The Analytics of the Greek Crisis*

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Abstract

This paper presents an interim and analytical report on the Greek Crisis of 2010. The Greek crisis presents a number of important features that sets it apart from the typical sudden stop, sovereign default, or lending boom/bust episodes of the last quarter century. We provide an analytical account of the Greek crisis using a rich model designed to capture the main financial and macro linkages of a small open economy. Using the model to parse through the wreckage, we uncover the following main findings: (a) Greece experienced a more prolonged and severe decline in output per capita than almost any crisis on record since 1980; (b) the crisis was significantly backloaded, thanks to important financial assistance mechanisms; (c) a sizable share of the crisis was the consequence of the sudden stop that started in late 2009; (d) the severity of the crisis was compounded by elevated initial levels of exposure (external debt, public debt, domestic credit), vastly in excess of levels observed in typical emerging economies. In summary: Greece experienced a typical Emerging Market Sudden Stop crisis, with the initial exposure levels of an Advanced Economy.

1 Intro and Motivation: We're not back in Ithaca yet...

This paper presents an interim and analytical report on the Greek Crisis of 2010. We find that, while sharing many characteristics, the Greek crisis presents also a number of important features that sets it apart from the typical sudden stop, sovereign default, or lending boom/bust episodes of the last quarter century. We present a rich model designed to capture the main features of small open economies

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in crisis in general, and of the Greek crisis in particular. The model features important macro and financial linkages and allows us to provide an analytical account of the Greek crisis. Using the model to parse through the wreckage, we uncover the following main findings: (a) Greece experienced a more prolonged and severe decline in output per capita than almost any crisis on record since 1980; (b) the crisis was significantly backloaded, thanks to important assistance mechanisms; (c) a sizable share of the crisis was the consequence of the sudden stop that started in late 2009; (d) the severity of the crisis was compounded by elevated initial levels of exposure (external debt, public debt, domestic credit), vastly in excess of levels observed in typical emerging economies. In summary: Greece experienced a typical Emerging Market Sudden Stop crisis, but with the levels of exposure of an Advanced Economy, and precious few accommodation mechanisms. Financial assistance and alternative funding sources proved essential in 2009 and 2010 in softening the blow, but ultimately insufficient to avoid one of the most extreme economic downturns on record. The Greek economy may not take a full twenty years to recover, but its is still far from Ithaca!

2 The Greek Economy Before and During the Crisis

This section reviews briefly salient facts about the Greek crisis and sets the stage for our analytical exercise.

2.1 Pre-Crisis

GDP. Figure 1 plots GDP per capita, in 2014 purchasing Power Parity (PPP) adjusted US dollars, from 1980 onwards. In this figure, as well as in and subsequent figures and tables in this Section, we compare Greece to the four other major Eurozone (EZ) countries that were hit by the Eurozone sovereign debt crisis: Italy (IT), Ireland (IE), Spain (ES), and Portugal (PT).

As of 1980, Greek GDP per capita was above that of Ireland, Portugal, and Spain. During the 1980s Greece experienced relative stagnation, and was overtaken by Ireland and Spain. Greece grew faster during the period 1996-2000 and especially from 2001, when it entered the Eurozone (EZ), until 2008. By 2008, Greece had almost caught up with Spain.

Motivated from Figure 1, we divide the period 1996-2014 into three sub-periods: the period 1996-2000, during which Greece experienced a boom in anticipation of EZ entry; the period 2001-2008 during which the boom continued with Greece inside the EZ; and the crisis period 2009-2014.[1] In

[1]Greek GDP per capita contracted by 0.4% in 2008, so an alternative split is to add 2008 to the crisis period. We do

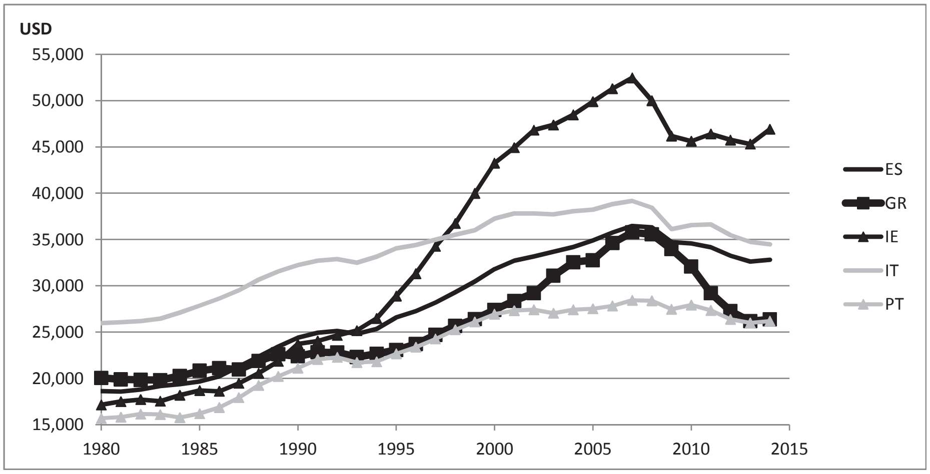

Figure 1: **GDP per capita for Greece and other EZ crisis countries, 1980-2014.** The data come from The Conference Board Total Economy Database. GDP is expressed in 2014 US dollars and is adjusted for PPP using 2011 weights.

the tables constructed in the rest of this section, we report averages of macro-economic variables for the three sub-periods. In some of the tables we also compare with the year 1995, which we take as indicative of the Greek economy before the (actual or anticipated) effects of EZ entry.[2]

Investment. Table 1 reports the level of investment in Greece during the periods 1996-2000, 2001-2008, and 2009-2014, and compares with 1995. The table also decomposes investment into corporate, residential, and public, and compares with Ireland, Italy, Portugal, and Spain.

Greece experienced the second-largest increase in corporate investment from 1995 to 1996-2000, after Portugal. Corporate investment remained at elevated level during 2001-2008. Thus, EZ entry and its anticipation was associated with a significant rise in corporate investment in Greece. That rise, however, occurred from a low base, and corporate investment remained significantly lower than in the other countries.

Unlike Ireland and Spain, Greece did not experience a significant increase in residential investment from 1995 to 1996-2008. Residential investment was already high in 1995, however, and the real-estate boom in Ireland and Spain only meant that residential investment in those countries caught up with and exceeded somewhat that in Greece.

The increase in Greece's corporate investment was driven almost exclusively by domestic firms;

not include 2008 in the crisis years because the contraction occurred only in the fourth quarter of that year.

[2] An average during the period 1980-1995 would have been more informative of the state of the Greek economy before EZ entry. We use only the year 1995 because data before 1995 are not available or precise enough.

	Total Investment			
	95	96-00	01-08	09-14
ES	22.0	23.7	28.8	21.0
GR	**20.4**	**23.1**	**23.7**	**14.6**
IE	18.2	22.3	26.1	16.2
IT	19.0	19.4	21.1	18.6
PT	23.3	26.5	23.9	17.4

	Corporate Investment				Residential Investment				Public Investment			
	95	96-00	01-08	09-14	95	96-00	01-08	09-14	95	96-00	01-08	09-14
ES	11.7	13.0	13.9	12.0	6.0	7.0	10.7	5.7	4.3	3.7	4.2	3.3
GR	**8.4**	**10.5**	**10.3**	**7.7**	**8.6**	**8.8**	**9.2**	**3.7**	**3.4**	**3.8**	**4.2**	**3.2**
IE	10.6	12.3	11.4	11.0	5.2	7.1	10.6	2.7	2.4	2.9	4.1	2.5
IT	11.3	11.8	12.9	10.8	5.1	4.8	5.3	5.1	2.6	2.8	2.9	2.7
PT	11.6	13.8	13.7	11.1	7.3	7.7	6.1	3.1	4.4	5.0	4.1	3.2

Table 1: **Investment in Greece and other EZ crisis countries, 1995-2014, as percentage of GDP.** The data come from AMECO. Investment is measured by the series "Gross fixed capital formation: total economy," and does not include inventories. Residential investment is measured by "Gross fixed capital formation: dwellings;" corporate investment by "Gross fixed capital formation: private sector" minus residential investment; and public investment by "Gross fixed capital formation: government."

foreign direct investment (FDI) played only a small role. During the period 2001-2008, for example, FDI in Greece was 1.1% of GDP, the lowest value among all European Union (EU) 28 countries.

Net Foreign Assets. The fast growth of Greek GDP per capita during the period 1996-2008 was associated with an increase in external indebtedness. Figure 2 plots net foreign assets (NFA) from 1980 onwards, as percentage of GDP. NFA for Greece were negative throughout that period. They were a relatively small fraction of GDP in absolute value until the mid-1990s, and they subsequently declined to a much more negative fraction. Greece's NFA position deteriorated at a comparable rate to Portugal's and Spain's, while Ireland experienced a more abrupt deterioration.

The behavior of Greece's NFA from the mid-1990s onwards is indicative of large current account deficits. Table 2 reports the level of the current account in Greece, Ireland, Italy, Portugal, and Spain during the periods 1996-2000, 2001-2008, and 2009-2014, and compares with 1995. The table decomposes the current account into (i) net exports and (ii) the sum of net current transfers and net primary income.

Greece's current account deteriorated from 1995 to 1996-2000, and deteriorated further during 2001-2008. The deterioration from 1996-2000 to 2001-2008 was particularly severe: 6.0% of GDP, larger than in the other countries. During 2001-2008, Greece was running an average current account

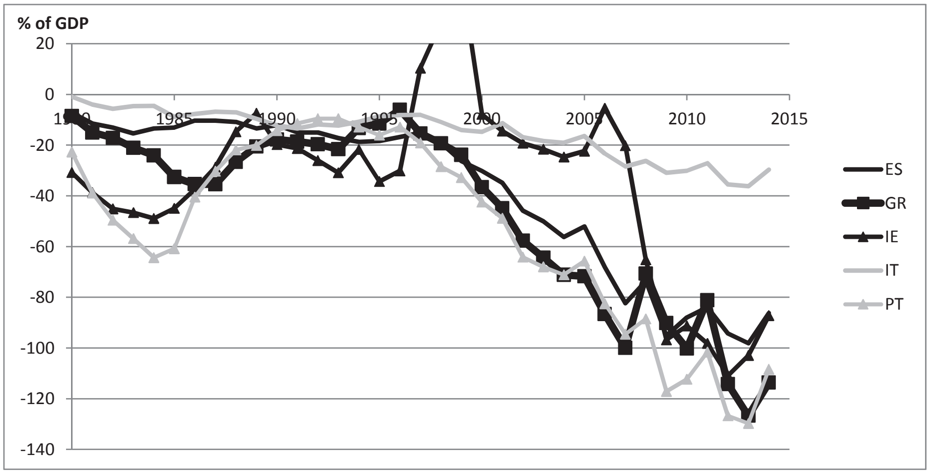

Figure 2: **Net foreign assets in Greece and other EZ crisis countries, 1980-2014, as percentage of GDP.** The data come from Lane and Milesi-Ferretti (2007).

	Current Account Surplus				Net Exports				Net Current Transfers plus Net Primary Incomes			
	95	96-00	01-08	09-14	95	96-00	01-08	09-14	95	96-00	01-08	09-14
ES	-1.2	-2.0	-6.7	-1.6	-1.0	-1.1	-4.1	0.8	-0.2	-0.9	-2.6	-2.4
GR	**-2.8**	**-5.7**	**-11.7**	**-7.3**	**-8.3**	**-9.1**	**-10.6**	**-5.9**	**5.5**	**3.4**	**-1.1**	**-1.4**
IE	2.6	1.2	-2.3	1.7	10.9	12.0	12.4	19.2	-8.3	-10.8	-14.7	-17.5
IT	2.0	1.5	-1.1	-1.0	3.7	2.8	0.1	0.4	-1.7	-1.3	-1.2	-1.4
PT	-3.4	-7.7	-9.8	-4.5	-6.4	-9.1	-8.5	-3.0	3.0	1.4	-1.3	-1.5

Table 2: **The current account in Greece and other EZ crisis countries 1995-2014, as percentage of GDP.** The data come from AMECO. Net exports are measured by the series "Net exports of goods and services;" net current transfers by "Net current transfers from the rest of the world;" and net primary income by "Net primary income from the rest of the world." The current account surplus is the sum of the three series.

deficit of 11.7% of GDP, also larger than in the other countries.

The deterioration of Greece's current account from 1995 onwards was primarily driven by a decline in net current transfers and net primary income. Net current transfers to Greece declined partly because of the drop in EU subsidies, especially after the 2005 EU enlargement, as funds were redirected to new entrants that were poorer than Greece. Net primary income declined also because workers' remittances became smaller as Greece became a net immigration country, and because of growing interest payments on Greece's rising external debt. Greece's trade balance also deteriorated, through that period, reaching -10.6 percent of GDP during the period 2001-2008.

Savings. We next use the identity

$$\textit{Current Account Surplus} = \textit{Savings - Investment}$$

to examine how the inflows of foreign capital associated with Greece's larger current account deficit during the periods 1996-2000 and 2001-2008 were allocated between investment and consumption. Table 3 reports the level of savings for all five countries and four sub-periods. The table decomposes total savings into private and government savings. Subtracting the sum of investment reported in Table 1 and inventories which are not reported, from the savings reported in Table 3, yields the current account surplus reported in Table 2.[3]

	Total Savings				Private Savings				Government Savings			
	95	96-00	01-08	09-14	95	96-00	01-08	09-14	95	96-00	01-08	09-14
ES	21.2	22.1	22.4	19.8	23.2	20.9	18.0	24.5	-2.0	1.2	4.4	-4.7
GR	**20.0**	**19.0**	**13.3**	**7.2**	**26.1**	**20.4**	**16.1**	**13.1**	**-6.1**	**-1.4**	**-2.8**	**-5.9**
IE	21.6	24.1	23.7	18.8	21.8	19.5	19.9	25.0	-0.2	4.6	3.8	-6.2
IT	21.7	21.2	20.3	17.7	25.5	21.4	20.0	18.8	-3.8	-0.2	0.3	-1.1
PT	20.9	19.7	14.6	13.1	22.6	19.2	16.1	18.2	-1.7	0.5	-1.5	-5.0

Table 3: **Savings in Greece and other EZ crisis countries, 1995-2014, as percentage of GDP.** The data come from AMECO and the European Commission (EC). Total savings are measured by the AMECO series "Gross national savings." Government savings are measured by the EC series "Gross savings; general government." Private savings are the difference between the two series.

Table 3 shows a sharp decline in private savings in Greece from 1995 onwards. Private savings declined by 5.7% of GDP from 1995 to 1996-2000, and declined by a further 4.3% of GDP from 1996-2000 to 2001-2008. The cumulative decline of 10% of GDP was significantly larger than in the other countries. Portugal was next with 6.1%.

Total savings in Greece were lower than in the other countries, and comparable to those in Portugal until the crisis. The gap between Greece and Portugal on one hand, and Ireland, Italy, and Spain on the other, was small in 1995, but widened during 1996-2000 and became particularly wide during 2000-2008. Although the wide gap was driven by the combined behavior of government savings and private savings, the decline in Greece's total savings mostly reflects the decline in private savings. Government savings in Greece were chronically low—lower than the other countries, and always negative, with a small exception in 1999 when the Greek government was trying hard to meet the Maastricht criteria for initial membership into the EZ. From 2000 onwards, private savings continued to deteriorate while public savings declined modestly, leaving total savings significantly below those in Ireland, Italy and Spain. Italy was similar to Greece in its combination of relatively low government savings and high private savings in 1995. Private savings in Italy, however, did not decline as much in the subsequent years, and government savings were kept better in check after EZ entry.

Tables 1, 2, and 3 indicate that the increase in Greece's current account deficit from 1995 to 1996-

[3] We report investment net of inventories in Table 1 to focus on the increase in productive capacity.

2000 was associated with an increase in corporate investment and hence in productive capacity. Indeed, the current account deficit increased by 2.9% of GDP, corporate investment increased by 2.1%, and public investment by 0.4%. The increase in the current account deficit from 1996-2000 to 2001-2008, however, was associated with an increase in consumption. Indeed, the current account deficit increased by 6.0% of GDP, total savings declined by 6.7%, and corporate investment dropped slightly.

The fact that, in the years immediately preceding and following EZ entry poorer members of the union –like Greece– would run large current account deficits was not a surprise. Rather, it is precisely what theory suggests should happen when countries catch-up and converge, as argued by Blanchard and Giavazzi (2002) in an influential paper that examined the experience of Greece and Portugal.[4]

Government Debt. Figure 3 plots government debt from 1980 onwards, as percentage of GDP. As of 1980, government debt in Greece was 21.4% of GDP, lower than in all other countries except for Spain. Debt rose sharply during the 1980s, and by 1993 it had reached 94.4% of GDP, a level larger than in all other countries except for Italy. A combination of fiscal tightening to meet the criteria for EZ entry, and sharply lower interest rates in anticipation of that entry, helped stabilize and even reduce slightly the ratio of debt to GDP—to 88.5% in 1999. Budget discipline became looser after EZ entry, and especially after 2007. As a consequence, debt to GDP increased—to 103.1% in 2007 and 126.8% in 2009—despite the fast growth in GDP during the period 2001-2008.

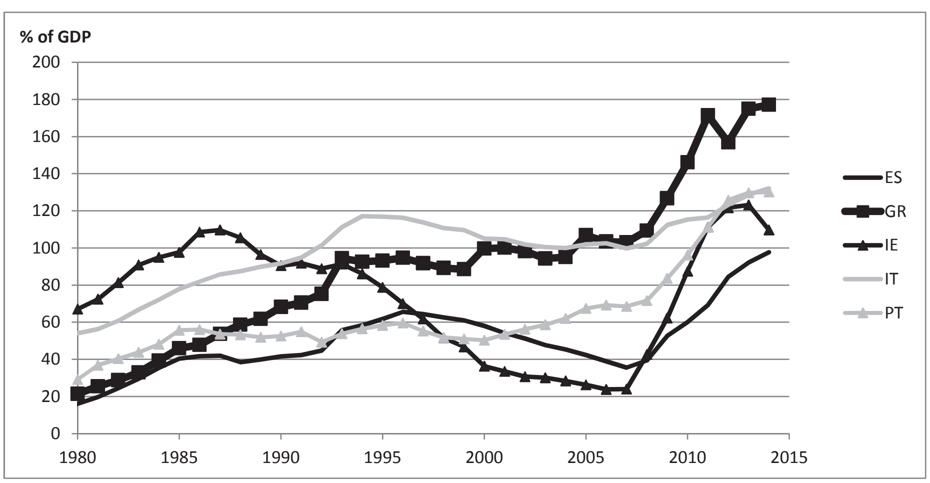

Figure 3: **Government debt in Greece and other EZ crisis countries, 1980-2014, as percentage of GDP.** The data come from AMECO, series "General government consolidated gross debt."

[4]That paper too. noted that Greece did not experience an investment boom following EZ entry and that the decline in savings was mostly driven by private savings.

While debt to GDP increased only mildly from 1999 to 2007, there was a sharp increase in the amount of the debt held by foreign entities, and a consequent decrease in the amount held domestically. That trend was due mainly to the sharp decline in private savings, shown in Table 3. Figure 4 plots gross government external debt for Greece, and compares with the same series for Portugal and Spain, and with Greece's NFA.[5] Gross government external debt for Greece essentially coincides with the negative of NFA. By contrast, gross government external debt for Portugal and Spain is significantly lower than the negative of those countries' NFA (which are not plotted but are similar to Greece's from Figure 2). Figure 4 thus indicates that Greece's current account deficit essentially financed government borrowing.[6]

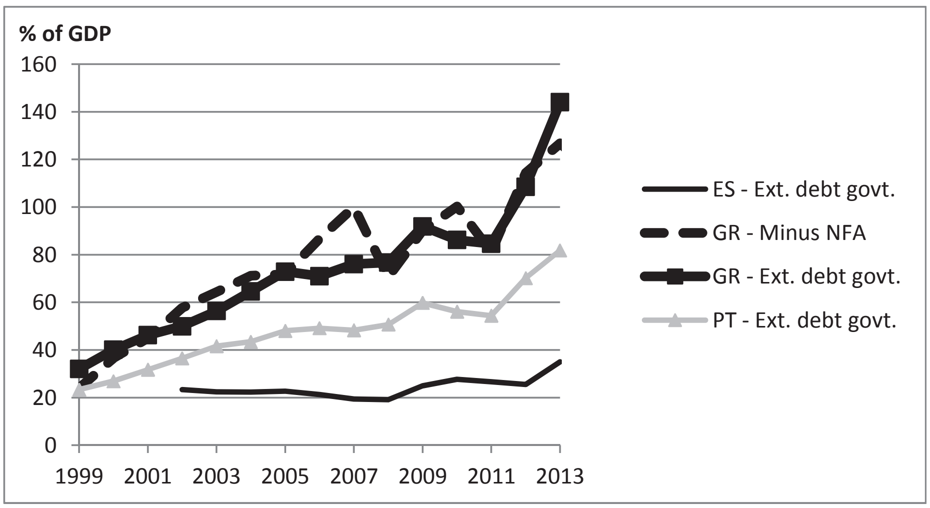

Figure 4: **Gross government external debt for Greece, Portugal, and Spain, 1999-2013, as percentage of GDP.** The data come from the ECB, series "Gross External Debt – Government." The data are quarterly, and we report the average over each year.

Figure 5 plots government deficit as percentage of GDP. The figure compares Greece to Italy, which was the most similar to Greece in terms of the size of its government debt until the crisis, and to the EU average. The figure confirms the improvement in Greece's public finances in the run-up to EZ entry, and the subsequent worsening. It also shows that from 2000 onwards the government deficit in Greece was significantly larger than in Italy and the EU average. This is consistent with the comparison of government savings between Greece and the other countries in Table 2.

Banks and Credit. From the mid-1990s and until the crisis, Greece experienced a boom in

[5]Figure 4 starts in 1999 rather than 1980 because data before 1999 are not available. Subsequent figures also start later than 1980 for the same reason.

[6]While Figure 4 plots gross rather than net government external debt, gross external assets of the Greek government were negligible, as shown by Hyppolite (2016).

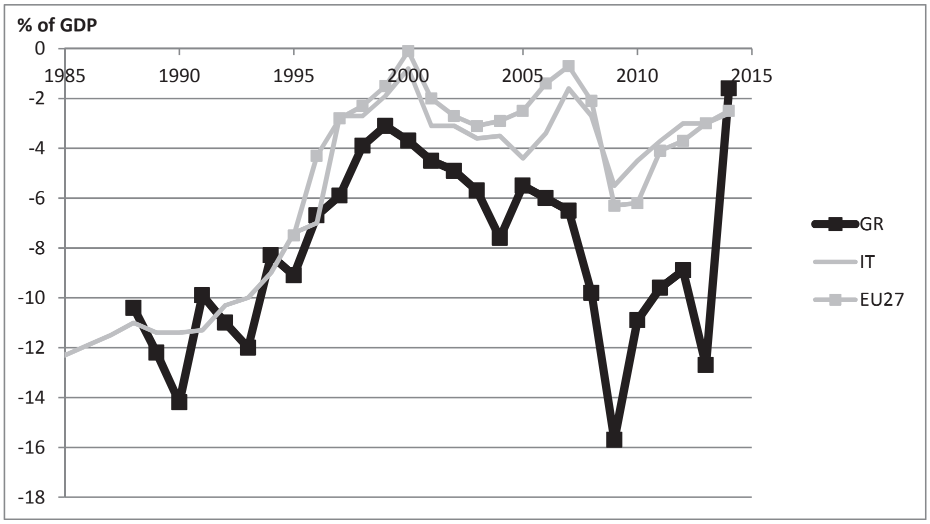

Figure 5: **Government deficit in Greece, Italy, and the EU average, 1985-2014, as percentage of GDP.** The data come from the EC, series "Surplus (Net lending or net borrowing; general government)."

private credit. An extensive program of financial liberalization that took place in the late 1980s and the 1990s paved the way for the credit boom. It was also fueled by easier access to foreign capital following EZ entry (and the anticipation of it). Figure 6 plots bank loans to the non-financial private sector for Greece, Ireland, Italy, Portugal, and Spain, as percentage of GDP.

Private-sector loans to GDP were significantly lower in Greece than in the other countries before EZ entry: they stood at 34.1% of GDP in 1998, compared to 60.8% in Italy, 74.6% in Spain, 80.31% in Portugal, and 82.8% in Ireland. Loans to GDP grew faster in Greece than in any other country, however, after EZ entry. As of 2008, they stood at 103.0%, a ratio smaller than Ireland's, Portugal's, and Spain's, but larger than Italy's.

To finance their increasing lending activity, Greek banks became more reliant on wholesale funding through the interbank market. Figure 7 plots gross external debt for Greek banks, and compares with Ireland, Italy, Portugal, and Spain. Gross external debt of banks consists mainly of interbank loans. Gross external debt of Greek banks increased from 12.3% of GDP in 1999 to 46.2% of GDP in 2008. As in the case of private-sector loans to GDP, the growth rate was higher than in the other countries, and the 2008 level was smaller than Ireland's, Portugal's, and Spain's, but larger than Italy's.

We next return to the asset side of Greek banks' balance sheet and examine the banks' exposure to the sovereign. Figure 8 plots two measures of that exposure, and compares with Ireland, Italy, Portugal,

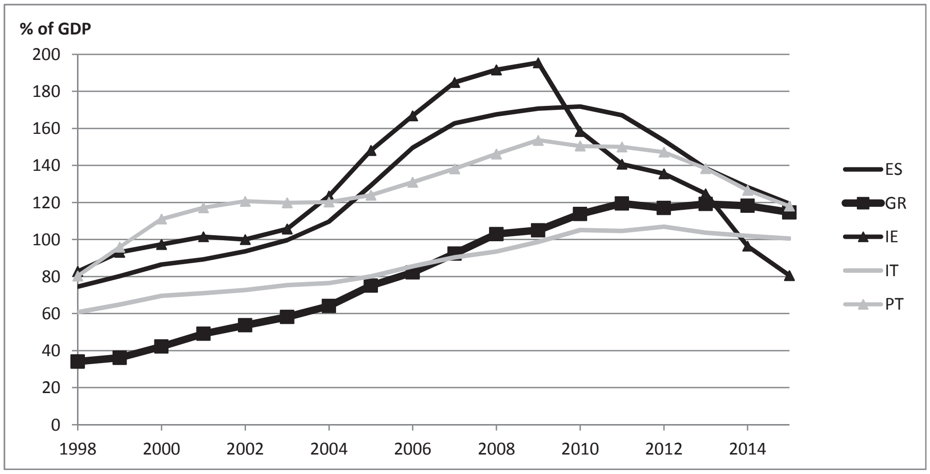

Figure 6: **Bank loans to the private sector excluding financial firms in Greece and other EZ crisis countries, 1998-2014, as percentage of GDP.** The loans data come from the Bank of Greece (BoG) in the case of Greece and from the European Central Bank (ECB) in for the other countries. (The ECB series for Greece is almost identical to the BoG series, except for an increasing divergence during the period 2004-2009, which leads to a discontinuity between 2009 and 2010 in the ECB series. The divergence is likely due to a change in loan classification by the BoG, which has not been incorporated in the ECB database.) The loan data are monthly and are sampled in December of each year.

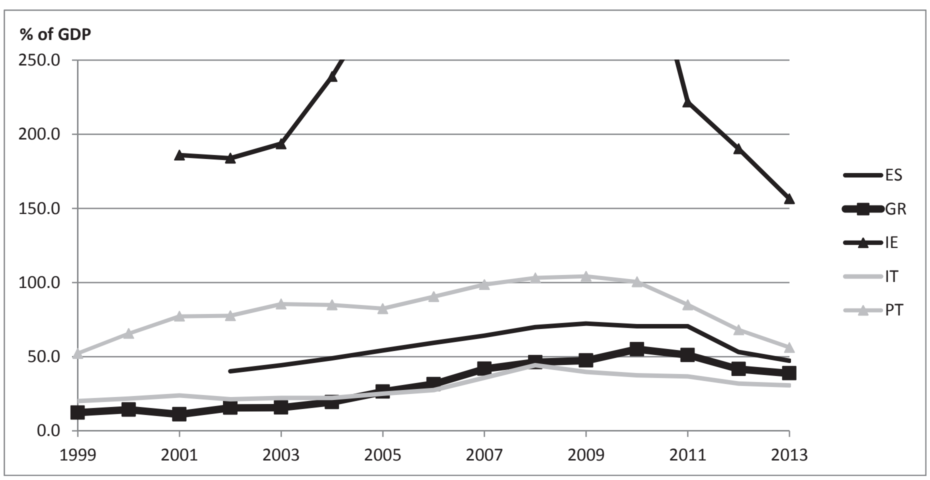

Figure 7: **Gross external debt of financial firms for Greece, Italy, Portugal, and Spain, 1999-2013, as percentage of GDP.** The data come from the ECB, series "Gross External Debt – MFIs." The data are quarterly, and we report the average over each year.

and Spain. The first measure is the percentage of the banks' government-bond portfolio invested in domestic bonds. The second measure is the banks' exposure to their sovereign as percentage of their equity capital. Both measures are computed from information that the European Banking Authority (EBA) collected in December 2010 as part of its stress tests of the European banking sector. Figure 8 shows that the government-bond portfolio of Greek banks was more "home-biased" than in the other countries, and that Greek banks' exposure to their sovereign was also a larger percentage of their equity capital. The large exposure of Greek banks to their sovereign was damaging during the crisis, to which we next turn.

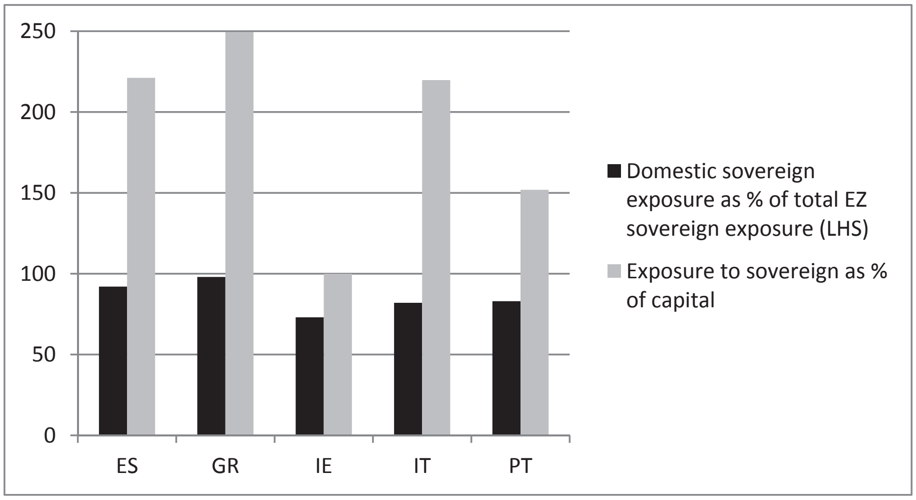

Figure 8: **Sovereign exposure of Greek banks, 2010.** The data come from the EBA.

2.2 Crisis

The Three Shocks. The global financial crisis that began in 2007 found Greece in a highly vulnerable position. As of 2007, Greece's current account deficit had reached 15.9% of GDP, NFA stood at -99.9%, government deficit at 6.5%, and government debt at 103.1%. On all four measures, Greece fared worse than Ireland, Italy, Portugal, and Spain. Greece's banking system was also vulnerable. While the ratio of private-sector loans to GDP in Greece was lower than in Ireland, Portugal, and Spain, the exposure of Greek banks to their sovereign was larger than in those countries.

Greece was hit by three interdependent shocks during the crisis. The first shock was a *sovereign debt crisis*: investors began to perceive the debt of the Greek government as unsustainable, and were no longer willing to finance the government deficit. The second shock was a *banking crisis*: Greek banks had difficulty financing themselves, and their solvency was in doubt because of projected losses to the value of their assets. The third shock was a *sudden stop*: foreign investors were no longer willing to lend to Greece as a whole (government, banks, and firms), and so the country could not finance its current account deficit.

The three shocks were interlinked. The banking crisis made the government's fiscal problems worse.

This was because the government had to inject equity capital into the banks, and had to provide them with guarantees so that they could borrow in the interbank market. Moreover, because banks had to curtail their lending, the economy slowed down and the government's tax revenues declined. These channels were at play starting from the Fall of 2008, when Greek banks faced significant difficulties financing themselves in the interbank market. The Greek government passed a law in December 2008 that provided support to the banks, in the form of guarantees and equity capital.

Conversely, the sovereign crisis made the banks' liquidity and solvency problems worse. This was because concerns about default risk by the Greek government reduced the value of the Greek banks' government-bond portfolio, and this put the banks' solvency in doubt. Moreover, the government had to engage in significant fiscal tightening, and the ensuing recession meant that firms and households had difficulty repaying their loans, adding to the banks' solvency problems. Finally, the guarantees given by the government to Greek banks diminished in value. That applied both to the guarantees intended to help the banks borrow in the interbank market, and to the government-supplied deposit insurance. Hence, banks had more difficulties financing themselves, and their liquidity problems worsened. These channels were at play starting from September 2009, when investors began to perceive the debt of the Greek government as unsustainable.

Both the sovereign and the banking crises were closely linked to the sudden stop. Indeed, most of government debt was held by foreign investors: out of government debt equal to 103.1% of GDP in 2007, the debt held by foreign investors was 76.1% of GDP. Greek financial firms had also significant foreign debt: their gross external debt was 41.8% of GDP in 2007. Since the Greek government and Greek banks intermediated most of the flow of foreign capital to Greece, the withdrawal of foreign capital meant that both sectors' access to funds was seriously impaired.

Ireland, Italy, Portugal, and Spain were hit by some or all of the same shocks. The shocks' effects were more severe in the case of Greece, however, given the country's increased vulnerability.[7]

Assistance to the Sovereign, and Sovereign Default. In May 2010, Greece agreed to follow an adjustment program financed and monitored by European institutions and the IMF. Under the terms of the agreement, Greece received a loan so to avoid a default on its private creditors and reduce more smoothly its government deficit. In exchange, it had to engage in significant fiscal tightening and implement a battery of structural reforms. The agreed loan amount was 110bn Euros, or 44% of Greece's 2010 GDP. Out of that amount, 80bn came from other EZ countries and the remaining 30bn

[7] Ireland and Spain had significantly lower levels of public debt. Italy had much lower levels of net external debt. Portugal was in a position somewhat similar to Greece, although with smaller government debt and deficits.

from the IMF. The first adjustment program was rolled over into a second, agreed in February 2012. A third program began in August 2015.

In March 2012, Greece agreed a debt restructuring with its private creditors. Under the terms of this Private Sector Involvement (PSI), government debt with face value 199.2bn Euros was replaced by debt with face value 92.1bn. Greece was the only EZ country to default on its creditors.

Assistance to the Banks, Recapitalizations, and Capital Controls. In addition to the loans made to the Greek government under the adjustment programs, assistance was provided to Greece through ECB loans to its banking system. These loans were administered either directly from the ECB, with a low interest rate and stringent collateral requirements, or indirectly via the Bank of Greece (BoG) as emergency liquidity assistance (ELA), with a higher interest rate and less stringent collateral requirements. ECB loans were necessary to address the liquidity problems of Greek banks.

ECB loans rose from 48bn Euros in January 2010 to a maximum of 158bn Euros in February 2012, then dropped to a minimum of 45bn Euros in November 2014, and then rose again to a maximum of 122bn in September 2015. ECB loans were at their maxima around times when there was a high risk of Greece exiting the EZ (Grexit). The risk of Grexit was high around the double election of May and June 2012, and during the first half of 2015 after a new Greek government opposed to the adjustment programs had been elected in January 2015.

The time-varying perceptions of the risk of Grexit can be seen indirectly in the behavior of bank deposits. Figure 9 plots bank deposits by households from 2009 onwards, for Greece, Ireland, Italy, Portugal, and Spain. Deposits are normalized to one in January 2009. Between January 2010 and January 2012, a "bank jog" took place in Greece, with deposits dropping gradually by a total of 27%. The bank jog intensified until the June 2012 election, with a further 10% drop in deposits. After that election, fears of Grexit subsided, and deposits went up by 7% until November 2014. Deposits subsequently dropped by 23% until June 2015. Deposit withdrawals culminated with the bank run of June and July 2015, and the ensuing imposition of capital controls.

Figure 9 shows that Greece was the only country in which there was a significant drop in bank deposits. Deposit flight reflected depositors' concerns with losing their savings, which could reflect the risk of a haircut on bank deposits, as happened in neighboring Cyprus in 2013, or re-denomination risk.

Greek banks went through a series of recapitalizations. Losses on the banks' government-bond portfolio reduced the capital of all banks and rendered most of the large ones insolvent. Some of the

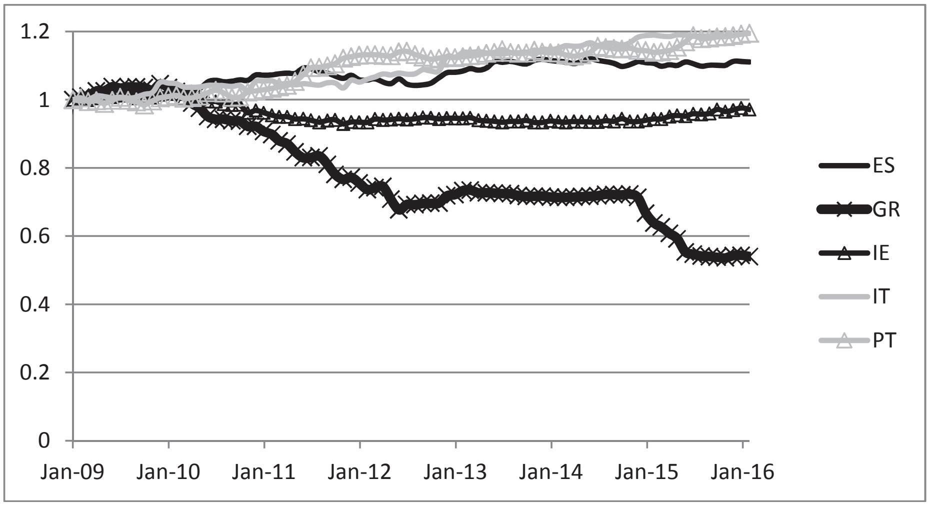

Figure 9: **Bank deposits by households in Greece and other EZ countries, 2009-2016.** The data come from the ECB. Deposits are normalized to one in January 2009.

banks were resolved, and their deposits and some of the loans were transferred to the four largest banks. The latter were recapitalized. The resolution and recapitalization process was completed in July 2013, and involved 38.9bn Euros of public funds, which were loaned to Greece. An additional 3.1bn Euros were raised by private investors. That first, large-scale recapitalization was followed by a second in April and May 2014, when the banks raised 8.3bn, solely from private investors. A third recapitalization took place in the fourth quarter of 2015. The total amount that was raised then was 13.7bn, of which 8bn was raised from private sources via new investment and debt-equity conversions. The second and third recapitalizations were made necessary because of increased projected losses on banks' loans to the private sector.

Macroeconomic developments. We finally review the macroeconomic developments during the crisis period 2009-2014, following a roughly similar order as for the pre-crisis period. Greek GDP per capita declined sharply during the crisis, as shown in Figure 1. The decline was 25.8% between 2008 and 2014. It was much sharper than in Ireland (6.1%), Italy (10.3%), Portugal (7.8%), and Spain (9.6%).

The decline in GDP was accompanied by a large decline in investment. The latter decline can be seen in Table 1 by comparing the crisis period with the pre-crisis one. It can be seen even more clearly by comparing investment in 2014 to that in 2008. Table 4 reports the level of investment in those two years in Greece. The table also decomposes investment into corporate, residential, and public, and compares with Ireland, Italy, Portugal, and Spain.

	Total Investment		Corporate Investment		Residential Investment		Public Investment	
	2008	2014	2008	2014	2008	2014	2008	2014
ES	29.2	18.9	14.2	12.8	10.4	4.1	4.6	2.0
GR	**23.7**	**11.5**	**10.7**	**6.7**	**8.1**	**1.0**	**4.9**	**3.8**
IE	24.2	16.4	10.7	12.1	8.3	2.4	5.2	1.9
IT	21.2	16.8	12.4	10.0	5.8	4.6	3.0	2.2
PT	22.8	14.6	14.4	10.2	4.7	2.4	3.7	2.0

Table 4: **Investment in Greece and other EZ countries, 2008 and 2014, as percentage of GDP.** Data sources are listed in Table 1.

Investment in Greece in 2014 was less than half of its 2008 value, having dropped by 12.2% of GDP. Both the relative and the absolute declines were larger than in the other countries. The level of investment in 2014 was also significantly lower than in the other countries.

During the crisis, Greece reduced and almost eliminated its current account deficit. That deficit stood at 2.2% of GDP in 2014, down from 16.5% in 2008. The adjustment occurred entirely through a drop in investment (taking also into account inventories which are not reported in Table 4.) Total savings did not change: government savings increased as a result of the fiscal tightening that took place during the crisis, but that effect was offset by a decline in private savings. Table 5 illustrates these developments by reporting the level of savings in 2008 and 2014 in Greece, and decomposing savings into private savings and government savings. The table also compares with Ireland, Italy, Portugal, and Spain.

	Total Savings		Private Savings		Government Savings	
	2008	2014	2008	2014	2008	2014
ES	20.4	20.1	19.8	23.8	0.6	-3.7
GR	**8.2**	**8.4**	**14.6**	**8.4**	**-6.4**	**0.0**
IE	18.4	24.8	19.9	28.6	-1.5	-3.8
IT	18.9	18.5	18.1	18.9	0.8	-0.4
PT	11.0	15.4	12.3	18.4	-1.3	-3.0

Table 5: **Savings in Greece and other EZ countries, 2008 and 2014, as percentage of GDP.** Data sources are listed in Table 3.

Private savings in Greece in 2014 were much lower than in the other countries. They stood at 8.4% of GDP, while the next lowest was Portugal with 18.4%. Moreover, Greece was the only country in which private savings declined between 2008 and 2014. Conversely, it was the only country in which government savings increased during the same period. Thus, the austerity undergone by Greece during the crisis was significantly more severe than in the other countries. The more severe austerity was unavoidable to some extent because of Greece's larger deficit and debt before the crisis.

During the crisis, public debt to GDP followed explosive dynamics, rising from 103.1% in 2007 and 126.8% in 2009 to 177.1% in 2014. The increase resulted from the deficits ran during the crisis and from the drop in GDP. For example, had GDP remained at its 2007 level, debt to GDP would have been 136.2% instead of 177.1%. The debt restructuring agreed in 2012 countered these effects somewhat. Greece eliminated its primary budget deficit in 2014—it ran a primary surplus of 0.4% in that year.

The ratio of private-sector loans to GDP declined slowly during the crisis. As Figure 6 shows, it stood at almost the same level as Portugal's and Spain's in 2014, and above Ireland's and Italy's. The slow decline of private-sector loans to GDP in Greece is due to the sharp decline in GDP and the relatively slow pace of resolving non-performing loans.

3 The Greek Crisis: Facts and Myths.

The previous discussion showed that Greece experienced three quasi simultaneous and interlinked shocks: a sudden stop, with the abrupt withdrawal of private foreign capital starting in 2009; a sovereign debt crisis, with rapidly deteriorating fiscal accounts in 2008 and 2009, culminating in a sovereign default in 2012; and a banking crisis with the bursting of a boom in credit to the private non-financial sector in 2008. This section provides a systematic comparison between Greece and other countries experiencing each type (and sometimes combinations) of similar shocks.

3.1 The incidence of Crisis

We begin by identifying episodes of sudden stops, sovereign defaults and lending booms/busts.

Sudden Stops. Starting with the work of Dornbusch and Werner (1994), Calvo et al. (2006), and many others, an abundant literature has explored the macroeconomic consequences of a sudden reversal in foreign lending. Calvo et al. (2006) compiled a list of 33 sudden stop episodes between 1980 and 2004 for a sample of 31 emerging markets. In the authors' classification, a sudden stop is identified by the combination of (a) a reversal in capital flows, (b) an increase in emerging market bond spreads, capturing times of global stress on financial markets, and (c) a large drop in domestic output. Mendoza (2010) adopts a similar classification, while Korinek and Mendoza (2014) extend the Calvo et al. (2006)

sample to 2012 and to advanced economies.[8] As in these earlier work, we define a sudden stop episode as a sharp reduction in foreign lending that coincides with a large decline in output.[9] With this criterion, we identify 49 sudden stop events, 36 for emerging economies and 13 for advanced economies (see Table 6).

Sovereign defaults. We identify sovereign debt crisis as in Gourinchas and Obstfeld (2012). They correspond to periods of default on domestic or external public debt, as tabulated by Reinhart and Rogoff (2009), Cantor and Packer (1995); Chambers (2011); Moody's (2009); Sturzenegger and Zettelmeyer (2007).[10] Since 1980, we record 64 default episodes in emerging economies, and one in an advanced economy: Greece in 2012.

Lending booms/busts. Finally credit boom episodes are defined as in Gourinchas et al. (2001), from the deviation of the ratio of credit to the non-financial sector to output from its trend.[11] A lending boom episode is recorded when this cyclical deviation exceeds a given boom threshold. The lending boom then coincides with the year in which the maximum deviation of credit to GDP occurs. Our calculations identify 114 lending boom episodes, 96 of which in emerging countries.

Finally, we identify 'Trifecta' episodes: sovereign defaults that coincide with a lending boom and a sudden stop.[12] We find 9 such crises for emerging markets, including well-known episodes such as Mexico in 1982, Chile in 1983, Indonesia and Russia in 1998, Ecuador in 1999, Argentina and Turkey in 2001. Again, Greece is the only advanced economy to have experienced a 'trifecta' in our sample.

Table 6 reports the incidence of each type of crisis for advanced and emerging economies. It illustrates the relative prevalence of sovereign defaults, lending booms and 'trifecta' crises among emerging economies. By contrast, sudden stops are roughly distributed in proportion to the number of countries in each group.

We compare each type of episode to the Greek crisis. For the purpose of this exercise, we consider that the Greek episode begins in 2010.[13]

[8] Like Calvo et al. (2006), Korinek and Mendoza (2014) focus on 'systemic' sudden stops that occur in times of turmoil on global bond markets.

[9] The appendix provides additional details. In short, we identify large output drops when the peak-to-trough cumulated output decline in a recession exceeds the median cumulated output decline across all recessions for advanced and emerging economies respectively. A sudden stop occurs when this large output drop overlaps a capital flow reversal episode, defined as a year-on-year decline in net capital inflows that is more than two standard deviations away from the country mean.

[10] See Gourinchas and Obstfeld (2012) for details.

[11] See details in the appendix.

[12] Technically, we record a 'trifecta' episode when the sovereign default event occurs during a lending boom episode and during a sudden stop episode.

[13] Different dimensions of the Greek crisis unfolded at different times. According to our dating procedure, the lending

	Sudden Stop	Sovereign Default	Lending Boom	Trifecta	# Countries
Advanced Economies	13	1	18	1	22
Emerging Markets	36	64	96	9	57
Total	49	65	114	10	79

Table 6: **Crises Incidence in Advanced and Emerging Economies, 1980-2014**. Details on how each type of episode is identified are in the appendix.

3.2 The data.

We construct a database of macro variables for a large sample of advanced and emerging economies between 1980 and 2014.[14] The sample contains 22 advanced economies (including Greece) and 57 emerging market economies, distributed across six broad regions. The list of emerging market economies includes all countries classified as emerging according to leading outlets and are therefore reasonably well integrated into global bond markets.[15]

In the spirit of a large literature in international macroeconomics, we examine the behavior of key macroeconomic variables around the three types of shocks discussed above : sudden stops, sovereign debt crisis, and lending booms/busts episodes, as well as Trifecta crises.[16] Our event study considers the response of eight macroeconomic variables: output, consumption, investment, exports and imports of goods and services, the trade balance, credit to the non-financial sector, and public debt. The data is collected from the World Bank's Development Indicators, the IMF's International Financial Statistics and Reinhart and Rogoff (2009) estimates of total (domestic and external) gross public debt for a large number of countries.[17] In addition to these macroeconomic variables, we use Reinhart and Rogoff's *de facto* exchange rate regime classification and sort countries into 'pegs' or 'floats' based on the exchange rate regime in the year preceding the episode. Further, we split 'pegs' into 'de-peggers', i.e. countries that abandon their peg within two years of the shock, and 'strict peggers' who maintain their peg for at least two years. This will allow us to contrast the macroeconomic response of countries based on

boom peaked in 2008, the sovereign default occurred in 2012 and the collapse in output during the sudden stop episode occurred in 2013. Nevertheless 2010 is a natural starting point since specific concerns about the Greek economy arose first in late 2009. The 5-yr spread between Greece and Germany was 120bp in September 2009, but climbed to 277bp by January 2010, before reaching 680bp by April of that year.

[14] We choose to begin in 1980 because of data availability and also because this period marks a phase of growing financial integration, especially for emerging market economies.

[15] Our list includes all countries listed as emerging economies in either J.P. Morgan's EMBIG index, the FTSE's Group of Advanced or Secondary Emerging Markets, the MSCI-Barra classification of Emerging or Frontier economies and the Dow Jones list of Emerging Market Economies. We add to these countries Israel, Hong-Kong and Singapore, all countries that are now often included in the group of advanced economies but belong to the group of emerging market economies for most of the sample. The list of countries in our sample is included in the appendix.

[16] See Eichengreen et al. (1995) and Kaminsky and Reinhart (1999) for seminal contributions.

[17] Detailed sources for each variable are provided in the appendix.

their post-shock exchange rate regime. This is an important consideration given the argument -often heard- that the main constraint on the Greek economy is its lack of exchange rate flexibility.

3.3 Findings

Figure 10 reports the output response to a typical sudden stop across our 48 episodes (excluding Greece). It measures output per capita, relative to its pre-crisis level at t-2, in 100-log points, so that a value of x indicates that output per capita is $e^{x/100}$ above or below pre-crisis output. The figure also includes point-wise one-sided 10% confidence intervals (the greyed area), as well as the trajectory of Greek output (in red with bullets) in the 2010 episode. As expected, since our definition of sudden stops requires a large output drop, the mean response indicates a sharp decline in output, marginally significant, close to 10% below its peak in the year of the sudden stop, followed by a gradual recovery. By year t+2, output has typically recovered to its pre-crisis level and continues to expand. Two facts are relevant here. First, Greece experiences a strikingly worse decline in output after 2010. By t+3, i.e. in 2013, Greek output per capita was 25% below it pre-crisis level ($e^{-0.29} = 0.75$), significantly below the average response and showing few signs of recovery. Second, unlike the typical sudden stop, Greece's output path was 'backloaded.' The initial recession in 2009 and 2010 ($t-1$ and t) is similar to a typical episode and milder than the subsequent declines in output. By contrast, typical episodes are more 'front loaded with a more pronounced 'V' shape. This is not surprising if we consider that Greece's sudden stop was of a particular nature. As discussed in the previous section, the sudden withdrawal of foreign lending was accommodated -at least initially- via ECB lending against collateral, and after 2010 with official assistance from the IMF and the European Union. Hence there was no need immediate downturn, as is often the case for countries that experience sudden loss of market access.

Claim 1. The Greek crisis is significantly more severe, persistent and backloaded than that of countries that experience a typical sudden stop with output collapse.

Figure 11 reports a similar analysis for the consumption and investment ratios to output. As for output, each variable is expressed in 100-log points, relative to its value at t-2, i.e. at the beginning of the episode. Equivalently, this figure reports the growth difference between consumption or investment and output since $t-2$. The left panel reports the consumption output ratio. In a typical sudden stop, consumption mostly moves in line with output. By contrast, in Greece, consumption grew modestly faster than output, although not significantly so. By contrast, the investment output ratio (right

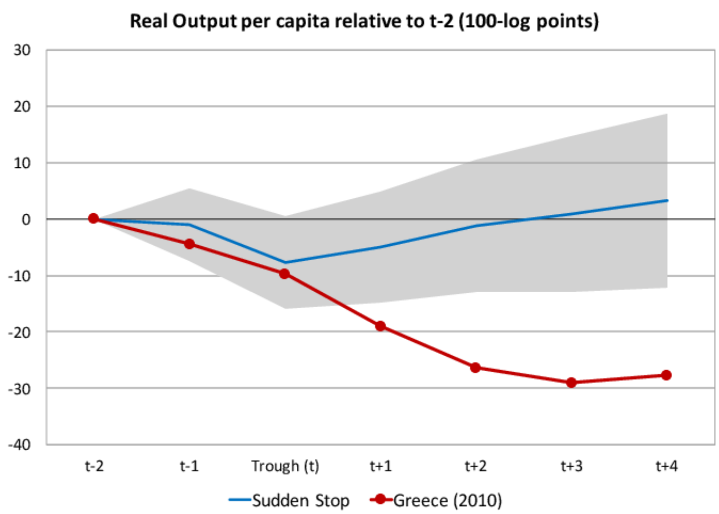

Figure 10: **The response of output to a sudden stop**. The figure reports real output per capita relative to period $t-2$, in 100 log-points for a typical sudden stop episode (with output collapse) and for Greece in the 2010 crisis. See the appendix for data sources.

panel) collapsed dramatically, much more so than in a typical sudden stop. By $t+3$, i.e. in 2013, the investment to output ratio was about half of its pre-crisis level ($e^{-0.76} = 0.47$), while a typical sudden stop sees a decline of 20% to 30%. Given the decline in output per capita documented in Figure 10, real investment per capita collapsed by almost two-thirds between 2008 and 2013 ($0.75 * 0.47 = 0.35$).

Claim 2. The collapse in Greek aggregate investment in this crisis was unprecedented in its persistence and magnitude, in comparison to the experience of countries that experienced a sudden stop.

A sudden withdrawal of foreign capital is only one of the shocks that Greece has experienced since 2009 and one might be concerned that the previous comparison might be too unfavorable to Greece. For instance, Argentina in 2001, Chile in 1983 or Indonesia in 1998, among others, experienced a simultaneous drying-up of foreign capital, a sovereign default and a collapse in lending, i.e. a 'Trifecta' shock. These episodes are amongst the worse documented economic crisis in postwar history, often accompanied by a banking crisis, and unprecedented levels of economic hardship and political turmoil. In light of the economic and political dislocation associated with it, one would expect the Greek crisis to be on a comparable scale.

To investigate this, Figure 12 reports the average output response to each of the following shocks:

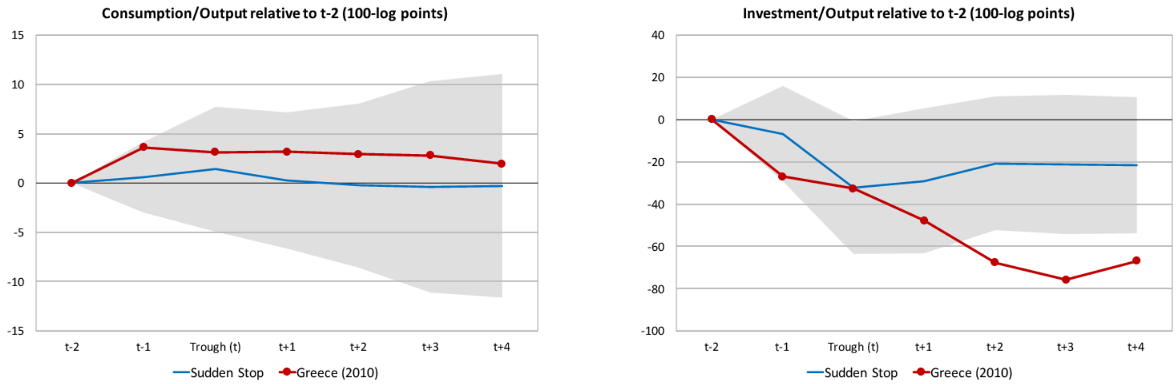

Figure 11: **The response of consumption and investment to a sudden stop**. The figure reports the consumption-output ratio (left panel) and the investment output ratio (right panel) relative to period $t-2$, in 100 log-points for a typical sudden stop episode (with large output collapse) and for Greece in 2010. See the appendix for data sources.

a sovereign default, a lending boom/bust, as well as the 'Trifecta' shock that consists of these two shocks occurring during a sudden stop. As an additional point of comparison, the figure also includes the average output response for Ireland, Italy, Portugal and Spain, i.e. the other peripheral countries besides Greece most affected by the Eurozone crisis (under the label 'IIPS'). Finally, the graph also includes 10% point-wise one-sided confidence intervals for the 'Trifecta' shocks.

The figure illustrates how much of an outlier the Greek crisis truly was. While output per capita initially declined in line with that of a 'Trifecta' crisis, by 2011 (i.e. $t+1$), output had declined significantly more and kept falling. By contrast, in a typical trifecta crisis, output is back to its pre-crisis level by $t+3$. The figure allows us to make a number of additional points. First, 'Trifecta' crises are more severe than a typical default crisis, although the differences are small and often insignificant. Second following a lending boom, output keeps growing. This is because many lending booms in our sample are not always followed by an economic downturn or crisis, as noted also by Gourinchas et al. (2001) and Ranciere et al. (2008). Lastly, the trajectory for the 'IIPS' countries illustrates that, in these countries too, the crisis has been much more persistent then expected, with output still 7% below pre-crisis level as of 2014.

Claim 3. The collapse in Greek output per capita has been significantly more severe and more persistent than the typical 'Trifecta' crisis.

Figure 13 makes the same point even more vividly. The panel on the left reports the output

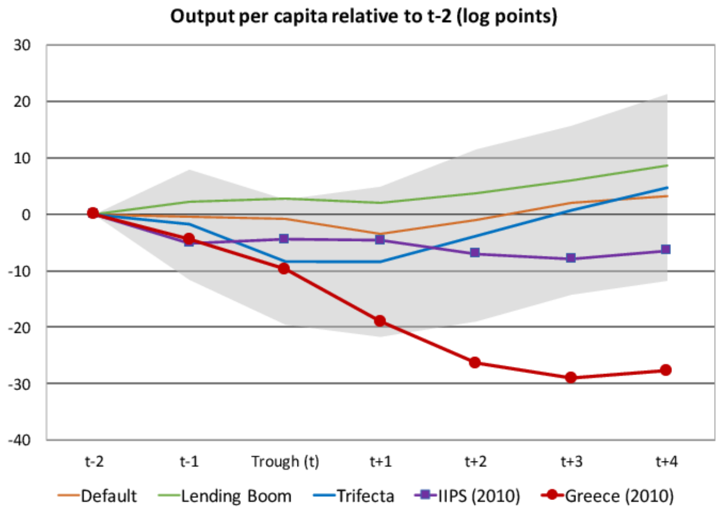

Figure 12: **The response of output to various crises**. The figure reports the mean output per capita relative to period $t-2$, in 100 log-points for various episodes, and for Greece in 2010. One-sided point-wise confidence intervals at 10% for 'Trifecta' episodes. See the appendix for data sources.

trajectory for *all* countries that experienced a sudden stop in our sample. The panel on the right presents similar results for all 'Trifecta' episodes. Both panels also report the Greek 2010 episode. As is clear from both figures, Greece's economic performance is cumulatively much worse than all episodes from the last 35 years, including crises such as Argentina in 2001, or Uruguay in 1983, with the single exception of the Dubai crisis of 2009.[18]

We next consider the role of the exchange rate regime. Our dataset includes information on the *de-facto* exchange rate regime from Reinhart and Rogoff (2009). We use this data to construct an indicator of the exchange rate regime in the year of the shock, and the preceding year (peg/float). We further subdivide pegs based on whether countries maintain their peg for at least two years after the crisis (strict peggers) or abandoned it (de-peggers).[19] Figure 14 contrasts the output response following an emerging market sudden stop for de-peggers, strict peggers and floaters, together with that of Greece

[18] The economy of the United Arab Emirates experienced a sudden stop episode in 2009, as a consequence of the burst of a real estate bubble, and the sharp decline in oil and natural gas prices in the immediate aftermath of the Global Financial Crisis. real output per capita declined by 11 percent, 10.7 percent and 16.4 percent in 2007, 2008 and 2009 respectively, culminating with the collapse of Dubai World in November 2009.

[19] We classify countries into peggers and floaters based on the 'fine classification' of Reinhart and Rogoff. Peggers have a Reinhart and Rogoff index smaller than 9.

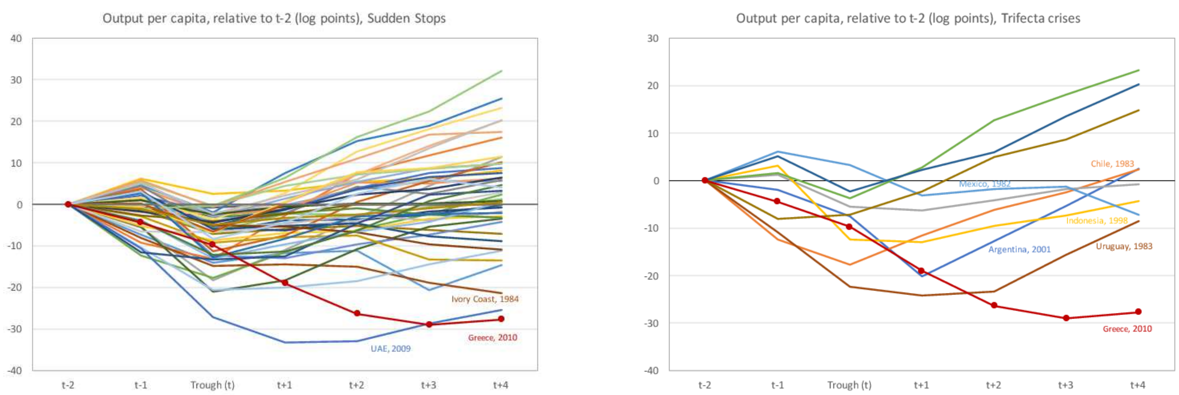

Figure 13: **The distribution of output responses to sudden stops and 'Trifecta' crises** The figure reports output per capita relative to period $t-2$, in 100 log-points for each sudden stop episode (left panel), and for each 'trifecta' crises (right panel), together with Greece in 2010. See the appendix for data sources.

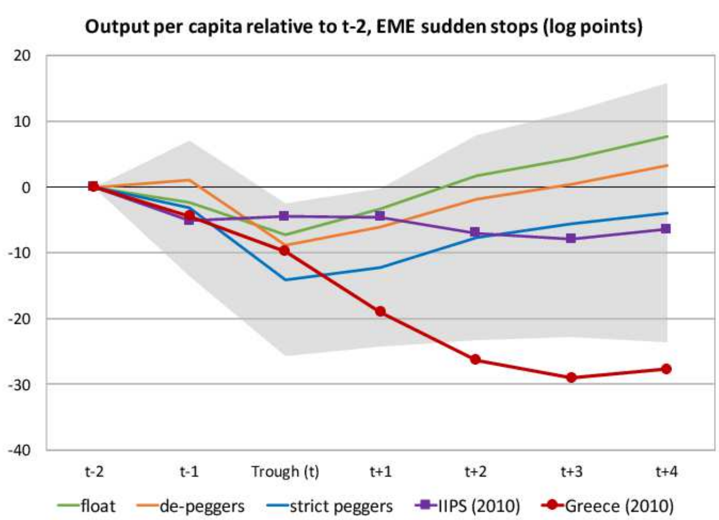

Figure 14: **The role of the exchange rate regime**. The figure reports output per capita relative to period $t-2$, in 100 log-points for Emerging Market Sudden Stops, by exchange rate regime, together with Greece in 2010. One-sided point-wise confidence intervals for 'strict peggers'. See the appendix for data sources.

and of the IIPS countries. The figure also reports 5% point-wise confidence intervals for strict peggers. Unsurprisingly, we find that strict peggers experience a worse adjustment than de-peggers, who in turn perform worse than floaters: by $t+4$, output is still 4% below its pre-crisis level for strict peggers, while it is 3% (resp. 8%) above trend for de-peggers (resp. floaters): a more flexible exchange rate regime is associated with a less severe and less persistent crisis. Greece's experience is very singular in that respect as well: its output loss is much larger and significantly more persistent than for countries that maintained their exchange rate. By contrast, the experience of the 'IIPS' countries is more in line with that of 'strict peggers', albeit less severe in 2010 and 2011 ($t$and $t+1$).

There are two ways to think about this result. One possible interpretation is that the severity of the Greek crisis cannot be attributed entirely to the strictures of the common currency, since it significantly underperformed other 'strict fixers.' This would direct our attention towards other features of the Greek economy than just the exchange rate regime. This is not the only interpretation. Clearly, countries can and often choose their exchange rate regime in response to the economic environment. Therefore, the sample of 'strict fixers' may consist precisely of countries who stand to lose relatively less from keeping the exchange rate pegged in the aftermath of a sudden stop. This could be the case in particular if these countries were experiencing a relatively modest decline in output. To investigate this question further, Figure 15 reports the data for strict fixers, alongside that for Estonia, Latvia and Greece. Both Latvia and Estonia experienced severe recessions following their 2009 sudden stop episode. Estonia's output per capita declined by 19% between 2007 and 2009, while that of Latvia declined by 14% between 2008 and 2009. Nevertheless, both countries chose to maintain their peg to the euro and 'doubled down' by subsequently adopting the common currency, in January 2011 for Estonia and January 2014 for Latvia. Overall, both countries have an experience similar to that of the full sample of strict peggers. Yet, it could hardly be argued that the costs of maintaining a fixed exchange rate were small for either country. Instead, their decision to carry forward and adopt the Euro can be related to historical and geo-strategic reasons, in particular the desire to anchor their country firmly in the West. Both countries, therefore, adopted the euro *despite* the large short run costs associated with doing so: the comparison of their trajectory with Greece's is unlikely to suffer from a strong selection bias. It is therefore interesting that the experience of Greece appears significantly worse than either country.

Claim 4. The Greek crisis was significantly more severe than the typical emerging market sudden stop, even for countries that maintained a fixed exchange rate in the aftermath of a sudden stop and large output drop.

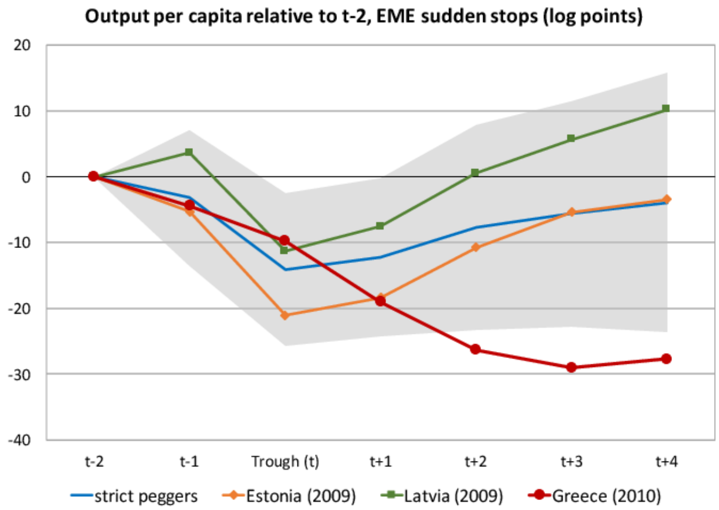

Figure 15: **Output response for 'strict peggers'**. The figure reports output per capita relative to period $t-2$, in 100 log-points for Emerging Market strict peggers, together with Estonia (2009), Latvia (2009) and Greece (2010). One-sided 10% point-wise confidence intervals for 'strict peggers'. See the appendix for data sources.

Figure 16 reports credit to the non financial sector (left panel) and public debt (right panel), relative to output. The credit-to-output ratio is measured in deviation from an hp-filter trend, while the debt-to-output ratio is measured relative to the country mean. Each variable is expressed in percent of GDP. The left panel reports 10% one-sided point-wise confidence bands for lending boom/bust episodes, while the right panel reports similar confidence bands for 'Trifecta' episodes since these episodes witness the largest increase in public debt. Starting with the credit-to-output ratio, we see that the initial leverage was high, but not as high as in typical lending boom episodes, around 10% of GDP. The ratio of credit to GDP was gradually reduced, although at a more measured pace than in typical episodes. Overall, the contraction in credit to the economy is similar to what is observed in other countries and the confidence bands are quite large.

Turning to public debt, we observe an elevated level of public debt even before the crisis (18% of GDP above mean in 2008), increasing rapidly and remaining significantly more elevated than in other episodes. We can see on the graph the effect of the 2012 debt restructuring (in $t+2$), reducing the debt-to-output ratio from 80% to 60% of GDP above its mean, but followed by a subsequent worsening, in part due to the collapse in economic activity in 2013 and 2014. Compared to 'Trifecta' or other

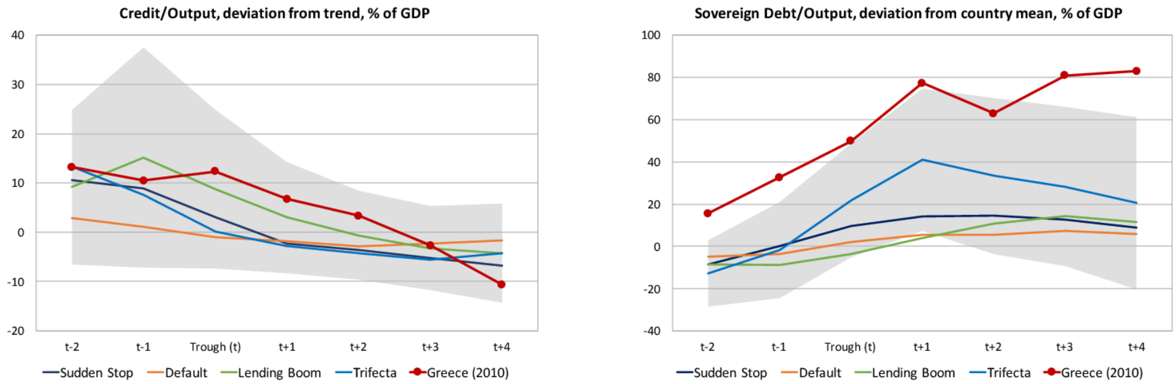

Figure 16: **Credit and Government Debt** The left panel reports the ratio of credit to the non financial sector to output, in deviation from a Hodrick-Prescott trend, in percent of GDP. The right panel reports the ratio of government debt to output, in deviation from a country mean, in percent of GDP. Both panels report the typical response over each type of episode, together with Greece in 2010. One-sided 10% point-wise confidence intervals for lending boom (left panel) and Trifecta (right panel). See the appendix for data sources.

episodes, levels of public debt remain extraordinarily high and it is clear from this figure that efforts to bring public debt back to sustainable levels have failed.

Claim 5. Domestic leverage in Greece was similar to other lending boom/bust episodes and evolved similarly. By contrast, public debt to output remained extremely elevated. Efforts to reduce the public debt burden mostly failed, despite a substantial debt restructuring in 2012.

Figure 17 reports the trade balance to output ratio as well as the CPI-based multilateral real exchange rate compiled by the IMF. As for domestic credit and public debt, the trade balance-to-output ratio is measured in deviation from country means and expressed in percent of GDP. The multilateral real exchange rate is expressed in percentage deviation from its country mean. The figure also reports 10% point-wise one-sided confidence intervals for sudden stop episodes. The left panel (trade balance) illustrates the gradual but large improvement of the Greek trade balance between 2008 and 2014, in excess of 10% of GDP, compared to the typical sudden stop episode. Unlike typical sudden stops, where loss of market access forces the trade balance and current account to improve overnight, the overall improvement in Greece was spread out gradually. The cumulated improvement in the trade balance in a typical sudden stop represents 6.2% of output, 5% of which occur in the year of the sudden stop itself. As discussed in the previous section, financial assistance and access to the liquidity facilities of the European Central Bank allowed Greece to spread out a massive and

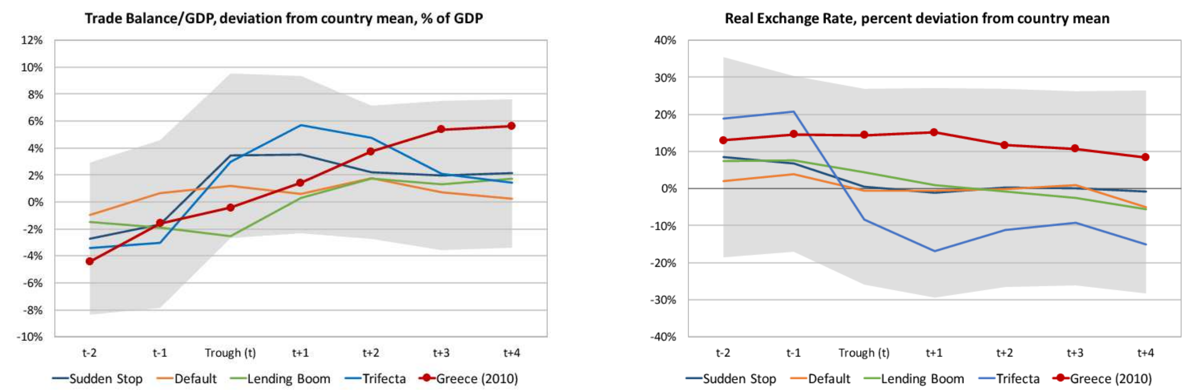

Figure 17: **Net Exports and Real Exchange Rate** The left panel reports the ratio of net exports on goods and services to output, in deviation from country mean, in percent of GDP. The right panel reports the multilateral real exchange rate, in percentage deviation from a country mean. Both panels report the typical response over each type of episode, together with Greece in 2010. One-sided point-wise confidence intervals for Trifecta episodes. See the appendix for data sources.

necessary adjustment in its trade balance. The right panel indicates that most of this adjustment occurred without major adjustments in the real exchange rate. Like other countries experiencing a sudden stop, Greece's real exchange rate was initially over-appreciated by about 13 percent. Yet, while the real exchange rate depreciates by 10% in the aftermath of a typical sudden stop (and a massive 35% following a 'Trifecta'), Greece's real exchange rate only depreciated by 4.5 percent between 2008 and 2014.

Claim 6. The adjustment of external balances occurred more gradually but was nevertheless very significant in size. The improvement in external accounts occurred despite any significant movement in the real exchange rate.

4 Model

This section presents a stylized model of a small open economy in a currency union, with rich macro-financial linkages. The model is designed to answer two sets of distinct questions. First, we want a realistic enough model that allows us to understand which shocks were responsible for the performance of the Greek economy, both during the buildup towards and the aftermath of the crisis. Second, we want to use the model to perform some simple counterfactual exercises. To achieve these objectives, the model needs to remain stylized. In particular, while we introduce many macro-finance features, we abstract from a full micro-founded model of the banking sector that would put excessive constraints on the data. The model features seven exogenous stochastic processes. They are called ζ's and are assumed to follow AR(1) processes. A generic shock $\zeta^i$is therefore

$$\zeta_t^i = \rho^i \zeta_{t-1}^i + \sigma^i \varepsilon_t^i, \tag{1}$$

where the persistence and volatility parameters $\left(\rho^i, \sigma^i\right)$ are estimated and the innovations ε_t^i are i.i.d. with mean zero and unit variance.

4.1 Government

The government imposes a flat tax on income, spends G_t on goods and services and makes social transfers T_t. Let $B_{\$,t-1}^g$ be the face value (in units of the common currency) of the debt issued at time $t-1$ and due at time t. The nominal budget constraint of the government, conditional on not defaulting, is

$$\frac{B_{\$,t}^g}{R_t^g} + \tau_t P_{H,t} Y_t = P_{H,t}\left(G_t + T_t\right) + B_{\$,t-1}^g, \tag{2}$$

where $P_{H,t}$ is the price index of home goods (so $P_{H,t}Y_t$ is nominal GDP), and $B_{\$,t}^g$ is the nominal face value of debt issued at t and due at $t+1$. It will be convenient to work with real variables. For government debt, this means the face value divided by the current price level: $B_t^g \equiv \frac{B_{\$,t}^g}{P_{H,t}}$. We can then write the budget constraint (conditional on not defaulting) as

$$\frac{B_t^g}{R_t^g} + \tau_t Y_t = G_t + T_t + \frac{B_{t-1}^g}{\Pi_t^H}, \tag{3}$$

where $\Pi_t^H \equiv \frac{P_{H,t}}{P_{H,t-1}}$ is PPI inflation from $t-1$ to t. This formula makes it clear how unexpected inflation at time t lowers the real debt burden. We use this convention for all other nominal assets. We allow the tax rate to vary over time to match the path of government revenues.

Sovereign default. Sovereign risk plays a key role in the Greek crisis. The literature on sovereign risk is large and we can only refer the reader to the classic contribution of Arellano (2008) and the recent survey by Aguiar and Amador (2014). To analyze sovereign risk, we need to specify the decision to default. We introduce a default shock $\tilde{\varepsilon}_t^{dg}$ and we assume that the default process is

$$\tilde{d}_t \quad = \quad \mathbf{1}\left[\tilde{\varepsilon}_t^{dg} < F\left(\frac{B_{t-1}^g}{\Pi_t^H}; Y_t\right)\right].$$

The function F is increasing in the real debt burden B_{t-1}^{g}/Π_{t}^{H} and decreasing in real GDP Y_t. For instance, F could simply be the ratio of debt to GDP. Upon default, government debt is reduced by some haircut. We write the expected default rate as

$$\mathbb{E}_t\left[\tilde{d}_{t+1}\right]=\Pr\left(\tilde{\varepsilon}_{t+1}^{dg}<F\left(\frac{B_t^g}{\Pi_{t+1}^H};Y_{t+1}\right)\mid\mathcal{I}_t\right),$$

where $\mathcal{I}_t$ is the information set of investors. Notice that the distribution of $\tilde{\varepsilon}_t^{dg}$ can be time varying. What matters most in our model, however, are *expected* credit losses, which take into account expected default, loss given default. Let d_t^g denote these expected credit losses. In our quantitative analysis, we find that the following log-linear equation fits the data well:

$$d_t^g=\bar{d}_g\frac{B^g}{Y}\left(b_t^g-\mathbb{E}_t\left[y_{t+1}\right]-\mathbb{E}_t\left[\pi_{t+1}^h\right]+\zeta_t^{dg}\right), \tag{4}$$

where $\frac{B^g}{Y}$ is the average debt-to-GDP ration, $\bar{d}_g$ is a sensitivity parameter, and lowercase variables represent log deviations from their steady state values. ζ_t^{dg} is a sovereign risk shock which follows an AR(1) as explained in equation (1):

$$\zeta_t^{dg}=\rho^{dg}\zeta_{t-1}^{dg}+\sigma^{dg}\varepsilon_t^{dg}.$$

We will estimate $\left\{\bar{d}_g,\rho^{dg},\sigma^{dg}\right\}$. The rate the government needs to pay on its debt is (in log deviations)

$$r_t^g=r_t+d_t^g,$$

where r_t is the (exogenous) international interest rate. We can incorporate risk premia via the coefficients of equation (4).

Fiscal policy. The government's spending policy and its social transfer policy are described by the same rule

$$\{g_t;t_t\}=F_l\times\{g_{t-1};t_{t-1}\}-F_nn_t-F_rr_t^g-F_bb_t^g+\zeta_t^{spend},$$

where g_t,t_t are the log deviation of spending and transfers, and n_t, r_t^g, and b_t^g are log deviations of employment N_t, government funding costs R_t^g, and government debt B_t^g from their steady-state values, F_n, F_r, and F_b are fixed parameters, and ζ_t^{spend} is a spending shock.

4.2 Households

Households are heterogeneous in their time preferences, as in Eggertsson and Krugman (2012) and Martin and Philippon (2014).[20] There are two types of households: a measure $1-\chi$ of patient households indexed by $i=s$ (who will be *savers* in equilibrium), and a measure χ of impatient households indexed by $i=b$ (who will be *borrowers* in equilibrium). They have identical preferences over goods and hours worked, but they differ in their discount factors. We assume that $\beta_s > \beta_b$. Household i maximizes lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_i^t \left(\frac{(\mathbf{C}_{i,t})^{1-\gamma}}{1-\gamma} - \frac{N_{i,t}^{1+\varphi}}{1+\varphi} \right),$$

where $\mathbf{C}_{i,t}$ is a bundle of home and foreign goods, defined as in Gali and Monacelli (2008) by

$$\mathbf{C}_{i,t} \equiv \left[(1-\varpi)^{\frac{1}{\epsilon_h}} C_{i,H,t}^{\frac{\epsilon_h-1}{\epsilon_h}} + \varpi^{\frac{1}{\epsilon_h}} C_{i,F,t}^{\frac{\epsilon_h-1}{\epsilon_h}} \right]^{\frac{\epsilon_h}{\epsilon_h-1}},$$

where ϵ_h is the elasticity of substitution between home and foreign goods and ϖ is the openness of the economy. We can then define the home consumer price index (CPI) as

$$\mathbf{P}_t \equiv \left[(1-\varpi) P_{H,t}^{1-\epsilon_h} + \varpi P_{F,t}^{1-\epsilon_h} \right]^{\frac{1}{1-\epsilon_h}}.$$

Household default. Households borrow at the rate R_t^h and can default on their debts. Let d_t^h be the credit loss rate on household loans. Default is a loss for the banks and a positive transfer to borrowers, similar to the financial shock described in Iacoviello (2015). The *borrowers*' budget constraint, following the same convention as with the government, is

$$\mathbf{P}_t \mathbf{C}_t^b = (1-\tau_t) W_t N_{b,t} + \frac{P_{H,t} B_t^h}{R_t^h} - \left(1-d_t^h\right) P_{H,t-1} B_{t-1}^h + P_{H,t} T_t^b. \tag{5}$$

Households are subject to the borrowing limit:

$$B_t^h < \frac{\bar{B}_t^h}{\chi}.$$

[20] There are two types of models with heterogeneity. One where types are transient, as in Bewley models, as in Guerrieri and Lorenzoni (2010). Another where the types are permanent, as in Campbell and Mankiw (1989), Mankiw (2000), Eggertsson and Krugman (2012), and Martin and Philippon (2014). Midrigan and Philippon (2010) propose an hybrid model that includes precautionary savings but is simple enough to use a standard macro model.

In our notations, B_t^h is a *per-capita* measure. We later derive the *aggregate* limit $\bar{B}_t^h$ from the lender's problem, and we anticipate the result that only impatient households borrow in equilibrium. The credit loss rate is assumed to follow the process:

$$d_t^h = -\bar{d}_{hy} y_t + \bar{d}_{hb} b_t^h + \zeta_t^{dh},$$

where ζ_t^{dh} follows (1). We will use data on non-performing loans to estimate $\left\{\bar{d}_{hy}, \bar{d}_{hb}, \rho_{dh}, \sigma_{dh}\right\}$. Note that d_t^h are *realized* credit losses, unlike d_t^g which is an *expected* loss that may of may not materialize at $t+1$.

The *savers*' budget constraint is

$$\mathbf{P}_t \mathbf{C}_{s,t} = (1-\tau_t) W_t N_{s,t} + \tilde{R}_t P_{H,t-1} S_{t-1} - P_{H,t} S_t + P_{H,t} T_t^s, \tag{6}$$

where $\tilde{R}_t$ is the after tax return on savings at time t. This return is complicated to write down because savers are residual claimants: they hold shares of firms and of banks, but also deposits and government bonds. Notice however, that in equation (3) we have assumed a uniform tax rate on aggregate income, and this is what matters in the end. The savers' Euler equation is

$$\mathbb{E}_t \left[\beta \left(\frac{\mathbf{C}_{s,t+1}}{\mathbf{C}_{s,t}} \right)^{-\gamma} \frac{\tilde{R}_{t+1}}{\Pi_{t+1}} \right] = 1$$

,where Π_{t+1} is CPI inflation from t to $t+1$. Finally, in the aggregate, we have

$$\begin{aligned} C_{H,t} &= \chi C_{H,t}^b + (1-\chi) C_{H,t}^s \\ \mathbf{C}_t &= \chi \mathbf{C}_t^b + (1-\chi) \mathbf{C}_t^s. \end{aligned}$$

Nominal Wage Rigidity We assume a standard model of wage stickiness, with a representative union setting wages à la Calvo. The wage equations are standard and satisfy:

$$\begin{aligned} \pi_t^w &= \beta \mathbb{E}_t \pi_{t+1}^w - \lambda^w (w_t - \gamma c_t - \varphi n_t), \\ \pi_t &= (1-\varpi) \pi_t^h + \varpi \pi_t^f, \\ w_t &= w_{t-1} + \pi_t^w - \pi_t^h, \end{aligned}$$

where π_t^w is wage inflation, w_t is the real wage, π_t is CPI inflation, π_t^h is home inflation, π_t^f is foreign inflation, and λ^w is derived from the Calvo wage setting parameter.

4.3 Non Financial Firms

In the real world, non financial firms have access to a large set of financial instruments. For simplicity when we write the Calvo price setting conditions, it is convenient to separate firms into capital producing and good producing firms.

4.3.1 Capital Producing Firms

Capital firms convert consumption goods into capital through investment, and rent this capital to goods producing firms for a rental rate $Z_{k,t}$. The capital stock evolves according to

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

and real period profits (i.e., scaled by $P_{H,t}$) for these firms are given by

$$Div_t = Z_{k,t} K_{t-1} - I_t - \frac{\varphi_k}{2} K_{t-1} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 ,$$

where the last term captures adjustment costs to physical capital. Let R_t^k be the firm's funding cost. We will explain later the spread between R_t^k and R_t. The firms' problem is

$$V\left(K_{t-1}\right) = \max_{I_t, K_t} \left\{ Z_{k,t} K_{t-1} - I_t - \frac{\varphi_k}{2} K_{t-1} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 + \mathbb{E}_t \left[\frac{\Pi_{H,t+1}}{R_t^k} V\left(K_t, B_t^k\right) \right] \right\}$$

subject to:

$$I_t \quad = \quad K_t - (1-\delta)\, K_{t-1}.$$

Let $x_t \equiv \frac{K_t - K_{t-1}}{K_{t-1}}$ be the net investment rate. Given our homotheticity assumptions, we guess and verify that the value function can be written as

$$V\left(K_{t-1}, B_{t-1}^k\right) = \mathcal{V}_t K_{t-1}$$

where

$$\mathcal{V}_t = \max_{x_t} \left\{ Z_{k,t} - x_t - \delta - \frac{\varphi_k}{2} x_t^2 + (1 + x_t) \mathbb{E}_t \left[\frac{\Pi_{H,t+1}}{R_t^k} \mathcal{V}_{t+1} \right] \right\}. \tag{7}$$

Let us define Tobin's Q as the end of period value of assets divided by the end of period replacement cost of capital

$$Q_t \equiv \mathbb{E}_t \left[\frac{\Pi_{H,t+1}}{R_t^k} \mathcal{V}_{t+1} \right]. \tag{8}$$

We get the standard Q equation

$$x_t = \frac{Q_t - 1}{\varphi_k}. \tag{9}$$

4.3.2 Goods Producing Firms

Goods producing firms produce the domestic good using capital and labor. The production function for a producer of good j is

$$Y_t(j) = AK_t(j)^{\alpha} N_t(j)^{1-\alpha},$$

where labor costs wage W_t, capital costs $P_{H,t} Z_{k,t}$ to rent from the capital firms, and A is aggregate total factor productivity (TFP). We focus here on the case where TFP is constant because the model is simpler to present and fits the data quite well. Goods firms are subject to a financial friction that requires them to pay part of the wage bill in advance, before production is undertaken.[21] This is standard in the literature, see for example Christiano et al. (2005) or Jermann and Quadrini (2012). Let ψ_{sk} denote the fraction of input cost that needs to be financed by working capital loans. Profits are given by

$$\text{Profits}_t = \text{Revenues}_t - \text{Costs}_t \left[1 + \psi_{sk} \left(R_t^k - 1 \right) \right].$$

Standard cost minimization yields an expression for the nominal marginal cost,

$$\mathtt{MC}_t^{\$} = \frac{\left[1 + \psi_{sk} \left(R_t^k - 1 \right) \right]}{A} \left(\frac{P_{H,t} Z_{k,t}}{\alpha} \right)^{\alpha} \left(\frac{W_t}{1 - \alpha} \right)^{1-\alpha}$$

Notice that the working capital friction can be represented by an incremental marginal cost for the firm. This will be an important property, as it allows financial frictions to pass through to inflation.

[21] The assumption that this loan is intra-period is made for simplicity. The fact that the loan is made by the bank still allows for financial shocks to pass through to the production sector, with the added advantages that: (i) we do not need to keep track of an extra state variable, and (ii) we avoid any complications arising from the interaction of two dynamic frictions: nominal rigidities and financial frictions. If debt were inter-temporal, we would have to keep track of a joint distribution of prices and debt, as firms with different preset prices would produce different quantities and thus borrow different amounts. Intra-period loans allow us to introduce a financial friction that is static from the firm's point of view.

Differentiated goods producers will then solve a standard Calvo problem, given factor demands. Given real marginal cost $\mathtt{MC}_t \equiv \frac{MC_t}{P_{H,t}}$, we can write the (log-linear) Phillips Curve as

$$\pi_{h,t} = \lambda_p \mathtt{mc}_t + \beta \mathbb{E}_t \pi_{h,t+1} + \zeta_t^{\pi h},$$

where the log real marginal cost is

$$\mathtt{mc}_t = \frac{\psi_{sk} R^k}{1 + \psi_{sk}(R^k - 1)} r_t^k + \alpha (z_{k,t} + p_{h,t}) + (1 - \alpha) w_t - p_{h,t},$$

and $\zeta_t^{\pi h}$ is an AR(1) markup shock

$$\zeta_t^{\pi h} = \rho^{\pi h} \zeta_{t-1}^{\pi h} + \varepsilon_t^{\pi h}.$$

Finally, we have static optimality condition for labor demand

$$\frac{K_{t-1}}{N_t} = \frac{\alpha}{1-\alpha} \frac{W_t}{P_{H,t} Z_{k,t}}.$$

4.4 Banks, Sudden Stop, and Funding Cost

A previous version of our paper included a full model of banking intermediation following the seminal work of Gertler and Kiyotaki (2010). Unfortunately we do not have the right data to estimate the structural restrictions of such a model (see Faria-e-Castro (2016) for a more ambitious estimation). There is, however, one fundamental insight from the model that is theoretically straightforward and, as we show later, empirically relevant. At the heart of the banking model is a capital requirement of the type

$$V_t^{bank} \geq \kappa \left(\frac{B_t^k}{R_t^k} + \frac{B_t^h}{R_t^h} \right). \tag{10}$$

Equation (10) says that bank equity V_t^{bank} must cover a fraction κ of the total credit exposure to firms B_t^k and to households B_t^h both measured at the end of period t. The second important equation (11) is the current account of the banking sector:

$$\Pi_{H,t} E_{t+1} = \left(1 - d_{t+1}^k\right) B_t^k + \left(1 - d_{t+1}^h\right) B_t^h - D_t. \tag{11}$$

Real bank earnings $\Pi_{H,t}E_{t+1}$ are repayment from firms and households net of default losses, minus the repayment of banks' liabilities. Finally, bank value solves a Bellman equation

$$V_t^{bank} = \max_{\{B_t\},D_t} Div_t + \mathbb{E}_t\left[\frac{\Lambda_{t+1}}{\Pi_{t+1}}\Pi_{H,t+1}\left((1-\sigma)E_{t+1} + \sigma V_{t+1}^{bank}\right)\right], \tag{12}$$

where σ is an exogenous exit rate, Λ_{t+1} is the pricing kernel of savers, and dividends satisfy $Div_t \leq E_t$.

Equations (10), (11) and (12) capture the fundamental credit channel in the economy. Credit losses reduce banks' earnings (11), lower bank value (12) and tighten capital requirement (10). This then leads to an increase in the economy's funding cost. And, all else equal, this channel is stronger the higher is bank leverage. All this is pretty obvious from a theoretical perspective. We capture this idea in two steps. First, we model the banks' funding cost r_t^d (in a log linear approximation) as

$$r_t^d = r_t + \zeta_t^r + \xi^d L \mathbb{E}_t\left[d_{t+1}^p\right],$$

where L is bank leverage (assets over equity capital), ξ^d is a sensitivity parameter to be estimated, d_{t+1}^p measures losses on *private* credit portfolio (households and firms' loans), and ζ_t^r is a 'sudden stop' shock that increases funding costs to banks. We only have data on total non performing loans so we will assume $d_t^h = d_t^k \equiv d_t^p$. This cost of funds is passed on to banks customers (with a constant margin that drops out in logs), therefore

$$r_t^k = r_t^d.$$

Note that in our notations above, r_t^k is the *funding cost* of firms which enters directly the Q equations (7) and (8), while r_t^h is the interest rate on households' loans, gross of expected losses, that enters the budget constraint (5). Therefore $r_t^h = r_t^d + \mathbb{E}_t\left[d_{t+1}^h\right]$. Of course, if we were to quote an interest rate for corporate loans, it would be $r_t^d + \mathbb{E}_t\left[d_{t+1}^k\right]$, and the expected return would be r_t^b. With our assumptions, the sudden stop shock is an increase in the country's funding cost above and beyond what can be explained by domestic intermediation spreads.

5 Equilibrium

All transactions with the rest of the world happen at the world interest rate R_t. Let NFA_t denote the net foreign assets of the country (in units of domestic goods). By definition, they evolve as

$$\frac{NFA_t}{R_t} = NFA_{t-1} - \mathbf{P}_t\mathbf{C}_t + P_{H,t}\left(Y_t - G_t - I_t - \frac{\varphi_k}{2}K_{t-1}\left(\frac{K_t}{K_{t-1}} - 1\right)^2\right).$$

As is common in the literature, we make a technical assumption to ensure stationarity of NFA.[22] We assume that there is a (small) price impact of NFA on the country's borrowing (or saving) rate

$$\frac{\partial \log R_t}{\partial \log NFA_t} = -\epsilon_r,$$

where ϵ_r is a small but strictly positive number. Clearing in the market for domestic goods requires

$$Y_t = C_{Ht} + \left(\frac{P_{Ht}}{P_{Ft}}\right)^{-\epsilon_f} C_t^F + G_t + I_t + \frac{\varphi_k}{2}K_{t-1}\left(\frac{K_t}{K_{t-1}} - 1\right)^2,$$

where C_t^F is foreign demand for domestic goods, and ϵ_f is the demand elasticity. We take foreign demand as exogenous and model it (in log deviations) as

$$c_t^F = \rho^{cf} c_{t-1}^F + \varepsilon_t^{cf}.$$

Household Debt. Banks lend to households and we assume that borrowers are impatient enough to hit their borrowing limits, so

$$\chi B_t^h = \bar{B}_t^h.$$

The basic model does not pin down a unique rate R_t^h. As long as $R_t^h > R_t^d$, banks are willing to lend more. As long as $\beta_b \mathbb{E}_t\left[\frac{R_t^h}{\Pi_{t+1}} u'(c_{t+1})\right] < u'(c_t)$ borrowers want to borrow more. In steady state, any $R^h \in \left(\beta_s^{-1}, \beta_b^{-1}\right)$ is potentially an equilibrium.[23] This issue is present in and out of steady state. For the steady state, however, we can easily solve the problem. The reasonable assumption is that the

[22] See Schmitt-Grohe and Uribe (2003).

[23] To see why simply pick some $R^h \in \left(\beta_s^{-1}, \beta_b^{-1}\right)$ and ignore the borrowers. Given this rate and the other parameters, there is a unique steady state for bank equity, bank size, etc. It also implies a unique value for B^h. Now, as long as interest payments do not violate the non-negativity of consumption (which never happens for reasonable values), then this level of B^h also satisfies the households' problem since for them B^h is a constraint. This shows that any any $R^h \in \left(\beta_s^{-1}, \beta_b^{-1}\right)$ is potentially an equilibrium, with different values of B^h.

lending spread is pinned down by free entry into banking. Thus, we will directly calibrate the steady spread $\Delta_t \equiv \frac{R_t^h}{R_t}$ using empirical studies of financial intermediation: Philippon (2011) shows that the spread is remarkably stable in the long run at $\Delta = 1.02$. Out of steady state, we expect both loan supply and loan demand to decrease in response to an increase in bank's funding cost, so we specify, in log deviations from steady-state values

$$b_t^h = adj_{bh} b_{t-1}^h - \xi^{bh} r_t^d + \zeta_t^{bh}. \tag{13}$$

where ζ_t^{bh} is an AR(1) shock and ξ^{bh} is estimated.

Interest Rates and Funding Costs in the Model. There are four interest rates in the model, so it is useful to summarize them here. First of all, there is the baseline interest rate r_t that enters the NFA and the Euler equation of savers. Above and beyond this rate there are spreads and expected losses, so that

$$\begin{aligned}
r_t^d &= r_t + \zeta_t^r + \xi^d L \mathbb{E}_t \left[d_{t+1}^p \right] \\
d_t^p &= -\bar{d}_y y_t + \bar{d}_b b_{t-1} + \zeta_t^{def} \\
r_t^k &= r_t^d \\
r_t^h &= r_t^d + \mathbb{E}_t \left[d_{t+1}^p \right] \\
r_t^g &= r_t + d_t^g \\
d_t^g &= \bar{d}_g \frac{B^g}{Y} \left(b_t^g - \mathbb{E}_t \left[y_{t+1} \right] - \mathbb{E}_t \left[\pi_{t+1}^h \right] + \zeta_t^{dg} \right)
\end{aligned}$$

Notice our assumptions here. First, savers do not earn higher expected returns when there is a sudden stop. They earn r, which remains essentially constant and equal to the rate in the eurozone. Second, the banks are sensitive to the sudden stop and to credit losses. The sudden stop ζ_t^r enters the economy via the banks, which then pass it on to their customers. Non performing loans d_{t+1}^p hurt banks and increase the funding costs of all private agents. We only have data on total non performing loans, so we do not model separately firm and household defaults. We assume that they move together and we estimate only one equation for d_t^p. The shock ζ_t^{def} captures the evolution of NPLs that is not predicted by macroeconomic fundamentals. But we will see that the fit of this equation is excellent and in fact ζ_t^{def} is rather small.

Fourth, the government is not necessarily affected by the same sudden stop as the private sector. The shock ζ_t^{dg} raises the cost of funds for the government. It captures pessimism by investors about the credit worthiness of the government, whether or not this pessimism is born out in equilibrium. There are many reasons why ζ_t^{dg} and ζ_t^r are different, but let us jut mention two. First as we discussed, the ECB provided funding to Greek banks both directly and indirectly via Emergency Liquidity Assistance, insulating them from sovereign risk, in particular during the sovereign debt restructuring. Second government debt is now largely held by official creditors, insulating sovereign debt from banking risk.

Finally, while the two shocks $\zeta^r$and ζ^{dg} are conceptually distinct, the model features important feedback loops between the sovereign and the banks. This 'doom loop' has been extensively discussed in policy circles and analyzed in stylized models (see Brunnermeier et al. (2011) and Farhi and Tirole (2016)). The impact of banks on the sovereign is always present via general equilibrium effects and tax revenues. If banks experience a sudden stop, the economy contracts and credit risk, both private and sovereign, increases. Conversely, if sovereign risk increases, the worsening of economic outcomes increases default in the private sector, affecting bank values.

6 Estimation

In this section, we describe the estimation of the model. We combine the Kalman Filter with Bayesian Techniques, which allow us to recover estimates for the structural shocks that affected Greece during the 2000's. These estimates for the shocks can then be used to conduct counterfactual exercises.

6.1 Data, Observables and Calibration

6.1.1 Data

The sample is annual, from 1999 to 2015. Figure 18 shows the seven series that we feed into the model, all measured in log deviations from steady-state.

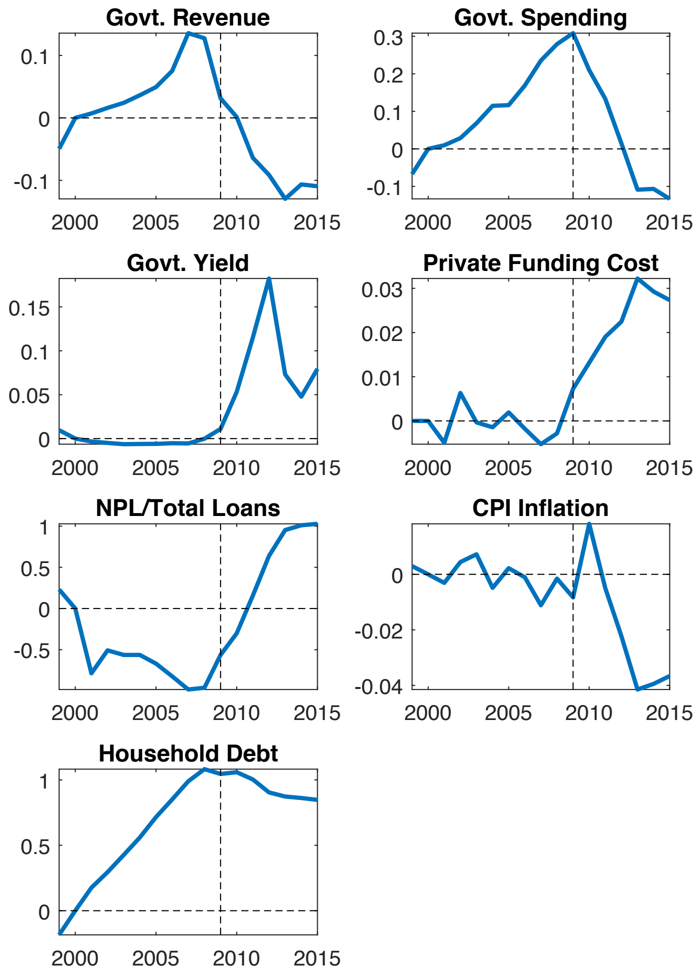

Figure 18: **Observables: Filtered Data**. Notes: All series are in log deviations from steady state.

To avoid stochastic singularity we have as many shocks as observables, which are described in Table 7. The only variable that does not follow exactly the procedure described above is inflation. Inflation is (very) noisy, so we add measurement error to CPI inflation. We assume that we observe $\tilde{\pi}_t$, where

$$\tilde{\pi}_t = \pi_t + \varepsilon_t^{error}$$

and ε_t^{error} is measurement error in the Greek CPI.[24] For household debt, we take as a proxy the series for total credit to the private non financial sector for Greece.

[24] In practice, as we will see, the inflation deviates most from the model in 2010. According to the Bank of Greece, that year saw a surge in inflation due to a significant rise in oil prices and an increase in indirect taxes, in particular VAT.

Observable	Description	Shock	Shock Description
B_t^h	Household credit	ζ_t^{bh}	Household credit shock
$G_t + T_t$	Government spending	ζ_t^{spend}	Govt. spending shock
τY_t	Government revenues	ζ_t^{tax}	Tax rate shock
R_t^g	Greek Govt.. spread over EZ	ζ_t^{dg}	Sovereign risk shock
R_t^k	SME spread over EZ	ζ_t^r	Funding cost shock
Π_t	Greece CPI - EZ CPI	$\zeta^{\pi h}$	PPI cost push shock
$\exp(d_t^p)$	Non-performing loans/total loans, $def = npl$	ζ^{def}	Private default shock

Table 7: **Observables and Shocks**

6.1.2 Summary of Calibration

We use a combination of calibration and estimation. We calibrate parameters that affect steady state variables, and most of the calibrated parameters take standard values for small open economies. We estimate the "dynamic" parameters, i.e. those parameters that are not required to compute the steady state and that only affect the dynamics of the model, such as the pass-through elasticities and the persistence as well as the standard deviation of the exogenous shocks (ρ^i, σ^i). Most of the calibrated parameters are standard for small open economies. We list the parameters in Tables 11, 12 and 13 in the Appendix.

6.2 Estimation Results

We estimate the remaining "dynamic" parameters using standard Bayesian estimation techniques following An and Schorfheide (2007). We estimate a total of 21 parameters: the persistence and variance of the structural shocks (and the variance of measurement error), as well as six other dynamic parameters: the elasticity of expected sovereign default losses with respect to debt to GDP, the elasticities of private default with respect to GDP and debt, the persistence of the household credit equation, the elasticity of household credit with respect to the cost of funds, and the pass-through of future default to current lending rates.

The estimation results, along with our choice of priors, are described in table 8. Our priors impose that most estimated parameters be in the $[0, 1]$ interval, with the exception of some of the elasticities for which we assume Gamma priors.

Parameter	Description	Prior	Prior Mean	Prior SD	Post. Mean	Post. 90% Interval	
ρ_{tax}	Persistence of Tax Shock	Beta	0.85	0.1	0.7676	0.5918	0.9332
σ_{tax}	SD of Tax Shock	Beta	0.2	0.1	0.0320	0.0139	0.0478
ρ_r	Persistence of Sudden Stop Shock	Beta	0.85	0.1	0.7202	0.5831	0.8585
σ_r	SD of Sudden Stop Shock	Beta	0.2	0.1	0.0062	0.0041	0.0082
ρ_{spend}	Persistence of Spending Shock	Beta	0.25	0.1	0.2587	0.1056	0.4038
σ_{spend}	SD of Spending Shock	Beta	0.7	0.2	0.0559	0.0371	0.0728
ρ_{bh}	Persistence of Credit Shock	Beta	0.25	0.1	0.4133	0.1978	0.6055
σ_{bh}	SD of Credit Shock	Beta	0.7	0.2	0.0953	0.0573	0.1338
ρ_{dg}	Persistence of Sov Risk Shock	Beta	0.85	0.1	0.6996	0.5223	0.9049
σ_{dg}	SD of Sov Risk Shock	Beta	0.2	0.1	0.2475	0.1343	0.3553
$\rho_{\pi h}$	Persistence of Markup Shock	Beta	0.85	0.1	0.7532	0.5707	0.9468
$\sigma_{\pi h}$	SD of Markup Shock	Beta	0.1	0.05	0.0166	0.0039	0.0287
ρ_{def}	Persistence of Default Shock	Beta	0.85	0.1	0.7923	0.6537	0.9374
σ_{def}	SD of Default Shock	Beta	0.2	0.1	0.2067	0.1302	0.2753
σ_{error}	SD of CPI Meas. Error	Beta	0.2	0.1	0.0244	0.0156	0.0329
$\bar{d}_g$	Impact of $\frac{B^g}{Y}$ of Sovereign Risk	Beta	0.2	0.1	0.1159	0.0663	0.1646
$\bar{d}_y$	Elasticity of default to GDP	Gamma	5	1	5.0171	3.5809	6.3844
$\bar{d}_b$	Elasticity of default to debt	Beta	0.1	0.05	0.1037	0.0252	0.1760
adj_{bh}	Adjustment Speed of b^h	Beta	0.85	0.1	0.9506	0.9083	0.9935
ξ^{bh}	Elasticity of credit to funding cost	Gamma	2	1	1.5977	0.4102	2.8079
ξ^d	Impact of default on funding cost	Beta	0.001	0.0005	0.0011	0.0005	0.0018

Table 8: **Priors and Posteriors**

Figure 19 plots the priors in orange and the estimated posterior distributions in blue for the non-shock related parameters, with the posterior mode highlighted in black. Our default priors for shock persistence and variances are Beta distributions with mean 0.85 and variance 0.1, and mean 0.2 and variance 0.1, respectively. The only exceptions are the spending and household debt shocks, where we lower the persistence and raise the variance due to the presence of an autoregressive term in the structural equations for these variables.

6.2.1 Smoothed Variables

The smoothed shocks are reported in the Appendix. Given the way we set up the model, the model fits all observables perfectly. On top of this, we can extract the sequences implied by the model for the remaining endogenous variables from the Kalman Filter. This is a good way of gauging the fit of the model. We present some examples in figure 20, where we plot the data and model-implied paths for GDP, Corporate Investment, CPI Inflation and Net Exports. It is important to emphasize that we did not use this data at all to estimate the model. Our model replicates well the paths of output and investment even though we have used neither in the estimation. For inflation, whose measurement we think is noisy, we plot the observed CPI (which the model can fit perfectly) against the smoothed CPI

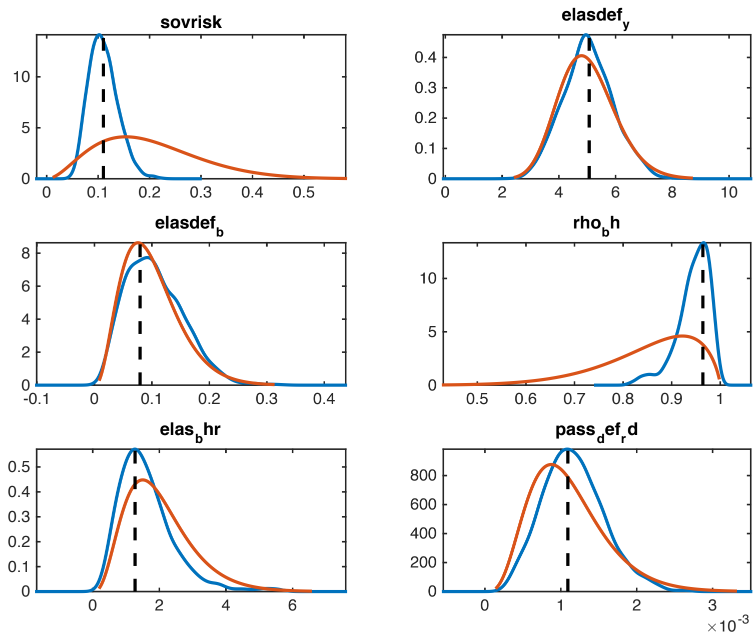

Figure 19: **Priors (orange), Posteriors (blue) and Mode (black).** Notes: The blue line is the posterior density, the orange line is the prior density and the black dashed line is the posterior mode.

implied by the model, without measurement error.

6.2.2 Decomposition with Estimated Shocks

Knowledge of the structural shocks and the structural matrices that describe the law of motion for the endogenous variables as functions of the states allows us to estimate the contribution of each shock to the observed behavior of each variable in the model. This can be done for any endogenous variable, observed or not. In figures 21-24, the black line is the smoothed value of the corresponding endogenous variable in percent deviations from steady state. Each colored bar represents the contribution of the smoothed shocks to the smoothed value of the corresponding variable at each point in time. Note that the plotted contributions of the shocks do not need to add up to the value of the variable due to initial conditions.

For GDP (figure 21 left panel), we see the familiar story of Greece in the boom, from 2000 to 2007. Credit demand is high and credit risk is low, so households and firms borrow and consume. At the same time, government spending increases, as captured by the positive spending shocks. Overall, the output gap is around +15% in 2007. The recessionary shocks arrive in sequence. The model finds that sudden stop starts in 2009 and remains very significant until 2013. Government default risk

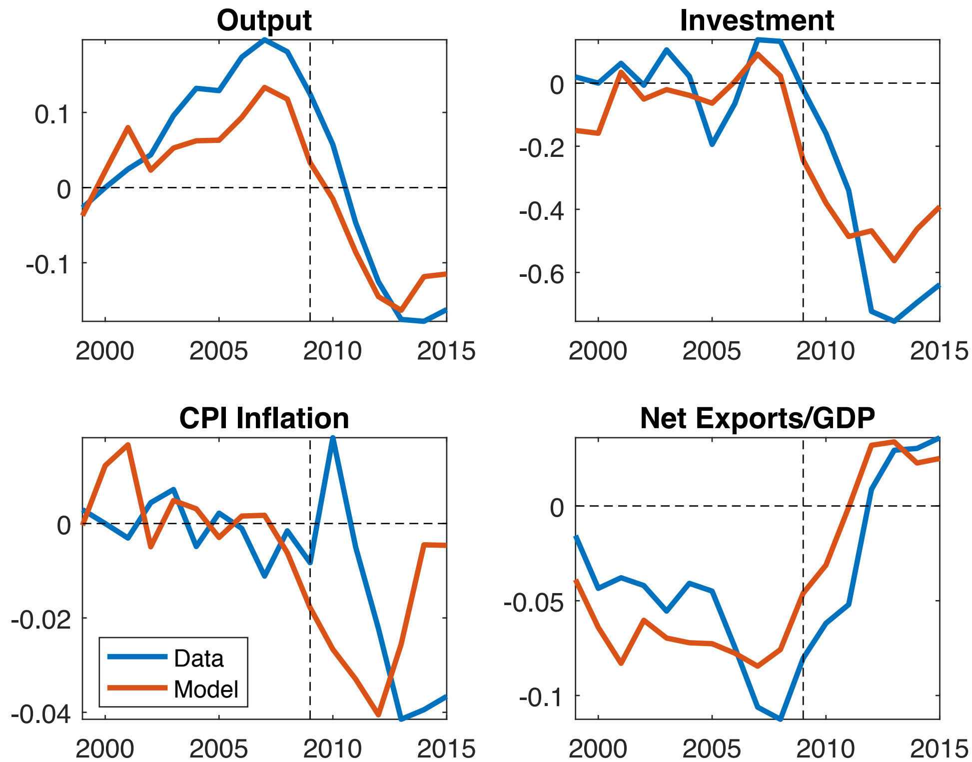

Figure 20: **Smoothed Variables**

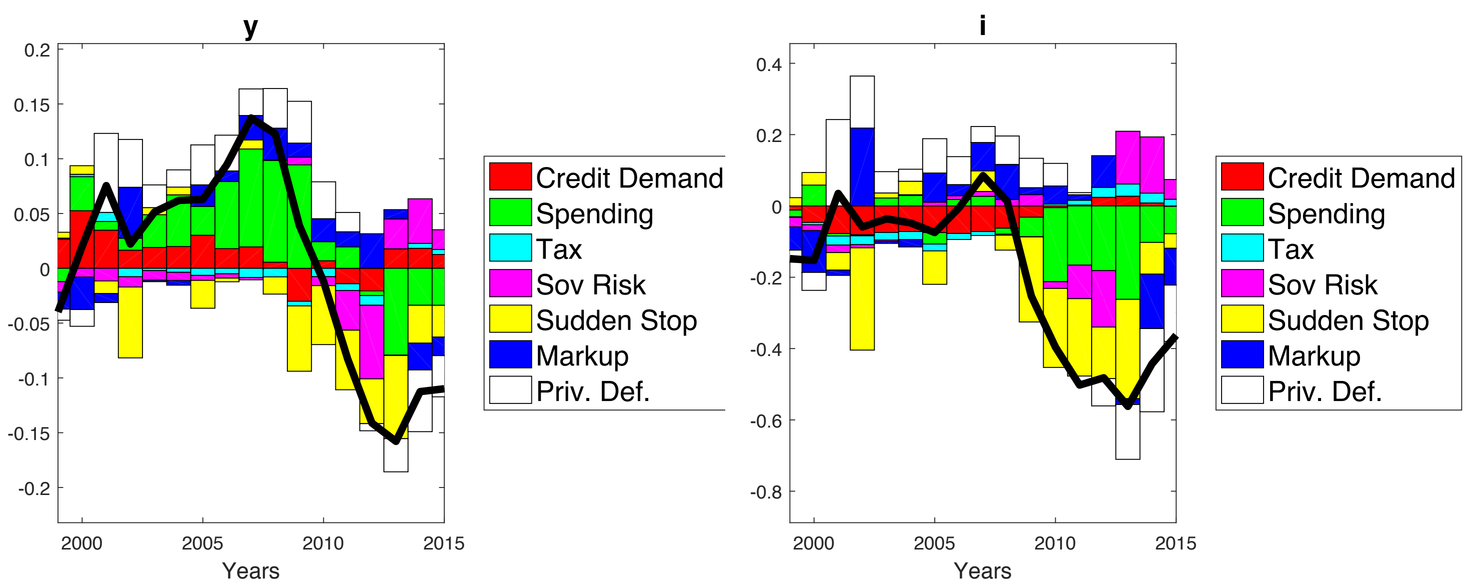

Figure 21: **Decomposition of GDP and Investment**

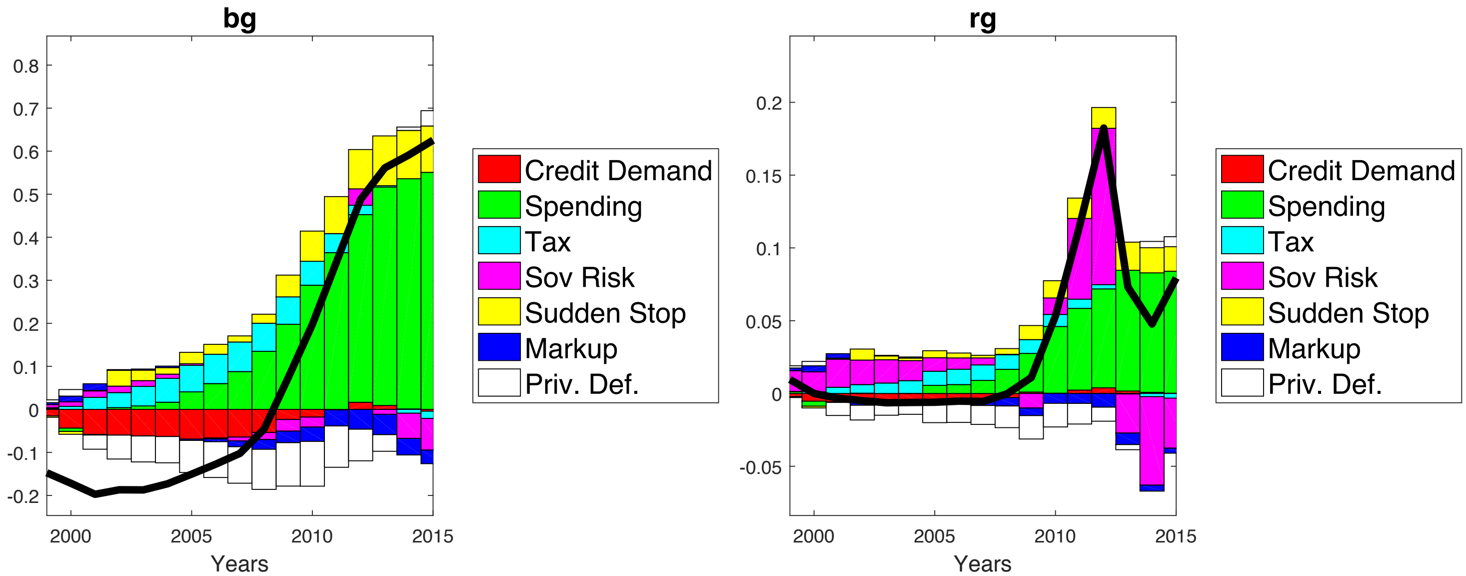

Figure 22: **Decomposition of Govt. Debt and Yield**

increases in 2011 and especially in 2012, the year of the sovereign default. Up to that point, there is no autonomous austerity, i.e. negative spending shock. In other words, the drop in government spending is explained by the increase in funding costs and the decline in economic activity. Our estimates indicate that large autonomous negative spending shocks did happen in 2013 and to a lesser extent 2014 and 2015. This coincides with the more the implementation of stringent conditionality under the 2012 IMF and Eurogroup program.[25] Finally, starting in 2013, the most important factor dragging down the economy are non performing loans. Investment (figure 21, right panel) is mostly affected by the sudden stop, but also by credit risk. Since 2013, in particular, private sector credit risk seems to have been a major drag on aggregate investment.

Figure 22 reports the decomposition for government debt and its yield. We see that the accumulation of government debt is mostly the consequence of past spending decisions. The yield on government debt is also mostly affected by the fiscal shock, and also by by sovereign risk.

Figure 23 reports both expected private defaults (left panel) and the funding cost of the private sector (right panel). Private default was low early in the sample (recall these are log deviation, so they need to go to $-\infty$ to explain a zero percent NPL). Later on default is mostly the consequence of macro dynamics. Private funding costs reflect mostly the sudden stop, and then also the exogenous default risk. Notice that the sudden stop also works through the default channel.

[25] One of the main aims of these measures was to eliminate Greece's primary deficit, which stood at 10% in 2010. Our estimates indicate that these measures had a significant contractionary effect.

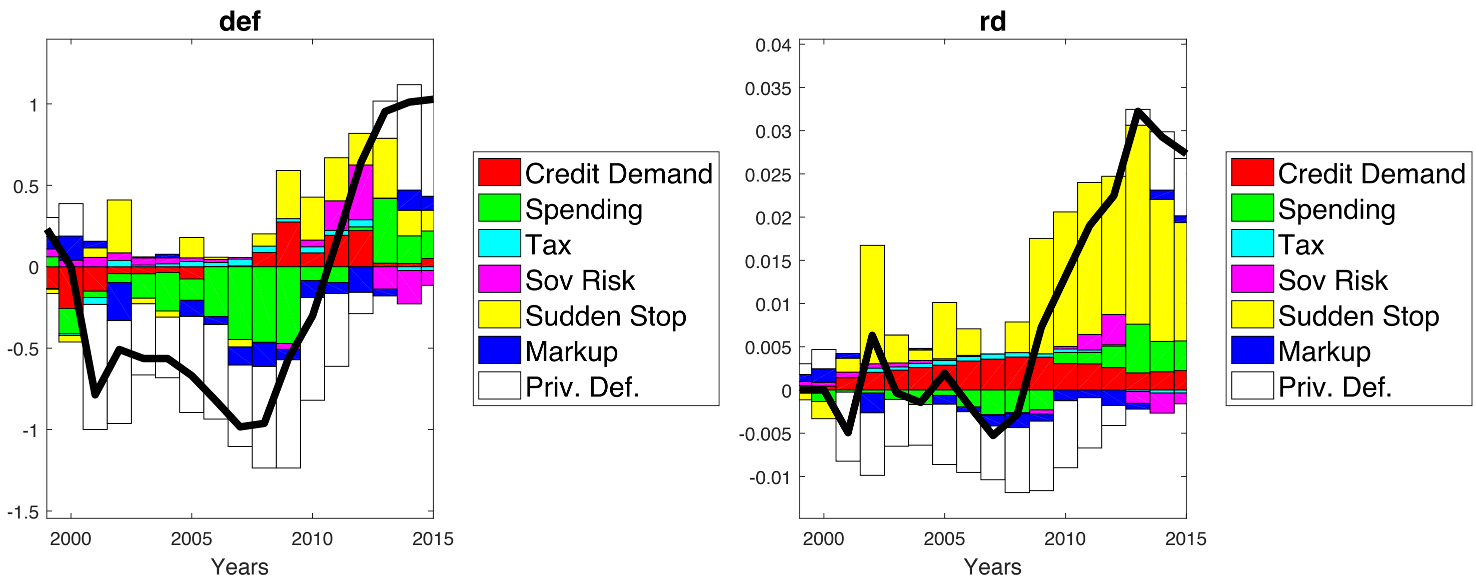

Figure 23: **Decomposition of Private Default and Funding Cost**

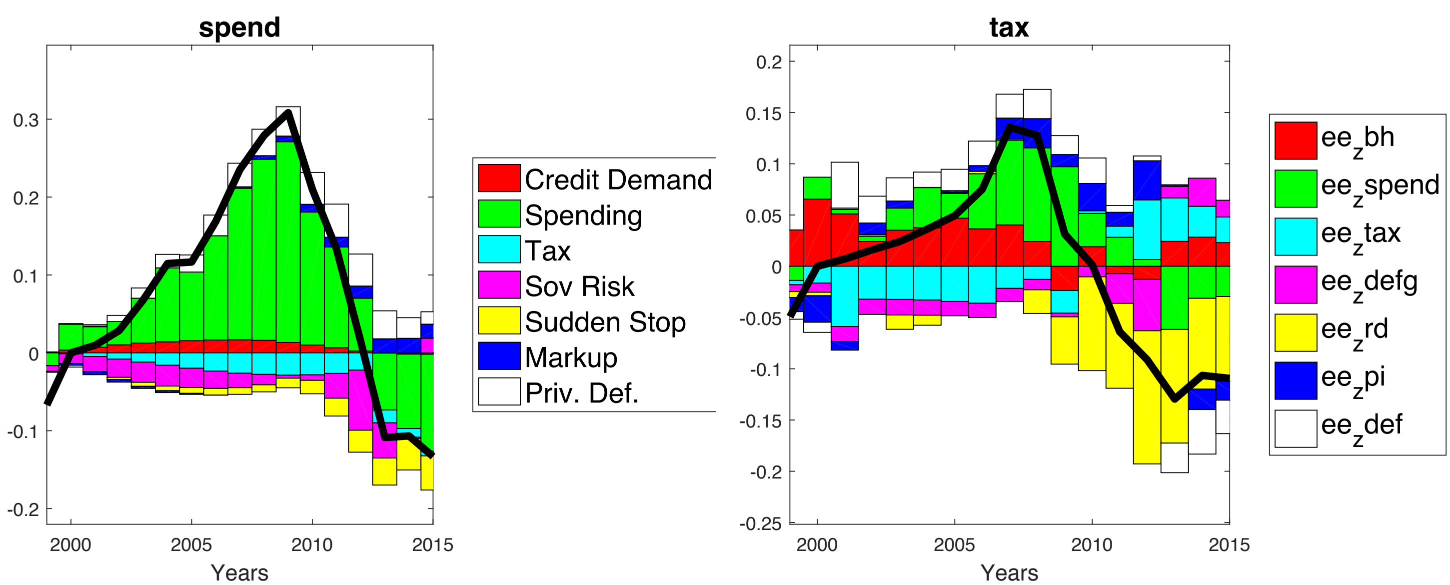

Figure 24: **Decomposition of Govt. Spending and Revenues**

Finally, figure 24 reports government spending and revenues. Government spending is largely autonomous in the boom, a finding consistent with Martin and Philippon (2014). In the bust, it is explained by the funding constraint, and then by restrictions consistent with the IMF/eurogroup program. Government revenues are dominated by macro dynamics.

7 Impulse Responses

We plot some impulse responses (estimated at the posterior means) to illustrate the mechanics of the model. We focus on the following shocks:

1. Household credit demand, ε_t^{bh}
2. Government spending, ε_t^{spend}
3. Private default, ε_t^{p}
4. Sovereign default risk, ε_t^{dg}
5. Sudden stop, ε_t^{r}

We focus on the impulse responses for the shocks that play a key role in our model.

Figure 25 shows the response of the economy to credit demand shock. Households borrow to finance consumption. Private debt increases, which leads to more credit risk in the future. This increases the private funding cost and decreases investment.

Figure 26 shows the response of some variable to a shock to T. Our model is not Ricardian. An increase in fiscal transfers from the government to households raises the consumption of borrowers, as well as output, employment, and inflation. Interest rates on government debt and corporate debt rise as well, and corporate investment drops.

Figure 27 shows the response of some variable to a shock to ε_t^{def}. An increase in credit risk leads to an increase in funding costs and a drop in investment.

Figure 28 shows the response of some variable to a shock to ε_t^{dg}. Because the government must fund itself with a higher interest rate, it adopts a more contractionary fiscal policy. This leads to a drop in output, and an increase in private credit risk, which then feeds back into higher funding costs. There is thus a version of the sovereign/bank look here, but it is entirely via indirect macro effects.

Figure 29 shows the response of some variable to a shock to ζ^r. An increase in the country's funding cost causes corporate investment to decline. Household debt declines as well, and so does borrower

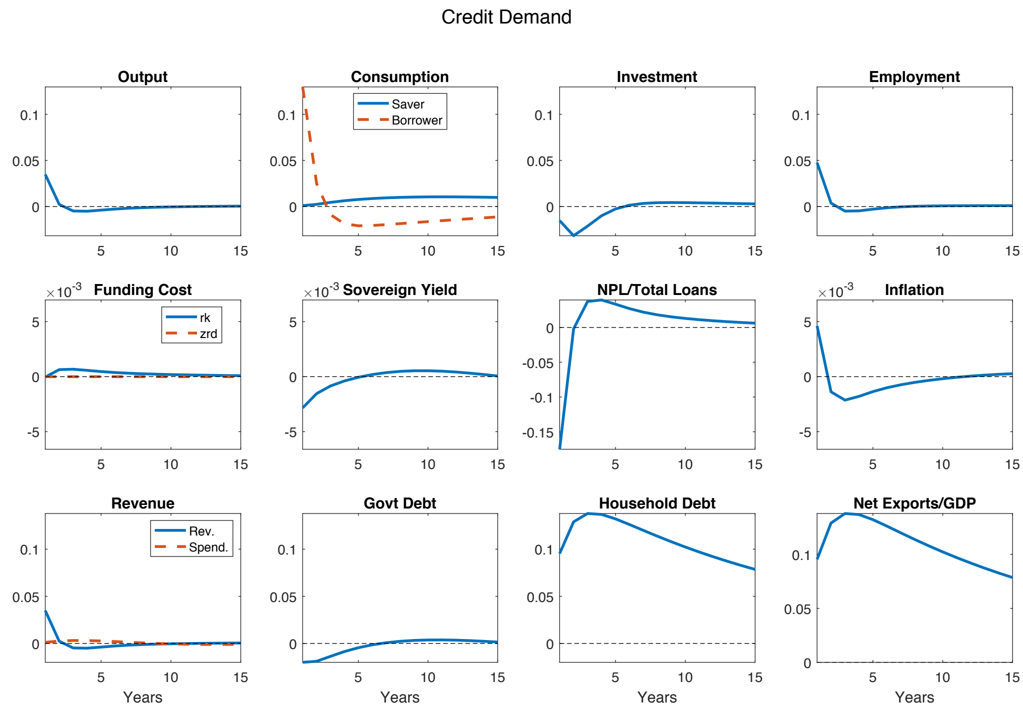

Figure 25: **Household Credit Demand Shock**

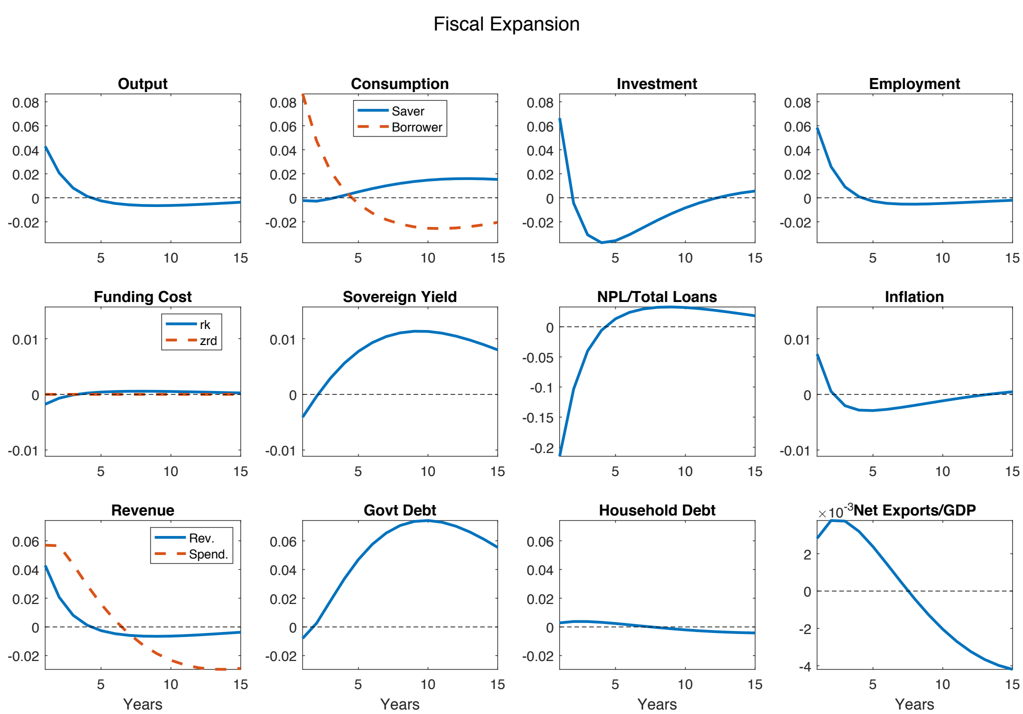

Figure 26: **Fiscal Expansion Shock**

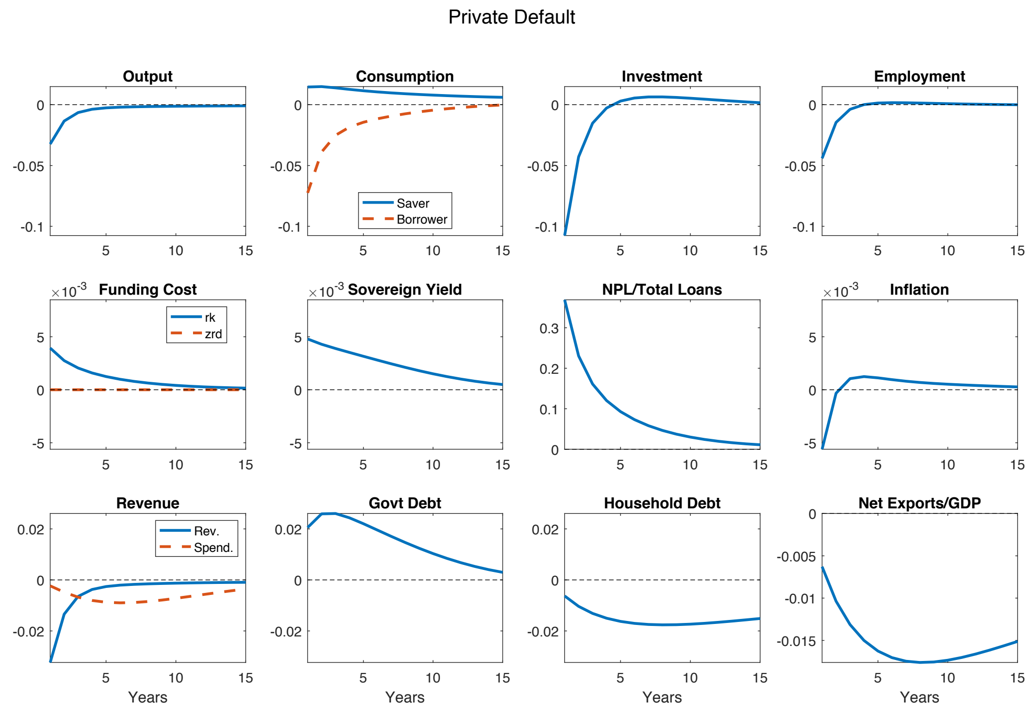

Figure 27: **Private Default Shock**

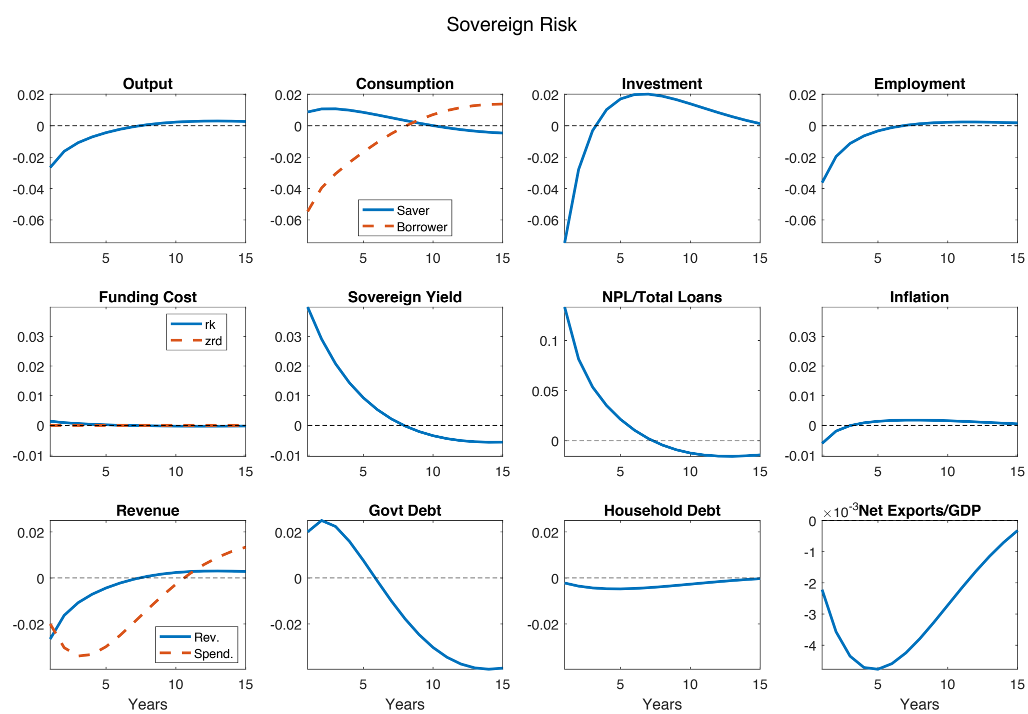

Figure 28: **Sovereign Risk Shock**

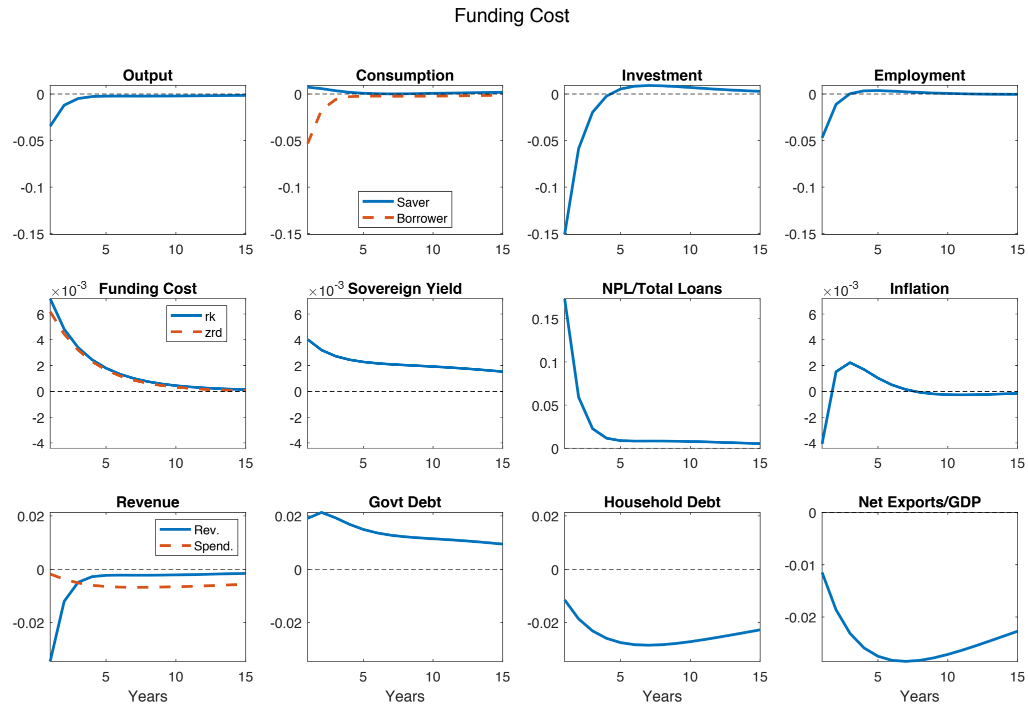

Figure 29: **Sudden Stop**

consumption. The decline in consumption and investment drives output down. The interest rate on government debt increases because sovereign risk increases.

8 Counterfactuals

In this section, we run two counterfactual exercises. First we ask: what would Greece have looked like without a "sudden stop"? For this, we simulate all the variables of the model using the path of estimated shocks except for ε_t^r, which we set to zero. We then compare the path of the variables to the ones we estimated and the ones we observe in the data. This counterfactual path corresponds to the experience that Greece would have had if the Eurozone had had a well-functioning banking union. Note that while the banking union removes the risk of a run on domestic banks, it does not remove the risk of default of the sovereign.

The second counterfactual exercise consists of asking the following question: how would had Greece reacted to the estimated sequence of shocks if it had the leverage ratio of a typical emerging market of Section 2. This second counterfactual is motivated by the evidence from section 3, that documents the severity and persistence of the Greek crisis when compared to many other – especially Emerging

Market crises.

To understand our counterfactual exercises, it is useful to think as follows: let y_{it} denote the observation of variable i at date t, and let $\hat{x}_{it}$ denote the smoothed value for variable i at date t. Let $\hat{x}_i^T \equiv \{\hat{x}_{i,t}\}_{t=0}^T$ denote the estimated sequence for variable i in our sample period $t = 0, \ldots, T$. Every estimated sequence can be written as a function of the estimated parameters $\hat{\Theta}$, and of the sequences of smoothed shocks, $\left\{\hat{\varepsilon}_k^T\right\}_{k=1}^K \equiv \{\hat{\varepsilon}_{k,t}\}_{k=1,t=0}^{K,T}$,where K is the number of shocks in our model,

$$\hat{x}_i^T = \Gamma\left(\hat{\Theta}, \left\{\hat{\varepsilon}_k^T\right\}_{k=1}^K\right), \forall i$$

For the purposes of our exercise, we let $\hat{\Theta} = \left\{\Theta^{cal}, \hat{\Theta}^{est}\right\}$ denote the combination of calibrated parameters and the mode of the posterior that results from the estimation procedure outlined in the previous sections. Naturally, both this object as well as the sequence of smoothed shocks are functions of the original data $\left\{y_i^T\right\}_{i=1}^N$ as well as of the priors that we choose. We omit these arguments for simplicity.

8.1 No Sudden Stop Shocks: A Banking Union counterfactual

For our first counterfactual exercise, we use the same vector of parameters that we estimated, $\hat{\Theta}$, and we recompute $\hat{x}_i^T$ based on a new sequence of smoothed shocks. This new sequence is identical to the one that we estimated, with the exception that we set $\hat{\varepsilon}_t^{rd} = 0, \forall t \geq 0$. We take all other shocks and recompute a new path for the Greek economy, $\left\{\hat{x}_i^{T,NSS}\right\}_{i=1}^N$ (which we index by NSS, for "No Sudden Stop").

Our results are in Figure 30. We plot the data in dotted yellow lines, the model's smoothed variables in red dashed lines and the counterfactual experiment in solid blue lines.

The counterfactual reveals that the absence of sudden stop would have almost no impact on the path of output during the build up. Recall that the path for output prior to 2007 was largely driven by high credit demand, as well as by the stimulative effect of expansionary fiscal policies. The eventual consolidation of fiscal accounts would have needed to take place, with or without a private sudden stop. In other words, a banking union would not insulate Greece from the consequences of unsustainable fiscal policies. However, the absence of a sudden stop would have made a large difference on private investment (top right panel) after 2010, contributing to a milder decline in output by about 5% of steady state output.

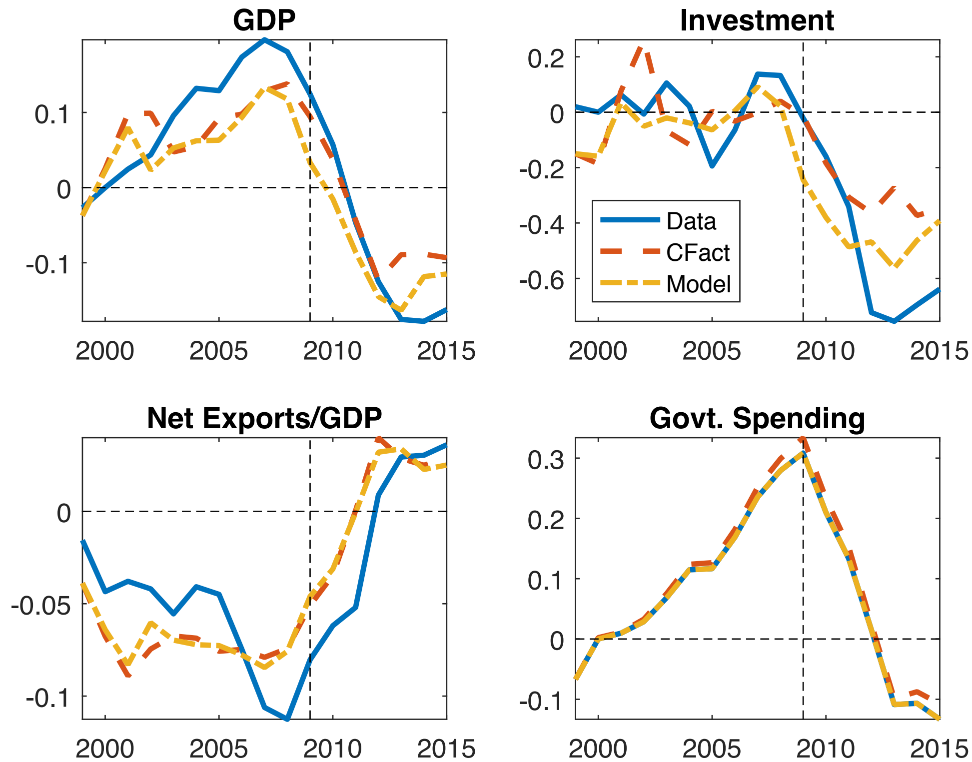

Figure 30: **Counterfactual: No Sudden Stop**

8.2 Low Leverage Economy

An alternative counterfactual that our model allows us to conduct is the following: what would have happened if Greece had experienced the same set of shocks, but with less leverage for the government, private and banking sectors? In this experiment, we modify the calibrated parameters of the model, Θ^{cal} in order to reflect lower leverage.

	Greece	Typical EME	Min	Max
Credit / GDP	1.01	0.46	0.025	1.46
Sovereign Debt / GDP	1.38	0.343	0.063	0.68
Current Account	-0.083	-0.039	-0.10	+0.17

Table 9: **Leverage and Imbalances Before Sudden Stop**
Notes: Average from t-6 to t-2 where t is sudden stop.

Table 9 compares the leverage of Greece to the leverage of other EME that have experienced a sudden stop as described in section 3. It is clear that leverage is much higher in Greece, in particular with respect to sovereign debt. To understand the impact of leverage, we reduce $\frac{B^h}{Y}$, $\frac{B^g}{Y}$, $\frac{G}{Y}$, $\frac{T}{Y}$ and bank leverage at the steady state by half. Then, we feed in the estimated parameters Θ^{est}, and the

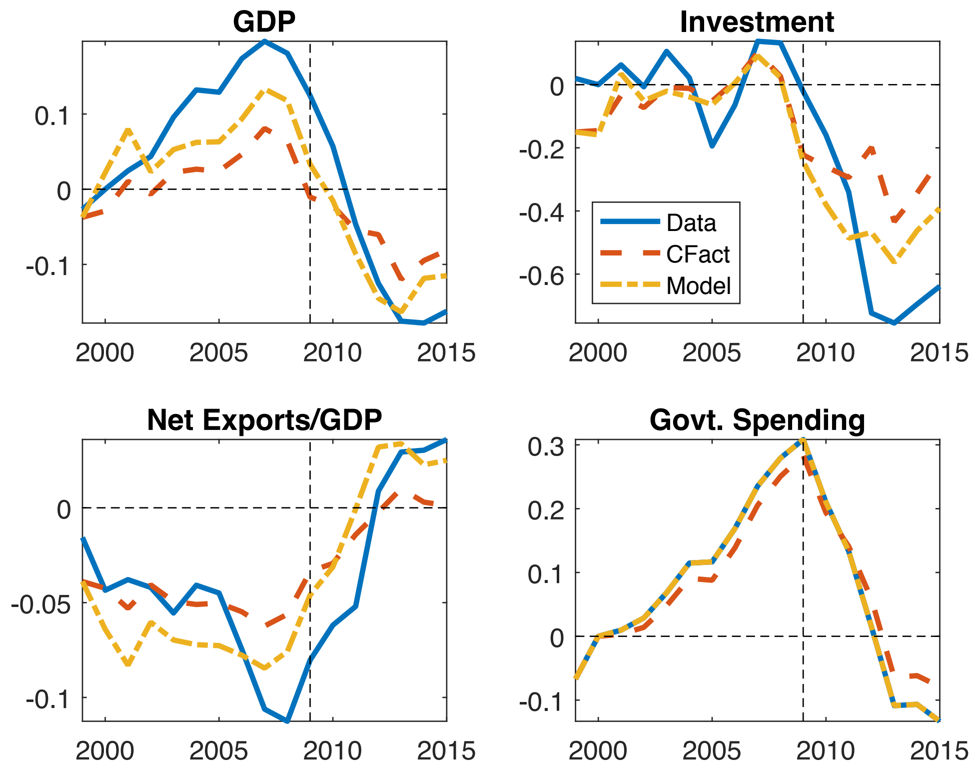

Figure 31: **Counterfactual: Low Leverage**

same sequence of smoothed shocks $\{\hat{\varepsilon}_k^T\}_{k=1}^K$ and recompute the path of the endogenous variables, $\left\{\hat{x}_i^{T,LL}\right\}_{i=1}^N$ (which we index by LL, for "low leverage").

In this counterfactual, Greece would have been much more constrained in the build up phase of the crisis. The smaller size of its government sector would have prevented it from excessively stimulating its economy. Once the fiscal contraction, sudden stop and sovereign risk materialize, we find that they would have a substantially more muted impact on the economy. For instance, much of the excess drop in investment observed in figure 11 can be attributed to the exceptional leverage of the Greek economy relative to other emerging economies that experience sudden stops.

In summary, Greece has experienced a emerging market trifecta crisis, but with initial levels of exposure and leverage more commonly associated with advanced economies.

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Appendix

Empirical Appendix

The list of countries and regions is in Table 10. To be completed.

Calibration

This appendix contains more details on the calibration. Table 12 contains the parameters that we choose to match steady state targets for Greece. Table 13 contains the fiscal rule parameters that we calibrate rather than estimate.

Table 10: List of Countries.

Region	Countries
Latin America (13)	Argentina, Brazil, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, Jamaica, Mexico, Panama, Peru, Uruguay, Venezuela
Asia (11)	China, Hong-Kong, India, Indonesia, South Korea, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Thailand
Middle East and North Africa (10)	Egypt, Iraq, Israel, Jordan, Kuwait, Lebanon, Morocco, Oman, Tunisia, United Arab Emirates
Central and Eastern European (15)	Bosnia, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Serbia, Slovak Republic, Slovenia, Turkey
South Saharan Africa (3)	Cote d'Ivoire, Nigeria, South Africa
Commonwealth of Independent States (5)	Belarus, Georgia, Kazakhstan, Russian Federation, Ukraine
Advanced Economies (22)	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States

Table 11: Standard Parameters

Parameter	Description	Value
β	Discount Factor	0.97
α	Capital Share	1/3
ϵ_h	Elasticity between H and F	1
ϵ_f	Elasticity between exports	1
φ	Inverse labor supply elasticity	1
γ	Risk Aversion	1
ϑ	Price Stickiness	0.5
ε	Elasticity of Substitution Goods	6
ϑ_w	Wage Stickiness	0.5
ε_w	Elasticity of Substitution Labor	6
ϵ_r	Elasticity of R to NFA	0.0001
φ_k	Adjustment Cost	1
δ	Depreciation	0.07
FC	Fixed cost of production, 10% of Y	0.097

Table 12: Internally Calibrated Parameters for Greece

Parameter	Description	Value
ϖ	Openness (Martin and Philippon (2014))	0.3
χ	Fraction of Impatient (Martin and Philippon (2014))	0.65
Δ	Annual lending spread of 2%	1.02
$\frac{B^h}{Y}$	Household debt to GDP of 50%	0.5
$\frac{B^g}{Y}$	Government debt to GDP of 120%	1.2
$\frac{G}{Y}$	Government consumption to GDP of 20%	0.2
$\frac{T}{Y}$	Public social expenditure to GDP of 20%	0.2
d^h	Steady state default rate for Households	5.4%
d^k	Steady state default rate for Corporates	5.4%
$\frac{B^k}{Y}$	Corporate debt to GDP of 50%	0.5
ψ_{sk}	Working Capital Constraint, not active	0
τ	Tax rate, budget balance in SS	0.436

Table 13: Other Parameters

Parameter	Description	Value
F_b	Elasticity of govt. spending to public debt	0.05
F_n	Elasticity of govt. spending to employment	0.025
F_r	Elasticity of govt. spending to the int. rate	0.5
F_l	Persistence of govt. spending	0.75

Shocks

Using the Kalman Smoother at the posterior mode, we can retrieve sequences for the structural shocks in the model, which are shown in 32. These are obtained by applying the Kalman Smoother for the sequence of observables, with all parameters set at their posterior modes.

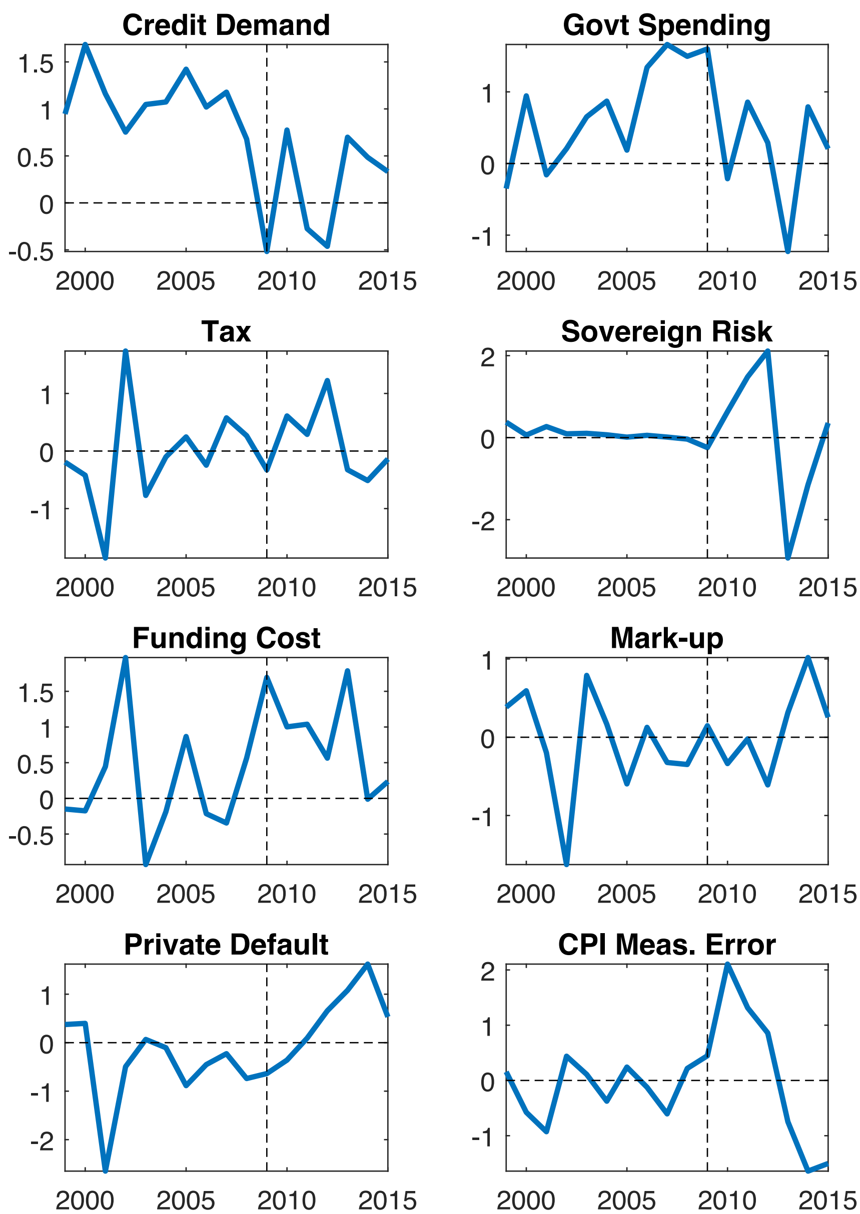

Figure 32: **Smoothed Shocks**