

by $\Delta SPB_{j,t}$, and (2.51) says that $\Delta SPB_{j,t}$ may in turn depend on output growth as well as on shocks correlated with output shocks. The reason why $\Delta SPB_{j,t}$ depends both on output growth and on output-related shocks is twofold. On the one hand, a negative output shock that decreases tax revenue and thus raises the budget deficit requires a fiscal response, and for highly indebted countries this will likely lead to implementing austerity measures, hence increasing $\Delta SPB_{j,t}$. On the other hand, the targeted level of public debt might respond to output-related shocks (such as an increase in the sovereign rate) as well as to output itself if countries follow a tight fiscal rule.[26] In either case, the implication is that $\Delta SPB_{j,t}$ is likely correlated with $u^Y_{j,t}$ and therefore endogenous.

Putting all together, it should now be clear that (2.46)-(2.48) are just decomposing (2.51) in terms of each of the components of $\Delta SPB_{j,t}$. The reason why this is helpful is that, although each of the components is still endogenous, they also depend on government preferences about the composition of fiscal adjustments as measured by the α's. Insofar these policy choices are exogenous to the cycle, the α's satisfy the two main IV requirements: correlation with the endogenous regressors, and independence with respect to output shocks. However, the standard IV estimator is not feasible here because by construction the weights must add up to one, meaning that each of them can be expressed as a linear combination of the others, thus leading to a perfect collinearity problem. We have three endogenous regressors in (2.45) but only two available instruments, precluding point identification of the multipliers.

Fortunately, an Indirect Least Squares estimator (ILS) is available. Substituting (2.46)-(2.48) into (2.45) and rearranging terms gives:

$$\Delta g^Y_{j,t} = \gamma_0 - \gamma_1(\beta^w - \beta^\tau)\alpha^w_{j,t} - \gamma_1(\beta^n - \beta^\tau)\alpha^n_{j,t} + v_{j,t} \tag{2.53}$$

where the regressors are now the weights of welfare and non-welfare spending, which can be recovered from the observables as follows:

$$\alpha^w_{j,t} = \frac{-g^w_{j,t}s^w_{j,t-1}}{\Delta SPB_{j,t}} \tag{2.54}$$

$$\alpha^n_{j,t} = \frac{-g^n_{it}s^n_{it-1}}{\Delta SPB_{j,t}} \tag{2.55}$$

[26]To provide further intuition, let $\Delta T - \Delta G$ be the change in the primary balance, where ΔT is the change in revenue and ΔG the change in spending. Then decompose $\Delta T = Y\Delta\tau + \tau\Delta Y$ (where τ is the tax rate and Y output) and use the fact that the change in the primary balance must equal the change in debt ΔD to find $Y\Delta\tau - \Delta G = -(\Delta D + \tau\Delta Y)$, where the LHS is now the improvement in the structural primary balance. Finally, let ΔD to depend on ΔY as well as on output shocks to obtain a simplified version of (2.51).

Since every country j engages in fiscal consolidation, $\Delta SPB_{j,t}$ is always positive and the weights are well defined. We also have:

$$\gamma_1 = \frac{\lambda}{(1 - \sum_i \beta^i \psi_1^i)}$$

Henceforth we assume $\gamma_1 > 0$.[27] Now we can estimate (2.53) using OLS and obtain consistent estimates of $-\gamma_1(\beta^w - \beta^\tau)$ and $-\gamma_1(\beta^n - \beta^\tau)$, whose signs depend on the relative differences between the multipliers. Subtracting the latter from the former, we obtain $-\gamma_1(\beta^w - \beta^n)$. It follows that the signs of the estimates are useful in determining which multiplier is the largest. The intuition why this works is straightforward: if other things equal a country increases α_{jt}^w (so that $\alpha_{j,t}^\tau$ decreases) and this leads to a fall in $\Delta g_{j,t}^Y$, it must be the case that the welfare multiplier is larger than the tax multiplier.[28]

Finally, note that we will estimate equation (2.53) by OLS without including any control variables (other than the lag of year t output growth for robustness). This is because under our assumptions (2.53) is a reduced form equation where the dependent endogenous variable is explained by strictly exogenous variables only. Since any other variable related to output growth that we can think of is likely to be endogenous, the inclusion of such variables in (2.53) would be incorrect.

2.5.2 Can we treat the weights as exogenous to the cycle?

As we argued in the introduction, the potential endogeneity problem associated with the composition of adjustments is of a different nature of that the standard one associated with changes in the fiscal variables. The previous equations clearly illustrate why this is the case. Endogeneity of the change in the fiscal variables in (2.45) is almost guaranteed in a scenario such as the one most European countries faced during 2010-13, with levels of debt and budget deficits way above the ones agreed in the Maastrich Treaty, and financial markets ready to punish countries unwilling to undertake "structural reforms".

In contrast, endogeneity related to the composition of adjustments is likely to be conditional on governments beliefs about the relative sizes of the multipliers. Equation (2.53) illustrates this view: if for example a Government believes $\beta^w < \beta^\tau$ then $\frac{d\Delta g_{j,t}^Y}{d\alpha_{j,t}^w} > 0$ and an optimal response to a negative output shock could be to

[27] Given that $\lambda > 0$, this assumption naturally follows provided that the betas in the denominator are not so high so that austerity becomes self-defeating, meaning that the Government is unable to improve the primary fiscal balance.

[28] Of course, we could also have written equation (2.53) in terms of the weight on taxation instead of α_{it}^n without changing fundamentally anything except the interpretation of the coefficients.

increase $\alpha^w_{j,t}$ to alleviate the impact of the shock on output growth. If instead a Government believes $\beta^w = \beta^n = \beta^\tau$ then the composition of the adjustment is irrelevant from the output point of view, as in this case the coefficients in (2.53) are zero and changes in the weights do not affect output growth.

Considering the evidence available at the time, governments' incentives to change the composition of adjustments in response to output shocks must have been very small. First, we know for a fact that uncertainty about the size of fiscal multipliers was remarkably high. As an example that speaks for itself, Perotti (2006) managed to find in the same paper a government investment multiplier as low as -0.3 for Australia and as high as 5.1 for Germany. Second, this uncertainty applied both within each fiscal item as well across them, making it difficult to tell if some multipliers were actually higher than others. For example, a note by the IMF staff to the G-20 meeting in March 2009 reported a range of multipliers of 0.3-0.6 for revenues, 0.5-1.8 for investment, and 0.3-1.0 for other spending, but at the same time Romer and Romer (2010), Alesina and Ardagna (2010) and IMF (2010) were providing evidence that the tax multiplier tended to dominate the spending one.[29]

Regarding welfare spending, we find similar patterns: Perotti (2006) mentions that transfers to households are typically regarded as the quickest and most effective spending instrument for stimulating demand, but fails to find evidence of this claim; Blanchard et al. (2009) argue that this type of fiscal action cannot achieve sufficient stimulus as the target groups tend to be small, and Zandi (2008) finds a multiplier as large as 1.6 for extensions of unemployment insurance benefits and temporary increases of food stamps.

Moreover, the whole discussion about optimal fiscal policy was very politically charged, and economists from different sides of the political spectrum were recommending quite different recipes for dealing with the crisis. While Krugman and others insisted that fiscal stimuli packages were actually too small to be effective and asked for huge investments in infrastructure, a statement by the CATO Institute signed by 200 well-known economists (among them Buchanan, Cochrane, Fama and Prescott) claimed that "*we the undersigned do not believe that more government spending is a way to improve economic performance*", and asked instead for "*Lower tax rates and a reduction in the burden of government*" as the best way of using

[29]Blanchard et al. (2009): "*A review of the literature suggests a lot of heterogeneity across fiscal multiplier estimates, depending on the identifying assumptions, the type of fiscal policy, and the country of interest. Indeed, estimates range from less than zero to larger than four.*". In addition, both Blanchard et al. (2009) and Schindler et al. (2009) warn against relying (!?) too much on available estimates as macroeconomic conditions at the time had not been experienced in recent decades and structural parameters may had changed, which in their opinion provides a strong argument for policy diversification and for not relying on a single fiscal tool to support demand.

fiscal policy to boost growth.[30]

In view of this morass, it is simply very hard to believe that governments may have reacted to output shocks by changing the composition of fiscal adjustments in any consistent manner that could lead to a significant endogeneity problem. Indeed, the best strategy for a risk-averse government choosing the composition based on output considerations and facing a high degree of uncertainty about the relative sizes of multipliers should have been to rely on full diversification independent of output shocks. Since all governments had access to the same information, this should have led to choices of the weights quite invariant across countries and over time. In other words, we should observe nearly degenerate marginal distributions of the weights. As shown in the next section, this is certainly not the case, as the observed marginal distributions feature a considerable degree of dispersion. This is hard to explain in the context of risk-averse countries choosing the composition under severe uncertainty, but consistent with countries choosing the composition based on country-specific political preferences.

On the other hand, if the composition of adjustments were to be dependent on output shocks, we should expect each of the weights to depend on them, which in turn would lead to a systematic correlation between the weights. To see this, consider the following linearized policy functions:

$$\alpha^w_{j,t} = \bar{\alpha}^w + \eta^w v_{j,t} + \theta^w_{j,t} \quad (2.56)$$

$$\alpha^n_{j,t} = \bar{\alpha}^n + \eta^n v_{j,t} + \theta^n_{j,t} \quad (2.57)$$

Here $(\bar{\alpha}^w, \bar{\alpha}^n)$ are the mean values on the weights, $v_{j,t}$ is the same output-related shock as in (2.53), $(\theta^w_{j,t}, \theta^n_{j,t})$ are country-year political shocks unrelated to the cycle, and (η^w, η^n) are parameters measuring the response of the composition to output shocks.[31] Insofar $(\eta^w, \eta^n) \neq 0$ (i.e. the composition responds to output shocks) we have an endogeneity problem, because in (2.53) each of the weights would be

[30] About Paul Krugman defending fiscal stimuli, see for example: https://www.theguardian.com/business/ng-interactive/2015/apr/29/the-austerity-delusion. The CATO statement is available at: https://object.cato.org/sites/cato.org/files/pubs/pdf/cato_stimulus.pdf.

[31] This can be easily generalized to allow for country-specific responses by assuming $\eta^w_j = \bar{\eta}^w + \xi^w_j$ with ξ^w_j being a random error with zero mean. In this case we only have an endogeneity problem if $(\bar{\eta}^w, \bar{\eta}^n) \neq 0$, meaning that on average countries respond systematically to output shocks.

correlated with $v_{j,t}$.[32] But if this is the case then we have:

$$cov(\alpha^w_{j,t}, \alpha^n_{j,t}) = \eta^w \eta^n \sigma_v^2 + cov(\theta^w, \theta^n) \qquad (2.58)$$

Since $\sigma_v^2 > 0$, $(\eta^w, \eta^n) \neq 0$ automatically implies a systematic relationship between the weights that should be reflected in the data, except in the very unlikely case where $\eta^w \eta^n \sigma_v^2 = -cov(\theta^w, \theta^n)$.[33] But as we show in the next section, we cannot reject the null hypothesis that the pair (α^w, α^n) is independently distributed. While this finding is at odds with weights responding systematically to output shocks, it can be explained satisfactorily if the weights depend mainly on exogenous country-specific political shocks that satisfy $cov(\theta^w, \theta^n) \simeq 0$.

Finally, we matched our data with the *Comparative Political Data Set*, a collection of political and institutional country-level data provided by Prof. Dr. Klaus Armingeon and collaborators, to see whether ideology or pre-conceived ideas about optimal fiscal policy might be a source of endogeneity. For example, governments might have the pre-conceived idea that, in spite of the lack of reliable information, for some reason is best to react to negative output shocks by putting more weight on welfare spending cuts. However, this is only a concern if governments reacted systematically to output shocks this way, and this line of thinking would be most associated with right-wing political parties. In other words, we would need that the majority of countries in our sample were ruled by right-wing parties with the same pre-conceived ideas about fiscal policy. And we find that in our sample of country-year observations the average of cabinet posts controlled by right-wing parties as a percentage of total cabinet posts only amounts to 27%, with an average of 19% for centrist parties and 39.55% for left-wing parties, with standard deviations of 30.53%, 31.51%, and 36.65%, respectively. Other measures such as the number of seats controlled by each type of party in the parliament give similar results. Hence we have a sample of countries with a sizable degree of ideological variety, precluding a systematic response to the cycle purely based on ideological considerations.

We conclude based on all these arguments that the main source of cross-country variation in the composition of adjustments cannot have been output shocks, but political preferences exogenous to the economy and generated by ideology and policy

[32] In the online Appendix we show that if governments exhibit convex preferences —so that they dislike extreme choices— either both (η^w, η^n) are zero or both are not. The assumption of convex preferences is consistent with the observed marginal distributions of the weights (see Figure 2), as for each of them the bulk of mass is concentrated around means that lie in the interior of the interval (0,1).

[33] In the online Appendix we derive a Bayesian-like approach to show that, even in this very unlikely scenario where output and political shocks perfectly offset each other, the expected bias associated with the estimation of (2.53) is too small to drive the empirical results.

preferences that are not systematic across countries, as Alesina and Ardagna have suggested.

2.5.3 Cyclical Adjustment of the Fiscal Variables

We first illustrate why we need to cyclically adjust our variables for taxes and welfare spending, and then discuss how to do so. Although we focus on taxation, the same rules apply to welfare spending.

In our empirical derivations we have assumed that changes in the tax rate are free of automatic stabilizers, in the sense that they only change if the Government actively chooses so, but in general this is not the case. Even if the nominal tax rate stays constant, the effective tax rate is likely to change automatically with the cycle.[34] From the theoretical point of view, a tax rate that depends automatically on the cycle is not particularly troubling. Let the tax rate be $\hat{\tau}_{jt} = \tau_{jt} + \xi \Delta g^Y_{jt}$, where ξ measures the automatic response of the tax rate to the cycle. Then we can decompose $-\beta_\tau(1+g_j)\Delta\hat{\tau_{jt}}$ as follows:

$$-\beta_\tau(1+g_j)\Delta\hat{\tau_{jt}} = -\beta_\tau(1+g_j)\Delta\tau_{jt} - \beta_\tau\xi(1+g_j)\Delta g^Y_{jt} + \beta_\tau\xi(1+g_j)\Delta g^Y_{jt-1}$$

The only consequence is that the term $\beta_\tau\xi\Delta g^Y_{jt}$ would be added to Δg^Y_{jt} in the LHS of (2.45) so that we would end up with all terms in the RHS divided by $(1+\beta_\tau\xi)$. In the government budget equations we could still define $\Delta SPB_{j,t}$ in terms of $\Delta\tau_{jt}$ so that exogenous weights could still be constructed. The practical problem is that we do not observe $\Delta\tau_{jt}$, but $\Delta\hat{\tau_{jt}}$ instead.

To deal with this issue, we follow the literature and proceed to cyclically adjust both the observed tax revenue/GDP (our proxy for the tax rate) and welfare spending/GDP. The method of adjustment is fairly simple and widely used by international institutions such as the European Commission, the IMF and the OECD. It essentially consists of multiplying the fiscal variable of interest by $\left(\frac{Y^p}{Y}\right)$ if the fiscal variable tends to correlate positively with the cycle (taxes) and by $\left(\frac{Y}{Y^p}\right)$ if the fiscal variable correlates negatively with the cycle (welfare spending), where $\frac{Y}{Y^p}$ is the ratio of actual output to potential output, also known as the output gap. The ratio tends to increase when output is above potential and decrease when is below potential, thus helping to correct for automatic changes in the fiscal variables only due to the cycle.

[34] Income taxes provide a clear example. Since the tax rate applied to an individual tax payer depends on how much income the individual is making, in bad times more people will declare less income, hence the tax rate applied to them will be smaller, even if the Government has not changed the menu of tax rates for each level of income.

In principle the ratio should be raised to the power of a constant that measures the elasticity of the responsiveness of the fiscal variable to the cycle, but the IMF staff recommends setting this exponent to 1 in cases of clear cyclicality such as taxes. The standard approach also calls for using a elasticity significantly smaller than one when applied to current spending, on the basis that the only component that is sensitive to the cycle is spending on unemployment insurance. However this is likely to be wrong: as shown by authors such as Darby and Melitz (2008), all the components of welfare spending have an strong automatic stabilizer component. Take for example the two biggest components of welfare spending, retirement pensions and health-care. It is well known that early retirements increase during bad times, hence inducing an automatic cyclical effect on the spending on pensions. Similarly, in most public heath systems governments require lower co-payments for those of low incomes, the disabled and the unemployed. Additionally, people may switch from private health-care to public one during bad times if the public provision is significantly cheaper.[35]

2.5.4 Selection of Episodes of Fiscal Adjustment

As already mentioned, for the weights to be well defined and for the estimates of (2.53) to have a clear interpretation, we require that the sample of countries under consideration engaged in fiscal adjustments. Hence we select from the available data country-year observations for which $\Delta SPB_{j,t}$ is above a positive threshold, that we vary for robustness.

This way of selecting episodes of fiscal consolidation is the same as in Alesina and Ardagna (2010), and it has been criticized in subsequent work (Guajardo et al. (2014) among others) on the basis that this procedure is unable to filter out all automatic fiscal responses to the cycle. In the context of the previous subsection, the problem would be that the observed $\Delta\hat{\tau_{jt}}$ still depends automatically on output even after the adjustment procedure because the automatic response to the cycle is so strong, like in a boom in the stock market.

However, This concern is not really warranted for the 2010-13 period, as we know from a wide variety of sources that most governments were indeed engaging in strong fiscal consolidation plans at the time. A large improvement in $\Delta SPB_{j,t}$ during the austerity period is much more likely to reflect a discretionary action from the government rather than a consequence from events purely related to the cycle.[36]

[35]Even if we were to ignore these effects and use the average OECD elasticity for advanced countries, this number would be around 0.6 for welfare spending (see OECD Economic Outlook 66, and note that welfare spending is about half of current spending). In the robustness checks we experiment by setting the constant to 1/2 and find that it barely changes anything.

[36]In Table 1 we list all the selected country-year episodes of fiscal consolidation, so that the

2.6 The Data

Our broadest sample consists of 41 country-year observations from 21 advanced OECD economies for which $\Delta SPB_{j,t}$ is above 0.5, although our benchmark sample will be a subset of 31 observations from 18 of these countries for which $\Delta SPB_{j,t}$ is above 1. The countries are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, United Kingdom and the United States. The years under consideration are 2010-13, and our data sources are the *OECD Economic Outlook* dataset, and the *OECD National Accounts at a Glance* dataset (complemented with data on spending from the IMF for Iceland). Table 1 lists all the selected country-year episodes.[37]

Table 2 shows summary statistics of the variables used through the estimation process. The first group includes real GDP growth and its long-run average (1990-2016), and household consumption growth relative to its long-run average. Looking at these statistics, it is fair to say that our sample of economies performed quite poorly compared to normal times, as we have an average GDP growth of -1.41% for the 2010-13 period as opposed to an average long-run rate of 2.42%.

The next group are the ratios of the fiscal variables to GDP (in percentage terms) and the ratio of potential GDP to actual GDP (the inverse of the output gap). In order to construct the welfare and non-welfare spending ratios, we disaggregate overall spending by its functional components using the COFOG classification, which enables us to distinguish between the different spending components of the General Government and classify them by their function as Health, Education, Social protection, General Services, Defense, Public order and safety, Economic affairs, Environmental protection, Housing and community amenities, and Recreation, culture and religion.

Then, we put together the components of Health and Social protection to form the welfare spending/GDP and group the remaining components to form the non-welfare/GDP. From this last ratio we subtract the payment of public debt interests (which is included by default in the General Services Component) and capital transfers. We exclude capital transfers because during this period several governments chose to nationalize or bail out private banks, which was very costly and increased the deficits, sometimes dramatically. Otherwise, we would discard observations on

reader can verify that all the "usual suspects" are there.

[37] We exclude the observation for Greece in 2013 because in that year Greece received a rescue package that it was used to bail out banks. This operation was accounted for as a huge increase in government spending that we have been unable to disentangle from other types of spending.

the basis that the country did not impose austerity measures when in fact is the opposite, but the change of the primary balance is negative due to the increase in capital transfers.[38] The shares of welfare and taxes shown have been already adjusted for the cycle. We have that the average share of welfare spending on GDP is about 23%, slightly higher than the share of non-welfare spending (18.5%). We use the tax revenue/GDP as our "estimate" for the tax rate of the economy.

We also provide the growth rates of welfare and non-welfare spending used to compute the weights, as well as the change in the tax rate. As expected by a group of countries that are imposing significant austerity measures, the growth rates are negative (-2.97% and -4.41% respectively) and the change in the tax rate positive (1.77 percentage points).

The last group of statistics come from the variables we construct, namely the improvement in the structural primary balance at time t as a percentage of $t-1$ output ΔSPB, and the weights measuring the composition of fiscal adjustments. The statistics indicate that fiscal adjustments based on welfare spending were the least popular option (average of 0.14 and median of 0.17), followed by non-welfare spending (0.23 in both cases) and taxes (0.63 and 0.51). Importantly, note that the standard deviations of the weights are comparable in magnitude to their means, indicating a high degree of dispersion that we corroborate in Figure 2 where we plot the kernel density functions for each of the weights. As already discussed, this finding is hard to explain if governments chose the weights based on output considerations under severe uncertainty (in which case we should expect close to degenerate distributions), but it follows naturally from weights chosen based on political considerations.

Finally, in Figure 3 we plot the weight on welfare spending against the weight on non-welfare. The absence of any type of relationship between the two is apparent, and a simple regression confirms this, as we cannot reject the null hypothesis that the covariance is zero at the conventional levels. Averaging the weights for each country leads to essentially the same result. Thus, we conclude that these two variables are likely to be independently distributed. Again, this finding is at odds with a composition of adjustments responsive to output shocks in a systematic way, but it is consistent with weights driven by exogenous political preferences.

[38]This is for example the case of Ireland. On the other hand, capital transfers are not the type of non-welfare spending associated with the multiplier we are interested in.

2.7 Regression Results

Although most economists would agree that the improvement in the primary balance and its components are most likely endogenous, it is still worth showing some partial correlations, just to get some sense of what the relationships between the variables are. This is what we do in Table 3, where we regress output and consumption growth relative to their long-run averages on ΔSPB (columns 1 and 2), and on the disaggregated components (columns 3 and 4), using the same specification as in (2.45). Very much in line with previous evidence, we find a negative and highly significant relationship between ΔSPB and output growth.[39] Figure 4 shows a scatter plot of the two variables illustrating the strong negative relationship.

In columns 3 and 4 we repeat the exercise but this time distinguishing between the fiscal components of welfare, non-welfare and taxes. As shown in (2.45), if these variables were exogenous we could interpret the coefficients as the fiscal multipliers. Under this interpretation, the multiplier of welfare spending stands out, with a point estimate of 1.72 and p-value below 0.01, followed by the tax multiplier, with a point estimate of 0.42 and a p-value below 0.05. In contrast the point estimate of non-welfare spending is small and not significant.

We now turn to our main results in Table 4, where we run regressions for the sample of countries with improvements in the structural primary balance above 1. As discussed in detail in section 5.2, there is a good chance that the weights measuring the composition of adjustments are exogenous to the cycle, and if so we can interpret the results as unbiased estimates of the effect of the composition on output growth.

In column 1 we regress output growth relative to its long-run average on the weights of welfare and non-welfare, and in column 2 on the weights of welfare and taxes. Columns 3 and 4 repeat the same exercise but with consumption growth relative to its long-run average as the dependent variable. From section 5.1 we know that a negative coefficient for the weight on welfare spending in column 1 indicates that the welfare multiplier is larger than the tax multiplier, and a negative sign in column 2 indicates that the welfare multiplier is larger than the non-welfare one. That is precisely what we find. Moreover, the coefficients are significant at the 1% level. Hence we conclude that the welfare-state multiplier is the largest of the three. As a visual illustration, Figure 5 shows the negative relationship between the weight of welfare spending and GDP growth relative to its long-run average in a scatter plot.

[39] See Mauro and Zilinsky (2015) for a discussion about cross-country correlations relating measures of austerity to economic performance.

The point estimates also have a clear economic interpretation. Take for example the coefficient of the weight on welfare spending from column 1. The point estimate of -6.26 measures by how many percentage points GDP growth relative to its long-run mean would fall if a country improving the structural primary balance by about 3 percentage points switches from a fiscal adjustment without welfare spending cuts to a fiscal adjustment fully based on welfare cuts, holding the weight of non-welfare constant. Therefore, the results indicate that the choice of the composition of a fiscal adjustment is far from trivial, as the economic performance can range from a mild recession to a large economic downturn, depending on how much the fiscal consolidation plan is based on welfare spending cuts. Related to this, the fact that the point estimates in columns 3 and 4 are of a similar magnitude as those in previous columns connects the empirical results to the theory even further, because what drives a recession in our model is precisely a fall in household demand in response to a permanent cut in welfare spending.

2.7.1 Robustness Checks

In Table 5 we conduct a first round of robustness checks. Columns 1 and 2 include the lag of output growth as a control, columns 3 and 4 include all country-year observations for which $\Delta SPB > 0.5$ (thus relaxing the selection criteria and increasing the number of observations), and in columns 5 and 6 we regress country-average output growth for the 2010-13 period on the country-average weights for the same time window, thus running a purely cross-sectional regression with 18 observations. The idea behind these last two columns is to control for the possibility that the fact that some fiscal adjustments may have been conceived as multi-year plans (and thus foreseeable) may be affecting our results.[40] In all columns the coefficient of the weight on welfare spending remains negative and significant at the 1% level.

In Table 6 we conduct a second round of robustness checks. In Columns 1 and 2 we cyclically adjust welfare spending/GDP by multiplying it by $\sqrt{\frac{Y}{Y^p}}$ instead of $\frac{Y}{Y^p}$ (thus reducing the cyclical correction by a factor of a half), columns 3 and 4 show results from the robust regression estimator, and columns 5 and 6 show results from the quantile regression estimator. These two estimators are designed to deal with the influence of possible outliers, an important issue when the number of observations is not too big. In all columns the coefficient of the weight on welfare spending remains negative and significant at the 1% level, except in the last column where it is significant at the 5% level. In addition, we ran regressions excluding countries

[40] Alesina, Favero, and Giavazzi (2015) emphasize this concern, related to the issue raised by Ramey (2011) about the distintion between announced and unanticipated shifts in fiscal policy.

one at a time and we never lost significance at the 5% level at least.

In summary, our results are robust to dynamic output effects, to the choice of the threshold of ΔSPB, to the possibility that fiscal adjustments may have been conceived as multi-year plans, to the degree of the cyclical adjustment of welfare spending, and to estimators designed to deal with outliers.

2.8 Concluding Remarks

In this paper we have argued that current New-Keynesian models cannot explain larger-than-normal multipliers associated with the austerity period of 2010-13 if austerity measures were expected to be permanent. To solve this puzzle, we have developed a simple New-Keynesian model with incomplete markets, heterogeneous households exposed to idiosyncratic health shocks, and welfare-state spending in the form of public healthcare, as well as standard non-welfare spending as in many other models. We have shown that, at the zero lower bound, a permanent welfare spending cut leads to a larger-than-normal multiplier whereas a permanent non-welfare spending cut does not. At the same time, the model delivers a larger-than-normal multiplier when the non-welfare spending cut is temporary, consistent with previous models.

On the empirical side, we have tested the model prediction of a welfare multiplier larger than the others during the austerity period, and found strong support for this hypothesis. We have argued that, based on available evidence, the composition of adjustments during 2010-13 is likely to have been independent from output shocks, in which case the weights measuring it are good instruments that deliver unbiased estimates.

Putting these two findings together, we arrive to the conclusion that, from the perspective of short-term output growth, the composition of fiscal adjustments at the zero lower bound is far from trivial. This should be good news for policy-makers. If all the multipliers were equal and positive, a fiscal adjustment would unavoidably lead to a recession whose strength would only depend on the size of the adjustment. If instead the welfare multiplier is significantly larger than the others —as both theory and evidence indicate— then there is room for an optimal choice of the composition that can significantly reduce the negative short-terms effects on output. At the same time, since the optimal choice calls for a low (or even negative) weight on welfare spending, austerity measures might be easier to implement than previously thought: as the recent European experience has shown, welfare spending cuts are among the most unpopular choices a government can make.

Appendix

A. Solution without Unexpected Shocks

Combining equations (2.5) and (2.6) gives:

$$n_i = 1 - (\frac{1-\mu}{\mu})\frac{c_i}{w}$$

Integrating this expression over i, using the labor market clearing condition (2.34) and symmetry across monopolists (so that $Y = \int n_t(k)dk$) delivers:

$$Y = 1 - (\frac{1-\mu}{\mu})\frac{1}{w}\int c_i di \tag{2.59}$$

Next, use the fact that individual demands for medicines are $\theta - \frac{G_w}{q}$ for the sick household and 0 for the healthy, and that there is a mass q of sick households to obtain $\int m_i di = q\theta - G_w$. Plugging this into (2.32) gives $\int c_i di = C - q\theta + G_w$. Then, substitute this last result into (2.59), use the aggregate resource constraint, the fact that $G = G_n + G_w$ and rearrange terms to obtain

$$Y = \frac{\mu w + (1-\mu)(G_n + \theta q)}{1 - \mu + \mu w} \tag{2.60}$$

In the absence of unexpected shocks the optimal pricing condition holds, hence $w = \varepsilon$ and (2.60) becomes equation (2.36) in the text. Finally, plug (2.36) into the aggregate resource constraint and rearrange terms to get (2.37).

B. Solution with Welfare Spending Cuts

Here we derive a condensed version of the model with unexpected welfare spending cuts that will be very useful for proving our results. First, note that real profits can be written as $\frac{\Pi}{P} = Y(1-w)$, and that (2.60) can be rearranged to get $w(1-Y) = \left(\frac{1-\mu}{\mu}\right)(Y - G_n - \theta q)$. Using this, we find that

$$w + \frac{\Pi}{P} = \frac{1}{\mu}\left(Y - (1-\mu)(G_n + \theta q)\right) \tag{2.61}$$

Without loss of generality, let the government follow a balanced budget at each period, so that $G_n + G_w = \frac{T}{P}$.[41] Then combine this with (2.61) to find that the

[41] If the government lends or borrows, then simply replace (2.35) with $\int_0^1 b_{it}di = \frac{D_t}{P_t}$ (where D_t is nominal public debt) and define $\hat{b}_{it} = b_{it} - \frac{D_t}{P_t}$.

component $w + \frac{\Pi+T}{P}$ that is common to (2.16)-(2.21) can be written as:

$$\mu \left(w + \frac{\Pi + T}{P} \right) = Y - G_n - \theta q + \mu (\theta q - G_w)$$
$$= \bar{C} + \Delta Y - \mu \Delta G_w \quad (2.62)$$

The last line follows from (2.37) and $\Delta G_n = 0$, as in this equilibrium we do not consider non-welfare shocks. Next, use the bond market clearing condition (2.35) and the fact that we have $1-q$ healthy households purchasing b_h real bonds and q sick households purchasing b_s real bonds to get $b_s = -\frac{(1-q)}{q} b_h$. Finally, rewrite the sick household's demand for medicines as $m_s = -\frac{\Delta G_w}{q}$, plug in these two results together with (2.62) into (2.16)-(2.21), substitute these into the Euler Equations (2.22) and (2.23), and use that the Central Bank keeps a zero inflation policy and that $w = \varepsilon$ always holds in period 2 to obtain:

$$\frac{1}{\bar{C} + \Delta Y_1 - \mu(\Delta G_{w,1} + b_H)} = \frac{\beta(1+R_2)(1-q)}{\bar{C} - \mu(\Delta G_{w,2} - (1+R_2) b_H)} + \frac{\beta(1+R_2) q}{\bar{C} + \mu(\frac{(1-q)}{q} \Delta G_{w,2} + (1+R_2) b_H)} \quad (2.63)$$

$$\frac{1}{\bar{C} + \Delta Y_1 + \mu \frac{(1-q)}{q}(\Delta G_{w,1} + b_H)} = \frac{\beta(1+R_2)(1-q)}{\bar{C} - \mu(\Delta G_{w,2} + \frac{(1-q)}{q}(1+R_2) b_H)} + \frac{\beta(1+R_2) q}{\bar{C} + \mu \frac{(1-q)}{q}(\Delta G_{w,2} - (1+R_2) b_H)} \quad (2.64)$$

If the ZLB does not bind, then $\Delta Y_1 = 0$, $R_2 = Z_2$ and we have a system of two equations with unknowns b_h and Z_2. If instead the ZLB binds, then $R_2 = 0$ and the system has unknowns b_h and ΔY_1.

C. Proof of Proposition 1

Since we are in the flexible price equilibrium, $\Delta Y_1 = 0$ and $R_2 = Z_2$. First, let the spending cut be temporary, so that $\Delta G_{w,1} = \Delta G_w < 0$ and $\Delta G_{w,2} = 0$. This implies the absence of idiosyncratic risk in period 2 (as the government provides full insurance again), and that (2.63)-(2.64) simplifies to:

$$\frac{1}{\bar{C} - \mu(\Delta G_w + b_H)} = \frac{\beta(1+Z_2)}{\bar{C} + \mu(1+R_2) b_H}$$
$$\frac{1}{\bar{C} + \mu \frac{(1-q)}{q}(\Delta G_w + b_H)} = \frac{\beta(1+Z_2)}{\bar{C} - \mu \frac{(1-q)}{q}(1+R_2) b_H}$$

This is a simple system of two equations and two unknowns that can be solved by hand, delivering $1+Z_2 = \frac{1}{\beta}$ and $b_H = -\left(\frac{\beta}{1+\beta}\right)\Delta G_w$. This proves the first part of the proposition.

We prove the second part of the proposition by contradiction. Thus, suppose $\beta(1+Z_2) \geq 1$. Since the spending cut is permanent, $\Delta G_{w,1} = \Delta G_{w,2} = \Delta G_w$ with $\Delta G_w < 0$, and equations (2.63)-(2.64) become:

$$\begin{aligned}
\frac{1}{\bar{C}-\mu(\Delta G_w + b_H)} &= \frac{\beta(1+Z_2)(1-q)}{\bar{C}-\mu(\Delta G_{w,2}-(1+Z_2)b_H)} \\
&+ \frac{\beta(1+Z_2)q}{\bar{C}+\mu(\frac{(1-q)}{q}\Delta G_w + (1+Z_2)b_H)}
\end{aligned} \tag{2.65}$$

$$\begin{aligned}
\frac{1}{\bar{C}+\mu\frac{(1-q)}{q}(\Delta G_w + b_H)} &= \frac{\beta(1+Z_2)(1-q)}{\bar{C}-\mu(\Delta G_w + \frac{(1-q)}{q}(1+Z_2)b_H)} \\
&+ \frac{\beta(1+Z_2)q}{\bar{C}+\mu\frac{(1-q)}{q}(\Delta G_w - (1+Z_2)b_H)}
\end{aligned} \tag{2.66}$$

Focus on the first equation. Since $\beta(1+Z_2) \geq 1$, we must have:

$$\frac{1}{\bar{C}-\mu(\Delta G_w + b_H)} \geq \frac{(1-q)}{\bar{C}-\mu(\Delta G_w-(1+Z_2)b_H)} + \frac{q}{\bar{C}+\mu(\frac{(1-q)}{q}\Delta G_w + (1+Z_2)b_H)}$$

From Jensen's Inequality, we have that $E[f(x)] > f(E[x])$ when f is a strictly convex function and the distribution of x is not degenerate. In our application, $f(x) = \frac{1}{\bar{C}+\mu(1+Z_2)b_H+x}$, where $x = -\mu\Delta G_w$ with probability $(1-q)$ and $x = \mu\frac{(1-q)}{q}\Delta G_w$ with probability q. Since $\Delta G_w < 0$, x is not a degenerate random variable. Hence $E[x] = 0$ and consequently:

$$\frac{1}{\bar{C}-\mu(\Delta G_w + b_H)} > \frac{1}{\bar{C}+\mu(1+Z_2)b_H}$$

or

$$(1+Z_2)b_H > -(\Delta G_w + b_H)$$

Repeating the same process with (2.66) gives:

$$(1+Z_2)b_H < -(\Delta G_w + b_H)$$

And combining the two inequalities, we obtain $\Delta G_w < \Delta G_w$, a contradiction. ■

D. Proof of Proposition 2

To simplify notation, let $y = \Delta Y_1$, $b = b_H$ and $g = \Delta G_w$. Define functions F_1 and F_2 as follows:

$$
\begin{aligned}
F_1(y,b,g) &= \frac{1}{c_H(y,b,g)} - \frac{1-q}{c_{HH}(b,g)} - \frac{q}{c_{HS}(b,g)} \\
F_2(y,b,g) &= \frac{1}{c_S(y,b,g)} - \frac{1-q}{c_{SH}(b,g)} - \frac{q}{c_{SS}(b,g)}
\end{aligned}
$$

where

$$
\begin{aligned}
c_H(y,b,g) &= \bar{C} + y - \mu(g+b) \\
c_S(y,b,g) &= \bar{C} + y + \mu\frac{(1-q)}{q}(g+b) \\
c_{HH}(b,g) &= \bar{C} - \mu(g-b) \\
c_{HS}(b,g) &= \bar{C} + \mu(\frac{(1-q)}{q}g + b) \\
c_{SH}(b,g) &= \bar{C} - \mu(g + \frac{(1-q)}{q}b) \\
c_{SS}(b,g) &= \bar{C} + \mu\frac{(1-q)}{q}(g-b)
\end{aligned}
$$

Note that when $F_1 = F_2 = 0$ we recover the system (2.42)-(2.43). If we impose this condition, differentiate with respect to (y,b,g) and rearrange terms we obtain, in matrix notation:

$$
\begin{bmatrix} \frac{dy}{dg} \\ \frac{db}{dg} \end{bmatrix} = \begin{bmatrix} F_{1,y} & F_{1,b} \\ F_{2,y} & F_{2,b} \end{bmatrix}^{-1} \begin{bmatrix} -F_{1,g} \\ -F_{2,g} \end{bmatrix}
$$

where $F_{i,j}$ denotes the partial derivative of function i with respect to element j, given by:

$$
\begin{aligned}
F_{1,y} &= -\frac{1}{c_H^2} \\
F_{1,b} &= \mu\left(\frac{1}{c_H^2} + \frac{1-q}{c_{HH}^2} + \frac{q}{c_{HS}^2}\right) \\
F_{1,g} &= \mu\left(\frac{1}{c_H^2} + (1-q)\left(\frac{1}{c_{HS}^2} - \frac{1}{c_{HH}^2}\right)\right) \\
F_{2,y} &= -\frac{1}{c_S^2} \\
F_{2,b} &= -\mu\frac{(1-q)}{q}\left(\frac{1}{c_S^2} + \frac{1-q}{c_{SH}^2} + \frac{q}{c_{SS}^2}\right) \\
F_{2,g} &= \mu\frac{(1-q)}{q}\left(-\frac{1}{c_S^2} + (1-q)\left(\frac{1}{c_{SS}^2} - \frac{1}{c_{SH}^2}\right)\right)
\end{aligned}
$$

In turn, we have that

$$\begin{bmatrix} F_{1,y} & F_{1,b} \\ F_{2,y} & F_{2,b} \end{bmatrix}^{-1} = \frac{1}{F_{1,y}F_{2,b} - F_{1,b}F_{2,y}} \begin{bmatrix} F_{2,b} & -F_{1,b} \\ -F_{2,y} & F_{1,y} \end{bmatrix}$$

Since households have log utility, individual consumption is always positive as long as the cost of buying medicines after the spending cut is not too high (which is why we require$-q((1-q)\mu)^{-1}\bar{C} < \Delta G_w < 0$). It follows that $F_{1,y}F_{2,b} - F_{1,b}F_{2,y} > 0$. This has two implications. First, the Jacobian of (F_1, F_2) is always invertible, so that by the Implicit Function Theorem there exists unique continuously differentiable functions $v_1(g)$ and $v_2(g)$ such that $y = v_1(g)$ and $b = v_2(g)$. This proves part $i)$ in the proposition.

The second implication is that, from the matrix equations, we only have to show $F_{2,g}F_{1,b} - F_{2,b}F_{1,g} > 0$ to establish $\frac{dy}{dg} > 0$. Using the expressions for the partial derivatives, this is equivalent to show that

$$\frac{-\frac{1}{c_S^2} + q\left(\frac{1}{c_{SS}^2} - \frac{1}{c_{SH}^2}\right)}{\frac{1}{c_S^2} + \frac{1-q}{c_{SH}^2} + \frac{q}{c_{SS}^2}} + \frac{\frac{1}{c_H^2} + (1-q)\left(\frac{1}{c_{HS}^2} - \frac{1}{c_{HH}^2}\right)}{\frac{1}{c_H^2} + \frac{1-q}{c_{HH}^2} + \frac{q}{c_{HS}^2}} > 0$$

The denominators are strictly positive, and from the expressions for individual consumption $g < 0$ implies $c_{SS} < c_{SH}$ and $c_{HS} < c_{HH}$, which in turn implies that the terms in parentheses are strictly positive too. Thus, we just need to show

$$\frac{\frac{1}{c_H^2}}{\frac{1}{c_H^2} + \frac{1-q}{c_{HH}^2} + \frac{q}{c_{HS}^2}} > \frac{\frac{1}{c_S^2}}{\frac{1}{c_S^2} + \frac{1-q}{c_{SH}^2} + \frac{q}{c_{SS}^2}}$$

To do this, use that in equilibrium $\frac{1}{c_H} = \frac{1-q}{c_{HH}} + \frac{q}{c_{HS}}$ and $\frac{1}{c_S} = \frac{1-q}{c_{SH}} + \frac{q}{c_{SS}}$ to find, after some algebra:

$$\left(1 + \frac{\frac{1-q}{c_{HH}^2} + \frac{q}{c_{HS}^2}}{\left(\frac{1-q}{c_{HH}} + \frac{q}{c_{HS}}\right)^2}\right)^{-1} > \left(1 + \frac{\frac{1-q}{c_{SH}^2} + \frac{q}{c_{SS}^2}}{\left(\frac{1-q}{c_{SH}} + \frac{q}{c_{SS}}\right)^2}\right)^{-1}$$

Note that the only reason why the two ratios might differ is because the first one depends on μb whereas the second depends on $-\mu\frac{(1-q)}{q}b$, so we can think of the ratios as the same function $f(x)$ evaluated at different points of x . Since this function is continuous and differentiable, the above inequality would be true if the function is strictly decreasing in x and b happened to be positive. Let $A_1 = \bar{C} - \mu g$ and

$A_2 = \bar{C} + \mu\frac{(1-q)}{q}g$. Given that $g < 0$, $A_2 < A_1$. Then $f(x)$ can be written as:

$$f(x) = \frac{\frac{1-q}{(A_1+x)^2} + \frac{q}{(A_2+x)^2}}{\left(\frac{1-q}{A_1+x} + \frac{q}{A_2+x}\right)^2}$$

and the sign of $\frac{df(x)}{dx}$ will be determined by the sign of its numerator. With some algebra, this can be shown to be

$$(-1)\left(\frac{1-q}{A_1+x} + \frac{q}{A_2+x}\right)\left(\frac{(1-q)q}{(A_1+x)(A_2+x)}\right)\left(\frac{1}{A_1+x} - \frac{1}{A_2+x}\right)^2$$

Since consumption is always positive, the first two terms in parentheses are positive too, and $\left(\frac{1}{A_1+x} - \frac{1}{A_2+x}\right) > 0$ as $A_2 < A_1$. Since all are positive and they are multiplied by -1, the numerator is indeed negative. Thus $f(x)$ is strictly decreasing in x.

It remains to show that $b > 0$, which we prove by contradiction. Suppose $b \leq 0$ instead. Since $\left(\frac{1-q}{A_1+x} - \frac{q}{A_2+x}\right)$ decreases with x, we must have:

$$\frac{1-q}{c_{SH}} + \frac{q}{c_{SS}} \leq \frac{1-q}{c_{HH}} + \frac{q}{c_{HS}}$$

and the Euler Equations then imply $\frac{1}{c_S} \leq \frac{q}{c_H}$. Substituting the expressions for consumption and rearranging terms, we end up with $b \geq -g$. But since $g < 0$, we have that $b > 0$, a contradiction. ■

E. Derivation of the Structural Econometric Model

Start with the Government's budget constraint at time t, given by

$$W_{j,t} + N_{j,t} + R_{j,t}D_{j,t-1} = \tau_{j,t}Y_{j,t} + D_{j,t} \tag{2.67}$$

This says that aggregate welfare spending $W_{j,t}$, non-welfare spending $N_{j,t}$ and debt payments $R_{j,t}D_{j,t-1}$ must be financed with tax revenue $\tau_{j,t}Y_{j,t}$ and new issued debt $D_{j,t}$. Subtracting the budget at $t-1$ from the budget at t gives:

$$\Delta W_{j,t} + \Delta N_{j,t} + \Delta(R_{j,t}D_{j,t-1}) = \Delta(\tau_{j,t}Y_{j,t}) + \Delta D_{j,t} \tag{2.68}$$

Next, note that we can decompose the change in tax revenue as follows:

$$\begin{aligned}\Delta(\tau_{j,t}Y_{j,t}) &= \tau_{j,t}Y_{j,t} - \tau_{j,t-1}Y_{j,t-1} \\ &= Y_{j,t-1}\left(\Delta\tau_{j,t} + \tau_{j,t}g^Y_{j,t}\right) \\ &\simeq Y_{j,t-1}\left((1+g_j)\Delta\tau_{j,t} + \tau_{j,t-1}g^Y_{j,t}\right)\end{aligned}$$

The last part follows from adding and subtracting $g_j\Delta\tau_{j,t}$, ignoring the component $\Delta\tau_{j,t}\Delta g^Y_{j,t}$ (because is very small) and rearranging terms.[42]

If we now plug this decomposition into (2.68), divide both sides by $Y_{j,t-1}$, ignore the pre-determined component $\frac{\Delta(R_{j,t}D_{j,t-1})}{Y_{j,t-1}}$ and rearrange terms we obtain:

$$(1+g_j)\Delta\tau_{j,t} - s^w_{j,t-1}g^w_{j,t} - s^n_{j,t-1}g^n_{j,t} = -\left(\tau_{j,t-1}g^Y_{j,t} + s^D_{j,t-1}g^D_{j,t}\right) \tag{2.69}$$

Note that by definition the LHS equals $\Delta SPB_{j,t}$. The equation says that an improvement in the structural primary balance follows from either a fall in tax revenue $\tau_{j,t-1}g^Y_{j,t}$, a decrease in debt $s^D_{j,t-1}g^D_{j,t}$, or both.

Using the definitions of the weights, we have:

$$s^w_{j,t-1}g^w_{j,t} = -\alpha^w_{j,t}\Delta SPB_{j,t} \tag{2.70}$$
$$s^n_{j,t-1}g^n_{j,t} = -\alpha^n_{j,t}\Delta SPB_{j,t} \tag{2.71}$$
$$(1+g_j)\Delta\tau_{j,t} = \alpha^\tau_{j,t}\Delta SPB_{j,t} \tag{2.72}$$

so that the weights satisfy $\sum_i \alpha^i_{j,t} = 1$. Next, take a first order expansion of these equations around the average values of the sample to obtain:

$$d(s^w_{j,t-1}g^w_{j,t}) = -(\Delta S\bar{P}B)d\alpha^w_{j,t} - \bar{\alpha}^w d(\Delta SPB_{j,t}) \tag{2.73}$$
$$d(s^n_{j,t-1}g^n_{j,t}) = -(\Delta S\bar{P}B)d\alpha^n_{j,t} - \bar{\alpha}^n d(\Delta SPB_{j,t}) \tag{2.74}$$
$$d((1+g_j)\Delta\tau_{j,t}) = (\Delta S\bar{P}B)d\alpha^\tau_{j,t} + \bar{\alpha}^\tau d(\Delta SPB_{j,t}) \tag{2.75}$$

where d denotes the difference between a variable with respect to its average value. We can also take a first order expansion of (2.69) to get:

$$d(\Delta SPB_{j,t}) = -\bar{\tau}dg^Y_{j,t} - \bar{s}^D dg^D_{j,t} \tag{2.76}$$

and assume that

$$dg^D_{j,t} = \mu dg^Y_{j,t} + u^D_{j,t} \tag{2.77}$$

[42]Recall that g_j is long-run GDP growth and $\Delta g^Y_{j,t}$ GDP growth relative to g_j.

where $cov(u^D_{j,t}, u^Y_{j,t})$ may not be zero. That is, the change in debt depends on output growth as well as on debt shocks possibly correlated with output shocks (and thus is endogenous). Substituting (2.76) and (2.77) into (2.73)-(2.75) then gives a set of equations that depend linearly on the weights, on output growth, and on debt shocks that take the same form as equations (2.46)-(2.48) in the paper.

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TABLE 1: Country-Year Episodes of Fiscal Adjustment, 2010-13

Country	diff structural primary balance above 0.5	diff structural primary balance above 1
Austria	2012, 2013	2013
Belgium	2012, 2013	2013
Czech Republic	2012, 2013	2012, 2013
Denmark	2013	2013
Finland	2012, 2013	
France	2012	
Germany	2012	
Greece	2010, 2011, 2012	2010, 2011, 2012
Hungary	2012	2012
Iceland	2010, 2012	2010
Ireland	2011, 2012, 2013	2011, 2012, 2013
Italy	2012, 2013	2012, 2013
Luxembourg	2012	2012
Netherlands	2012, 2013	2012, 2013
Poland	2012	2012
Portugal	2011, 2012, 2013	2011, 2012, 2013
Slovak Republic	2011, 2013	2013
Slovenia	2012, 2013	2012, 2013
Spain	2010, 2011, 2012, 2013	2010, 2011, 2012, 2013
United Kingdom	2011	2011
United States	2011, 2012, 2013	2013

TABLE 2: Summary Statistics

Variable	Obs	Mean	Median	Std. Dev.	Min	Max
GDP growth	31	-1.41	-1.06	2.51	-9.13	1.68
long-run growth	31	2.42	2.12	1.44	0.63	5.89
diff consumption growth	31	-3.32	-3.15	2.33	-9.57	0.31
% welfare spending/GDP	31	23.14	21.28	3.18	16.19	32.15
% non-welfare spending/GDP	31	18.51	18.81	1.99	13.39	22.41
% tax revenue/GDP	31	37.74	36.94	5.48	27.00	49.23
ratio potential/GDP	31	1.05	1.04	0.03	1.00	1.15
welfare spending growth	31	-2.97	-2.30	4.02	-13.30	2.28
non-welfare spending growth	31	-4.41	-2.97	5.28	-16.61	4.06
tax rate change	31	1.77	1.57	1.25	0.23	5.01
diff structural primary balance	31	3.39	2.31	2.57	1.13	11.00
weight welfare spending	31	0.14	0.17	0.24	-0.42	0.66
weight non-welfare spending	31	0.23	0.23	0.26	-0.59	0.69
weight taxes	31	0.63	0.51	0.41	0.06	2.01

Notes: Long-run growth is the average GDP growth from 1990 to 2016. Diff consumption growth is consumption growth minus its long-run average. The ratios of welfare spending and tax revenue to GDP shown are the cyclically adjusted ones. Consequently, the growth rate of welfare spending and the change in the tax rate are constructed from the cyclically adjusted ratios. The diff structural primary balance (ΔSPB) and the weights are constructed as explained in the text.

TABLE 3: Exploratory Correlations

	(1)	(2)	(3)	(4)
VARIABLES	ΔGDP growth	Δcons growth	ΔGDP growth	Δcons growth
ΔSPB	-0.74***	-0.67***		
	(0.06)	(0.10)		
Δwelfare spending			1.72***	1.76***
			(0.28)	(0.39)
Δnon-welfare spending			0.08	-0.03
			(0.21)	(0.31)
Δtaxes			-0.42**	-0.26
			(0.16)	(0.29)
Constant	-1.23***	-0.90**	-1.71***	-1.47***
	(0.25)	(0.39)	(0.31)	(0.51)
Observations	41	41	41	41
R-squared	0.694	0.485	0.774	0.571

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: ΔGDP growth is GDP growth minus its long-run average, and Δcons growth is consumption growth minus its long-run average. ΔSPB and its components are constructed as explained in the text. If these variables were exogenous, their coefficients in column (3) could be understood as the point estimates of the fiscal multipliers.

TABLE 4: Main Results

	(1)	(2)	(3)	(4)
VARIABLES	ΔGDP growth	ΔGDP growth	Δcons growth	Δcons growth
weight welfare	-6.26***	-7.78***	-5.88***	-7.90***
	(1.46)	(2.10)	(1.25)	(1.87)
weight non-welfare	1.53		2.02	
	(0.95)		(1.56)	
weight taxes		-1.53		-2.02
		(0.95)		(1.56)
Constant	-3.27***	-1.75**	-2.94***	-0.92
	(0.32)	(0.84)	(0.62)	(1.06)
Observations	31	31	31	31
R-squared	0.396	0.396	0.320	0.320

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: ΔGDP growth is GDP growth minus its long-run average, and Δcons growth is consumption growth minus its long-run average. For all observations, ΔSPB is above 1.

TABLE 5: Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ΔGDP growth	ΔGDP growth	ΔGDP growth	ΔGDP growth	ΔGDP growth	ΔGDP growth
weight welfare	-4.82***	-5.62***	-4.30***	-5.86***	-7.08***	-10.09***
	(1.26)	(1.86)	(1.07)	(1.95)	(1.58)	(2.01)
weight non-welfare	0.80		1.57		3.01***	
	(1.06)		(1.11)		(0.61)	
weight taxes		-0.80		-1.57		-3.01***
		(1.06)		(1.11)		(0.61)
GDP growth (-1)	0.28**	0.28**				
	(0.10)	(0.10)				
Constant	-3.11***	-2.31**	-3.31***	-1.74*	-3.33***	-0.32
	(0.37)	(0.88)	(0.33)	(0.98)	(0.34)	(0.46)
Observations	31	31	41	41	18	18
R-squared	0.527	0.527	0.281	0.281	0.576	0.576

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Columns (1)-(2) include the lag of GDP growth as a control, for columns (3)-(4) ΔSPB is above 0.5, and in columns (5)-(6) we aggregate over the whole 2010-13 period, so that the variables are mean values of country-year observations for which ΔSPB is above 1, and thus the variation is purely cross-sectional.

TABLE 6: More Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ΔGDP growth	ΔGDP growth	ΔGDP growth	ΔGDP growth	ΔGDP growth	ΔGDP growth
weight welfare	-5.56***	-7.14***	-5.54***	-7.19***	-5.66***	-7.20**
	(1.26)	(1.96)	(1.31)	(2.04)	(1.97)	(3.07)
weight non-welfare	1.58		1.65		1.53	
	(0.97)		(1.19)		(1.79)	
weight taxes		-1.58		-1.65		-1.53
		(0.97)		(1.19)		(1.79)
Constant	-3.86***	-2.28**	-3.10***	-1.45	-2.99***	-1.45
	(0.37)	(0.83)	(0.40)	(1.04)	(0.60)	(1.57)
Observations	30	30	31	31	31	31
R-squared	0.370	0.370	0.391	0.391		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: For columns (1)-(2), the variables are constructed by using the square root of the adjustment factor for the ratio of welfare spending to GDP (hence the cyclicality correction for welfare spending is reduced by a factor of a half). Columns (3)-(4) are obtained by using the robust regression method, and columns (5)-(6) use the quantile regression method. Both methods are designed to deal with the influence of possible outliers.

FIGURE 1: Numerical Illustration

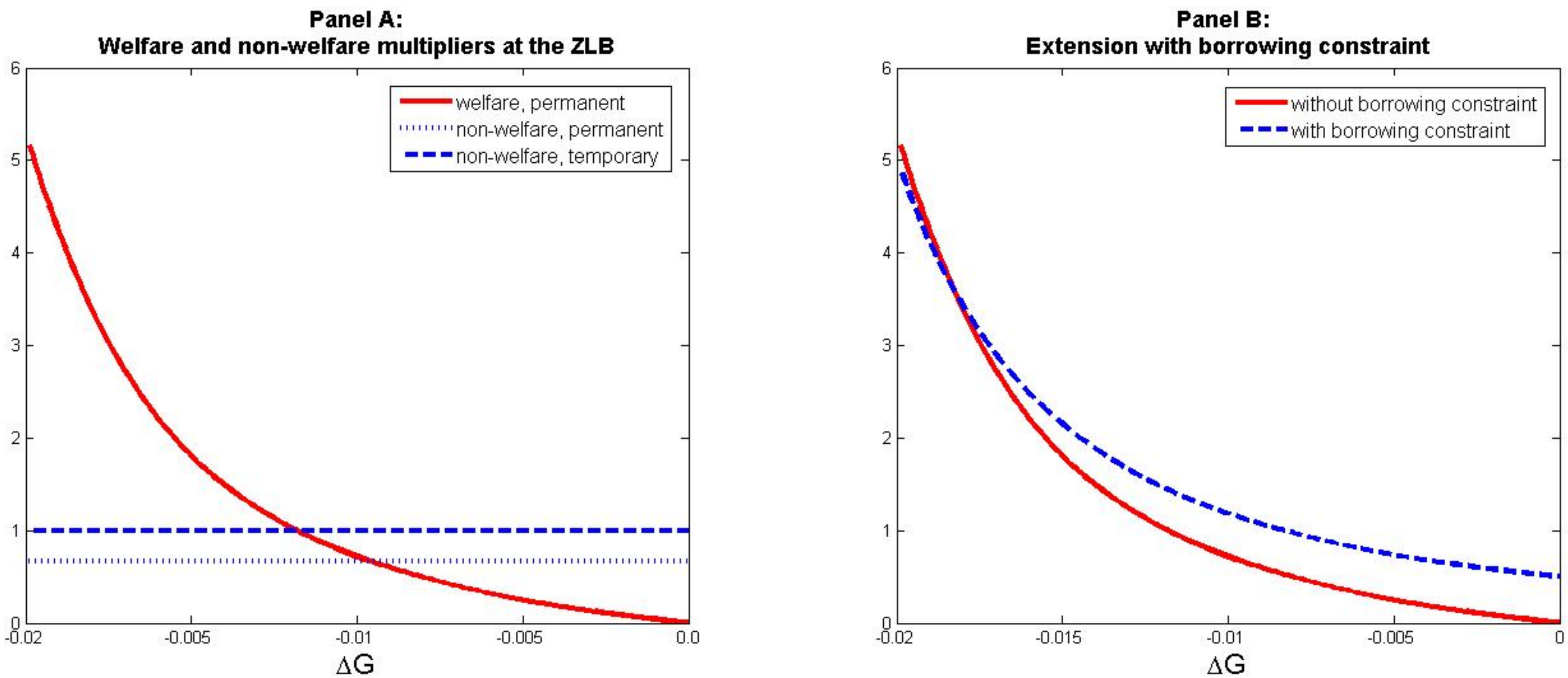


FIGURE 2: Observed Marginal Distributions of the Weights

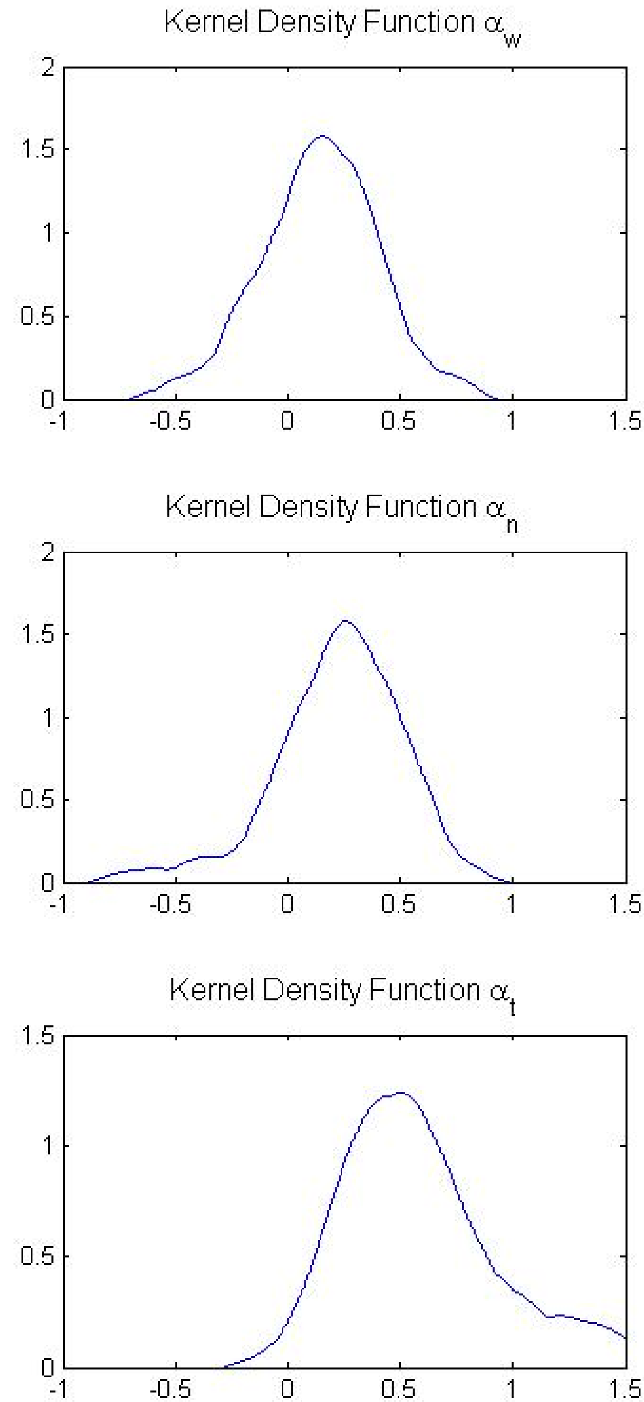
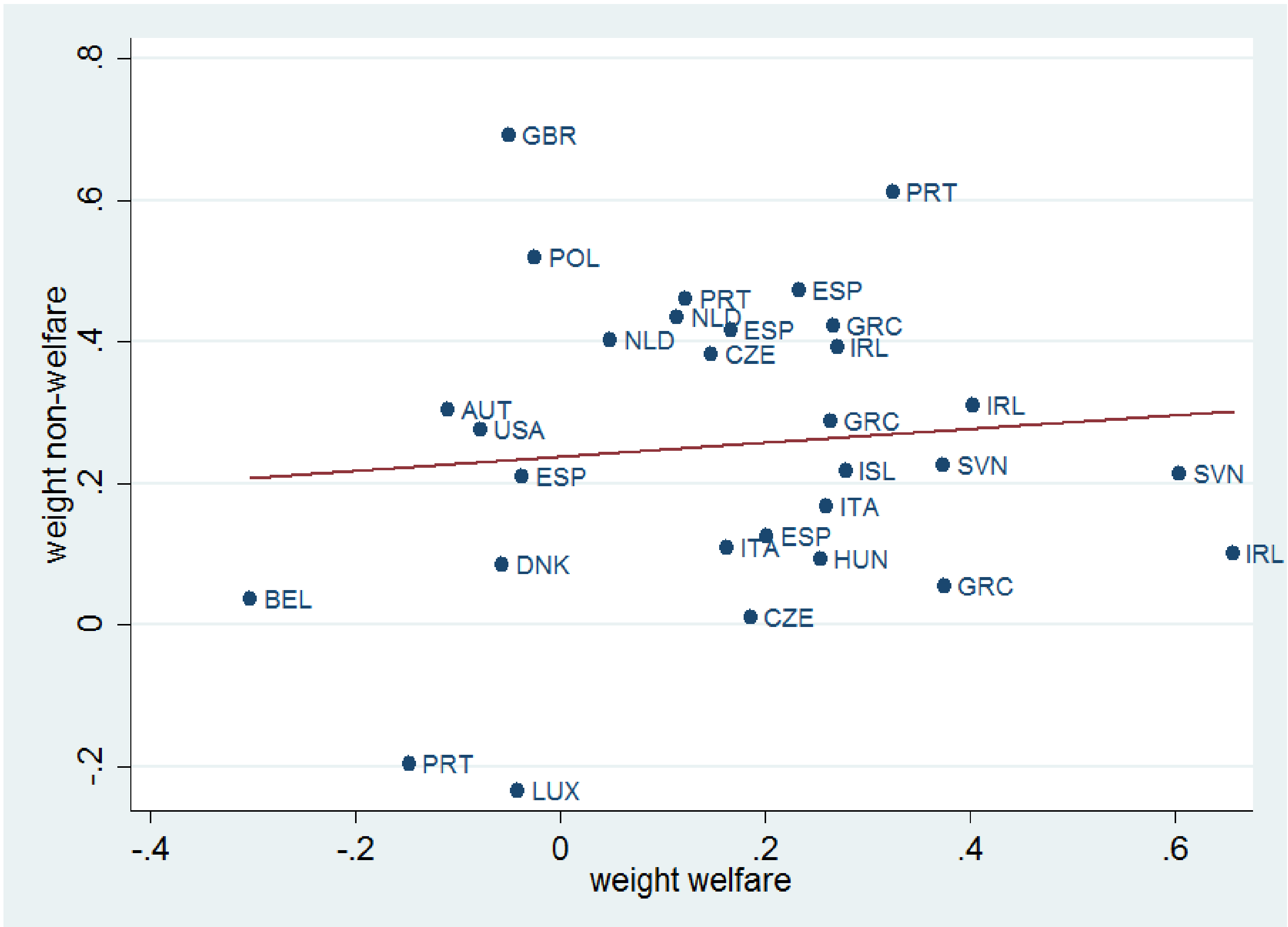
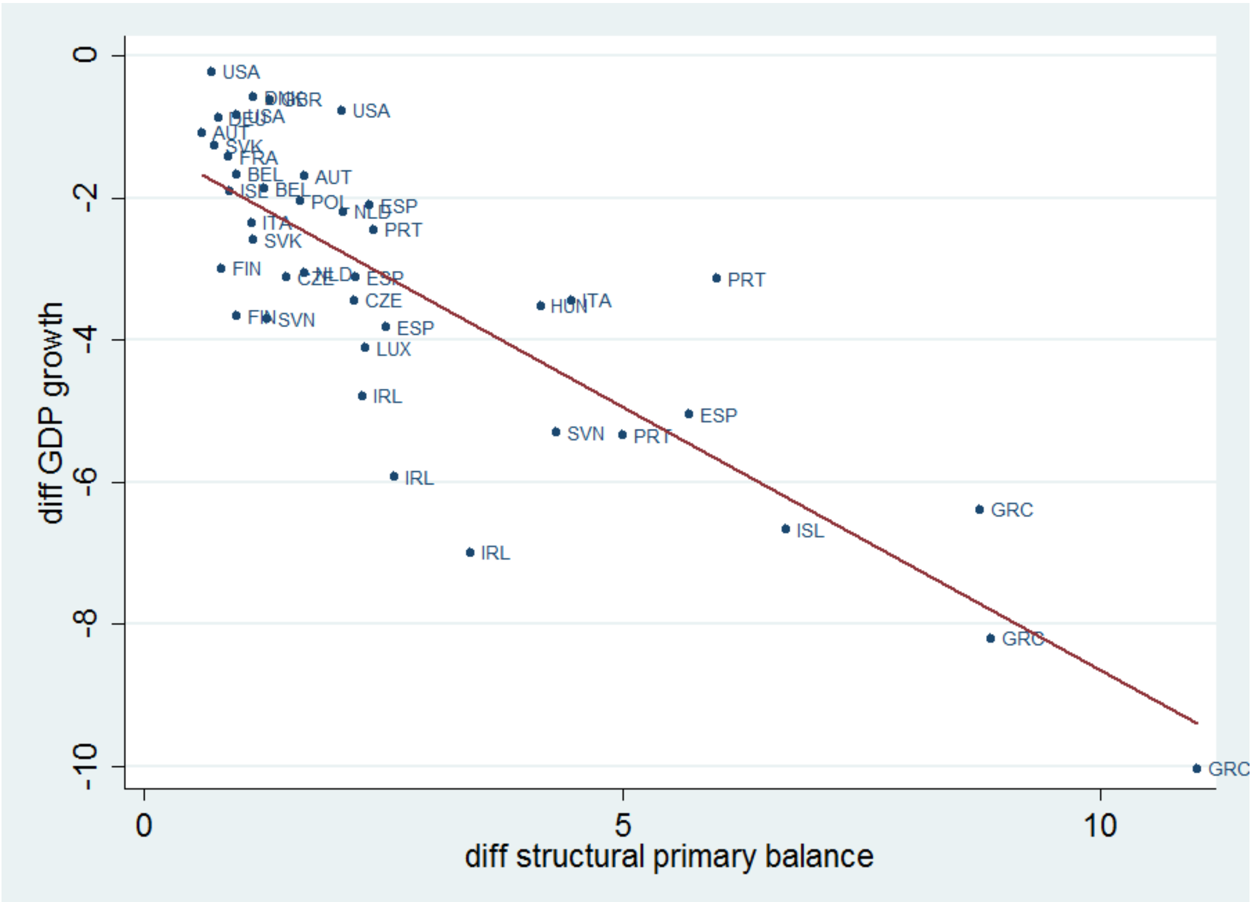


FIGURE 3: Weight of Welfare-State Spending vs. Weight of Non-Welfare Spending



Notes: this observed joint distribution is for country-year observations for which ΔSPB is above 1. We exclude the observation of Slovak Republic as it is an outlier.

FIGURE 4: ΔSPB vs. ΔGDP Growth



Notes: For all the observations ΔSPB is above 0.5. A country may show up more than once because there can be multiple country-year observations for a given country (Spain improved its primary balance above 0.5 four consecutive years, for example).

FIGURE 5: Weight of Welfare Spending vs. ΔGDP Growth